To survive or to thrive: An investigation into fatigue and associated factors on surgical performance

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Supervisor: Professor Paul Ridgway

Dale Francis Whelehan, BSc. (Physiotherapy)

Volume One

Declaration

I, Dale Francis Whelehan declare that:

a) This research has not been submitted as an exercise for a degree at this or any other University.

b) This research is entirely my own work and I led the following projects in collaboration with other researchers as follows:

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- Dr. Michael Alexander
- Ms. Amy Gillis
- Mr. Umair Muhammad
- Dr. Taryn Taylor
- Lt. Col. Niall Buckley
- Prof. Kevin Conlon
- Ms. Tara Connelly
- Dr. Cathleen McCarrick
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Summary

Background

The issue of fatigue has been long-standing in the profession of surgery. Typically the term has been associated with performance decrement, and in particular, focus has been on mitigating fatigue to prevent error-making. Emerging fields of fatigue research is beginning to explore the motivational components, and how fatigue and performance relationships are much more complex. This research uses surgery as a case study example of how a dysfunctional profession, with high-stake outcomes, can culminate in complex understandings between causes and effects of fatigue. It also proposes a significant change in paradigm to that of what is required to 'survive' with fatigue or to 'thrive' in work and life.

Methods

This is a mixed-methods research approach being primarily explored through a post-positivist lens. It is informed by the Medical Research Council Framework for Complex Interventions. Initially, a narrative and systematic review were conducted to identify the impact of sleep deprivation on aspects of surgical performance. Thereafter, a single-site observational study, exploring the impact of on-call models of sleep and performance outcomes, in surgeons was completed. An exploration of clinical decision-making, as an aspect of non-technical performance, ensued through four methods: a review of the literature, an exploratory survey study of variables influencing clinical decision-making, a validation of a simulated scenario of clinical decision-making, and a pilot exploration of the impact of cognitive load on decision-making outcomes. Following this, three qualitative studies were conducted on a single-site cohort, informed by a thematic analysis, identifying the phenomena of fatigue, thriving, and the confounding role of the COVID-19 pandemic in surgery. These thematic findings informed the design and validation of an extensive survey study design which sought to establish trends between health, well-being, lifestyle, work, and performance outcomes. Triangulated findings merged with theoretical underpinning of the COM-B model of behaviour change, culminating in the design of an individualised behaviour-change intervention. This was piloted and tested for feasibility in a single-site. Finally, collected data informed the design of a theory exploring the relationship between fatigue, performance, and thriving, and the required prerequisites to optimise performance. Cohorts of physiotherapists were used to explore comparisons of the outcomes of this research to healthcare professionals and systems as a whole.

Results

The literature based on fatigue in surgery is conflicted. While more studies identified no impact on simulated or real-life performance, decrement was higher in studies with cognitive

performance requirements. Systematic findings suggest a decrement in technical performance of 11.9%-32% in validated simulated scenarios. These findings were verified by the observational study, which also identified that both current workflow and on-call models predispose surgeons to early onset sleep. In exploring the ramifications of clinical decision-making, a validated clinical decision making assessment method identified that intuitive decision-making processes are predominantly influenced by practitioner and disease-related factors, and the deployment of greater risk-taking in decision-making was associated with those surgeons who then reported higher cognitive load. The self-identified causes and effects of fatigue were numerous, and included both work and non-work related factors for surgeons. The presence of COVID-19 added additional stressors, but resulted in contrasting levels of fatigue between surgeons. Trends in survey findings identified a symbiotic relationship between self-identified health, well-being, and performance, which was influenced by a myriad of lifestyle factors including sleep, stress and physical activity. In addition the work factors of culture and resource also influenced performance outcomes. There are opportunities for thriving in surgery. Surgeons perceived fatigue and sleep deprivation to be the main inhibitor to them thriving in work, but the theoretical objective synthesis identified that both states can co-occur, as long as there is a higher level of recovery processes, psychological capital, and psychological skill use. The use of a behaviour-change intervention which identified two phases, education and coaching, proved to be a feasible way to enable greater access to thriving states. These findings have comparisons to other context-specific healthcare professions, such as physiotherapy, where similar issues of fatigue and sleep deprivation exist.

Conclusion

A fundamental shift in understanding of fatigue in surgery has been provided, with triangulating evidence suggesting the impact of the state on all aspects of surgical performance. The primary responsibility for performance optimisation lies with the individual themselves, but environmental restructuring to facilitate performance optimisation, particularly through biomathematical modelling of work-life and positive cultures will likely sustain behavioural efforts. There is oftentimes a focus on negative performance domains, and the impact of current environmental and cultural restrictions on surgical performance. This thesis provides legitimate and warranted need for further exploration of the positive aspects of performance, and how the roles of three variables in particular – recovery processes, psychological capital, and psychological skills utilisation may influence the relationship between performance in fatigued surgeons who ‘survive’ or those who ‘thrive’.

Acknowledgement

As the African proverb goes, it takes a village to raise a child. It similarly takes a community of exemplary people to support a PhD candidate. An unsurmountable amount of appreciation must be given to several people who have helped me throughout this process.

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"Dear incomprehension, it's thanks to you I'll be myself, in the end" – Samuel Beckett

Ethical Consideration

Three ethics committees approved projects for use within this thesis - The St James and Tallaght Research and Ethics Committee, Tallaght Hospital, Dublin 24 (JREC); The Royal College of Surgeons Research and Ethics Committee (RCSI); and The School of Medicine Research and Ethics Committee, University of Dublin, Trinity College (TCD). Written informed consent was gained from all participants to utilise the data collected for research and publication. For anonymous survey studies, informed consent for research and publication was indicative of completion of the survey. The reference list and associated study chapters are as follows:

Chapter 3: JREC 2019-07

Chapter 4: JREC 2020-02, JREC 2020-03, TCD 2018-1105, RCSI 212495199

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Chapter 6: JREC 2020-05

Chapter 7: JREC 2020-02, JREC 2020-03, JREC 2020-11

Chapter 8: JREC 2020-05, TCD 2019-0105

Permissions and Disclosures

Permission was sought and granted for any copyrighted material. Parts of this thesis contains published works by the primary author. Permission for use in this thesis have been sought and approved by all the journals.

Dissemination

Conferences Abstracts Accepted:

1. To examine If sleep deprivation from on-call impacts on simulated surgical performance (15th Annual Academic Surgical Congress, 2020)
2. Mapping modifiable lifestyle factors that impact on-call surgical performance (Freyer Surgical Conference, 2020)
3. Fatigued Surgeons – would you let them fly a plane? (Freyer Surgical Conference, 2020)
4. Dynamic and integrated assessment of the domains of good professional practice in surgeons: a validation study (Irish Network of Healthcare Educators, 2020)
5. Exploring the relationship between sleep deprivation and professional practice in Irish Physiotherapists (Irish Society of Chartered Physiotherapy Conference, 2019)

Scientific Articles Accepted:

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2. Whelehan, D.F. Baily-Scanlan M. and Ridgway, P.F., 2021. Is your physio tired? Exploring sleep deprivation in Irish physiotherapists. *Physiotherapy Practice and Research*. [Chapter 8]
3. Whelehan, D.F. Alexander, M. and Ridgway, P.F., 2020. Would you allow a sleepy surgeon operate on you? A Narrative Review. *Sleep Medicine Reviews*. [Chapter 2]
4. Whelehan, D.F., Conlon, K.C. and Ridgway, P.F., 2020. Medicine and heuristics: cognitive biases and medical decision-making. *Irish Journal of Medical Science*. [Chapter 4]
5. Whelehan, D.F. McCarrick, C.A. and Ridgway, P.F. 2020. A systematic review of sleep deprivation and technical skill in surgery. *The Surgeon*. [Chapter 2]
6. Whelehan, D.F. Conlon, K.C. and Ridgway, P.F. If in Doubt Don't Act Out! Exploring Behaviours in Clinical Decision Making by General Surgeons Towards Surgical Procedures. *World Journal of Surgery*. [Chapter 4]
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10. Whelehan, D.F., Alexander, M., Connelly, T.M., McEvoy, C. and Ridgway, P.F. 2021. Sleepy surgeons: a multi method assessment of sleep deprivation and performance in surgery. *Journal of Surgical Research*. [Chapter 3]
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Operational Definitions

Behaviour

An organism's activities in response to external or internal stimuli, including objectively observable activities, introspectively observable activities, and nonconscious processes (APA, 2007).

Behaviour Change Intervention

A coordinated set of activities designed to change specified behaviour patterns (Michie et al., 2011).

Coaching

Coaching is a deliberate practice activity which seeks to invoke knowledge attainment, wisdom, and self-awareness. It aims to enhance well-being and performance in both personal and work domains, and is an emerging discipline (Passmore and Lai, 2020).

Confirmability

Similar to that of objectivity, is the steps required by the researcher to illustrate reduced researcher bias (Lincoln and Guba, 1985).

Construct

This is a scientific measurement, comprising of a cluster of covarying behaviours used to understand a particular phenomenon in a person's thoughts, feelings, or actions, which cannot be directly observed. It allows assessment of naturally occurring phenomena and to explore relationship between different phenomena such as fatigue and burnout to see if they interact with one another. They are operationalised through a myriad of observable behaviours (Messick, 1981).

Credibility

Similar to internal validity, reflects the correct interpretation of the data by the researcher to ensure it is accurately represented (Lincoln and Guba, 1985).

Dependability

Similar to reliability, reflects the consistency of data findings. It was assured by establishing and managing an inquiry audit which showed the study to be consistent in process, trackable, and accurate (Lincoln and Guba, 1985).

Emotion

A complex reaction pattern, involving experiential, behavioural, and physiological elements, by which the individual attempts to deal with a personally significant matter or event (APA, 2007).

Fatigue

A subjective psychological state which is characterised by reported feelings of tiredness, and sometimes associated performance decrement (Hockey, 2013). Operationalised terminology of the construct is seen in *Chapter 1*.

Heuristic

A series of mental models which create cognitive shortcuts to assist in intuitive decision-making.

Psychological capital

Refers to the positive psychological development of an individual, as defined by the four resources of self-efficacy, hope, optimism, and resilience (Luthans et al., 2007).

Reliability

Reliability is concerned with the strength of relationships between observed scores and true scores. This refers to the extent in which scores are free from measurement error. It assesses consistency of a measurement over different cases (inter-case) and different examiners (inter-rater).

Surgical Performance

The observable aspect of behaviours on which the competency of a surgeon are evaluated. Performance is assessed through effectiveness in technical/non-technical domains.

Transferability

Similar to that of generalisability of external validity, it refers to the inferences that extends beyond the data findings (Lincoln and Guba, 1985).

Thematic Analysis

This is a qualitative analysis tool to identify phenomena which appear throughout the interview transcripts, as determined by the researcher, and then attempts to make interpretations on the meaning of these phenomena through theme formation (Clarke and Braun, 2015).

Triangulation

The use of multiple approaches to develop comprehensive understandings of phenomena such as fatigue and performance (Denzin, 1978). Four types of triangulation occurred in this project. These are data triangulation, methods triangulation, investigator triangulation, and theoretical triangulation.

Thriving

The joint experience of development and success (Brown et al., 2017) which captures the experience of full functioning, and can be observed via the concurrent subjective perceptions of high-level performance and wellbeing. It is influenced by two dimensions – a sense of learning and a sense of vitality (Spreitzer et al., 2005).

Validity

Validity is concerned with the strength of relationship between observed score and constructs of interest. The extent in which observed scores reflect true performance on a construct being tested, such as reporting of sleep deprivation versus actual sleep deprivation. Traditionally differentiated into content-related, criterion-related and construct-related.

Health and Wellbeing

Health is the state of combined and fulfilled physical, mental and social wellbeing, and not merely the absence of disease (WHO, 1948). Can be further differentiated into hedonic i.e. shorter-term (subjective) or eudemonic (psychological) i.e. longer-term.

Abbreviations

3DFI - 3D fatigue inventory

ACGME – Accreditation council for graduate medical education

aMT6s – Association of urinary 6-sulfatoxymelatonin

ASIT - Association of Surgeons in Training

BCTs - Behaviour change techniques

BCTT - Behaviour change techniques taxonomy

BCW – Behaviour change wheel

BEME - Best evidence in medical education

BPN – Basic psychological needs

BST - Basic surgical training

CEBM – Oxford Centre for Evidence-based Medicine

CFS – Chalder fatigue scale

CHERRIES - Checklist for reporting results of internet e-surveys

COREQ - Consolidated criteria for reporting qualitative research

COVID-19 – Coronavirus 2019

CRM - Crew resource management

DCS – Demand-control-support

DOPS - Direct observation of procedural skills

dVSS - da Vinci Skills Simulator

EEG - Electroencephalogram

ESS – Epworth sleepiness scale

EWTD – European Working Time Directive

FIRST - Flexibility in duty hour requirements for surgical trainees

fMRI – Functional magnetic resonance imaging

FRMS – Fatigue risk management system

GROW - Goals, reality, options, will

HEPA - Health enhancing physical activity

ICAO – International Civil Aviation Organisation

iCOMPARE - Individualised comparative effectiveness of models optimising patient safety and resident education

ISCP - Irish Society of Chartered Physiotherapists

KSS – Karolinska sleepiness scale

MBSR - Mindfulness-based stress reduction

MCQ – Multi-choice questionnaire

MEQ – Morningness-eveningness questionnaire

MIST-VR - Minimally invasive surgical trainer-reality system

MRC – Medical Research Council

MSLT – Multiple sleep latency test

NASA-TLX – Task load index

NOTSS - Nontechnical skills for surgeons

NREM – Non-rapid eye movement

OFER – Occupational fatigue exhaustion recovery

PANAS - Positive and negative affect schedule

PCQ - Psychological capital questionnaire

PRISMA – Preferred reporting items for systematic reviews and meta-analyses

ProMIS - Patient-reported outcomes measurement information system

PSQI – Pittsburgh sleep quality index

PVT – Psychomotor vigilance test

PWBI - Physician wellbeing index

RCSI - The Royal College of Surgeons in Ireland

REM – Rapid eye movement

RPQ – Reflective practice questionnaire

SAFTE - Sleep, activity, fatigue, and task effectiveness

SDT – Self-determination theory

SHO – Senior house officer

SIMP - Single-Item Measures of Personality

SMART - Specific, measurable, attainable, relevant, time based

SOAR – Coaching programme

TAW – Thriving at work

TDF – Theoretical domain framework

TOPS-2- SF - Test of performance strategies short form

UEMS - European Union Medical Specialist Fellowship Examinations for General Surgery

USMLE - United States Medical Licencing Examination

WCQ - Workplace Climate Questionnaire

WHO – World Health Organisation

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1. Chapter 1 – Introduction

1.1. INTRODUCTION

Ms. Libby Zion was an 18 year old freshman at Bennington College who was admitted to the emergency room on the night of March 4th 1984. She was presenting with ‘strange jerking motions’ and, as per standard procedure, she was allocated two residents. The residents examined her symptoms and prescribed her meperidine, an opioid similar to morphine. Both residents were busy with a large caseload, as was the norm every night on-call. One of the residents was later contacted by nursing staff who reported Ms. Zion’s symptoms were not improving. She was reviewed and prescribed haloperidol. By 6:30 a.m., Ms. Zion’s temperature climbed to 42 degrees Celsius. She went in to cardiac arrest, and died soon after.

Subsequent reflections identified that Ms. Zion had been taking the antidepressant, phenelzine, which, when combined with meperidine, caused the development of serotonin syndrome. In 1986, a grand jury indicted both residents with 38 counts of gross negligence. A life was lost, a family was devastated, and two careers were negatively impacted. Root cause analysis identified a myriad of systemic causes of this avoidable outcome – including insufficient trainee supervision, patient-centred care ideology, insufficient medication systems, and personnel fatigue. Efforts to tackle these causes have been ongoing within healthcare ever since, though fatigued healthcare staff remain as prevalent an issue in 2021 as it was that night in 1984.

1.2. WHAT IS FATIGUE?

Grind to a halt. Run out of steam. Burned out. Fatigue is a psychological state, subjectively experienced by individuals and heavily influenced in understanding by historical comparisons of humans as machines (Hockey, 2013, p.7). The state was first identified in medical literature in the late 1800’s as a “a disease of overwork and a sign that the body and mind have limited capacity for responding to the demands of modern working life” (Rabinbach, 1990, p.153). The term ‘fatigue’ is subjective, and varies in interpretation by individuals. Most industrial definitions rely on the core concept of ‘energy depletion’ as a process resulting in fatigue. This has embedded the phenomenology of fatigue in modern society as an energy-loss state.

Approaches to understand and measure fatigue have been reductionist, identifying decrement in performance as a quantifiable measurement of output. Subsequent and culminating definitions of fatigue have categorised it as a state of "extreme tiredness and reduced functional capacity that is experienced during and at the end of the work day" (Frone and Tidwell, 2015, p.274). From the perspective of the individual experiencing fatigue, and the organisation in which the individual works, it is evident that fatigue plays a confounding role in personal and professional performance.

Often the terms 'fatigued' and 'sleepiness' are used interchangeably, yet there are some unique characteristics to both states. Sleepiness is uniquely characterised by an increased sleep propensity and higher levels of drowsiness (Pigeon et al., 2003). Sleep deprivation can increase fatigue levels and both states have causes and effects which overlap. Both states negatively impact working memory capacity (Peng et al., 2020; Jain and Nataraja, 2019), leading to a reduced ability to store information in the 'working memory' or to recall from long-term memory (Alhola and Polo-Kantola, 2007). This has implications for cognition. Both states negatively impact affect and mood (Hockey, 2013; Rosen et al., 2006), which has implications for emotional regulation. Finally, negative impacts on procedural place-keeping (Stepan et al., 2020) have been found which has could have implications for technical skills. The states differ particularly in causes. Sleepiness results from a reduced sleep quantity or quality while theories of causes of fatigue require further exploration.

Theories of Fatigue

The objective evaluation of fatigue using functional magnetic resonance imaging (fMRI) seen in *Figure 1.1* shows differences between the occupationally 'chronically fatigued' and 'non-fatigued' brains in residents when completing clinical tasks (Durning et al., 2013). Higher exhaustion was associated with increased activity in the right posterior cingulate cortex and right middle frontal gyrus. Higher depersonalisation was associated with decreased activity in the bilateral praecuneus. On reflection tasks, lower activity in the right dorsolateral prefrontal cortex and right middle frontal cortex were identified.

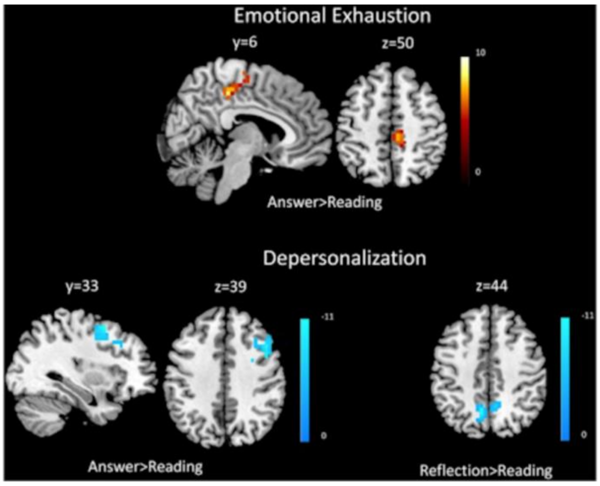


Figure 1.1. Brains of fatigued residents areas of involvement in those reporting higher emotional exhaustion and depersonalisation scores with permission granted (Durning et al., 2013)

It is evident therefore that the phenomena of fatigue has objective findings despite being a subjective state. To understand the causes of the fatigue, it is important to explore the two main theoretical underpinnings of the state. The first is cognitive load theory (Sweller and Chandler, 1991), while the second is the emerging motivational control of executive functions theory (Hockey, 2013).

Cognitive Load

Within the theory of cognitive load (Sweller and Chandler, 1991), it is hypothesised that the working memory can hold a finite amount of information. This places a 'cognitive load' on the brain. Typically individuals will have a cognitive load in relation to the specific task they are completing i.e. 'intrinsic', which can then be exacerbated by environmental stressors i.e. 'extraneous' leading to the 'split attention effect'. The final load relates to a 'germane' load, which is the utilisation of data processing mental tools to chunk large pieces of data together, known as 'schemas'. By having effective schemas, individuals can incorporate larger pieces of information from the 'intrinsic' load, but only in instances where the 'extraneous' load is reduced.

Motivational Demands

In addition to cognitive load, the emergence of theories which incorporate humanistic psychological aspects, such as motivation, have identified additional cognitive elements which could contribute to fatigued states. Within these theories, fatigue is hypothesised to occur with the use of three executive functions, in accordance with the motivational model of executive control, effort, and fatigue (Hockey, 2013).

The first function is effort regulation, which states when individuals are working in high effort states, with associated personal and environmental stressors, they are actively appraising their environmental and emotional demands in relation to the demands of the task (Frankenhaeuser, 1986). The second function is performance evaluation, which states fatigue signals executive control mechanisms to the decreasing utility of whatever current activities are being employed. The third function is goal regulation, which allows appraisal of the situation and consideration of whether alternative activities with alternative goals should be considered for attentional control. Goals are shaped by cognitive, somatic, and environmental events, and thus vary regularly. Work and life-factors, known as 'stressors', may also influence these aforementioned executive functions, and therefore fatigue levels. Work-related stress refers to the "adverse reaction people have to excessive pressures or other types of demand placed on them at work" (HSE, 2020). Fatigue increases when the individuals experience increased pressures, reflecting a state of internal competition between environmental demands for attention and available personal resource. This is more likely to occur in contexts where low agentic control is present, such as low perceived autonomy (Hockey, 2013, p.217), as well as being caused by personal-factors such as individuals perceived meaning in work, and their ability to cope with work stressors (Hockey, 2013, p.272).

There are three interesting insights that this emerging model of fatigue provide, that shifts perspectives about traditional views of the relationship between fatigue and performance, and offers further verification that the state is subjective and varies between individuals. First, the theory provides insights into the importance of cognitive appraisal processes involved in performance maintenance. In situations where there is a perceived difficulty, or 'strain' with a task, individuals opt either for an increase in effort to maintain performance or they reduce effort, allowing performance to diminish. Intrinsic motivational factors (Deci and Ryan, 2004) are defined as playing an important role in the processing of information, and in doing so, decide whether to induce fatigue signals. Cognitive appraisals are biased towards personally valued tasks. In situations where individuals are engaged in a task they enjoy, they may enter into a state of 'flow' (Csikszentmihalyi, 1990), characterised by optimal performance. In these instances, stressors play little role in impeding performance processes and outcomes. Alternatively, if for reasons beyond the control of the individual, such as reduced autonomy or resources, they are required to maintain tasks which do not meet their motivational demands, then strategies are employed to overcome this resistance and associated fatigue results in disengaged states of performance.

Second, the theory provides an alternative view of the fatigue signal. It states that fatigue is an 'emotional signal' which evolved as an adaptive response to assist individuals in management of personal goals and associated stressors. Fatigue states act as a warning to individuals that their current task may be in conflict with their motivational goal requirements, and that overcommitment to such a task may result in negative impacts on performance. In doing so, the signalling-state will increase awareness of neglected personal needs and suggest alternative goals, resulting in an appraisal of the benefit-cost of current task demands. Individuals will typically feel the urge for rest at this point, which allows the opportunity for more effective reappraisal, and for change in task to occur if required.

Finally, the theory describes the trajectory of fatigue and the complex relationship to performance decrement. In the emerging theories, the relationship can be conceptualised as a continuum seen in *Figure 1.2*. In the first instance, fatigue will emerge transiently in what is known as the 'acceptance' phase. In this instance, minor performance decrement occurs. If increased demands are placed on the individual, then there is an increase in subjective effort. This results in the second phase known as 'resistance', which is characterised by increased fatigue but maintenance of performance. If the 'resistance' phase is maintained for a long period of time, individuals enter the 'strain' phase which is similar in characteristics to the previous phase but also results in minor performance decrement. In both the 'resistance' and 'strain' phase fatigue after-effects exist (Hockey, 2013, p.66). Finally, individuals can enter a model of 'disengagement', which is characterised by significant performance decrement, due to a mismatch of high environmental demands and reduce personal information processing capacity (Wickens, 1991; Hockey, 2013, p.108). This mismatch is further exacerbated when there is associated sleep-disturbing work (Baulk et al., 2009).

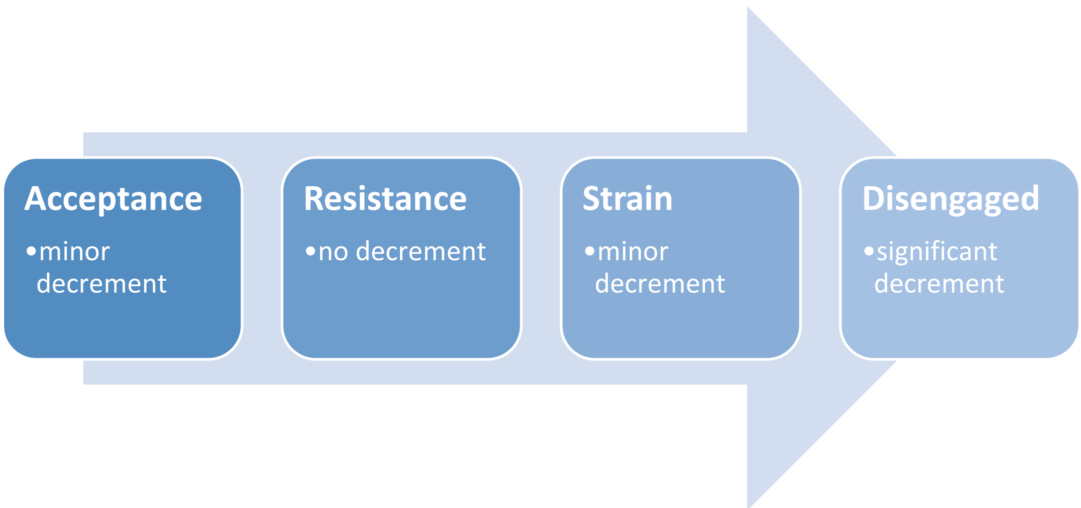


Figure 1.2. Adapted version of phases of fatigue and relationship to performance decrement (Hockey, 2013)

1.3. OPERATIONALISING DEFINITION OF FATIGUE

In attempts to better understand the phenomena of fatigue, an operationalising definition is warranted. The International Civil Aviation Organisation (ICAO) defines fatigue as "a physiological state of mental or physical performance capability resulting from sleep loss or extended wakefulness, circadian phase, or workload (mental/physical activity), that can impair a crew member's alertness and ability to safely operate an aircraft or perform safety-related duties" (ICAO, 2012, p.xii). The feeling of fatigue may also be regarded as a direct result of the use of increased effort to maintain task goals and protect performance during periods of demanding work (Hockey, 2013, p.13). Recognising the varied information above, which can contribute to understanding fatigue, the broad definition of fatigue referenced in thesis is one conceptualised as a state which determines changes in the "expression of an activity that can be traced to the continuing exercise of that activity under normal operational conditions, and that can be shown to lead, either immediately or after delay, to deterioration in the expression of that activity, or more simply to results within that activity that are not wanted" (Bartlett, 1953; Hockey, 2013, p13).

1.4. RESPONSES TO MANAGING FATIGUE

Since the industrial revolution, the focus of performance decrement mitigation has been increasing, largely in part to the increased reported levels of fatigue in the population. In particular, relationships between work and fatigue came to the forefront through the 'work-fatigue hypothesis' (Hockey, 2013, p.49) that posited increased fatigue resulted in decremented performance. As research emerged, application of findings to high-performance industries became popular. In particular, aviation applied fatigue mitigation strategies in the 1950's to reduce incidences of pilot incapacitation, and thus occurrence of high-stake errors. This saw the emergence of fields such as human factors and ergonomics. Rigorous protocols for performance management were implemented. The sector was largely successful and produced an abundance of research which has applicability to many sectors when exploring fatigue.

1.5. FATIGUE IN THE SURGICAL PROFESSION

Similar to aviation, surgery is a high performance industry, with associated high-stake error. On the other hand, surgery deviates significantly from aviation in how it has attempted to resolve issues of fatigue within the profession. This thesis will focus on surgery as a dysfunctional profession and explore the factors which have contributed to the normalisation of the 'sleepy' or 'fatigued' surgeon. As a case-study, surgery offers particularly interesting insights into the personal and environmental variables which can create a culture of operating in states of 'surviving'. Bridging the gaps between surgery with other high-performance industries is warranted, by exploring what is required in order to transition to states of 'thriving' in the profession.

The founding father of medicine, Hippocrates, was noted to have said "he who wishes to be a surgeon should go to war". With the emergence of the COVID-19 pandemic, analogies of hospitals as warzone-like territories became normalised. However, high pressured situations, coupled with diminished resource allocations and over-worked staff have been characteristic of surgery for a long time before the pandemic, alongside other unique characteristics. Evolving from the 'barber store' (Ackerkneckt, 1984), before merging with other parts of the profession of medicine, surgery brought with it unique professional norms and practices. The first is an overemphasis on technical skill performance, whereby surgeons were often only required to complete surgical procedures as part of their day-to-day practice. The second is issues of performance management and rest. Surgical training is modelled off the Halstedian era of residency training (Hughes, 1974). The founder, Dr. William Stewart Halsted, a professor at the John Hopkins Hospital, defined the necessity of life devotion to the profession, and 'residency' within the training centres, as prerequisites to becoming a competent surgeon. This structure neglected both the necessity for surgeons to have personal lives, as well as to focus efforts on anything other than procedural learning. One of the unique and significant consequences from this method of learning was increased sleep-related and work-related issues in subsequent generations of surgeons, which saw significant rise in fatigue levels. Subsequent reports on this approach have been regularly criticised in the literature, given the reputation of Halsted and his own personal performance sustainability methods (Hughes, 1974). Vestiges of this method of learning are the predominant method of practice to this day despite more recent efforts within organisational psychology to promote wellbeing within workplaces. Surgery is subsequently left in a precarious position whereby staff must be constantly alert and ready to perform in high-stake situations on a regular basis, irrespective of their personal needs. This leads to a cognitive dissonance (Festinger, 1957) between the perceived requirements of the profession and personal cognitions about maintaining health and wellbeing. The resulting impact could be the norm of a surgeon who will survive but may never thrive.

Surgery is unique in that the skillsets required for trauma cases often require a surgeon to be present on-site for 24-hours. The continuity of patient care is seen as pivotal to assuring patient safety (Van Walraven et al., 2010) and culminates in increased on-call duties for surgeons. This predisposes the profession to situations of unavoidable levels of sleep disturbance and increased work hours beyond regulatory requirements (Whang et al., 2003). The result is an overworked surgical cohort who are subject to reduced rest opportunities and increased sleep disturbances. Efforts to tackle these challenges have improved significantly since Halstedian times, mainly due to increasing pressure from judicial systems which have culminated in significant landmark laws to protect patient safety from the effects of overworked healthcare workers e.g. the Libby Zion Law (Spritz, 1991). National and international regulations were introduced in the beginning of the 21st century, such as the Accreditation Council for Graduate Medical Education (ACGME) regulations, which limits surgeons in the United States to 80 hours of work per week; and the European Working Time Directive (EWTD 2003/88/EC), which gives European Union workers the right to at least four weeks of paid holidays each year, rest breaks, and rest of at least eleven hours in a 24-hour period. The EWTD also stipulates rights regarding restricting excessive shift-work duty, a day off after a week's work, and the right to work a maximum of 48 hours per week. These changes have seen significant shifts in the pattern of surgical work, though issues of fatigue within the profession remain prevalent. Compliance with such regulations has been disputed. Large differences in reported Irish compliance have been discovered between the reporting by national health service (86-89% compliance), and the national workers union survey results of just above 25% compliance (Fagan, 2020). Formal research has found that the mean amount of work hours in Irish surgeons was 69.4 hours (Hayes et al., 2017). In addition to these issues, development of formal training programmes for medical disciplines in recent decades has begun to incorporate the required competencies of professional practice domains which go beyond traditional surgical procedural practice. These include increased perioperative and ward-setting responsibilities, which, when combined with all the aforementioned issues, means fatigue in surgery may also result from more recent increased work-demands and lower professional autonomy, which were not as prevalent as contributing factors in preceding times.

This thesis hypothesises that a series of modifiable and non-modifiable factors can contribute to the state of fatigue in surgery. This fatigue may then impact on aspects of surgical performance (*Figure 1.3*). Exploration of modifiable factors include sleep and stress, physical activity, rest, nutrition and hydration, training, and culture. While potentially modifiable, personality and resources are determined as non-modifiable for the purpose of the capacity of this research. Other determined non-modifiable factors are age, genetics, and medical conditions, which are beyond the scope of this project.

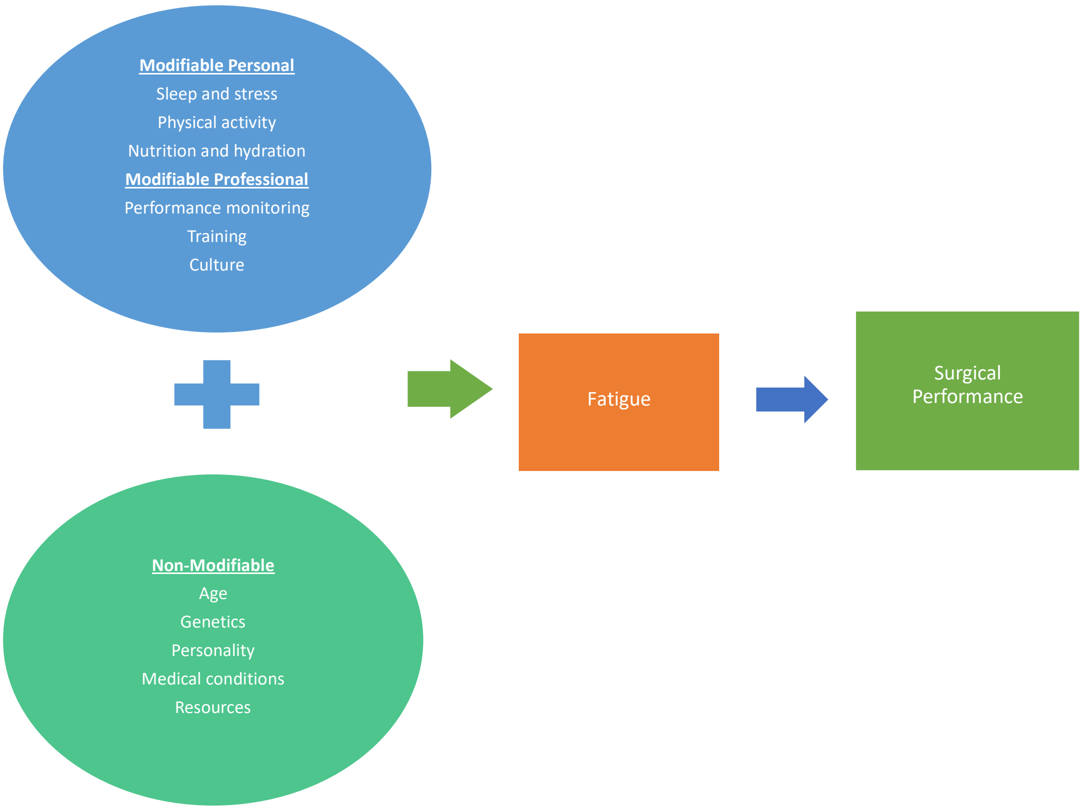


Figure 1.3. Proposed conceptual framework identifying fatigue between modifiable, non-modifiable factors and surgical performance

1.6. SURGICAL PERFORMANCE

The current models of assessing fatigue is best established through performance outcomes. The performance decrement is a ubiquitous characteristic of the effects of sustained attention, or prolonged work of any kind, and has long been regarded as the defining feature of the effects of fatigue on performance and, for many, its primary objective marker (Hockey, 2013, p.51).

Broadly, performance metrics are characterised by several outcomes (Jex and Britt, 2008, p.97) which are described in *Table 1.1.* For the purposes of this study, surgical performance will be defined in terms of 'effectiveness' as the metrics used to assess performance due to the individualised nature of this research.

Table 1.1. Adapted performance metrics and their associated description (Jex and Britt, 2008)

Outcome	Description
Effectiveness	Behaviours within the control of the employee
Productivity	The costs in achieving results
Efficiency	The results that can be achieved within a period of time
Utility	The value an organisation places on a combination of effectiveness, productivity and utility

Traditionally, surgical performance was defined by 'technical performance' only. The additional work responsibilities placed on surgeons broadened the required non-technical competency requirements in surgery. Non-technical skill can be defined as the 'thinking' and 'feeling' competencies in work, which play important roles in clinical decision-making and interpersonal relations. Hereafter, these will be referred to as 'cognitive performance' and 'affective performance'. The combination of these three domains of performance ensure the quality of patient care and safety optimisation (Medical Act, 2007). Eight areas of competency have been defined in the Irish context (*Figure 1.4*).

Figure 1.4. Adapted version of eight competencies of good professional practice as established by the Irish Medical Council (2007)

This thesis will discuss 'surgical performance' hereafter as referring to three domains at an individual level using Darzi's categorisation of technical performance (Darzi and Mackay, 2001). Furthermore, the researcher employs considerations of the additional categorisations of non-technical performance from a cognitive (Hall et al., 2003) and affective (Murden et al., 2018) perspective. Some of these determining characteristics as defined by the references given and determined by the researcher through exploration of surgical literature. They are listed, non-exhaustively, in *Table 1.2.* Their relationship to the competencies required for surgical performance in the Irish context are also provided in *Table 1.3.*

Table 1.2. Aspects of surgical performance and some associated characteristics

Technical	**Non-Technical**	
Technical Performance	**Cognitive Performance**	**Affective Performance**
Dexterity	Attention	Self-regulation
Coordination	Problem solving and decision-making	Emotional intelligence
Procedural place-keeping	Vigilance	Self-awareness
Visual-spatial perception	Situational awareness	Optimism
	Memory recall	Resiliency

Table 1.3. Performance domain and associated professional practice competency

	Technical Performance	Cognitive Performance	Affective Performance
Clinical Skill	✓	✓	
Relating to Patients			✓
Communication and interpersonal skill			✓
Collaboration and teamwork			✓
Management		✓	✓
Scholarship	✓	✓	
Professionalism		✓	✓
Patient safety and quality of patient care	✓	✓	✓

This shift towards additional performance domain considerations has not resulted in parity placed on non-technical performance by surgeons. It has been found that trainees place lower priority on non-technical aspects of competency such as being a manager, communicator and collaborator, when compared to more traditional roles such as scholar and medical expert (Arora et al., 2009). This suggests the necessity for rigorous review of these new domains of practice.

Establishing operational, objective, and realistic criterion to measure surgical performance is important to establish both the importance of non-technical skill, as well as establish the impact of fatigue on performance. Technical performance is historically assessed through logbook, and more recently simulation (for e.g. Aggarwal et al., 2004) and direct observational of procedural skills (DOPS) (Ahmed et al., 2011) in formalised training settings. These assessment methods are subject to limitations of fidelity to real-life environments which often involves additional stressors such as lower resources, less personal control, and higher-stake outcomes. Similarly, assessment in simulated environments can result in a distorted level of baseline performance as a result of the Hawthorne effect in assessment of performance (Landsberger, 1958). This refers to the alteration in behaviour within individuals, in response to their acute awareness of being observed. Objective metrics, such as mortality or morbidity associated with a surgical procedure, can be more strongly linked to particular aspects of technical performance. While this is advantageous in establishing how effective a surgeon is in attaining their primary outcome of patient safety, the criterion used may not be generalisable. Surgeons may perform technically well, but perform below standards in non-technical aspects such as postoperative management

(Binning and Barrett, 1989), thus meaning variability between surgeons is high due to a myriad of confounding variables.

It is even more difficult to explore the impact of non-technical skills. Current approaches primarily use subjective rating scales, and while emerging evidence is beginning to show a strong relationship between both technical and non-technical performance (Hull et al., 2012), issues of quantification and objectivity in non-technical skill performance remain. Cognitive performance markers can be easier to assess in standardised research settings, but transferability to real-life clinical scenarios is limited by lower simulated fidelity. This is particularly true for higher-stake surgical scenarios where biological changes such as increased stress (Arora et al., 2010), and environmental changes, such as team support (Welp et al., 2016), may play mediating roles. Clinical decision-making is a signature aspect of autonomous practice in healthcare professionals, but the variables which influence clinical decision-making, both theoretically and situationally, in surgery remain unknown.

The greatest difficulty however is in operationalising and assessing affective performance. This area of performance has been largely neglected in the non-technical domain of research. Current methods to assess affective performance include subjective ratings of affect or emotion in simulated scenarios. In particular, affective performance may have strong links to the fatigued state. Chronic sub-optimal affective performance may be associated with the state of burnout, which is characterised by emotional exhaustion, depersonalisation, and diminished sense of accomplishment (Maslach and Jackson, 1981). Rates of burnout in the profession are between 40% - 69% (Shanafelt et al., 2009; Lebares et al., 2018) which suggest it warrants further investigation. The state is also negatively associated with performance in work, such as reduced cognitive efficiency (Oosterholt et al., 2012), increased risk of medical error (Shanafelt et al., 2010), lower teamwork cohesion (Welp et al., 2016), and ultimately suboptimal patient care (Williams et al., 2007).

1.7. THESIS AIM AND OBJECTIVES

This thesis aims to explore the factors which influence fatigue levels in surgery, primarily through assessment of the surgical performance domains. It also aims to identify the requirements to optimise surgical performance. The three overall objectives of this research are:

- To explore the causes of fatigue in surgery and effects on surgical performance
- To explore the causes of thriving in surgery and effects on surgical performance
- To explore the impact of an evidence-based and theoretically informed intervention to optimise performance in surgery

It is hypothesised that an evidence-based and theoretically informed intervention may carry advantages for surgeons with regards to the three domains of surgical performance. The contribution of this thesis is to better explore the series of factors which impact on the surgical population by using a single-site population cohort. It concludes with the use of an evidence-based intervention informed by triangulated findings on a surgical cohort in a major tertiary hospital. Aspects of generalisability of the findings of the research to larger surgical cohorts are included as supporting studies to the primary hypothesis.

1.8. THESIS FORMAT SUMMARY

A summary of the flow of this thesis is illustrated in *Figure 1.5.*

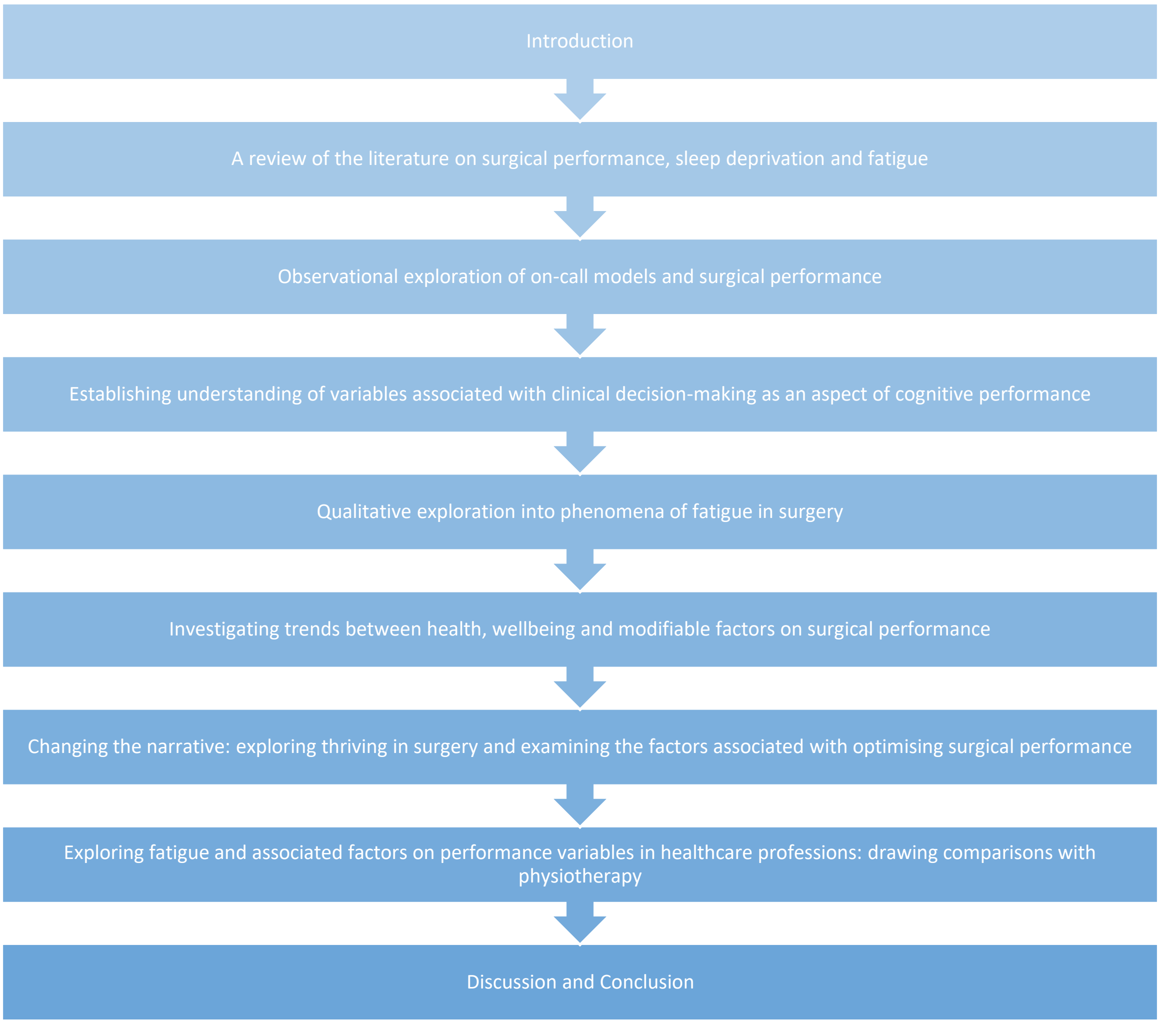


Figure 1.5. Thesis flow summary

1.9. THESIS FRAMEWORK

In order to establish understanding of, and inform evidence-based outcomes, the Medical Research Council Framework (MRC) for Complex Interventions (O'Cathain et al., 2019; Craig et al., 2008), which defines eleven key steps for evidence-based intervention design, seen in *Table 1.4,* is used.

Table 1.4. Adapted eleven step process for complex intervention development (Craig et al., 2008)

Steps	Part of thesis
1. Plan the development	Throughout thesis
2. Involve stakeholders, including those who will deliver, use and benefit from the intervention	
3. Bring together a team and establish decision-making processes	
4. Review published research evidence	Chapter 1, 2 and 9
5. Draw on existing theories	Chapter 1, 2, 5 and 7
6. Articulate programme theory	Chapter 7
7. Undertake primary data collection	Chapters 3, 4, 5, 6, 7 and 8
8. Understand context	Chapter 2, 5, 6, 7 and 8
9. Pay attention to future implementation of the intervention in the real world	Chapter 7, 8 and 9
10. Design and refine the intervention	Chapter 7
11. End the development phase	Chapter 7

1.10. RESEARCH PHILOSOPHY

Finally, in order to establish the paradigm in which this thesis is discussed, it is important to consider it through the research lens typically used in the discipline, in a branch of philosophy called epistemology. Similarly, ontology, defined as the branch of philosophy that studies the nature of reality is relevant in exploring these paradigms. Typically, surgery as a discipline used an ontological positivist approach (Comte, 1975). It identifies the necessity for empirical evidence, believing solely in information that is proven, accurate, and certain. The epistemological verification principle supports this philosophy by testing hypotheses against methods which are rigorous and quantifiable. One of the downfalls of this approach in the context of this research is the assumption that knowledge is built systematically and independent of subjective influence, thus failing to explore the societal and personal influences within the research process. This thesis will not employ a positivist approach as the research is behavioural science, and thus subject to psychological phenomena which are not always quantifiable.

This thesis is largely discussed through a post-positivist approach (Clark, 1998). The ontology associated with post-positivism is critical realism i.e. recognising a reality to exist, but understanding that reality cannot be fully understood objectively due to the limitations of humans as subjective researchers. While epistemology leans towards objectivity, it recognises all claims are refutable and subject to critical review in what is referred to as contextualism (Given, 2008). In addressing the limitations of post-positivism, a series of quality metrics are employed throughout. Quantitative studies employ validity and reliability testing, while the qualitative studies designs employ a variety of metrics to reduce subjectivity of the researchers bias into the analysis (i.e. credibility, transferability, dependability, confirmability). The evidence to support such claims are through triangulation of the findings – which are done through literature review studies, observational, simulation, survey, and mixed-methods of qualitative and intervention study designs in this thesis. This allows development of a deeper, richer understanding of the experiences of fatigue in the profession as well as the impacts on performance.

2. Chapter 2 – A review of the literature on surgical performance, sleep deprivation and fatigue

2.1. BACKGROUND

In surgery, fatigue is often used interchangeably with sleep deprivation. In addition, sleep-associated fatigue is highly prevalent in the profession and the relationship with performance outcomes remains surprisingly unclear. This chapter has two elements summarised in *Figure 2.1*. It explores the relationship between surgical performance, sleep deprivation, and associated fatigue. It also explores the literature base on modifiable interventions to enhance efficiency in performance through minimising the impacts of sleep deprivation and reducing associated fatigue. It concludes with future considerations for study design in exploring the relationship between surgical performance, sleep deprivation and fatigue.

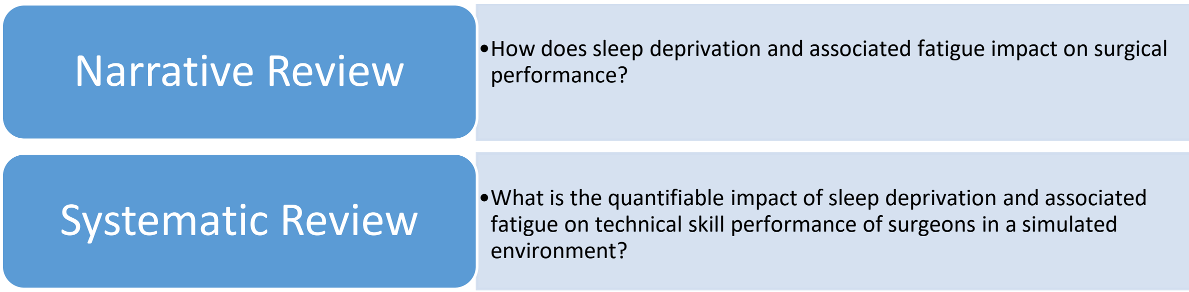


Figure 2.1. Elements of Chapter 2

2.2. NARRATIVE REVIEW ON SURGICAL PERFORMANCE, SLEEP DEPRIVATION AND ASSOCIATED FATIGUE

The question remains whether or not the surgical services provided are optimal within current work-flow patterns. Some outstanding inquiries remain around the definition of sleep deprivation itself in the surgical literature. Is it the quantity or quality of sleep, and does acute sleep deprivation differ in impact from chronic sleep deprivation? The focus of the research can be titrated into impacts on simulated surgical performance, and to retrospective analysis of patient outcomes, correlated with subjective evaluations of surgeons levels of sleep deprivation.

2.2.1. Research Question

How does sleep deprivation and associated fatigue impact on surgical performance?

2.2.2. Objectives

1. To ascertain whether fatigue and sleep deprivation impacts on performance in the surgical profession in simulated settings
2. To evaluate if fatigue and sleep deprivation influences real-life surgical outcomes
3. To document known interventions in the surgical profession, and to highlight potential interventions from other high-stake industries which may be applicable to prevent the negative effects of fatigue

2.2.3. Methods

2.2.3.1. Search Strategy

The review was conducted through the electronic database Journals Ovid. In addition to this, Medline, Embase, Cinahl and Google Scholar were also utilised. These search terms used were “sleep”, “performance”, “health care practitioner”, “professional practice”, “motor skills”, “surgical procedure”, “clinical competence”, “cognitive performance”, “technical skill”, “procedural skill”, “medical procedure”, “surgeons”, “physicians”, “consultants”, “medical staff, hospital”, “internship and residency”, “general surgery”, “psychomotor performance”, “computer simulation”, “patient simulation”, “virtual reality”, and “sleep deprivation”. Duplicate results were removed. References and bibliography lists and journal contents pages were hand searched, including JAMA, BMJ, and Sleep, but no further relevant articles were identified. Where the information was not available publicly, contact was made directly with the author to request availability.

2.2.3.2. Inclusion Criteria

All English language papers referencing sleep and performance in surgery were included. Papers using evidence from other healthcare professions were included if surgeons were among the study sample and they were considered relevant to sleep and surgery. Papers exploring interventions were also included from surgery and other high-stake industries.

2.2.3.3. Exclusion Criteria

Papers were excluded if they didn’t focus on performance and sleep deprivation. Papers were excluded if the focus of the intervention wasn’t in a high-stake industry.

2.2.4. Results

There was 548 full-text articles assessed for eligibility and a total of 91 references were read (*Figure 2.2*) of which 57 are quantified in *Figure 2.3.*

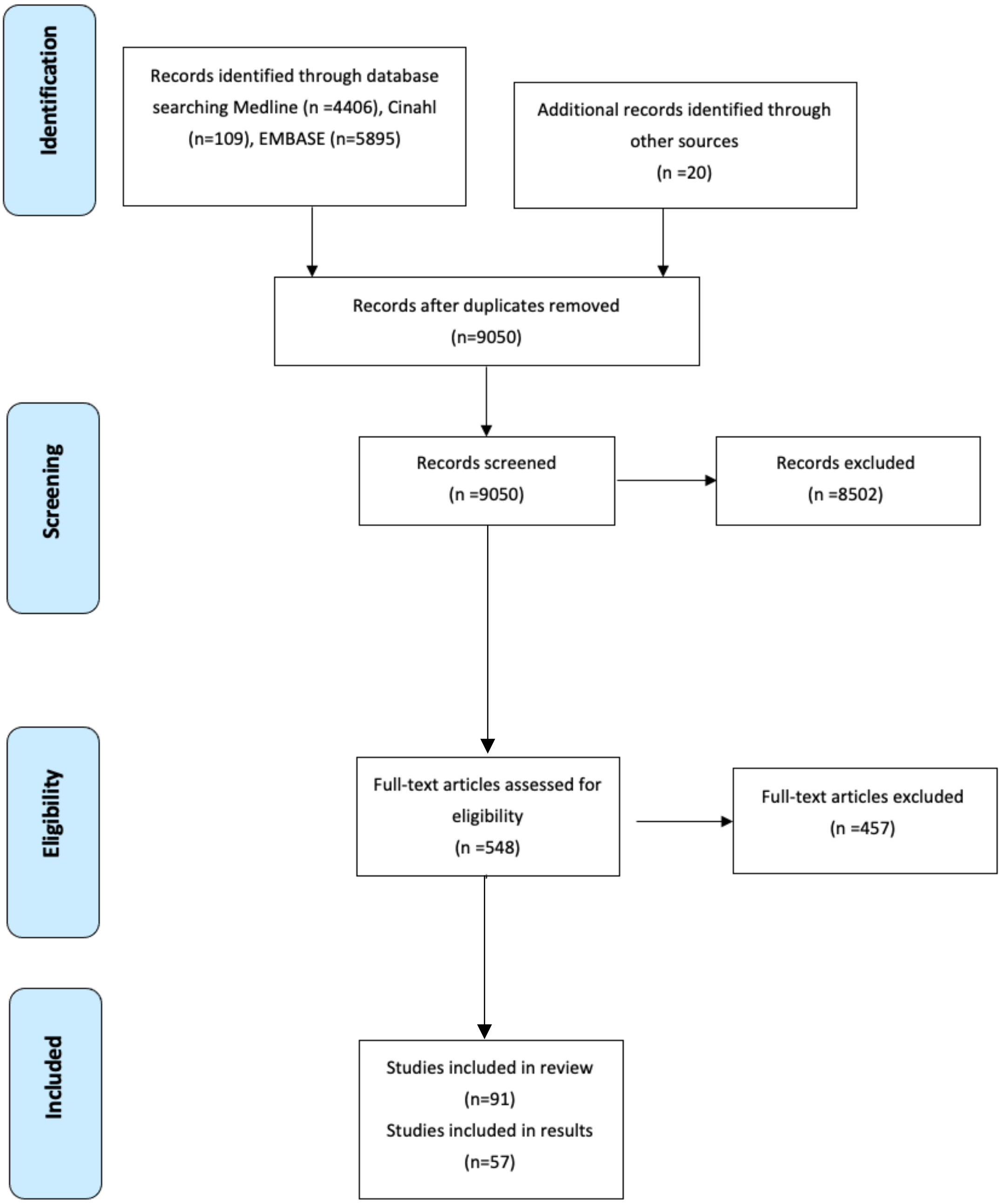


Figure 2.2. Flow diagram of studies eligible for review in the narrative review

2.2.4.1. *Performance is not negatively impacted*

The literature, as graphically summarised in *Figure 2.3*, shows the balance of studies which concluded sleep deprivation didn't impact on simulated or real-life performance. A majority of research exploring the impact of sleep deprivation and fatigue on surgical performance was prospective simulated assessment (34 studies), while real-life studies were retrospective analyses (23 studies).

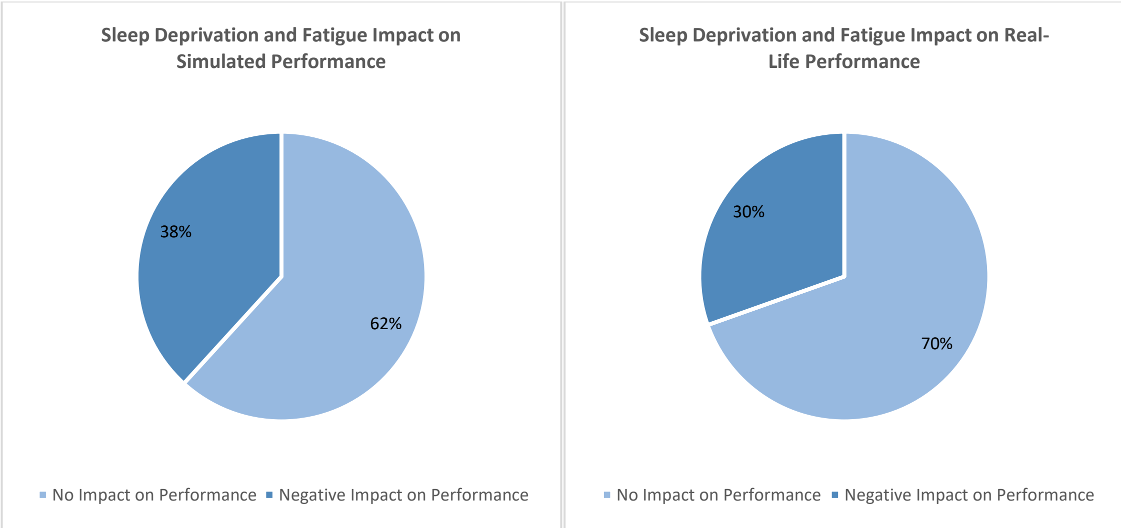


Figure 2.3. Pie chart showing the impact on sleep deprivation and fatigue on simulated and real-life performance

In simulated conditions, Lehmann et al. assessed surgeons' performance of laparoscopic tasks and found no difference between rested and sleep-deprived groups (Lehmann et al., 2010). Similarly, Uchal and colleagues observed two cohorts of post-work and post-call surgeons, each using procedural skills on a laparoscopic simulator, and found that fatigue had no effect on their ability to effectively complete the tasks (Uchal et al., 2005). Robison and colleagues explored the effects of fatigue on general surgery residents' performance using the validated da Vinci Skills Simulator™ (dVSS) (Intuitive Surgical Inc., California) (Robison et al., 2018), and found no difference in performance markers despite a statistically significant difference in reported sleep hours between pre-call and post-call participants. Similar findings have been described in literature surrounding the learning of surgical skill in a sleep-deprived state (Tomasko et al., 2012; Jensen et al., 2004; Browne et al., 1994), as well as across various surgical fields including endoscopic simulation (Jakubowicz et al., 2005), ocular simulated surgery (Waqar et al., 2011), and ophthalmology (Erie et al., 2011).

When comparing this to studies which retrospectively examined real-life surgical performance, a systematic review found no association between sleep/fatigue and surgical performance (Gates et al., 2018). In many of these studies the primary reported cause of sleep deprivation was related to working overnight or lengthy on-call shifts. Gates further explored, through meta-analysis, the effects of insufficient sleep, from overnight work or extended shifts, on surgery or laparoscopic simulations and found that there was no difference in operating time between sleep and non-sleep-deprived surgeons. Govindarajan also retrospectively explored the patient and surgical outcomes for night-shift work versus those not completing night-shift work. Based off a population of 38,978 patients, treated by 1448 physicians, they found no significant difference in the outcomes between the groups (Govindarajan et al., 2015).

These results have been extrapolated across many specialties including trauma (Sharpe et al., 2013), cardiac (Ellman et al., 2006), rectal (Schieman et al., 2008), obstetrics (Bailit et al., 2006), laparoscopic (Vinden et al., 2013), renal (Kienzl-Wagner et al., 2013) and emergency (Yaghoubian et al., 2010; Yaghoubian et. al., 2010). A more recent review of the literature exploring whether 'fatigue', broadly defined by working hours of the surgeon in most studies, concluded that postoperative mortality or total postoperative complications after elective surgeries were not impacted by the state (Koda et al., 2020). Two studies have even demonstrated a paradoxical improvement in surgical performance in sleep-deprived states (Schlosser et al., 2012; Micko et al., 2017).

There are a series of limiting factors to the aforementioned studies. Many had small sample sizes of a particular cohort of surgeons (e.g. residents, attending, and interns) and reported wide variations in the number of hours of sleep, both between and within groups. Several studies also failed to make allowances for the steep learning curve associated with task acquisition, which is likely to account for the two studies which found paradoxical improvements of performance in sleep deprived states (Micko et al., 2017; Schlosser et al., 2012). Similarly, most authors did not take into account the natural body clock rhythm, nor did they attempt to objectively measure the quality of sleep between participants. For example, in Uchal et al. (2005) there was inconsistency in standardised testing of the post-call participants, with the post-call group being assessed on a circadian upswing (8am to 9am), while post-work groups were assessed at a circadian low point (4pm to 5pm). Some studies also limited their procedures to electives which fails to capture and measure the influence of sleep deprivation on more abstract influencers, such as conflicting thought processes and resource management during acute emergency situations. These measurements are instead reflective of an ability to respond logically to well-practiced procedural tasks, something which could manifest differently in a state of sleep-deprivation. As well as this, many researchers didn't assess the quality of the procedures' outputs. Finally, many studies did not control for the potential mitigating role of stimulants such as caffeine which may have preserved performance.

2.2.4.2. Performance is negatively impacted

Several studies have also found sleep deprivation and fatigue increases the likelihood of professional performance error, as documented in *Table 2.1,* and that there is negative impact on surgical performance.

Table 2.1. Negative effects of sleep deprivation in medicine

Potential Negative Effects of Sleep Deprivation
↓Accuracy (Grantcharov et al., 2001)
↓Cognition (Philibert, 2005), (Gerdes et al., 2008), (Kahol et al., 2008)
↓Technical skill proficiency (Eastridge et al., 2003), (Grantcharov et al., 2001), (Leff et al., 2008)
↓Quality of sleep after night-shift (Åkerstedt,2003)
↑Medical errors by medical intern (Landrigan et al., 2004)
↑Time to perform (Taffinder et al., 1998)
↑Risk of percutaneous injuries in residents (Ayas et al., 2006)
↑Risk of interns having car accidents when commuting from work (Barger et al., 2005)
↑Drowsiness when completing psychomotor tasks comparable to 0.04 to 0.05 g% blood alcohol (Arnedt et al., 2005)
↑Likelihood of infection (Chu et al., 2011)
↓Mood (Lingenfelser et al., 1994)

Kahol and colleagues identify that it may be in tasks which are predominantly cognitive, as well as tasks which require a combination of cognitive and psychomotor skill, that decremented performance is more noticeable (Kahol et al., 2008). More recent research has suggested the potential role of cognitive processes which govern procedural skill, such as procedural place keeping, being negatively impacted by sleep deprivation (Stepan et al., 2020). Most of this research has been applied in simulated settings with decremented performance recorded on simulators such as the Minimally Invasive Surgical Trainer-Reality System™ (MIST-VR)(Virtual Presence Ltd, London) (Eastridge et al., 2003), Simbionix™ (Simbionix, Israel) (Tsafrir et al., 2015), Patient-Reported Outcomes Measurement Information System™ (ProMIS, Chicago) (Kahol et al., 2008), and dVSS™(Weinberg et al., 2014). Other psychomotor tasks have been used to target specific aspects of performance such as the ability to hold one's attention. Sanches and colleagues examined the effects of acute sleep deprivation resulting from night shift work on younger doctors (Sanches et al., 2015). They were particularly interested in looking at concentration capacity and psychomotor performance, and thus applied a battery of three reaction time tasks (StimulTest™, InstructTest™, and MovemTest™) (Memory Research Tech, Prague). They found that the sleep-deprived group reported higher daytime tiredness which correlated with poorer results in all tests, with the exception of the fine movement test (MovemTest™). This research supports several other studies which have found sleep-deprived doctors showed increased reaction time, increased response time variability, and increased drowsiness when completing psychomotor testing (Arnedt et al., 2005), while also suggesting that 'auto piloted' technical ability may be somewhat persevered in a state of sleep deprivation.

Studies have also argued that there is a change in real-life surgical performance among sleep-deprived surgeons. In particular, these performance decrements are noted with regards to mortality rates, complication rates, rates of re-operation and procedure quality. Increased mortality has been recorded amongst patients admitted at night compared with those admitted during the day (Ogbu et al., 2011), and increased complication rates have been noted in procedures carried out by surgeons who had less than six hours of sleep (Rothschild et al., 2009) when compared to well-rested surgeons. Higher septicaemia rates in patients operated on by sleep-deprived cardiothoracic surgeons (Chu et al., 2011) have been found, as well as increased complications after night-time surgeries (Fechner et al., 2008; Ricci et al., 2009). Finally, decrements in procedural quality have been observed, including a notable drop in case number of adenomatous polyps detected and removed when completing a colonoscopy in a sleep-deprived state (Benson et al., 2014). Such findings would suggest a difficulty in establishing the true impact of sleep deprivation on surgical performance. These studies counterargue the hypothesis that well-learned technical skills could be preserved in sleep deprived states, as well as the risk of decrement in both trauma and elective cases.

Similar limitations apply to this side of the debate on performance, sleep deprivation, and fatigue. Small sample sizes, alongside the lack of rigorous control of sleep processes such as the influence of the circadian rhythm, make it difficult to ascertain a relationship between performance and sleep. Similarly, alongside the studies which found no impact, most studies did not quantify 'sleep deprivation' as a concept, and failed to control for learning curve on simulation, rendering any conclusive outcomes from these studies difficult.

In summary, it would appear that there is an ongoing debate as to whether sleep deprivation and fatigue impacts upon surgical performance. This assessment is highly influenced by the inconsistency amongst the research in sleep measurement tools as well as performance metrics. To propose a broad overview, it would appear that cognitive skill is more impacted than technical skill in a sleep-deprived surgeon (Veddeng et al., 2014; Weinberg et al., 2014; Sanches et al., 2015), though it must be caveated that it is difficult to make conclusive judgements on the differences between technical and cognitive aspects of simulated performance if the study has not made specific provisions for such an assessment. Nonetheless, such a finding would support other literature which has found that fatigue reduces the capacity of working memory (Jain and Nataraja, 2019), thus impacting cognitive aspects of performance such as reaction time and decision-making.

2.2.4.3. Potential Interventions to mitigate the effects of sleep deprivation on performance

2.2.4.3.1. Fatigue Risk Management

Fatigue risk management is used to mitigate against the potential influence of sleep deprivation on performance in other industries. Some of these interventions include limitations on time spent working (ICAO, 2012), dedicated rest facilities (McClelland et al., 2017), and training on fatigue (Arora et al., 2007), all of which are underpinned by encouraging self-awareness and self-regulation, and supported by a culture of performance management. Such efforts have not been thoroughly explored in surgery and could offer opportunities for enhanced wellbeing and work performance. Strategies such as micro breaks from surgery (Park et al., 2017; Engelman et al., 2011), regular interaction, and bright lit rooms may reduce the impact of fatigue felt by surgeons. Surgeons might 'nap', which is common prior to commencing an on-call shifts, however evidence would indicate that it takes greater than normal off-periods to recover from non-typical work patterns (Åkerstedt et al., 2000). This is problematic if surgeons are on-call for more than one night a week.

2.2.4.3.2. Workflow

Given the urgency of some procedures surgical services are required 24-hours. In addition, Senior House Officers (SHO) complete shift-work patterns, which has resulted in debate in the surgical literature (Griner et al., 2010). In Ireland, surgery work-flow patterns are typically divided into three models. These are 'surgeon of the week', 'reduced elective' on-call, and 'supra-elective' on-call (Kelly et al., 2014). In 'surgeon of the week', surgeons are typically on-call in a shift-work pattern for five consecutive days. In 'reduced elective', surgeons work on a reduced day schedule to lessen the impact of working while on-call. In 'supra-elective', surgeons are on an enhanced elective schedule which is in addition to standard daily clinical duties. It remains unknown whether any particular model is more beneficial to a surgeon's performance, however most work-flow patterns subject surgical staff to increased levels of sleep deprivation and fatigue.

Despite initiatives to reduce work hours no mandatory interventions exist to prevent sleep deprived surgeons from carrying out their professional duties. This lack of regulation bifurcates significantly from other high-stake industries. In part, it may be due to the fact that egregious error in surgery may result in the death or disability of fewer civilians, and that surgeons themselves are not subject to the same personal repercussions if an error is made. There have been efforts however to explore alternative workflow patterns. The Flexibility in Duty Hour Requirements for Surgical Trainees (FIRST) trial (Bilimoria et al., 2016) and the Individualised Comparative Effectiveness of Models Optimising Patient Safety and Resident Education (iCOMPARE) trial (Desai et al., 2018), looked at residency programs and randomly-allocated programs which had alternative work-flows, yet their findings had unintended consequences. The 'flexible' group in the FIRST trial reported a negative effect on personal activities. The 'flexible group' in the iCOMPARE trial also reported a decrease in satisfaction with quality of education and wellbeing. It may be that compliance with regulatory directives are an issue, further impeded by cultural norms and political inertia to appropriately resource. It is estimated that more than 40% of practicing physicians in the USA continue to work in excess of 80 hours (Anim et al., 2009), and, more locally, Irish surgeons are working nearly double the EWTD limits (Hayes et al., 2017).

2.2.4.3.3. Simulation

Using simulated environments for procedural training could be beneficial for patient safety and/or performance enhancement, irrespective of a sleep deprived state. The jury remains out as to whether simulation correlates with real-life practice. Some researchers (Tsafrir et al., 2015) believe that errors in surgical simulators do not necessarily mean similar errors will be made during real-life situations, while other authors believe that a correlation of VR skills to performance in the operation room is established (Aggarwal et al., 2004). At a minimum, simulation assessment acts as a reliable means of screening aspects of technical skill and cognitive skill in sleep deprived surgeons' prior to real-life performance, which may accurately predict performance and patient caseload outcomes (Birkmeyer et al., 2013), and at a maximum simulation may 'warm up' tired surgeons prior to real-life performance and reduce on-call sleep inertia (Calatayud et al., 2010). Simulation could therefore be used as a screening 'breathalyser' for surgeons fitness to perform surgery under the influence of sleep deprivation.

2.2.4.3.4. Medication and Stimulants

Daytime sleep following surgical on-call work is generally inconsistent and poor in quality (Åkerstedt et al., 2003), and medication such as melatonin administration after a night shift could restore potential disturbed circadian rhythms, though further research is needed (Cavallo et al., 2005). Similarly, the use of performance eugeroic drugs, such as Modafinil in the air industry, has shown the potential to preserve pre-deprivation performance (Caldwell et al., 2004), though ethical issues exist with use of controlled medication for occupational performance enhancement. Caffeine and taurine may also mitigate some of the effects of sleep deprivation (Crochet et al., 2009) and are the most commonly used stimulants in the profession. To what extent these stimulants mask true performance should be further explored in the surgical context.

2.2.4.3.5. Experience

Level of experience may act as a protective factor against the effects of sleep deprivation, yet the evidence for this remains inconclusive. In one exploratory study, the more experienced surgeons felt they had a better overview and strategies, due to more experience and a higher skill level, despite their fatigue on night shifts (Amirian et al., 2013). It was felt this inured them somewhat to the effects of fatigue.

2.2.5. Study Design Considerations

From this narrative review, there are some important factors which must be considered in future areas of research into sleep deprivation and surgical performance.

2.2.5.1. Learning Curve

Paradoxical improvements are noted in two studies, and are likely due to the failure to control for the learning curve, resulting in a short practice phase in which residents actually improve their skills with practice, even when tired. A minimum performance requirement at baseline should be established to prevent this.

2.2.5.2. Consistency

Many researchers didn't assess the quality of the procedure's outputs in real-life surgeries. Reductionist outcome measures, such as mortality, which may not necessarily reflect 'surgical performance' were used instead. This poses the greater question of what defines 'surgical performance'. Is it quantifiable only through surgical outcome? Or is it more complex, encompassing a greater number of variables which can be more rigorously assessed in simulated environments? In the case of mortality as a measurement of performance, with a relatively low event rate and a multitude of factors including team dynamics, patient factors and disease factors influencing outcome, its occurrence cannot be conclusively said to be an indicator of a surgeon's performance. Similarly, with such a metric, it is difficult to attribute a meaningful utility with regards to the performance of a surgeon who is sleep-deprived, given the complexity of the surgical environment which often involves a series of variables which could influence alertness.

The specific tasks which are being assessed should be elaborated with regards to their role in technical or non-technical assessment. It may be that certain tasks requiring greater levels of concentration may avert the impact of sleep deprivation due to level of complexity or prior exposure. Alternatively these tasks may have the greatest negative impact from sleep deprivation. This has been hinted in some research with preservation of performance seen in fine movement testing (Sanches et al., 2015), while decrements were seen in reaction time, response time variability and other aspects of psychomotor testing (Arnedt et al., 2005). Working memory capacity and decision-making are aspects of the cognitive domain of performance, and the role sleep deprivation plays in their capacity warrants further exploration. To ensure accurate assessment of the potential effect of sleep deprivation on surgical performance, predetermined meta-analysis parameters for task length should be considered. In this instance, the minimum duration of a procedure or task considered 'long' is eight minutes (Pilcher and Huffcutt, 1996). Future studies should ensure that their testing is at a minimum this length.

Sleep deprivation is also likely to have an impact upon non-technical skills. These play a vital role in ensuring patient safety, and are associated with technical skills performance (Hull et al., 2012). Poor teamwork skills leads to a higher risk of patient complications and death (Mazzocco et al., 2009), and given the decrease in resources in night shifts, it is also likely that psychosocial impacts influence the real-life surgical outcomes**.** Future studies should consider adapting simulated environments to be more reflective of the psychosocial conditions associated with surgery, and should evaluate the confounding role of teamwork in surgical skill performance in simulated environments.

2.2.5.3. Objective Measurement

A consensus on a definition of 'sleep deprivation' is lacking in surgery. Most research has not provided definitions, while others have defined a cut-off point of four hours (Deaconson et al., 1988), three hours (Uchal et al., 2005), or two hours (Tomasko et al., 2012). Consistent timing of measurement is important for future studies. One study found that surgeons circadian rhythms are affected by night-shift work (Amirian et al., 2015). Non-invasive biological markers such as the metabolite of melatonin (aMT6s) measured in urine, and salivary cortisol may offer opportunities to assess circadian rhythm as an objective marker (Amirian et al., 2015). The roles of two hormones - melatonin and cortisol - are influential to a surgeon's biological rhythm (Bórbély et al., 2016) and level of performance. Their relationship would indicate that there is a pivotal time during night-shift work where surgeons are most susceptible to error. The secretion of melatonin commences at approximately 8 p.m., which reflects the start of an on-call workflow and peaks between 2:00 - 4:00 a.m., while cortisol has lowest levels during night hours (Hofstra and de Weerd, 2008). The influence of these hormones during the early morning hours may increase the risk of error in emergency surgery carried out by tired surgeons.

Greater discrimination in sources of fatigue within the surgical literature are also warranted by exploring their sources, responses, and underlying processes. While the surgical literature has significantly focused on two of these discriminations – i.e. fatigue from insufficient or poor sleep quality, and fatigue associated with circadian influences, less focus has been given towards fatigue deriving from a non-sleep associated state. In this instance, exploring fatigue through the lens of the theoretical underpinnings of fatigue, such as cognitive load and motivational demands, discussed in previous chapters are warranted.

2.2.6. Limitations

Since this narrative review was limited to English articles only it is likely that some articles from non-English speaking countries have been excluded. The search terms used may not have been specific or broad enough to fully capture all terms associated with sleep deprivation and surgical performance.

2.2.7. Conclusion

From this narrative review, it appears that there is indeed a problem of sleep deprivation and fatigue in the surgical profession. There are a wide array of studies of varying quality, methodology, and findings on the topic. Studies using real-life surgical outcome metrics are not necessarily reflective of surgical performance, hence why the use of simulation as a metric for surgical performance is more commonly studied. It cannot be conclusively agreed as to whether sleep deprivation impacts on simulated and/or real-life surgical performance. What is known is that, physiologically, sleep deprivation has been found to impact on individual's cognition, which results in decrements in domains of cognitive performance.

Given the unique nature of technical skill as a key component of performance in surgery, and the necessity for consideration of the learning curve effect alongside greater objectivity and consistency in assessment, a systematic and quantification exploration of the influence of sleep deprivation and fatigue on technical skill performance in simulated environments is warranted.

2.3. SYSTEMATIC REVIEW ON TECHNICAL SKILL PERFORMANCE, SLEEP DEPRIVATION AND ASSOCIATED FATIGUE IN SIMULATED ENVIRONMENTS

The narrative review in this chapter identified impact on performance, but quantifiable levels of technical performance impact remain unknown. A recent review on the impact of sleep deprivation on surgeons dexterity concluded the difficulty in establishing a meta-analytical conclusion of the research given the heterogeneity of outcome measurements and standard settings (Banfi et al., 2019). In addressing these limitations, this systematic review will attempt to explore the impact of sleep deprivation and associated fatigue on technical performance. In doing so, it encompasses aspects of procedural skill which are beyond dexterity alone. It also explores the literature with regard to the potential effect of experience as lessening the impact of sleep deprivation on technical skill performance. Finally, this systematic review examines whether this research has focused on the quality of sleep and its potential impact on performance, as well as the cumulative effect of chronic sleep deprivation on technical skill proficiency in surgeons.

2.3.1. Research Question

What is the quantifiable impact of sleep deprivation and associated fatigue on technical skill performance of surgeons in a simulated environment?

2.3.2. Objectives

1. To identify if sleep deprivation and associated fatigue, as measured by valid objective measures in a simulated environment, has an impact on technical performance in surgeons
2. To identify if the level of surgical experience influences technical skill performance in sleep-deprived surgeons
3. To explore the role of sleep quality, as defined by time spent in rapid eye movement (REM) and non-rapid eye movement (NREM) sleep cycles, on technical skill performance in surgeons
4. To establish the role of sleep quantity, defined as acute and chronic sleep deprivation, on technical skill performance in surgeons

2.3.3. Methods

2.3.3.1. Search Strategy

The review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, and utilised the electronic database Journals Ovid for the 1988-present period. In addition to this Medline, Embase, EBSCO (PsychINFO, ERIC) and the Cochrane Library were also searched. The MeSH terms and associated words were refined in conjunction with two other researchers (CMC, PFR). These terms were based on the MeSH terms “sleep deprivation”, “fatigue”, “sleep disorders”, circadian rhythm”, “sleep”, “sleep wake disorders”, “clinical competence”, “motor skills”, “psychomotor performance”, “professional competence”, “task performance and analysis”, “laparoscopy”, “surgeons”, “physicians”, “consultants”, “medical staff, hospital”, “internship and residency”, “general surgery”, “simulation training”, “computer simulation”, “patient simulation”, “virtual reality”, and “high fidelity simulation training". An elaborate search strategy can be found in *Appendix A.* Duplicate results were removed. References, bibliography lists and journal contents pages were hand-searched, but no further articles were identified as being relevant. Where the information was not available publicly, contact was made directly with the author to request availability.

2.3.3.2. Inclusion Criteria

All English language papers which included an assessment of technical skill proficiency in sleep-deprived surgical practitioners were retained. This was inclusive of papers where trainees were involved. Papers on proficiency, as measured by simulation with recorded evidence of validation, were included.

2.3.3.3. Exclusion Criteria

Papers were excluded if they did not include sleep deprived surgical staff or trainees. In addition, papers were excluded if they focused on the impact of sleep deprivation on non-technical skill proficiency. Papers were excluded if the simulator used to assess technical skill did not have any evidence of validation.

2.3.3.4. Data Extraction and Synthesis

Validation of the selection process followed with two independent reviewers (the author, and Dr. Cathleen McCarrick, Dublin, Ireland). An adapted version of a standard Best Evidence in Medical Education – BEME Guide Coding Sheet (*Appendix B*) was utilised (Hammick et al., 2010). Papers were reviewed independently in accordance with established headings and assigned a score from 1-5 regarding the strength of the research (*Table 2.2*). Where there was a difference between reviewers grading of a paper, a decisive independent adjudication occurred (PFR). An adapted version of the Oxford Centre for Evidence-Based Medicine (CEBM) was used (CEBM, 2011), seen in *Table 2.3*, with scores reversed to support weighting of the studies. Papers were categorised into sleep deprivation having no impact, having a positive impact, or having a negative impact.

Table 2.2. Strength of studies for systematic review

Grade	Description
1	No clear conclusion could be drawn; not significant
2	Results ambiguous; but there appears to be a trend
3	Conclusions can probably be drawn based on the results
4	Results are clear and very likely to be true
5	Results are unequivocal

Table 2.3. Study designs with associated level of evidence

Level	Type of Evidence
5	- Systematic review of RCTs with homogeneity - Individual RCT with narrow confidence interval
4	- Systematic review of cohort studies with homogeneity - Individual cohort study or low quality RCT - Outcomes research; Ecological studies
3	- Systematic review of case-control studies with homogeneity - Individual case-control study
2	- Case series and poor quality cohort and case-control studies
1	- Expert opinion without critical appraisal; or based solely on physiology or bench research

Four summative measures were assigned to weigh study quality. These measures were average sample size (n), quality scores (q), study design scores (sd), and composite scores (q+sd/2). These were calculated between the three groups - no impact, positive impact, and negative impact. Using the quality scores that were assigned to the studies by both investigators, an average score was derived for the three outcomes. Using a second assortment scoring sheet, the average study design scores for the three groups were calculated as a final summary measure, with a composite score being calculated between the three groups. This composite score calculated the average of the quality score and study design score.

A rating of the quality of each study was awarded independently by the two investigators. On a collective basis a protocol of statistical analysis was used for assessing assumptions of data normality. The assumptions of normality were violated. These violations included the skewness and kurtosis of data was not in the acceptable range. The Kolmogorov-Smirov and Shapiro Wilks Tests were significant; and the histograms were negatively skewed. The box plots show outliers indicating the use of non-parametric testing. Kruskal Wallis and Mann-Whitney U-tests were carried out to compare the quality score, study design score, and composite score.

2.3.4. Results

From the original 3136 articles identified, an initial screening revealed 154 eligible articles. These were further reviewed against inclusion and exclusion criteria, deeming a further 121 ineligible. Thirty-three heterogeneous studies were studies were eligible for review The screening process is elaborated further in *Figure 2.4*. The kappa score was high (κ=0.84), indicating strong inter-rater reliability between both investigators.

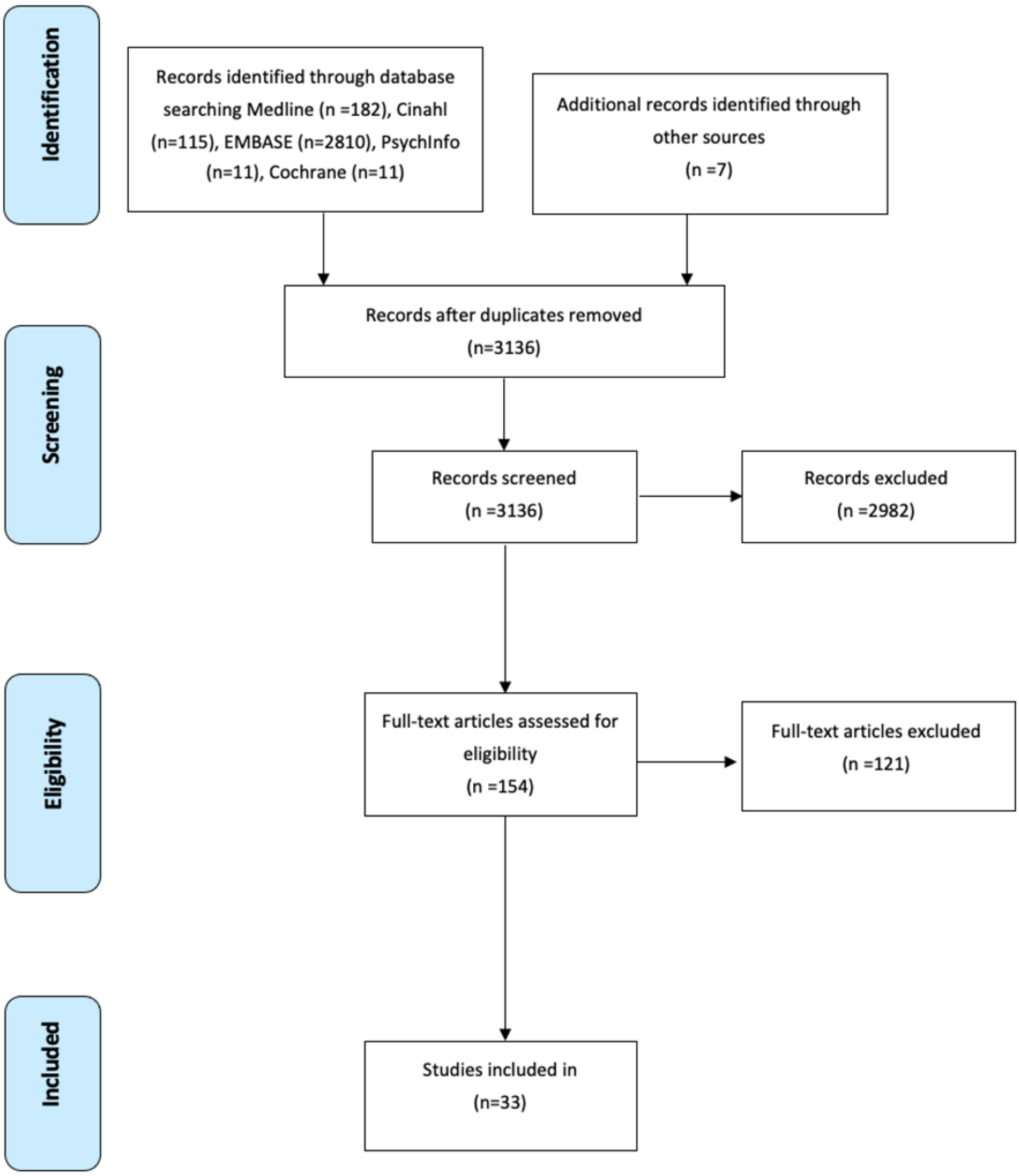


Figure 2.4. Flow diagram of studies eligible for review in the systematic review

2.3.4.1. *Study Characteristics*

Five studies were randomised controlled trials, while most study designs were prospective cohort (n=20). The remaining studies were case control (n=3), retrospective cohort study (n=2), cross sectional study (n=2), and meta-analysis (n=1), of varying quality level, as seen in *Table 2.4.* These studies yielded a total of 17 validated simulated assessment tools which comprised of both open and laparoscopic skills, and of varying level of difficulty seen in *Figure 2.5*. The total number of participants was 880 surgeons training in a variety of disciplines, including general surgery, obstetrics and gynaecology, orthopaedic, urology, vascular, neurosurgery, endovascular surgery, trauma, ophthalmology, and emergency.

Table 2.4. Quality level of studies in systematic review

Quality Level	Number of Studies
No clear conclusion drawn, not significant	5
Results ambiguous but there appears to be a trend	11
Conclusions can probably be drawn based off results	10
Results are clear and likely to be true	7
Results are unequivocal	0

Table 2.5. Simulated assessment tools used in studies

Name of Simulated Assessment	Number of Articles
Mist-VR (Aggarwal et al., 2004)	**8** - Aggarwal et al., 2011 ; Uchal et al., 2005; Eastridge et al., 2003; Taffinder et al., 1998; Leff et al., 2008; DeMaria et al., 2005; Grantcharov et al., 2001; Sugden et al., 2012
The Fundamentals of Laparoscopic Skills Trainer (Van Ginkel et al., 2020)	**5** - Olasky et al., 2014; Ganju et al., 2012; Kahol et al., 2008; Daruwalla et al., 2013; Brandenberger et al., 2010
dVSS (Kelly et al., 2012)	**4** - Robison et al., 2018; Bharathan et al., 2013; Mark et al., 2014; Yamany et al., 2015
ProMIS (Kahol et al., 2008)	**3** - Ganju et al., 2012; Kahol et al., 2008; Brandenberger et al., 2010
Own Simulator	**6** - Kahol et al., 2008 ; Jensen et al., 2004; Gerdes et al., 2008 ; Jakubowicz et al., 2005 ; Bharathan et al., 2013; Deaconson et al., 1988
Lap Mentor Simbionix (Zhang et al., 2008)	**3** - Tsafrir et al., 2015; Hegar et al., 2011; William et al., 2013
LaparoscopicSim (Kovac et al., 2012)	**2** - Schlosser et al., 2012; Daruwalla et al., 2013
Neurotouch (Alotaibi et al., 2015)	**1** - Micko et al., 2017
Interventional Simulation Trainer (Chaer et al., 2006)	**1** - Naughton et al., 2011
VEST (Lehmann et al., 2005)	**1** - Lehmann et al., 2010
LapSim Gyn VR Simulator (Larsen et al., 2009)	**1** - Amirian et al., 2014
Eyesi surgical simulator (Mahr and Hoge, 2008)	**1** - Erie et al., 2011
Rapidfire and Endo Tower simulator (Haluck et al., 2002)	**1** - Tomasko et al., 2012
SimSurgery Educational Platform	**1** - Veddeng et al., 2014

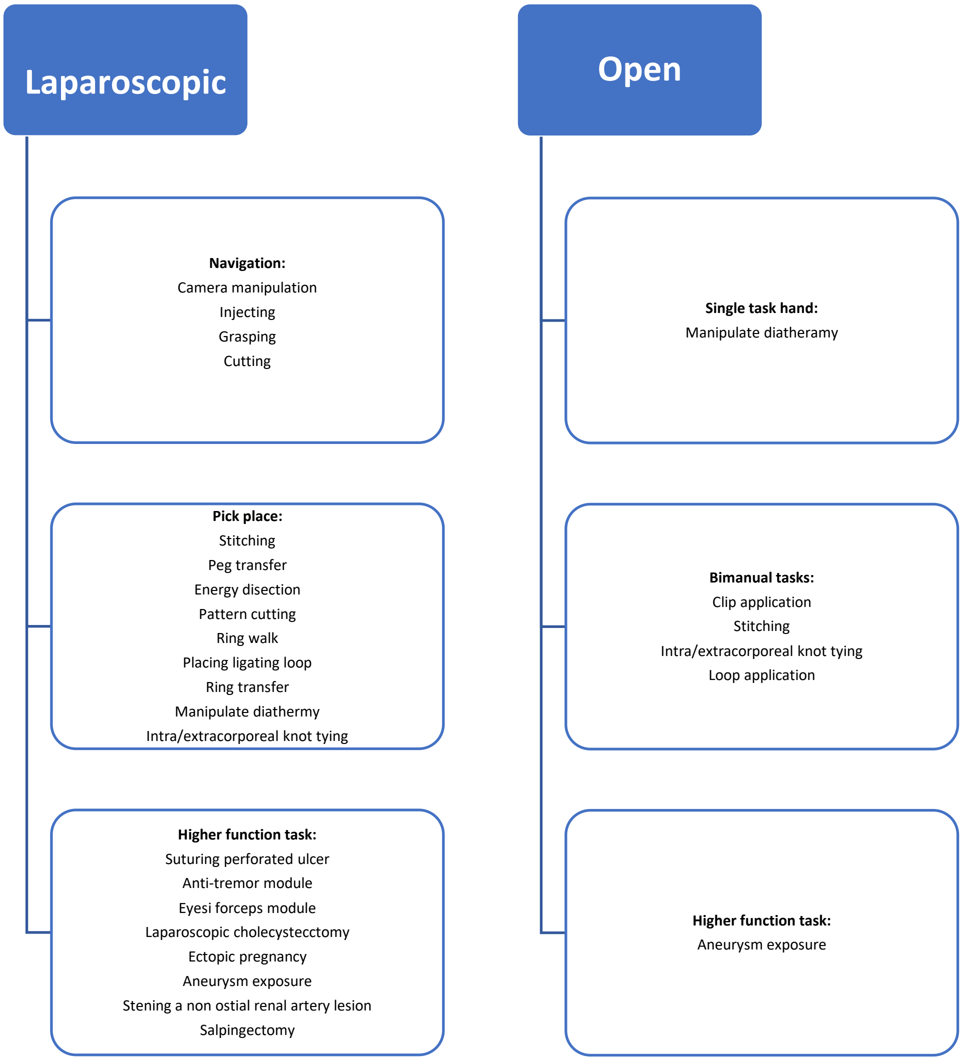


Figure 2.5. Simulated tasks of studies in the systematic review categorised by level of difficulty

2.3.4.2. Impact of Sleep Deprivation and Associated Fatigue on Technical Skill Performance

There was a total of 15 studies that found no impact of sleep deprivation on performance, as seen in *Table 2.6*. This is in contrast to the 2 studies which found that sleep deprivation had a positive impact on performance, and the 16 studies which found that sleep deprivation had a negative impact on performance. Scores of the four summary measures can be seen in *Table 2.7.*

Table 2.6. Study outcomes of impact of sleep deprivation on technical skill performance

No Impact (15)	Positive Impact (2)	Negative Impact (16)
Uchal et al., 2005	Micko et al., 2017	Aggarwal et al., 2011
Robison et al., 2018	Schlosser et al., 2012	Tsafrir et al., 2015
Olasky et al., 2014		Naughton et al., 2011
Lehmann et al., 2010		Eastridge et al., 2003
Sugden et al., 2012		Taffinder et al., 1998
Amirian et al., 2014		Leff et al., 2008
William et al., 2013		Kahol et al., 2008
Ganju et al., 2012		DeMaria et al., 2005
Erie et al., 2011		Gerdes et al., 2008
Jakubowicz et al., 2005		Bharathan et al., 2013
Jensen et al., 2004		Yamany et al., 2015
Deaconson et al., 1988		Daruwalla et al., 2013
Tomasko et al., 2012		Philibert et al., 2005
Hegar et al., 2011		Mark et al., 2014
Veddeng et al., 2014		Grantcharov et al., 2001
		Brandenberger et al., 2010

Table 2.7. Summary median measures scores of studies in systematic review

	No Impact Median	Positive Impact Median	Negative Impact Median
Quality Scores	2	3	3
Study Design Score	4	3.5	4
Composite Score	3	3.25	3.5
Average Sample Size	26	29	18

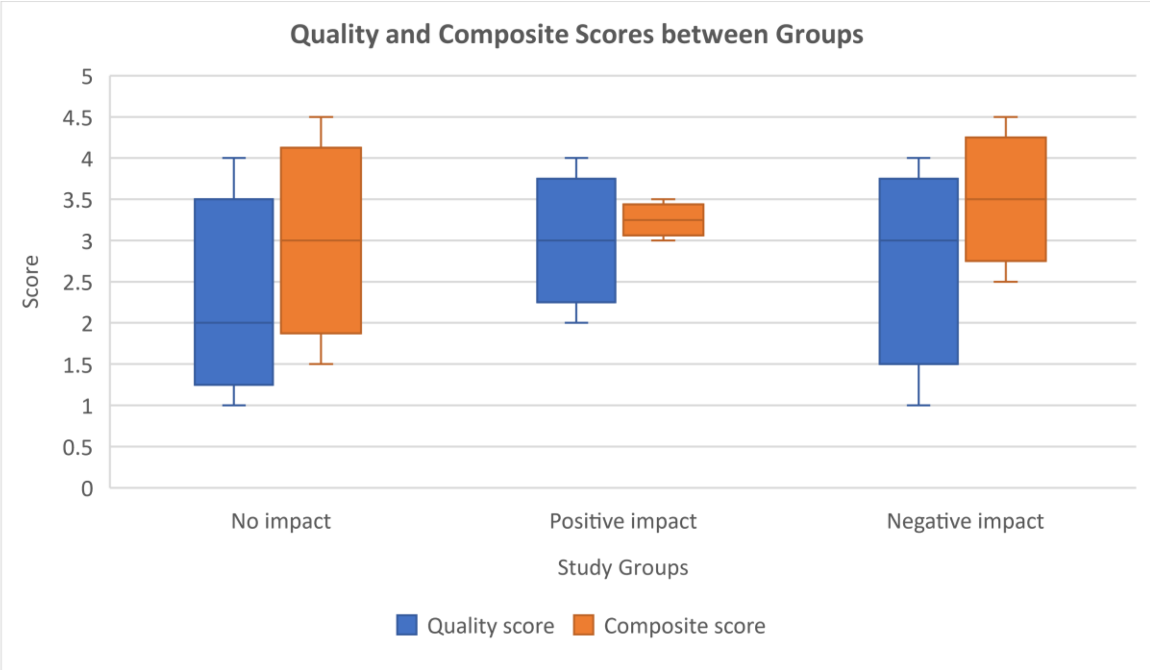


Figure 2.6. Boxplots showing the scores associated with study quality and composite scores between the three study groups

Study quality weighting between the three groups is seen in *Tables 2.8* and *2.9.* The results were then mapped on box plots seen in *Figure 2.6.* There was a trend towards higher quality and composite scores in studies which found there was a negative impact on performance. This trend was not statistically significant.

Table 2.8. Kruskal Wallis results between the three sub-groups of systematic review

	Study Quality Score	Study Design Score	Composite Score
Kruskal Wallis Score	0.685	1.596	0.628
P score	0.646	0.286	0.589

Table 2.9. Mann Whitney-U results between the three sub-groups of systematic review

	Study Quality Score	Study Design Score	Composite Score
Mann Whitney U-Score (No impact, Positive Impact)	10.5	10.5	13.5
P score	0.489	0.431	0.819
Mann Whitney U-Score (Negative Impact, Positive Impact)	14.5	10	15.5
P score	0.713	0.129	0.660
Mann Whitney U-Score (No impact, Negative Impact)	119.5	120.5	114.5
P score	0.447	0.311	0.320

Groups were then pooled into 'impact' and 'no impact'. The findings of the Mann-Whitney U tests can be found in *Table 2.10*. There was an increasing trend towards higher quality and composite scores in studies which found sleep deprivation did impact on technical skill performance, as seen in the box plots in *Figure 2.7.* These results were not statistically significant.

Table 2.10. Mann Whitney- U results between the two pooled groups of systematic review

	Mann Whitney U-Scores (No impact → Impact)
Quality score	p=0.388
Study design score	p=0.476
Composite score	p=0.333

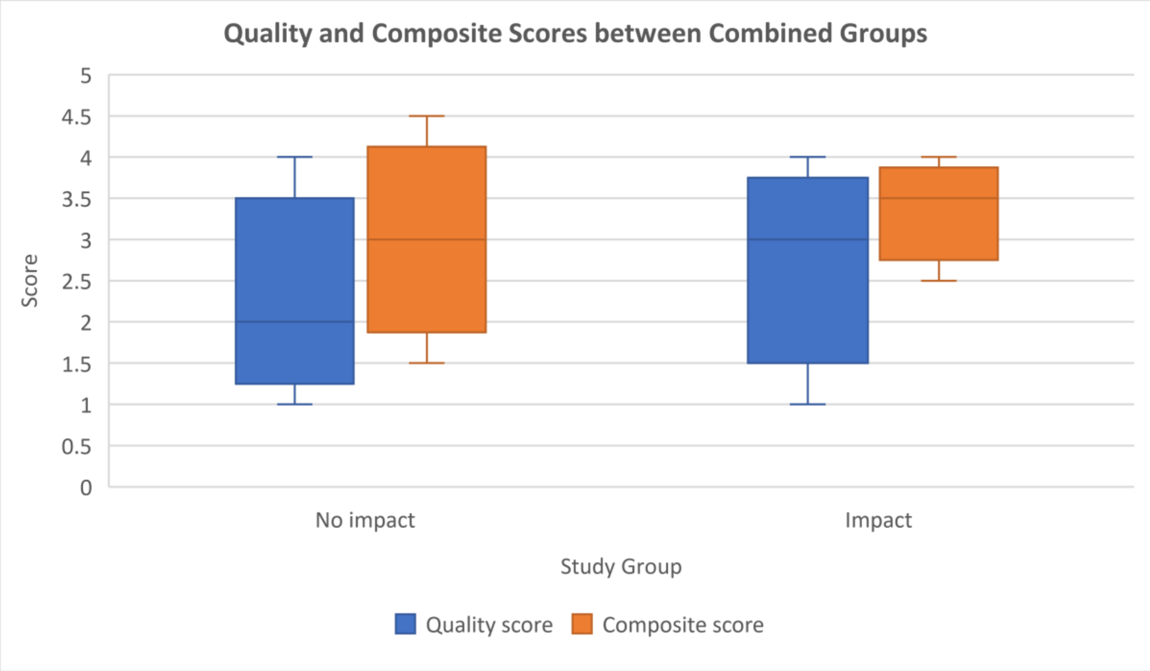


Figure 2.7. Boxplot showing the scores associated with quality and composite scores between the two pooled study groups

To establish effect sizes between the groups (i.e. the extent to which sleep deprivation impacted on performance), individual study value scores were explored based off three performance indicators where results were transparent:

1. time to complete the task
2. the economy of motion of the task
3. the number of errors in the task.

A 32% decrement in performance across 10 studies occurred in studies which found a negative impact of sleep deprivation on performance. When pooling these 10 studies which found a negative impact with 2 studies that found a positive impact, there was a 23.8% decrement in performance (i.e. across 12 studies). When including all studies which explicitly elaborated on results, an 11.9% decrement in performance was found in 24 studies across the 3 outcomes. An elaborative table indicating the individual and summative performance findings can be found attached in *Appendix C.*

2.3.4.3. *Role of Experience on Relationship between Sleep Deprivation and Technical Skill Proficiency*

In the studies identified, 31 involved residents, 7 involved attending surgeons, 6 involved interns, and 2 involved undergraduate medical students as participants. A sub-group analysis, seen in *Figure 2.8,* shows a breakdown of studies between level of training and whether sleep deprivation impacted on technical skill.

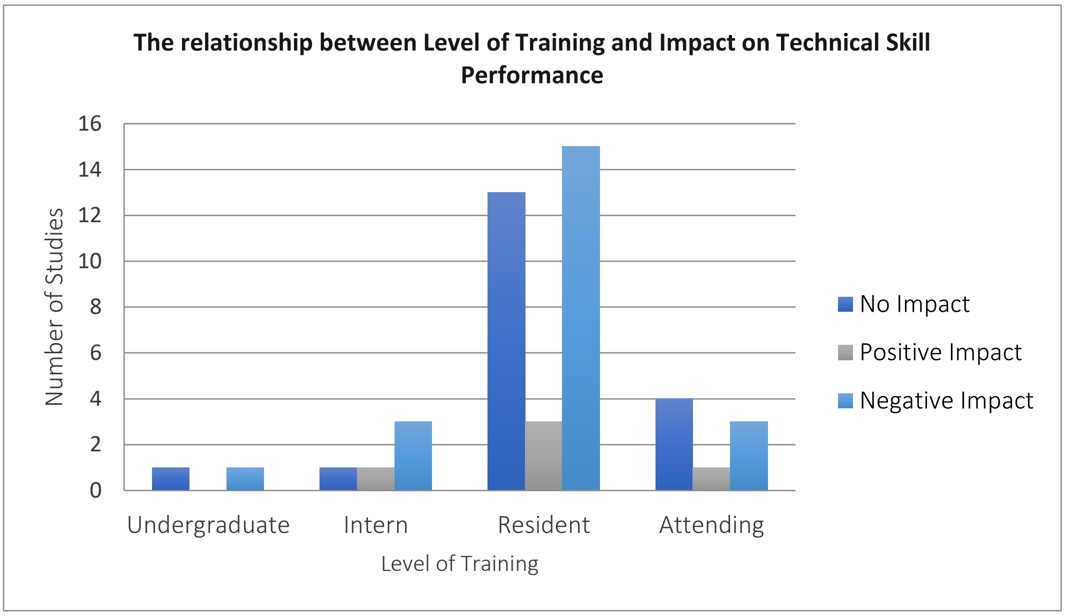


Figure 2.8. The relationship between level of training and impact on technical performance categorised by the three study groups

A subset analysis looking at whether studies distinguished between the level of training or level of experience was then carried out. In total, 21 studies attempted to distinguish between level of training and/or experience, as seen in *Table 2.11.* In this case, some studies categorised level of experience by career progression e.g. Micko et al. (2017), while others distinguished between level of training based upon the time spent performing a particular procedure e.g. Tsafrir et al. (2015). In order to attempt to control for the learning curve, others explicitly stated in their inclusion criteria that participants must have no experience with the laparoscopic simulation e.g. Naughton et al. (2011).

Table 2.11. Level of training and/or experience distinguished across studies in systematic review

Study	Distinguished Training	Distinguished Experience
Tsafrir (2015)	Residency	• Experienced > 20 laparoscopic
Uchal (2005)	Residency/attending	• All are 'experienced' in MIS
Robison (2018)	Residency	• Spread across 2-5 years
Olasky (2014)	Residency	• Residency and fellowship
Micko (2017)	Residency	• Junior resident (1-3) • Senior resident (4-6)
Naughton (2011)	Residency	• Had to have no experience
Lehmann (2010)	Residency	• Novice (<10 self-contained laparoscopic) • Expert (> 21 laparoscopic)
Eastridge (2003)	Residency	• PG 1-5
William (2013)	Residency	• PG 2-5
Schlosser (2012)	All three	• Controlled in subgroup analysis
Hegar (2011)	Intern/residency	• Interns and residents
Erie (2011)	Residency	• 3 from PGY2, PGY3, PGY4
Kahol (2008)	Residency	• Junior (PG 1-2) : Senior (PG 3>)
DeMaria (2005)	All three	• Intern, PG1-5, attending
Jakubowicz (2005)	Residency	• PG years 1-4
Veddeng (2014)	Residency/attending	• 17 trainees • 11 specialists
Gerdes (2008)	Residency/attending	• 5 trauma residents • 9 attending surgeons
Mark (2014)	Residency	• All trainees
Grantcharov (2001)	Residency	• Surgical trainee
Deaconson (1988)	Residency	• Surgical trainees
Brandenberger (2010)	Residency	• First year residents
Daruwalla (2013)	Residency/attending	• No
Tomasko (2012)	Intern	• No
Bharathan (2013)	Residency	• No
Sugden (2012)	No	• No
Philibert (2005)	Residents	• No
Taffinder (1998)	Interns/residents	• No
Amirian (2014)	All three	• No
Leff (2008)	Residency	• No
Aggarwal (2011)	Intern	• No
Jensen (2004)	Residency	• No
Yamany (2015)	Residency	• No
Ganju (2012)	Residency	• No

2.3.4.4. Role of Sleep Type on Relationship between Sleep Deprivation and Technical Skill Proficiency

Sleep is not objectively measured in any of the included studies. No study attempted to distinguish between the levels of REM and NREM sleep.

Four studies assessed sleep quality by observing the patterns of sleep of the participants (Sugden et al., 2012), capturing physiological processes such as pupillography and saliva cortisol (Schlosser et al., 2012), monitoring levels of physical activity during the night using actigraphy (Amirian et al., 2014), or recording hours of sleep in real time using sleep logs (Lehmann et al., 2010).

Most studies used subjective assessment of sleep using self-reported outcome measures to capture the level of fatigue or sleepiness of participants. These included validated outcome measures such as:

- The Stanford Sleepiness Scale (Aggarwal et al., 2011)
- The Epworth Sleepiness Scale (Uchal et al., 2005)
- The Karolinska Sleepiness Scale (Amirian et al., 2014)
- The Benhrenz and Monga questionnaire (Ganju et al., 2012)
- Self-created tools to measure fatigue such as a 5-point Likert of fatigue (Olasky et al., 2014).

2.3.4.5. Role of Sleep Duration on Relationship between Sleep Deprivation and Technical Skill Proficiency

Six studies explicitly stated what level of sleep loss constituted 'sleep deprivation'. It was defined as 24 hours awake in the clinic (Aggarwal et al., 2011), after a night on-call (Tsafrir et al., 2015), less than 4 hours' (Deaconson et al., 1988), less than 3 hours (Uchal et al., 2005; Jakubowicz et al., 2005), or less than 2 hours (Tomasko et al., 2012) in the preceding 24 hours.

Four studies controlled for acute and chronic sleep deprivation by ensuring that the control group had spent the 3 nights prior to baseline testing not on-call (Tsafrir et al., 2015; Amirian et al., 2014), stating in their inclusion criteria that participants had to sleep "6 hours each night prior to stress test"(Micko et al., 2017), or controlling participants to have > 6 hours of sleep per night on average for the week prior to baseline testing (Erie et al., 2011).

2.3.5. Discussion

On balance, the majority of studies found that sleep deprivation did impact on technical performance in simulation (18 vs 15). A decrement of up to 32% from baseline performance was found, when using studies which found a negative impact on performance, and provided enough information to create effect sizes. If pooling the studies which found a positive impact on performance, and those which found no impact on performance, this decrement is reduced to 23.8% and 11.9% respectively. The indicators used are important metrics in establishing construct validity of performance in a simulated surgical environment (Moody et al., 2003). Of the two studies which found sleep deprivation actually improved performance in a simulated environment, this may be explained by neither of these studies explicitly controlling for a learning curve.

Using statistical analysis, the quality and composite scores of the studies which found an impact (either negative or positive) of sleep deprivation on performance was higher. Decrement percentages were based on attempts to quantify the overall effect on performance using three performance indicators; time to complete the task, the economy of motion of the task, and the number of errors in the task. It is worth noting that other metrics were used to define performance, such as overall performance scores (Daruwalla et al., 2013; Micko et al., 2017). While these studies did not use the simulated performance metrics, they did use a combination of objective measurements and subjective DOPS such as checklists and global rating scales.

On balance, the decrement correlates to real-life performance in similar technical industries such as aviation. Research in sleep-deprived pilot performance has shown reduced precision with decrements of 25% recorded between peak and lowest performance scores (Previc et al., 2009). Such decrements in surgery may also be influenced by impaired information processing and delayed decision-making, highlighting the interdependency between the cognitive and psychomotor aspects of our brain.

From the studies included within this review, the level of training of surgeons may have a positive influence on the relationship between sleep deprivation and technical skill proficiency but the evidence is limited. A large amount of research has been carried out on the 'resident' category, with varying levels of definitions and information available according to each individual study. In the ‘residency’ group, 16 studies found that there was an overall negative impact compared to the 13 studies which found that no impact or a positive impact. Interestingly, this trend is reversed as the ‘attending level’. Albeit there are a smaller amount of studies, five of them found ‘attending’ surgeons performance was not impacted in contrast to three studies that found there was an influence on performance.

The literature has no established consensus on whether age or experience acts as a ‘protection factor’ against the negative effects of sleep deprivation on performance. More experienced surgeons may utilise or adapt learned strategies to minimise error in simple tasks which will impact their overall performance. Similarly, attending surgeons may not be subject to the same level of sleep deprivation as residents, which once again highlights the limitations of a poorly-defined consensus on what constitutes ‘sleep deprivation’. In pilots, preservation of highly practiced skills is seen when faced with high levels of sleep deprivation (Previc et al., 2009). This may indicate that repetition of tasks may support resistance to fatigue through a process known as implicit learning, reducing the germane and extraneous cognitive load in the process, which may have applicability to surgery.

There is no strong distinction made between quality and quantity of sleep in any of the studies included. All studies used self-reporting as the mechanism to capture the quantity of sleep of the participants. Given the subjective nature of this assessment, it is unlikely that the results are wholly reliable. Opportunities to use technology may elicit future insights into this limitation within most studies. One study attempted to quantify sleep through measuring inactivity with an actigraphy during the night (Amirian et al., 2014). As an objective measurement, actigraphy has an accuracy of 93% when compared with polysomnography and 85% when compared with reported sleep in recovery states (Bisgaard et al., 1999). Whilst these are innovative means of assessment, they are still prone to bias. In the case of actigraphy, whether or not the participant is awake or asleep is not ascertained. With the use of sleep logs, participants may forget to regularly complete the reporting. Other objective markers such as Amt6S and salivary cortisol (Amirian et al., 2015) could be more useful in measuring the impact of sleep deprivation on surgical performance. By establishing if decrements are seen in specific stages of the sleep cycle, researchers can begin to ascertain which type of sleep impacts on particular technical and non-technical skills. In particular, taxonomy of sleep types to different performance domains will become possible as experiment designs become more sophisticated (Walker, 2009).

Since there is a lack of consensus as to what defines ‘sleep deprivation’, what exactly constitutes the difference between acute and chronic sleep deprivation also remains an outstanding question. A small amount of studies attempted to control for levels of sleep prior to baseline testing by ensuring participants were off-call (Tsafrir et al., 2015; Amirian et al., 2014), or by establishing a cut-off of required >6 hours of sleep in the preceding week (Erie et al., 2011; Micko et al., 2017). There is evidence to suggest that daytime sleep following night shifts is fragmented and poor in quality (Åkerstedt et al., 2003), and given the regularity in which surgeons complete on-call work, suggests that chronicity may play a confounding variable in many of these study findings. Little research has been carried out on the potential impact of cumulative fatigue. This could bring about a diminished performance in surgery which is less detectable on simulator or in real life retrospective findings.

2.3.6. Limitations

The findings of this systematic review are limited by the inclusion criteria established by the investigator as well as the external validity, and conclusion validity of the researchers involved. Most of the research in this systematic review is lower in quality due to the study design and the small sample sizes. Using the BEME guidelines, the research which found no impact of sleep deprivation on performance leaned closer to ambiguous results. In contrast, the research which found sleep deprivation did impact on performance was approaching ‘probably be based off results’. Studies of a higher quality in design are needed to find more conclusive evidence. There may be publication bias in this field of research with research indicating that sleep deprivation does not impact on performance being less likely to be published as it argues counter to national and international legislations. Finally, the effect of stimulant use was not explicitly controlled for in the majority of studies, thus limiting the true evaluation of sleep deprivation on technical skill performance.

2.3.7. Study Design Considerations

There are some important factors which must be considered in future areas of research into sleep deprivation and surgical performance which will be subsequently addressed in *Chapter 3*.

2.3.7.1. Definition of sleep deprivation and fatigue

There is a lack of consensus as to what constitutes sleep deprivation. Many of the included studies didn’t adequately define this. For the purpose of subsequent research, sleep deprivation will be defined as <7 hours of sleep based off international recommendations on optimal sleep

(Hirschkowitz et al., 2015). Similarly, there is a lack of consistency in the use of the word 'fatigue' throughout the studies. Certain studies use it to indicate burnout, whilst others use it interchangeably with 'sleep deprivation'. This emphasizes the lack of consistency throughout the studies included in relation to the terms used. A validated assessment tool for fatigue should be used in subsequent research.

Future research should attempt to distinguish the effects of acute sleep deprivation on top of chronic partial sleep loss on performance. In order to capture the potential impact of chronic sleep deprivation versus acute sleep deprivation on performance, a stratified study could be conducted between different work rotas including 'surgeon of the week' and 'reduced elective call' models.

A lack of control for the influence of the circadian rhythm as a confounding variable could also have affected individual results. It is paramount that future studies state the parameters of a proposed time of assessment and standardise that assessment in pre-call and post-call states.

2.3.7.2. Tasks

Due to the heterogeneity of procedural tasks assessed, it is difficult to conclusively state that sleep deprivation is likely to impact on technical skill proficiency. Many of the studies did not supply sufficient information regarding the task which was used to assess technical proficiency, as well as its construct validity. Establishing level of difficulty of the task, as well as whether there are additional cognitive components such as decision-making in the task is required for future research. The level of complexity and the length of an assessment task, were not explicitly controlled for in most studies.

2.3.7.3. Training

Many studies failed to be fully transparent in revealing the level of training of participants, as well as their surgical specialty. Many studies failed to account for the effect of the learning curve on simulation. It is important to employ strategies which mitigate against the impact of the learning curve, which may otherwise corrupt the true results in outcome measurements. Such strategies may include mandating hands-on experience to reach a baseline of performance between novice and experienced residents (Tsafrir et al., 2015; Lehmann et al., 2010), or to use residents as their own controls (Tsafrir et al., 2015; Robison et al., 2018; Lehmann et al., 2010). Future research should also consider employing strategies to account for the influence of the learning curve.

2.3.7.4. Outcome Measurement

Research in the area of sleep deprivation is limited by the use of subjective outcome measures to capture the quantity and quality of sleep of participants. It will be important to use existing validated outcome measurements consistently in the future to allow greater comparisons between studies. Future research should look at establishing objective assessment tools for sleep. These may include the use of wearable tracker devices, and biological markers of sleepiness such as electroencephalogram (EEG).

2.3.8. Conclusion

On the basis of the 33 objective studies included in this systematic review, the balance found sleep deprivation did negatively impact on technical skill performance in a standardised setting. In addition, the findings of the narrative review suggest a greater impact of cognitive performance. The quality of the studies which did find an impact on technical skill performance was higher when compared to studies which found sleep deprivation did not impact on technical skill performance. This decrement in performance is estimated to be between 11.9% - 32%. There is a need for greater homogeneity of study designs and objectives to enable a more conclusive outcome regarding whether or not sleep deprivation impacts on both technical and cognitive performance in surgery. Future research should consider confounding variables such as definitions of sleep deprivation and fatigue, simulated tasks, training to reduce the learning curve and appropriate outcome measurements.

3. Chapter 3 – Observational exploration of on-call models and surgical performance

3.1. BACKGROUND

Despite efforts previously discussed, it is evident that both sleep deprived and fatigued surgeons exist in a variety of settings. A relationship was established between surgical performance, sleep deprivation and fatigue with the evidence weighing in favour of negative implications. There remains a series of research gaps identified in the literature, such as inconsistency in assessment of performance outcomes, and a dearth of objective sleep assessment measures which warrant further investigation.

In exploring these, an observational study design within an Irish hospital setting with on-call status was conducted. This hospital has two main models of on-call work previously discussed – 'surgeon of the week' and 'supra-elective' (Kelly et al., 2014) which provides opportunistic insights into different models of work and their influence on sleep and performance outcomes. This chapter has two elements summarised in *Figure 3.1*.

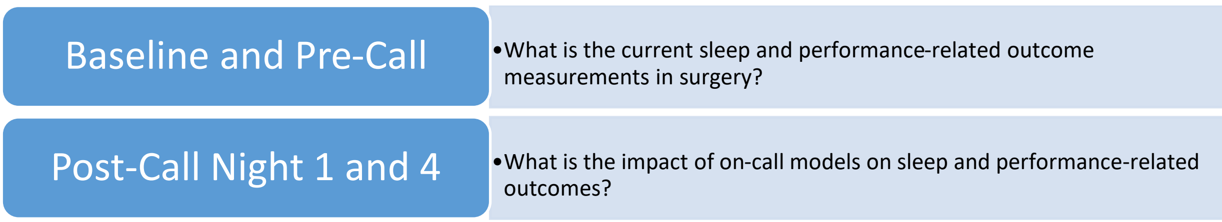


Figure 3.1. Elements of Chapter 3

3.2. RESEARCH QUESTION

'What level of sleep deprivation and fatigue exists in Irish surgery, and how does the role of on-call models influence sleep and performance outcomes?'

3.3. OBJECTIVES

1. To explore current sleep outcomes using a novel objective EEG approach, in conjunction with subjective measurements
2. To identify the impact of on-call models on performance outcomes
3. To identify demographic variables which mitigate the impact of sleep deprivation on performance in surgeons

3.4. METHODS

This study is reported according to the STROBE guidelines for observational studies (Von Elm et al., 2007).

3.4.1. Study Design

This was a single site observational study design exploring relationships between subjective and objective measurements of sleep deprivation, fatigue, and their impact on simulated surgical technical performance and cognitive performance. A single site was decided to establish internal reliability of the data. The typical work flow is provided in *Table 3.1*. The institutions two models of work which require surgeons to be available beyond typical working hours can be described as:

1. surgeons completing 5 nights of shift-work style on-call for 5 consecutive nights (*commencing on a day of rest*)
2. surgeons on-call for one 24 hour shift between 1-2 times a week (*commencing on a work-day*)

Table 3.1. Models of on-call for trainees and consultants

Level	Number of Nights in a Row	Hours scheduled	Regularity of night-associated work	Stays on-site during night	Stays on-site after night
SHO	5	8pm-8am	Once every twelve weeks	Yes	No
Registrar	1	8am-8am	One in every five days	Yes (may leave after 12am if not busy)	Yes (until 5pm)
Consultant	1	8am-8am	One in every five days	No (arrive on-site if required)	Yes (until 5pm)

Stratified randomisation was used in the study design to explore the potential role of job level on performance. Surgeons on-call on for one night were defined as 'acute sleep deprivation' while those completing 5 nights in a row shift-work, and likely to face significant circadian disruption in adapting to shift-work, was defined as 'sub-acute sleep deprivation'.

At recruitment, simulation training and baseline testing was performed. At this baseline assessment, demographic variables were recorded and participants completed performance assessments (cognitive and technical), as well as subjective evaluations of sleep and fatigue. Participants were next assessed the morning before going on-call, or in the case of SHO the Friday morning before they commenced shift-work. Participants were reassessed the morning after post-call. In the case of SHO, they were reassessed a 3rd time on the 5th night of shift-work.

In addition to testing at pre-call and post-call states, participants were encouraged to log a weekly sleep journal for 7 days during their week of on-call work. An opportunistic sample of participants also objectively tracked their sleep levels using the 'Pillow' app © (Neybox Digital Ltd., Nicosia).

3.4.2. Participants

Participants were recruited between September 2019 – February 2020 with a median phase of 4 weeks between recruitment and final assessment through convenience and quota sampling. Participants were recruited through an email list, tailored to surgeons through the Department of Surgery in Tallaght University Hospital, containing an invitation to participate *(Appendix D)* as well as a participant information letter (*Appendix E*). A reminder email was also sent out to individual emails after 4 weeks. The participants were considered recruited when they subsequently responded by email indicating their interest to participate.

Informed written consent was obtained from participants at recruitment. The study aimed for participants in total along the 3 levels (i.e. 6 at each level). The study assessed significance at the level of p<.05. Across 30 similar published studies which have explored surgeons and sleep deprivation the average number of participants has been 20.8. 18 was chosen as sample size as it was deemed achievable.

The inclusion and exclusion criteria are as follows:

Inclusion:

- Surgeons in the single-site institution
- Surgical trainees (SHO and Registrar)
- Surgical consultants
- Surgeons on-call for 1 night (24 hour call)
- Surgeons on shift-work rota (5 nights)
- Control cohort of physiotherapists

Exclusion:

- Non-surgical medical professional with the exception of a control group of physiotherapists
- Surgeons with any self-determined major recent physical event
- Surgeons who do not complete general on-call work

A cohort of 13 physiotherapists was recruited as a control group for this study. These were conveniently sampled from within the institution to match similar demographic characteristics of the surgical cohort. They completed the baseline reporting of measurements and performance tasks but not any other aspects of the assessment.

3.4.3. Study Instruments

The timeframes in which each assessment were completed are provided in *Table 3.2*.

Table 3.2. Timeframes of each aspect of the assessment for Chapter 3 study duration

Instrument	Recruitment	Pre-call/Pre-shift	Post-Night-1	Post-Night 4
Electroencephalogram (EEG)		✓	✓	✓
Sleep Tracker	✓	✓	✓	✓
Pittsburgh Sleep Quality Index (PSQI)	✓			
Sleep Log Journal	✓	✓	✓	✓
Epworth Sleepiness Scale (ESS)		✓	✓	✓
Chalder Fatigue Scale (CFS)		✓	✓	✓
Psychomotor Vigilance Task (PVT)	✓	✓	✓	✓
SIMENDO	✓	✓	✓	✓

3.4.3.1. Sleep Assessment

Objective sleep assessment was assessed through a modified Multiple Sleep Latency Test (MSLT) protocol (Littner et al., 2004). Participants attended the Neurophysiology department to complete an EEG performed by hospital neurophysiologists and technicians (Dr. Michael Alexander). The same process was followed the morning after on-call, or after their first and fourth night of shift-work. The assessment involved a 30 minute assessment which incorporated application of 30 EEG lines to the heads of participants (*Figure 3.2*) to measure neurophysiological response to rest. This produces an EEG report (*Figure 3.3)* which can be used to assess for cardinal signs of sleepiness in individuals.

Figure 3.2. Model demonstrating set up of EEG with permission granted

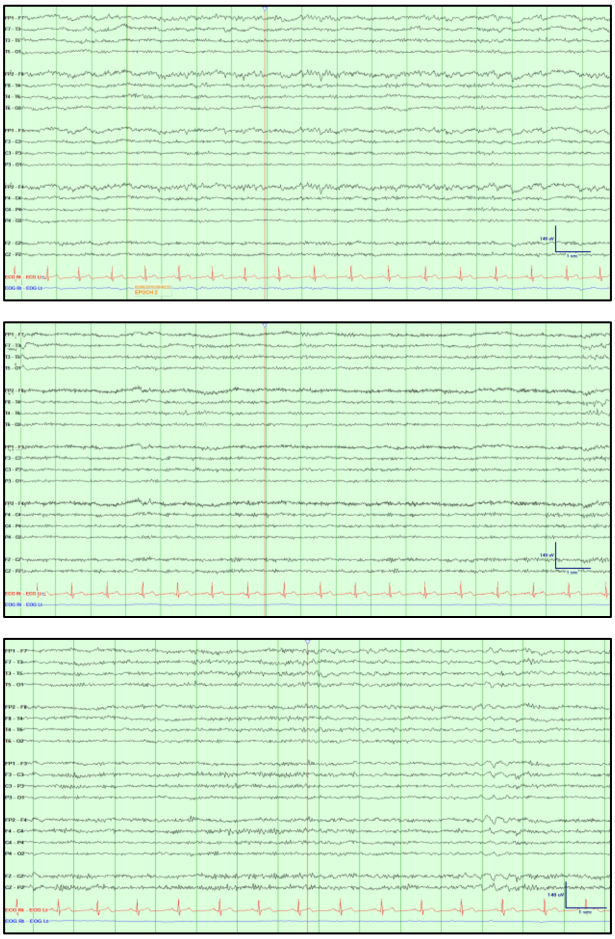


Figure 3.3. Example of an EEG of a rested, drowsy, and sleep deprived individual with permission granted

Sleep onset was determined by the time from 'lights out' to the first epoch of any stage of sleep, including stage 1 sleep, and is defined as the first epoch of greater than 15-seconds of cumulative sleep in a 30-second epoch. The absence of sleep on a nap opportunity is recorded as a sleep latency of 20 minutes. This latency is included in the calculation of mean sleep latency. Stage 1 sleep is associated with a break-up of alpha rhythms alongside low-frequency alpha waves (8-13Hz) (Rodenbeck et al., 2006).

A summary of the instruments used for objective and subjective sleep/fatigue measurement are seen in *Table 3.3.*

Table 3.3. Summary of the instruments used in Chapter 3 for sleep and fatigue measurement

Instrument	Purpose	Measures	Advantages	Disadvantages
EEG (Littner et al., 2004)	Objective sleep	Brainwaves response to rest	High reliability (Benbadis et al., 1995) Construct and face validity (Roehrs and Roth, 1992)	Costly Time requirements
Sleep Tracker ("Pillow" ©)	Objective sleep	Audible sounds Heart rate Body movement	Criterion validity (Bisgaard et al., 2009)	Costly Reliability
PSQI (Buysse et al., 1989)	Subjective sleep	19-item Subjective sleep quality, Sleep latency, Sleep duration, Habitual sleep efficiency, Sleep disturbances, Sleep medications, Daytime dysfunction	Moderate-high reliability (Spira et al., 2012; Backhaus et al., 2002) Criterion (Grandner et al., 2012; Spira et al., 2012) and content validity (Mollayeva et al., 2016)	Bias toward work-day
Sleep Log Journal	Subjective sleep	Wake-sleep state across 24-hour period	Moderate-high reliability when used for at least 5-days (Short et al., 2017) Criterion validity (Bisgaard et al., 2009)	Recall bias
ESS (Johns, 1991)	Subjective sleep	8-item Daytime sleepiness	High reliability (Hagell et al., 2007; Gibson et al., 2006; van der Heide et al., 2015) Criterion (Johns, 2000; Spira et al., 2012) and construct validity (John, 1991)	No prediction of risk Confound influences
CFS (Chalder, 1993)	Subjective fatigue	11-item Severity of tiredness or fatigue	Moderate-high reliability (Chilcot et al., 2016; Cella and Chalder, 2010) Construct (Cella and Chalder, 2010), content (Morriss et al., 1998; Fong et al., 2015) and criterion validity (Fong et al., 2015)	Ceiling effect Higher baseline scores

An elaborated summary of reliability and validity measures of the instruments used can be seen in *Appendix F*.

3.4.3.2. Performance Assessment

Psychomotor Vigilance Task (PVT): The PVT (Millisecond Software, Seattle) assessed reaction time (Dinges and Powell, 1985), a known aspect of cognitive performance. All participants completed a 10 minute task in which they reacted as quickly as possible to a visual que on the screen. Performance markers are preestablished on the software (e.g. > 500ms is a lapse). The reaction time was recorded for each 'click' of the spacebar as well as other metrics such as latency and lapses. It has high reliability (Dorrian et al., 2005). It has criterion (Whitney and Hinson, 2010) and construct validity (Doran et al., 2001; Dinges et al., 1997).

Standardised Simulated Tasks: The SIMENDO™ simulator (DelltaTech, Delft, The Netherlands) assessed participants' technical performance (*Figure 3.4*). Three tasks on the simulator were completed – pick up and drop (*simple technical task x 3 times*), needle threading (*moderately complex technical task x 3 times*), and sort the rings (*technical and cognitive task x 1 time*), ascending in order of difficulty and reflecting the more complex skills required for dual-transfer skills often required for common laparoscopic procedures. The task duration was greater than 8-minutes to match 'long' tasks from previous meta-analyses (Pilcher and Huffcutt, 1996). Performance was assessed on three main metrics: time taken to complete the task, number of errors made, and pathlength of the right and left instruments. Pre-established metrics for proficiency, as established based of average norms on the simulator, were also recorded. It has criterion (Verdaasdonk et al., 2007), face (van Ginkel et al., 2020), and construct validity (van Ginkel et al., 2020). Similar simulators have shown high reliability (Hogle et al., 2007).

Figure 3.4. Simulator used and examples of tasks completed with permission granted

3.4.3.3. Demographics

A series of demographics at baseline were taken from participants including gender, speciality, job specification, years since undergraduate medicine, caffeine intake, previous simulator experience, previous video-game experience, hand dominance, and recent work patterns (*Appendix G*).

3.4.4. Standard Setting

Learning Curve: Participants level of experience on simulation and video game use was recorded at recruitment. Participants were categorised by no laparoscopic experience (*no attempts*), limited experience (*1-10 attempts*), and advanced experience *(> 10 attempts*). Through stratifying the level, professional experience as a confounding variable on sleep deprivation and performance could be explored. An initial training on the simulator and PVT at the recruitment phase attempted to control for the learning curve effect within 2-3 weeks of their baseline assessment. Each participant completed three attempts at each simulated task and one attempt at the PVT. Education videos are pre-set on the simulator for participants to watch.

Circadian Rhythm: The timing of assessment was kept consistent at 7-9am to reduce the variable influence of the circadian rhythm on alertness and performance. This would reflect a time of peak performance for surgeons in line with circadian rhythm function (Borbély et al., 2016).

Caffeine: Caffeine has an approximate half-life of 5 hours and participants were not allowed to consume caffeine for at least 8 hours prior to assessment to control for the stimulant effect. A list of caffeine products was provided for participants as adapted from peer-reviewed research (Heckman et al., 2010) (*Appendix H*).

Control Group: A control group of matched physiotherapists in the hospital completed the performance assessment of the simulated tasks to establish construct validity. They completed the PVT at baseline similar to surgeons and completed subjective reporting of sleep outcomes. This allows not only comparisons to be drawn between the two professions but also highlights any potential generalisability of findings to the research sampling setting.

3.4.5. Statistical Analysis

A protocol of statistical analysis involving tests or normality was used (See *2.3.3.4. Data Extraction and Synthesis* for details). Non-parametric statistics were used. Spearman correlational analysis explored the relationship between objective and subjective sleep outcome measurements. Kruskal-Wallis and Mann-Whitney U tests explored relationships between variables of independence. Boxplots were used to describe the data. Wilcoxon-Signed ranks tests explored related groups measurements at different time points. Two follow-up attempts to collect missing data were completed. Data was analysed based on sample size available for each measurement.

3.5. BASELINE AND PRE-CALL RESULTS

3.5.1. Demographics

A total of 20 surgical trainees and consultants were recruited, of which 16 completed the performance and subjective assessment process pre and post-call, and 14 completed the MSLT and sleep log journals. A participant flow diagram is seen in *Figure 3.5*. The outstanding surgical trainees cited clinical or personal commitments as their reason for non-participation or completion. The demographic summaries alongside the control group of physiotherapists are seen in *Table 3.4.*

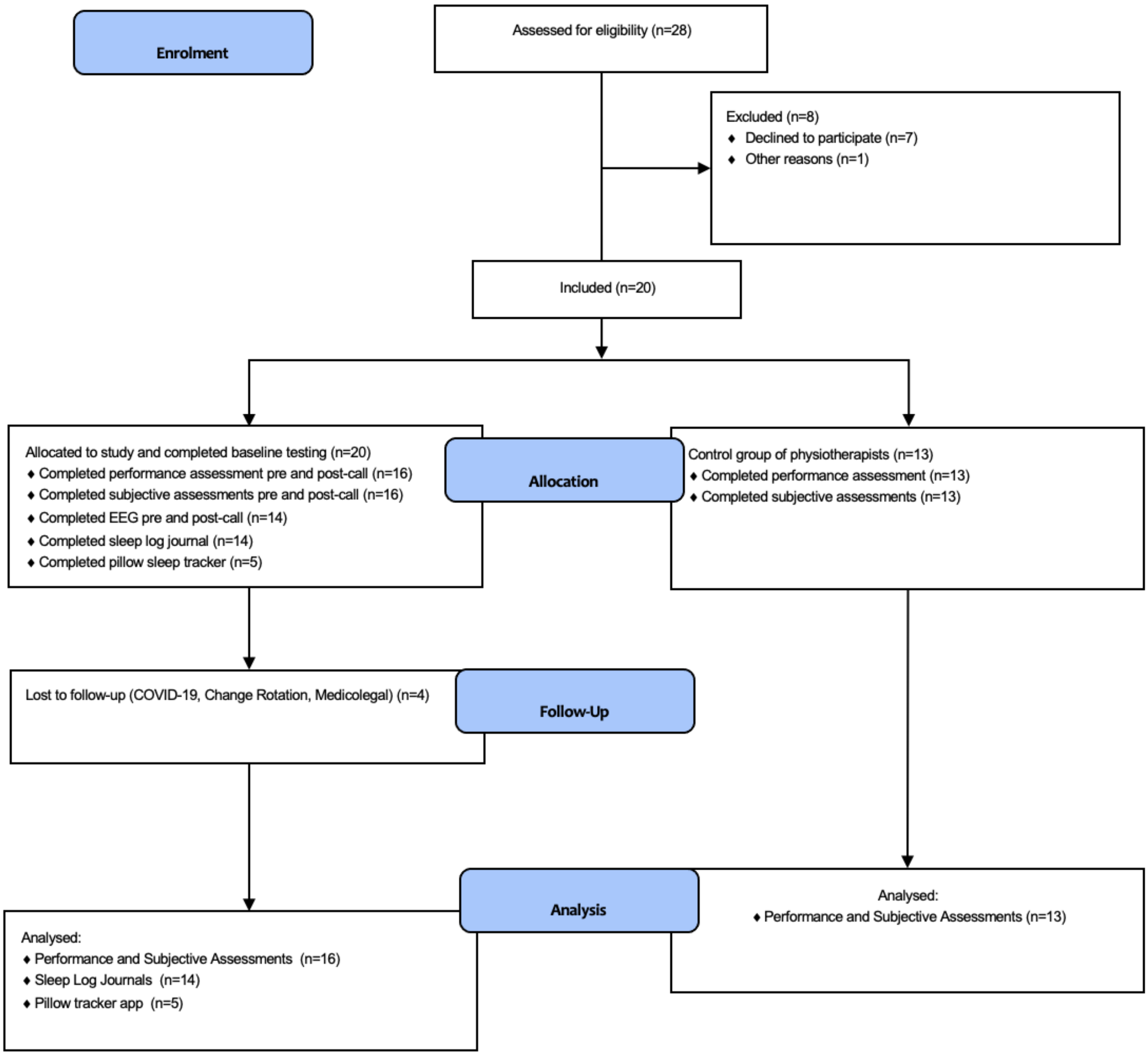


Figure 3.5. Participant flow diagram for Chapter 3 observational study

Table 3.4. Demographic summaries of participants and control group in Chapter 3

Surgeons	20		Physiotherapists	13
Nights on-call in last week				
On-call for one night	9 (45%)		1 in 2 weeks	4 (31%)
On-call for more than one night	6 (30%)		1 in 4 weeks	1 (8%)
Not on-call for the last week	5(25%)		1 in 5 weeks	1 (8%)
			1 in 6 weeks	1 (8%)
			1 in 8 weeks	2 (15%)
			Never	4 (31%)
Dominant Hand				
Left	3 (15%)		Left	1 (8%)
Right	17 (85%)		Right	12 (92%)
Age				
≤30	10 (50%)		≤ 30	6 (46%)
31-40	6 (30%)		31-40	6 (46%)
41-50	4 (20%)		41-50	1 (8%)
Gender				
Male	15 (75%)		Male	2 (15%)
Female	5 (25%)		Female	11 (85%)
Length since Undergraduate				
≤5 years	9 (45%)		≤5 years	3 (23%)
6-10 years	5 (25%)		6-10 years	3 (23%)
11-16 years	5 (25%)		11-16 years	6 (46%)
17-22 years	0 (0%)		17-22 years	1 (8%)
≥23 years	1 (5%)		≥ 23 years	3 (23%)
Current Job Title				
Senior House Officer	10 (50%)		Staff Grade	4 (31%)
Registrar	3 (15%)		Senior	8 (62%)
Specialist Registrar	3 (15%)		Assistant	1 (8%)
Consultant	3 (15%)			
Other	1 (5%)			
Specialty				
Orthopaedics	3 (15%)		Outpatients	3 (23%)
Urology	1 (5%)		Surgery	4 (31%)
General	15 (75%)		Neurology	2 (16%)
			Orthopaedics	4 (31%)
Experience Laparoscopic Simulation				
None	4 (20%)		None	13 (100%)
Limited (1-10 attempts)	9 (45%)			
Advanced (> 10 attempts)	7 (35%)			
Experience Video Games				
None	3 (15%)		None	12 (60%)
Limited (1-10 attempts)	5 (25%)		Limited (1-10 attempts)	5 (25%)
Advanced (> 10 attempts)	12 (60%)		Advanced (> 10 attempts)	3 (15%)

3.5.2. Sleep Results

3.5.2.1. EEG

The median global EEG score was 360 seconds which is indicative of early onset sleep (Littner et al., 2004). A summary of the pre-call scores are provided in *Figure 3.6.* There was a significant difference between independent level of profession (p=.018), and between trainees and consultants (p=.002) in EEG scores.

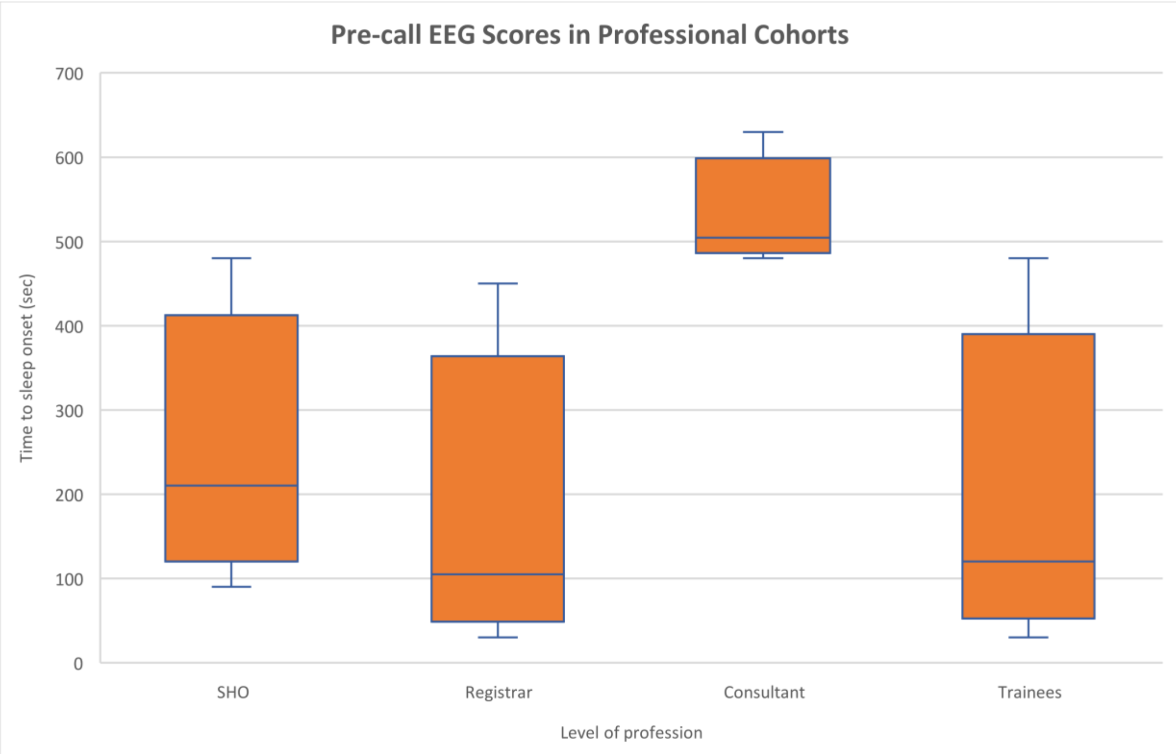


Figure 3.6. Differences in EEG pre-call scores between professional cohorts showing consultants taking the longest to fall asleep

3.5.2.2. PSQI

The median global PSQI score was 5 which is indicative of poor sleep quality (Buysse et al., 1989).

3.5.2.3. ESS

The median global ESS score was 7 which is indicative of higher normal daytime sleepiness (Johns et al., 1991). Scores for the summative component scores are demonstrated in *Figure 3.7.* There was no significant difference between surgeons and the control group. There was a significant difference between number of nights on-call in 'chance of dozing in a car, while stopped for a few minutes in traffic' with higher scores in those were on-call for more than one night (p=.004).

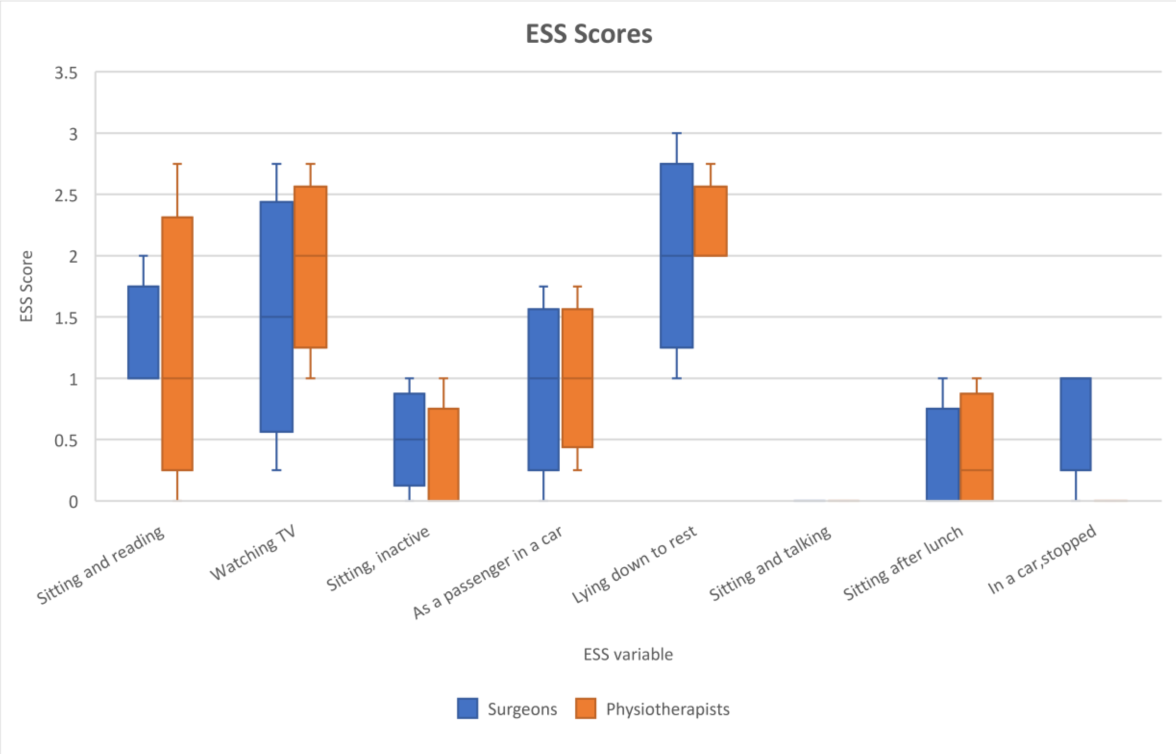


Figure 3.7. Baseline ESS characteristics between surgeons and physiotherapists

3.5.2.4. Sleep Tracker

Surgeons recorded between 203 and 511 minutes of total sleep. There was a range between 105 and 245 minutes of deep restorative sleep. The average sleep quality score was between 65% and 79.5% across 5 nights.

3.5.2.5. CFS

The median global CFS score was 11.5 which is indicative of normal levels of fatigue (Chalder, 1993). Scores for the summative component scores are demonstrated in *Figure 3.8*.

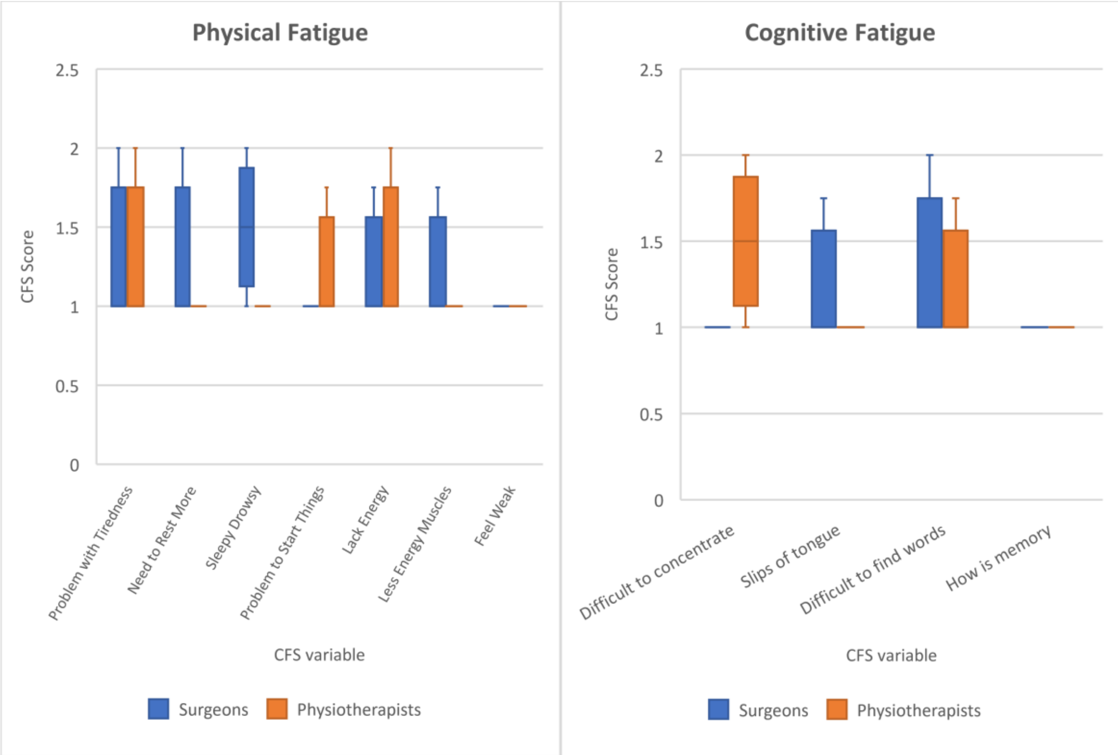


Figure 3.8. Baseline CFS characteristics between surgeons and physiotherapists

3.5.2.6. Sleep Log

Surgeons slept a median of 6.6 hours and adhered to the recommended 7-8 hours of sleep two times over a seven day period as seen in *Figure 3.9*. They had a 14.3% likelihood of achieving greater than eight hours of sleep at least once a week.

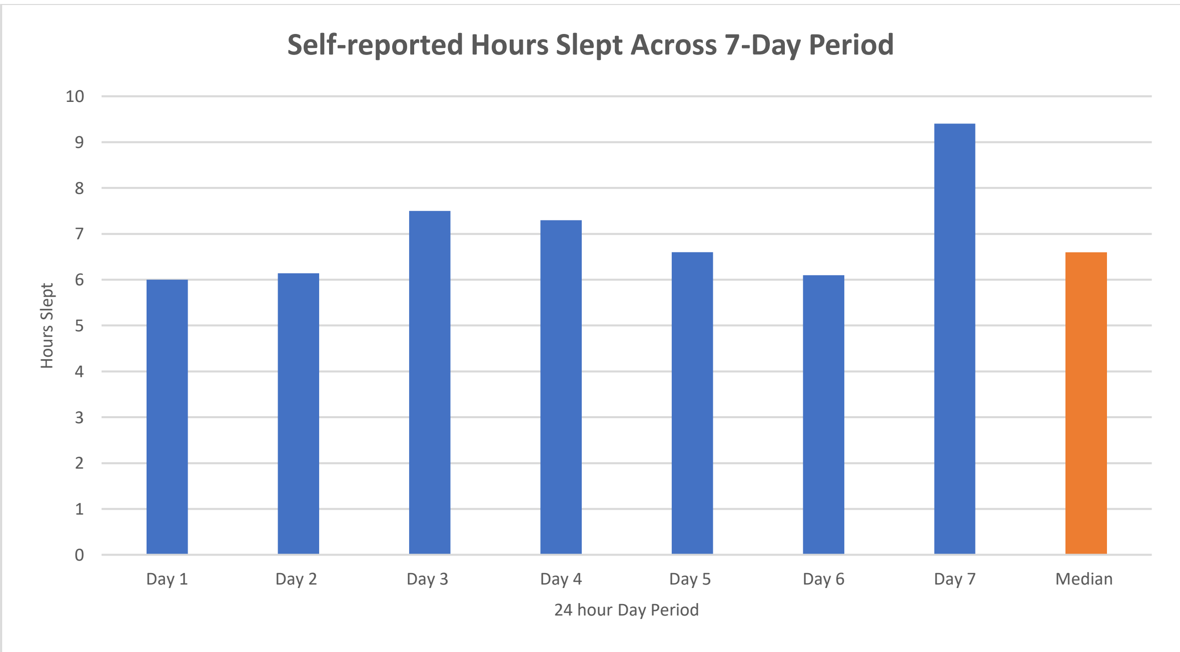


Figure 3.9. Weighted self-reported hours slept across 7-days

3.5.3. Performance Results

3.5.3.1. Technical Performance

A summary of the baseline and pre-call scores are provided in *Figures 3.10,3.11,3.12,3.13 and 3.14*. There was a significant decrease in errors made in '*Sort the Rings*' (baseline - 20 ; pre-call – 11.5, p=.015).

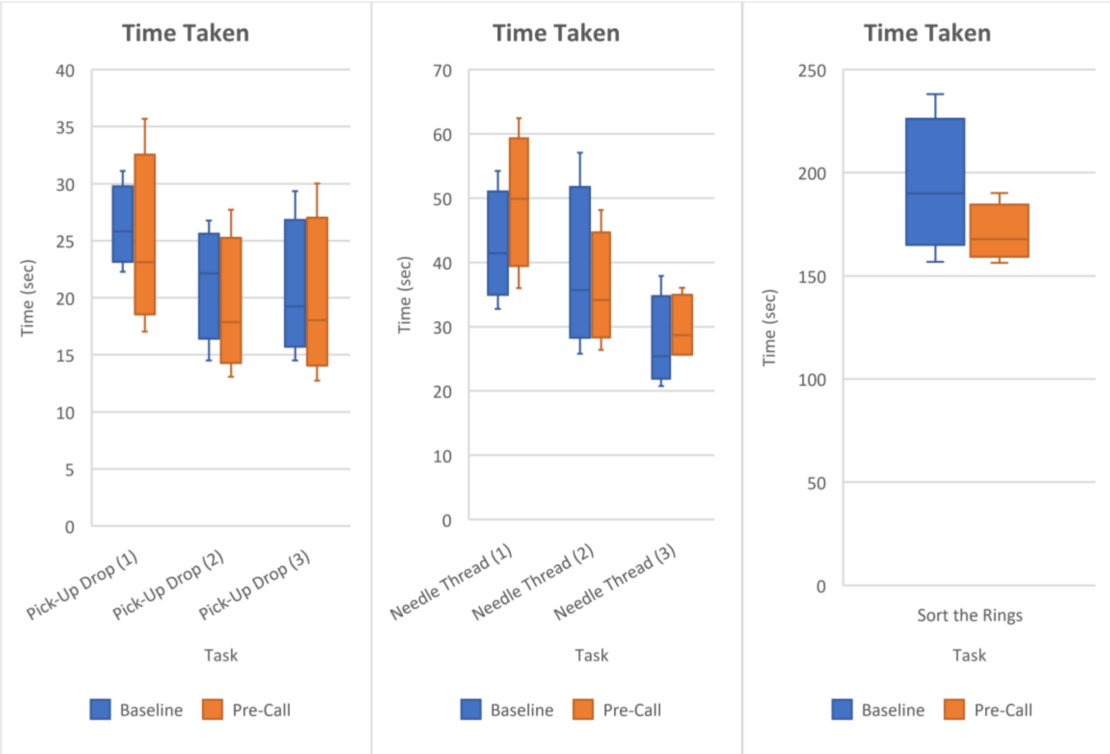


Figure 3.10. Differences in technical performance 'time taken' between baseline and pre-call assessment

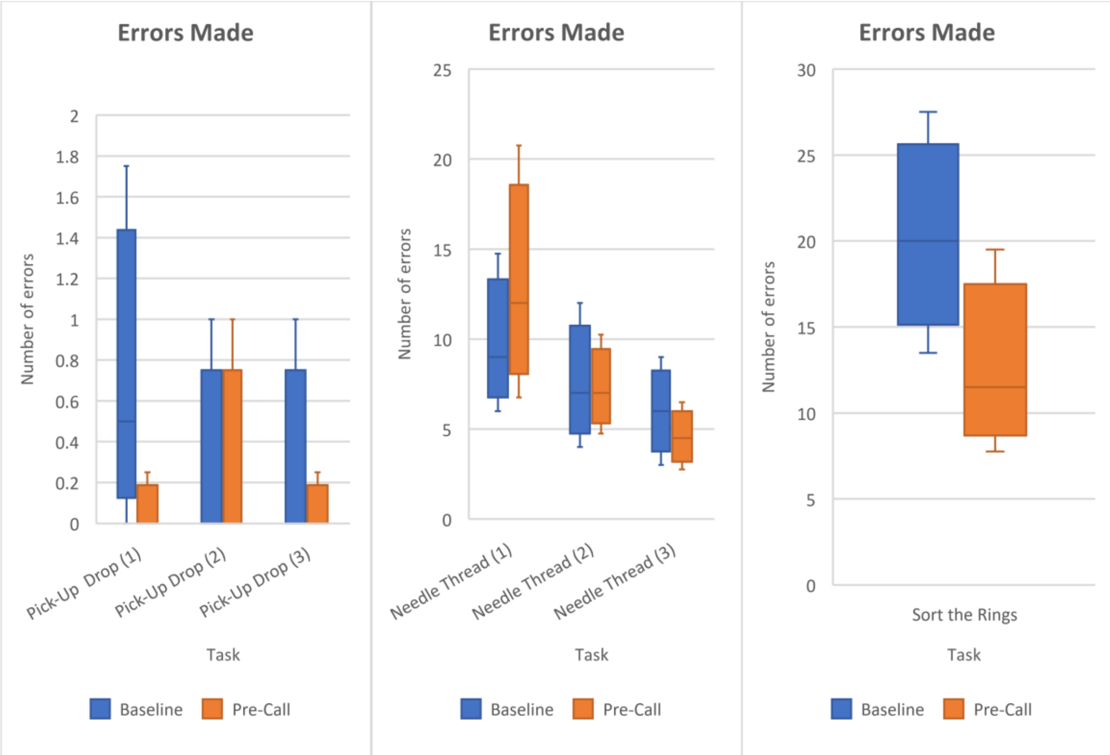


Figure 3.11. Differences in technical performance 'errors made' between baseline and pre-call assessment

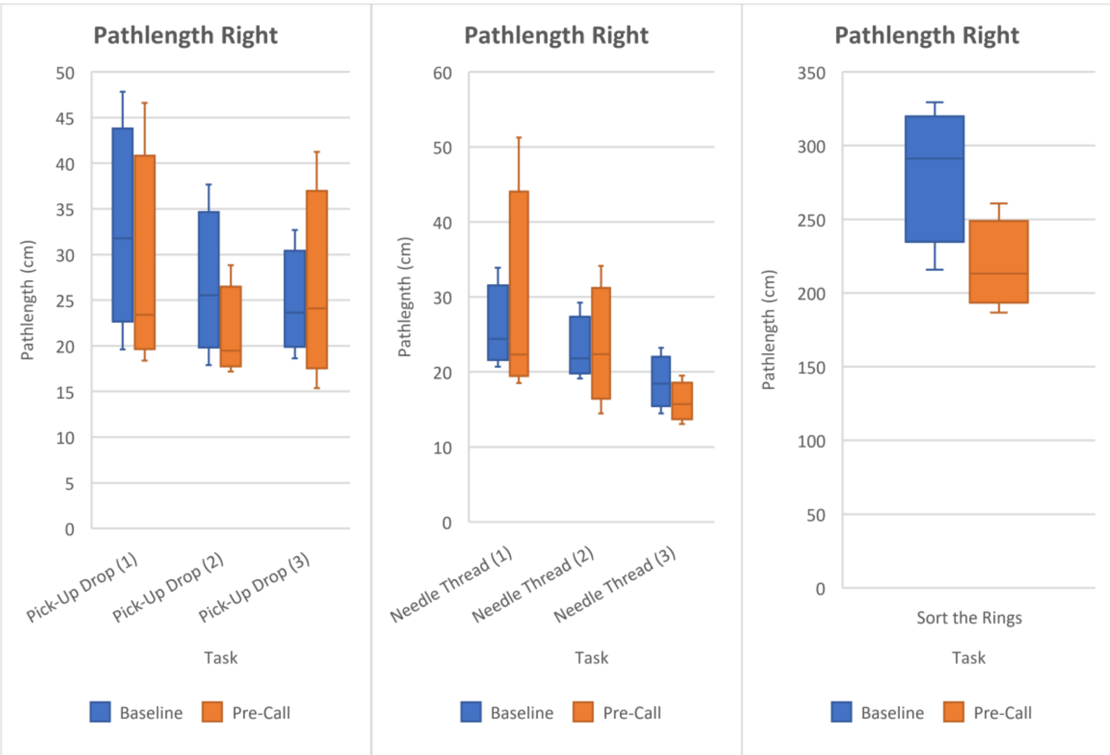


Figure 3.12. Differences in technical performance 'pathlength right' between baseline and pre-call assessment

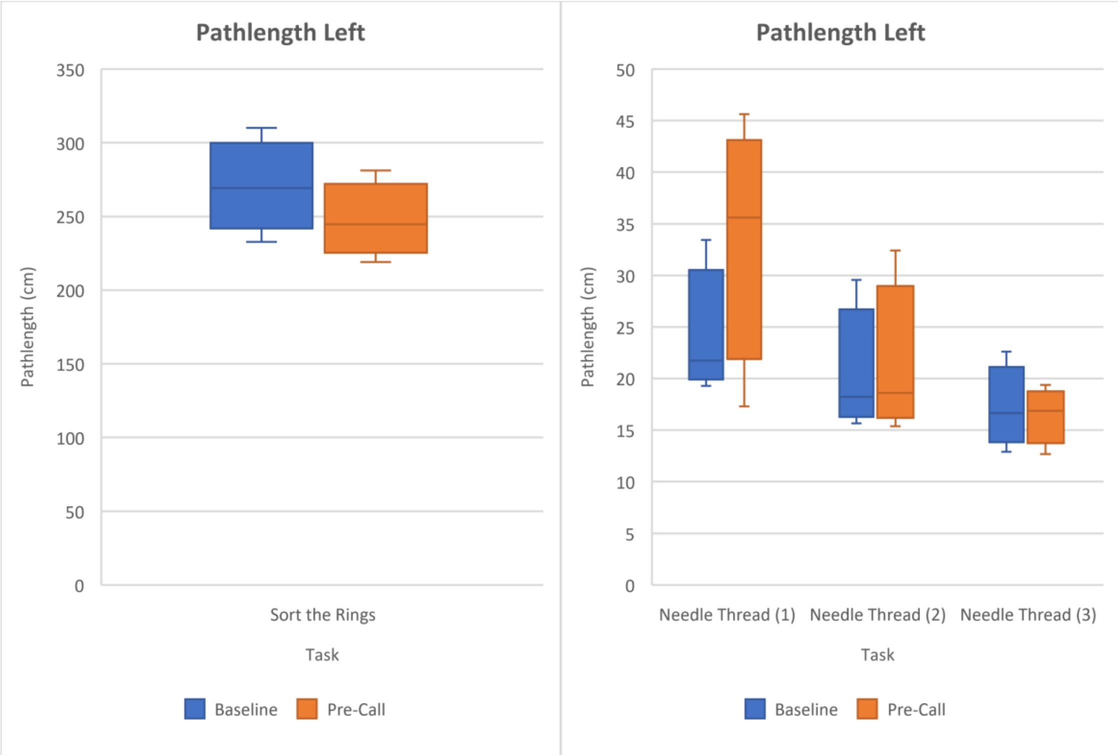


Figure 3.13. Differences in technical performance 'pathlength left' between baseline and pre-call assessment

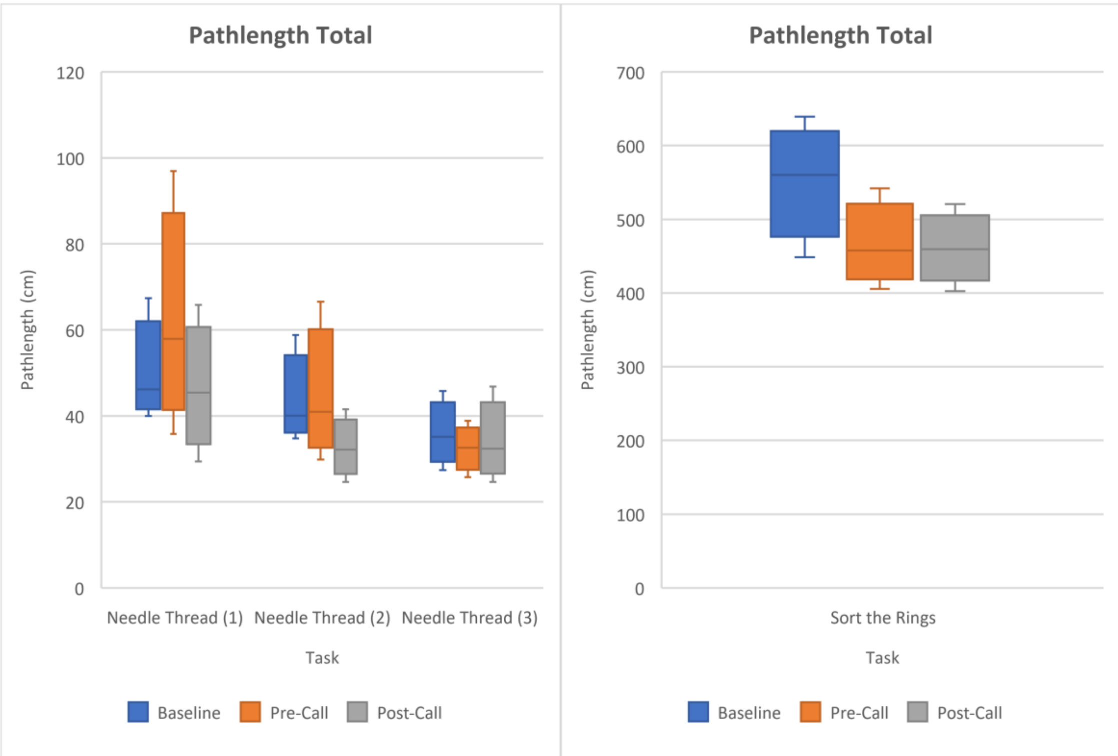


Figure 3.14. Differences in technical performance 'pathlength total' between baseline and pre-call assessment

3.5.3.2. Cognitive Performance

A summary of the baseline and pre-call scores are provided in *Figure 3.15.*

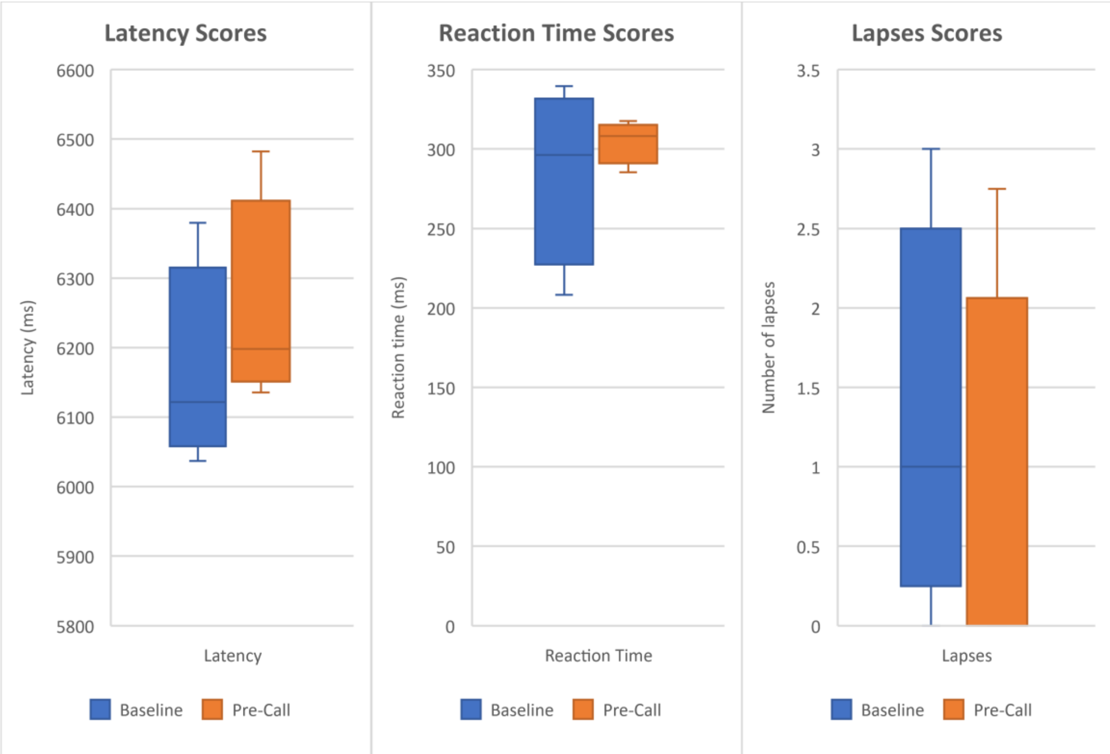


Figure 3.15. Differences in cognitive performance 'latency', 'reaction time' and 'lapses' indicators between baseline and pre-call assessment

3.6. DISCUSSION: BASELINE AND PRE-CALL FINDINGS

The baseline surgeon has early onset sleep latency, a median of 6.6 hours of sleep per night, and higher normal daytime sleepiness. This suggests that the issue of sleep deprivation may be an issue within the profession, irrespective of on-call associated work.

Objective measurement of sleep latency provides the most unique insights into the level of sleepiness in surgeons. On a baseline assessment, it took surgeons an average of 360 seconds to enter stage 1 NREM sleep. This baseline sleep latency was below the recommended average of ten minutes in accordance with clinical guidelines (Littner et al., 2004). There may be a few paradoxical reasons to explain these findings. The first may reflect an adaptive state by the surgeons. Given that the work of a surgeon is highly-demanding, they may have developed optimal rest strategies to maximise recovery states when opportunities arise, though the differences between the levels of training doesn't support this hypothesis. Alternatively, surgeons may be consistently working at a state of sub-alertness, which is mitigated by periods of highly-stimulated interactions with the environment which keeps them alert. Finally, the elimination of caffeine in the study, typically used as a stimulant in the profession, may have resulted in significant early onset sleep. Regarding sleep outcomes, registrars showed the highest level early-onset sleep, followed by SHOs and then consultants. There was significant differences between trainees and non-trainees in early onset sleep pre-call suggesting the potential role of training variables on sleep in surgeons.

Surgeons reported sub-optimal consistency in sleep quality and quantity measurements. The surgeons reported an objective sleep quality score of between 54-79.5% which is significantly lower than sleep efficiency reports from other EWTD-compliant settings (median 86%) (Brown et al., 2020). Surgeons slept on average 6.6 hours a night, mirroring that of American acute care surgeons (6.54 hours) (Coleman et al., 2019). In their study, 64.8% of participants were defined as being acutely sleep deprived which could be generalised to this cohort of surgeons. Independent of environmental influences such as on-call work, these baseline sleep scores suggest a level of insomnia within the profession. Insomnia is defined by the difficulties in either falling asleep, staying asleep, or waking up too early (Roth, 2007), and is influenced by myriad of stressors within an individual's life. This suggests the necessity for review of surgeons wellbeing in order to optimise sleep efficiency. Nonetheless, the role of on-call work may have one particularly important impact on sleep outcomes in surgeons. For two days, on average, the surgeons reached the recommended guidelines. On the other hand, oversleeping (i.e. getting more than the recommended guidelines of sleep) occurred on average once a week, reflecting what in many cases could be a recovery sleep post-call. This inconsistency in quantity of sleep throughout the week could be contributing to poorer reporting of sleep quality. Longitudinal research tracking sleep in surgeons has found it takes three days post-call for surgeons to return to baseline sleep levels (Coleman et al., 2019), while a different study reported it takes five days to return to baseline sleep duration, efficiency and quality (Brown et al., 2020). Given the regularity in which registrars and consultants complete on-call this suggests that current on-call models are not amenable to achieving an optimal level of sleep.

The baseline level scores on the ESS indicate that sleepiness of the cohort is within the normal ranges, indicative of 'higher normal daytime sleepiness' (Johns, 1991). This is a surprising result, especially given that surgeons were not permitted to consume caffeine in the preceding hours to baseline assessment. Interestingly, those who completed on-call more recently and more frequently (i.e. the cohort who have completed on-call more than once in the last week), reported higher scoring in the domain of 'chance of dozing in a car, while stopped for a few minutes in traffic' which reflects a state of sustained attention when compared to the other two cohorts. This may have implications for the mandated maximum requirements weekly on-call work to minimise risk associated with motor vehicle crashes (Barger et al., 2005).

3.7. POST-CALL RESULTS

3.7.1. Sleep Results

3.7.1.1. EEG

The median global EEG score was 164 seconds at post-call (Night 1) and 240 seconds as post-call (Night 4) which is indicative of early onset sleep (Littner et al., 2004). A summary of the pre-call and post-call scores are provided in *Figure 3.16.*

There was a strong correlation between pre-call EEG scores and post-call (Night 1) EEG scores ($r=-.815$) ($p<.001$). There was a strong correlation between pre-call EEG scores and post-call (Night 4) ESS scores ($r=-.971$) ($p=.001$). There was a significant decrease in sleep onset between pre-call and post-call (Night 1) and post-call (Night 4) EEG scores ($p=.016$). There was no significant difference between level of profession on post-call (Night 1).

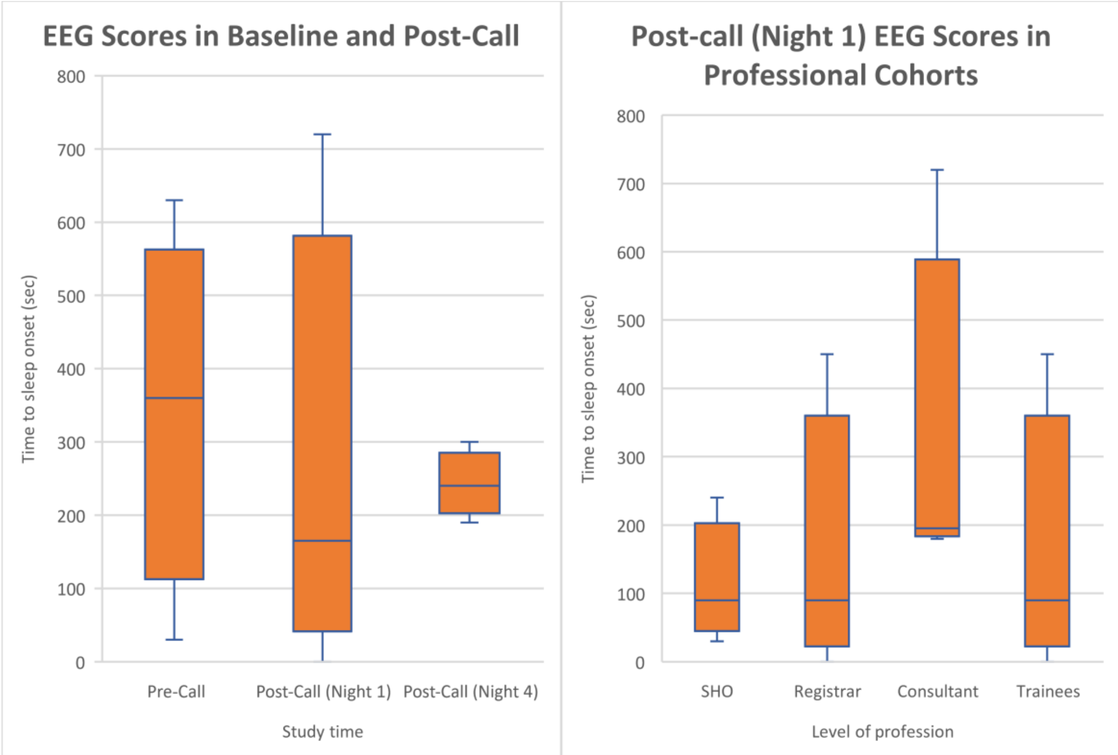


Figure 3.16. Differences in EEG scores between pre-call , post-call (Night 1) and post-call (Night 4) showing reduced sleep latency in post-call states

3.7.1.2. ESS

The median global ESS score was 13 at post-call (Night 1) and 12 post-call (Night 4) which is indicative of moderate and mild excessive daytime sleepiness respectively (Johns, 1991). A summary of the pre-call and post-call scores are provided in *Figures 3.17 and 3.18.*

There was a weak moderate correlation between baseline and post-call (Night 1) ESS scores (r=.520) (p=.047). There was a significant increase in scores between pre-call with post-call (Night 1) and post-call (Night 4) final ESS scores (p<.01). There was no significant difference between post-call (Night 1) and post-call (Night 4) scores in any components of the ESS.

There was a significant increase in sleepiness scores between pre-call post-call scores in:

- 'in a car, while stopped for a few minutes in traffic' (pre-call - 1 ; post-call (Night 1) - 2 ; post-call (Night 4) – 2, p=.015)
- 'lying down to rest in the afternoon when circumstances permit' (pre-call - 2 ; post-call (Night 1) - 3 ; post-call (Night 4) – 4, p=.015)
- 'sitting quietly after lunch without alcohol' (pre-call - 1 ; post-call (Night 1) - 3 ; post-call (Night 4) – 3, p=.025)

- 'sitting and reading' (pre-call - 1 ; post-call (Night 1) - 3, p=.012)
- 'watching TV' (pre-call – 1.5 ; post-call (Night 1) - 3, p=.003)
- 'sitting inactive in a public place' (pre-call – 0.5 ; post-call (Night 1) - 1, p=.002)
- 'as a passenger in a car for an hour without a break' (pre-call – 1 ; post-call (Night 1) - 2 p=.004)

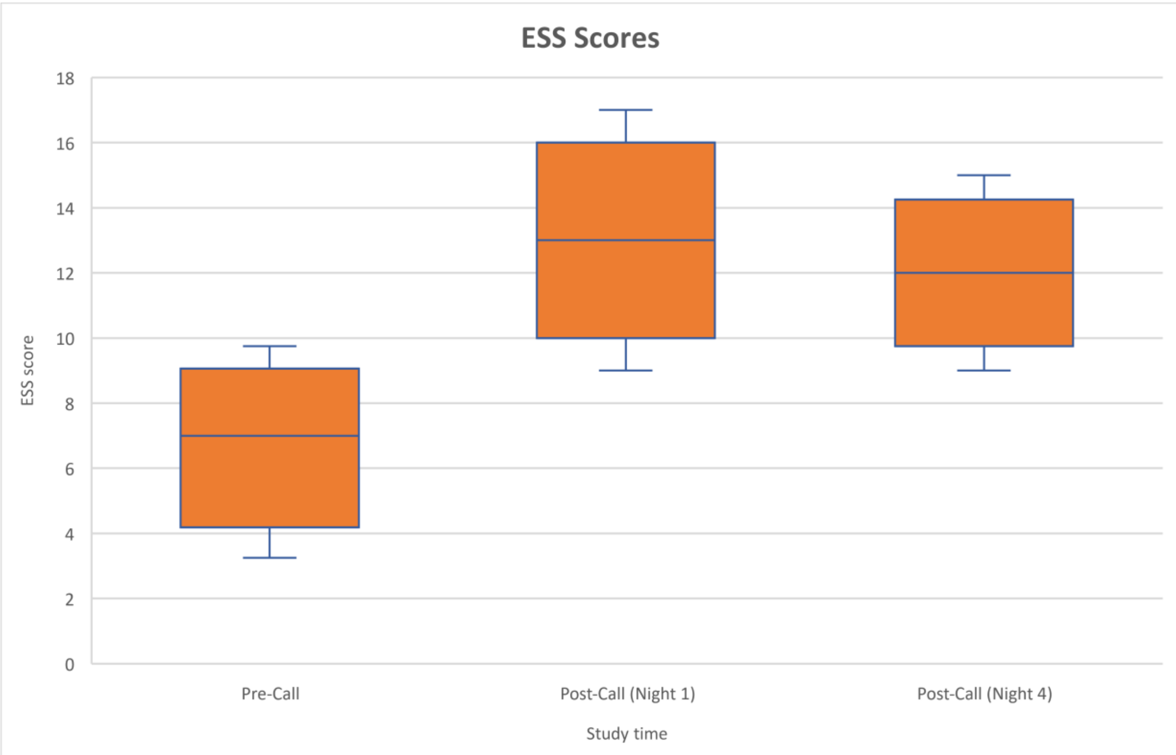


Figure 3.17. Differences in ESS scores between pre-call, post-call (Night 1) and post-call (Night 4) showing increased sleepiness in post-call states

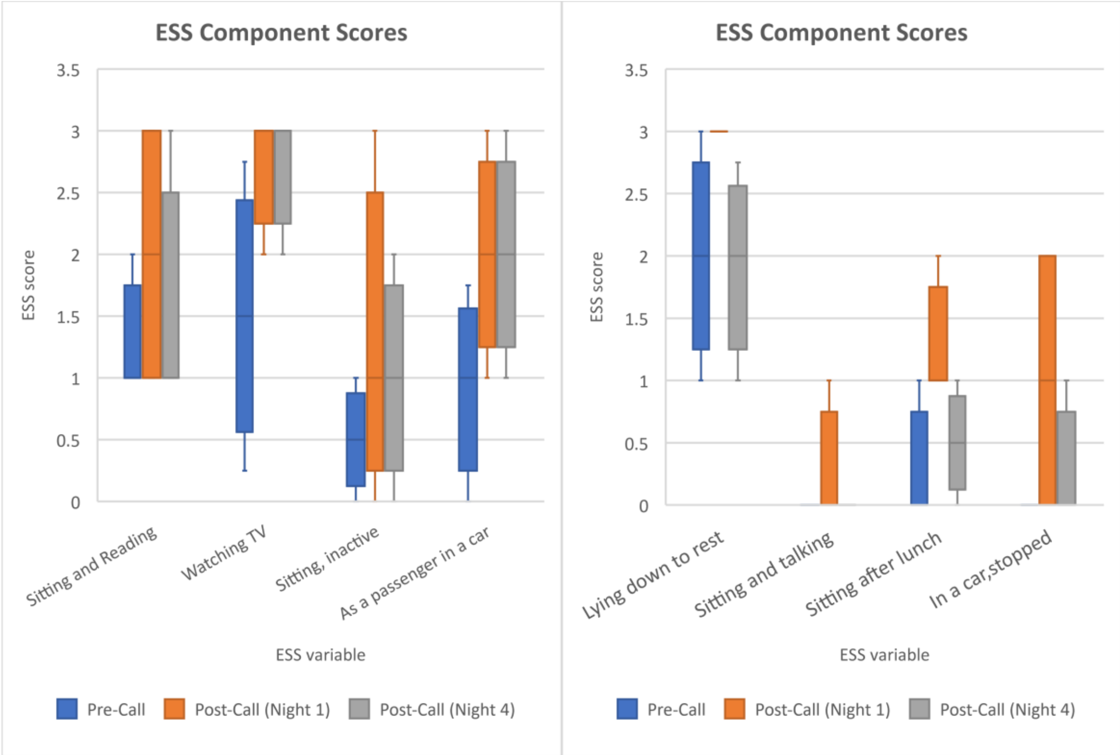


Figure 3.18. Differences in subcomponents of ESS scores between pre-call , post-call (Night 1) and post-call (Night 4)

3.7.1.3. CFS

The median global CFS score was 20 at post-call (Night 1) and 20 post-call (Night 4) which is indicative of higher than normal levels of fatigue (Chalder, 1993). A summary of the pre-call and post-call scores are provided in *Figures 3.19 and 3.20.*

There was a moderately strong correlation between baseline and post-call (Night 1) CFS scores (r=.691) (p=.004). There was a moderately strong correlation between post-call (Night 1) CFS scores and baseline PSQI scores (r=.606, p=.022). There was a moderate correlation between post-call (Night 1) ESS scores and post-call (Night 1) CFS scores (r=.620, p=.014). There was a statistically significant increase between pre-call, post-call (Night 1) and post-call (Night 4) final CFS scores (p<.01). There was no significant difference between post-call (Night 1) and post-call (Night 4) scores in any components of the CFS.

There was a significant increased reporting between pre-call post-call scores in:

- ‘lack energy’ (pre-call - 1 ; post-call (Night 1) - 2 ; post-call (Night 4) – 2, p=.039)
- ‘have difficulties concentrating’ (pre-call - 1 ; post-call (Night 1) - 2 ; post-call (Night 4) – 2, p=.039)
- ‘problems with tiredness’ (pre-call - 1 ; post-call (Night 1) - 32, p=.002)

- ‘feel sleepy or drowsy’ (pre-call – 1.5 ; post-call (Night 1) - 2, p=.020)
- ‘lack energy’ (pre-call – 1 ; post-call (Night 1) - 2, p=.005)
- ‘problems with tiredness’ (pre-call – 1 ; post-call (Night 1) - 2, p=.002)
- ‘make slips of the tongue when speaking’ (pre-call – 1 ; post-call (Night 1) - 2, p=.010)
- ‘find the right word’ (pre-call – 1 ; post-call (Night 1) - 2, p=.021)
- ‘how is your memory’ (pre-call – 1 ; post-call (Night 1) - 2, p=.008)

There was a significant increased reporting between number of nights on-call in post-call (Night 4) in:

- ‘need to rest more’ (on-call for one night - 3. ; on-call for more than one night - 2 ;. not on-call for the last week – 2, p=.039)
- ‘how is your memory’ (on-call for one night - 3. ; on-call for more than one night – 1.5 ;. not on-call for the last week – 2, p=.030)

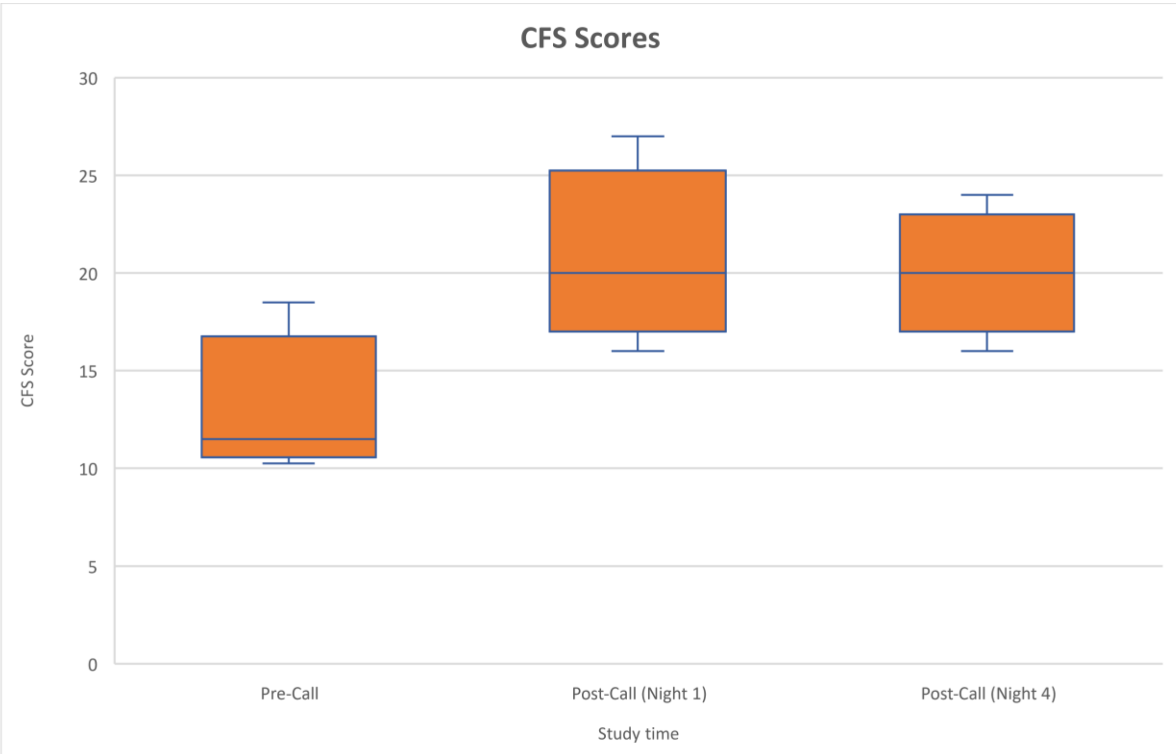


Figure 3.19. Differences in CFS scores between pre-call , post-call (Night 1) and post-call (Night 4) showing increased fatigue in post-call states

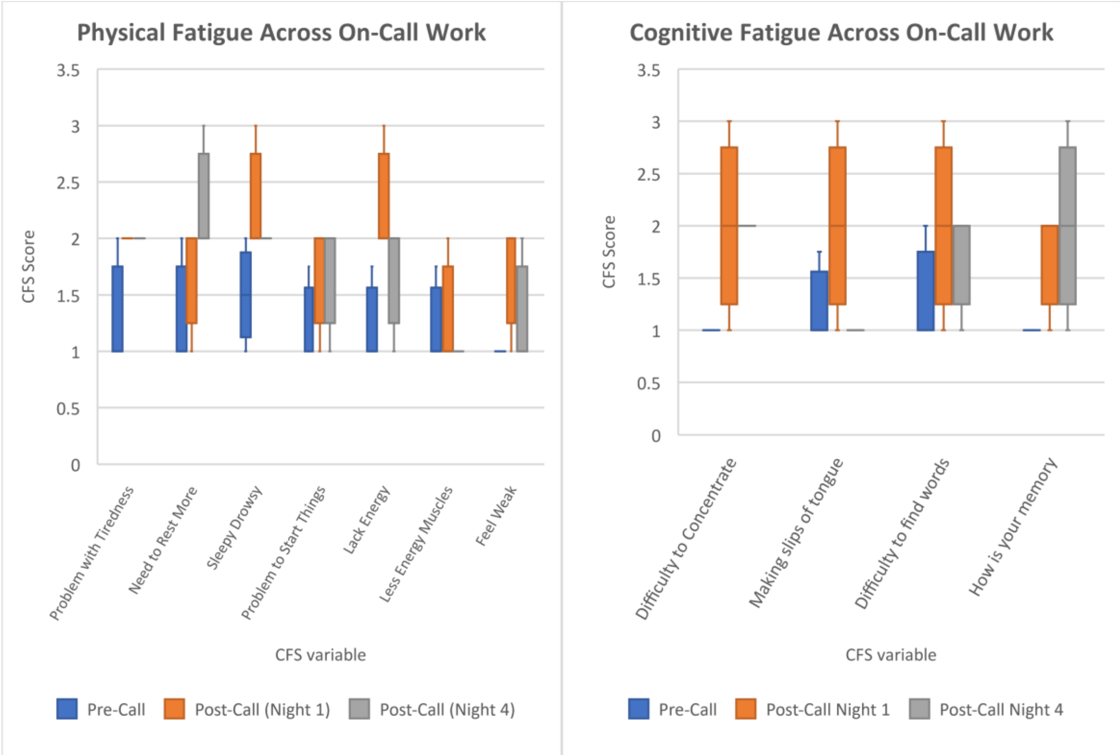


Figure 3.20. Differences in subcomponents of CFS scores between pre-call, post-call (Night 1) and post-call (Night 4)

3.7.2. Performance Results

3.7.2.1. Technical Performance

A summary of the pre-call and post-call scores are provided in *Figures 3.21,3.22,3.23,3.24 and 3.25*.

There was a significant improvement in performance between baseline, pre-call post-call scores in:

- Time taken in *'Needle Thread (2)'* (baseline – 35.72 ; post-call (Night 1) - 24.64, p=.009)
- Errors made in '*Sort the Rings'* (baseline - 20 ; post-call (Night 1) - 11.5, p=.008)
- Total pathlength in '*Sort the Rings'* (baseline – 560.37 ; post-call (Night 1) - 459.59, p=.00)
- Right pathlength in '*Sort the Rings'* (pre-call – 213.19 ; post-call (Night 1) - 221.55, p=.026)

There was a significant improvement in post-call (Night 1) performance associated with years of experience in:

- Errors made in *'Needle Thread (2)'* (p=.046)
- Right pathlength in *'Needle Thread (2)'* (p=.046)

There was a significant improvement in post-call (Night 1) performance associated with experience on laparoscopic simulation in:

- Errors made in *'Needle Thread (1)'* (p=.016)
- Right pathlength in *'Pick up and Drop (2)'* (p=.016)
- Right pathlength in *'Pick up and Drop (3)'* (p=.014)
- Right pathlength in *'Needle Thread (2)'* (p=.016)

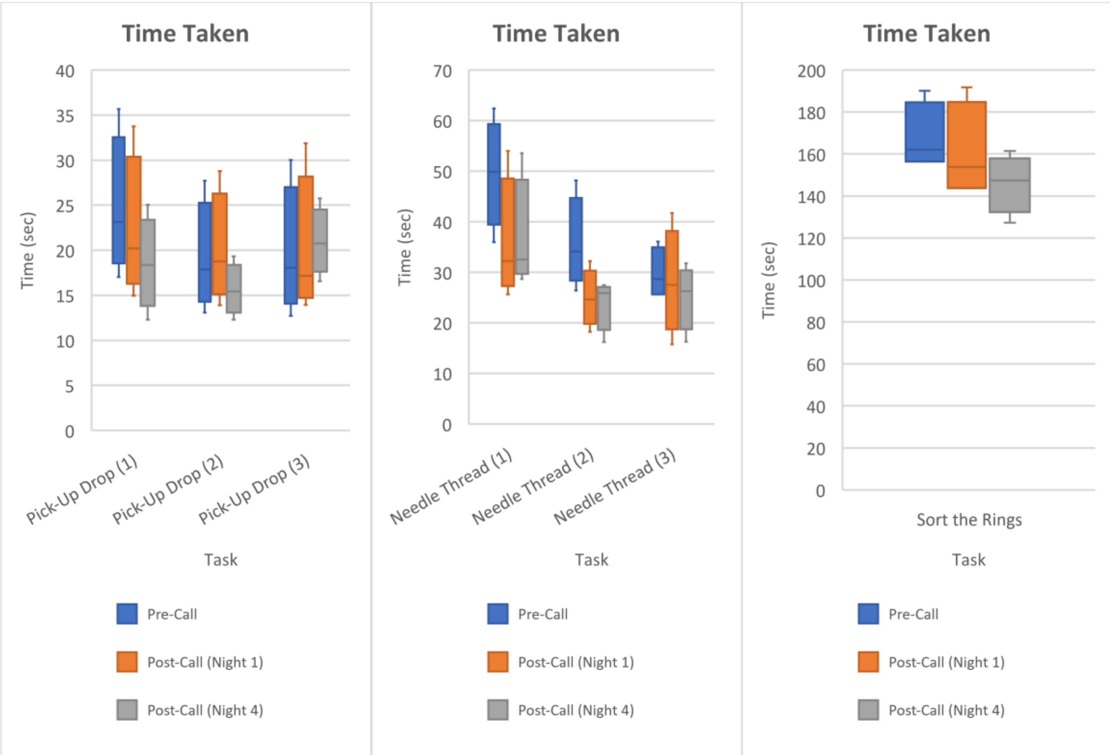


Figure 3.21. Differences in technical performance 'time taken' between pre-call, post-call (Night 1) and post-call (Night 4) assessment showing a predominantly downward trend in post-call states

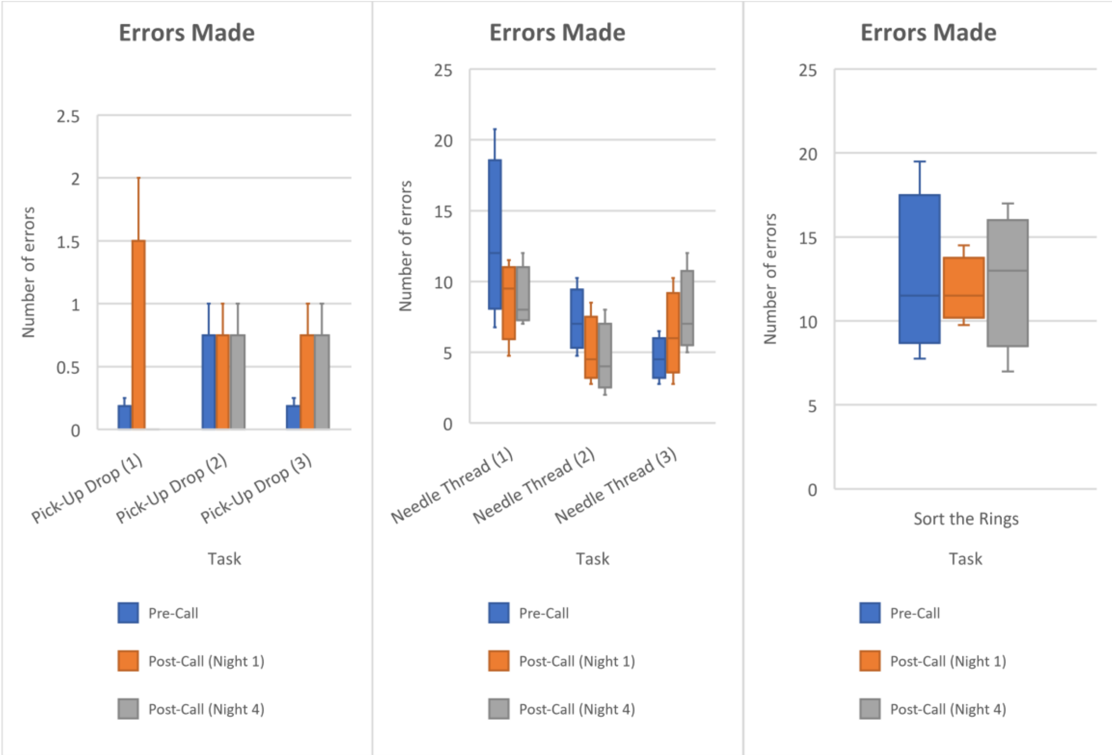


Figure 3.22. Differences in technical performance 'errors made' between pre-call, post-call (Night 1) and post-call (Night 4) assessment showing a mixed trend in post-call states

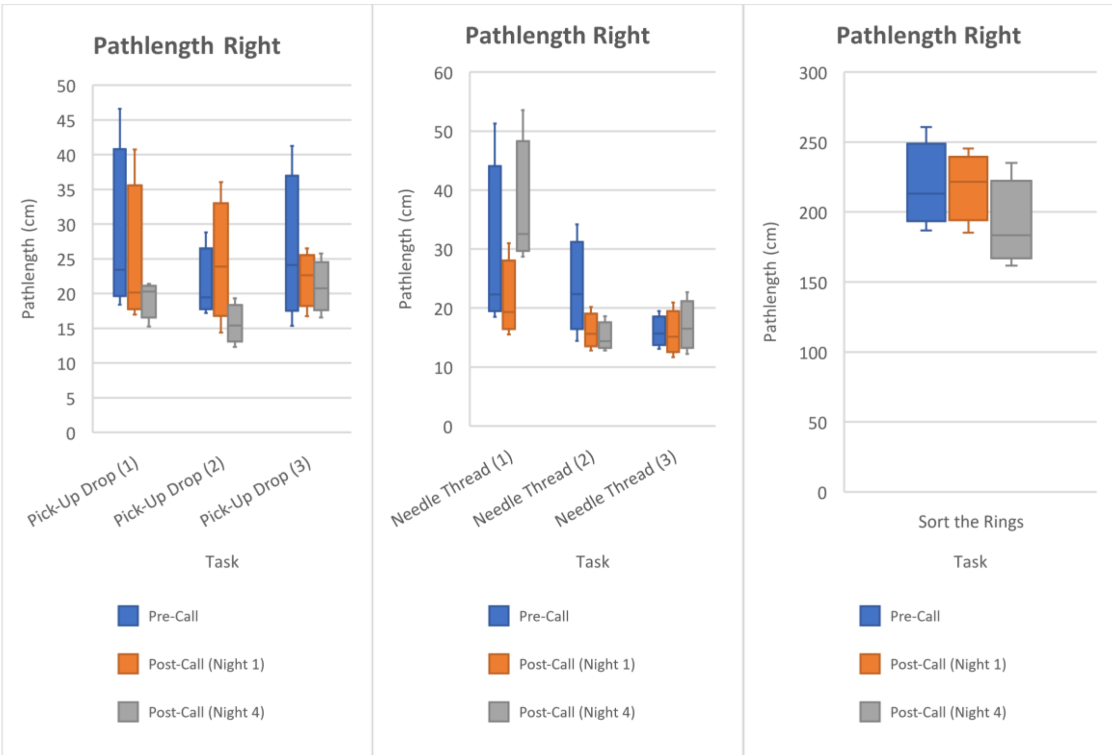


Figure 3.23. Differences in technical performance 'pathlength right' between pre-call, post-call (Night 1) and post-call (Night 4) assessment showing a mixed trend in post-call states

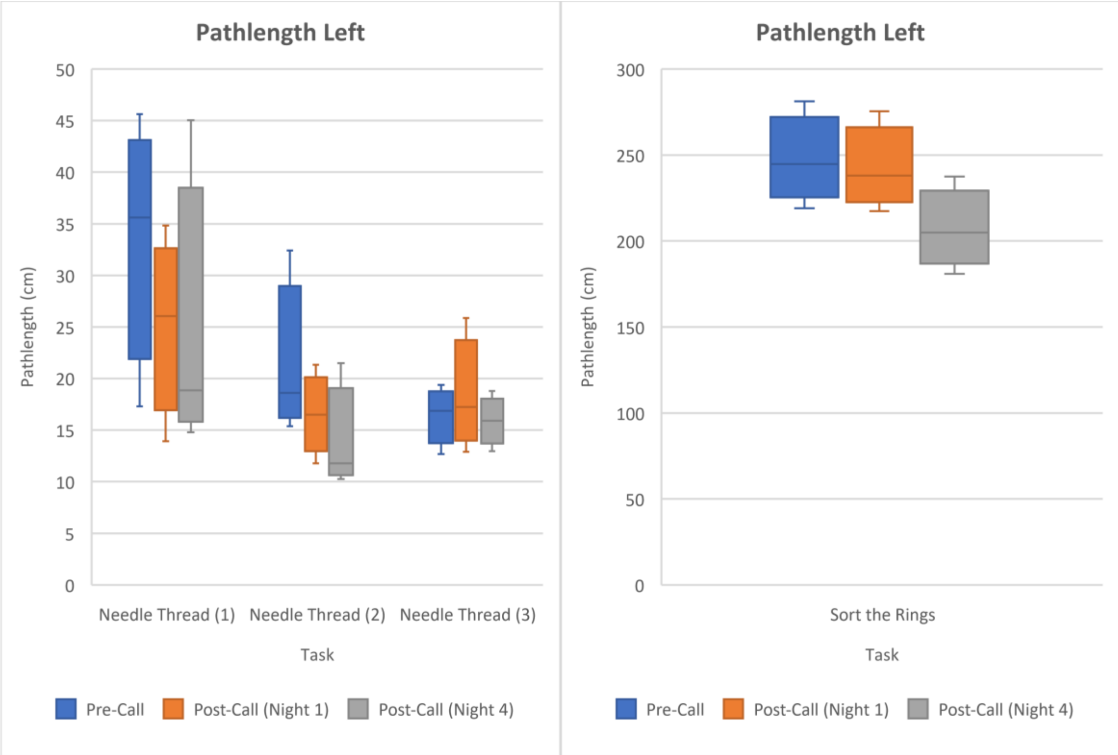


Figure 3.24. Differences in technical performance 'pathlength left' between pre-call, post-call (Night 1) and post-call (Night 4) assessment showing a downward trend in post-call states

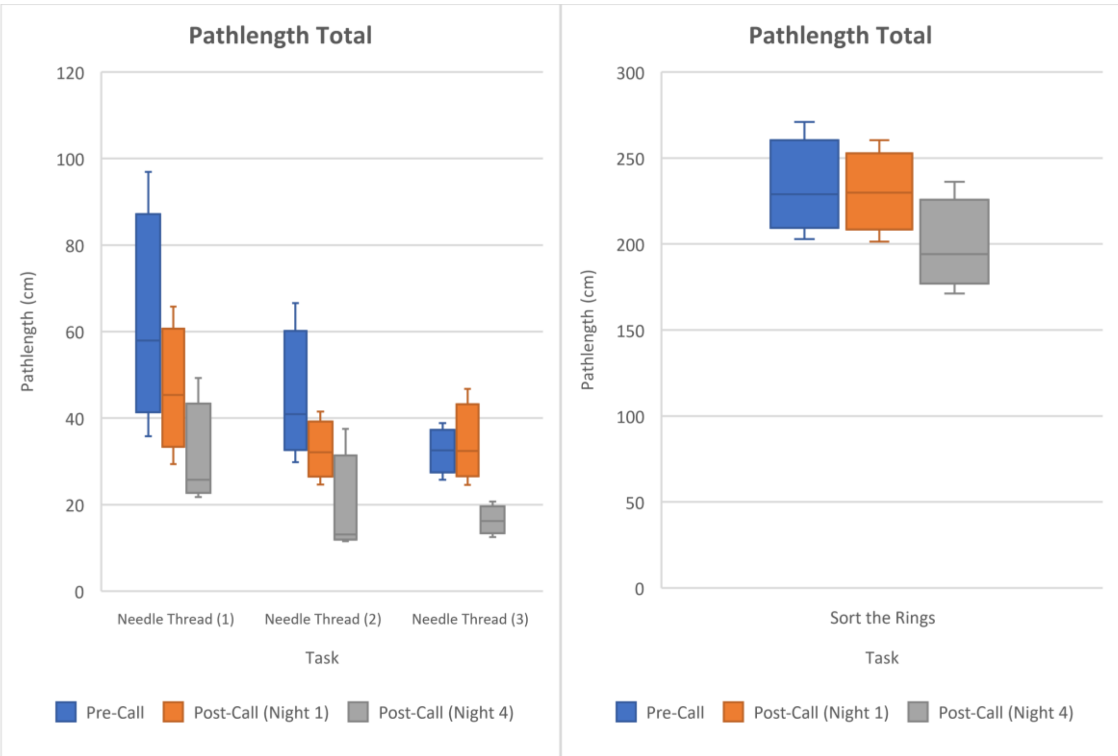


Figure 3.25. Differences in technical performance 'pathlength total' between pre-call, post-call (Night 1) and post-call (Night 4) assessment showing a predominantly downward trend in post-call states

3.7.2.2. Cognitive Performance

A summary of the pre-call and post-call scores are provided in *Figure 3.26.*

There was a significant decrement in performance between baseline or pre-call and post-call scores in:

- Latency (baseline – 6121.65 ; post-call (Night 1) - 6386, p=.004)
- Reaction time (baseline – 308.27 ; post-call (Night 1) - 350.16, p=.016)
- Reaction time (baseline – 308.27 ; post-call (Night 4) - 318.56, p=.043)
- Reaction time (pre-call – 308.07 ; post-call (Night 1) - 340.16, p=.006)

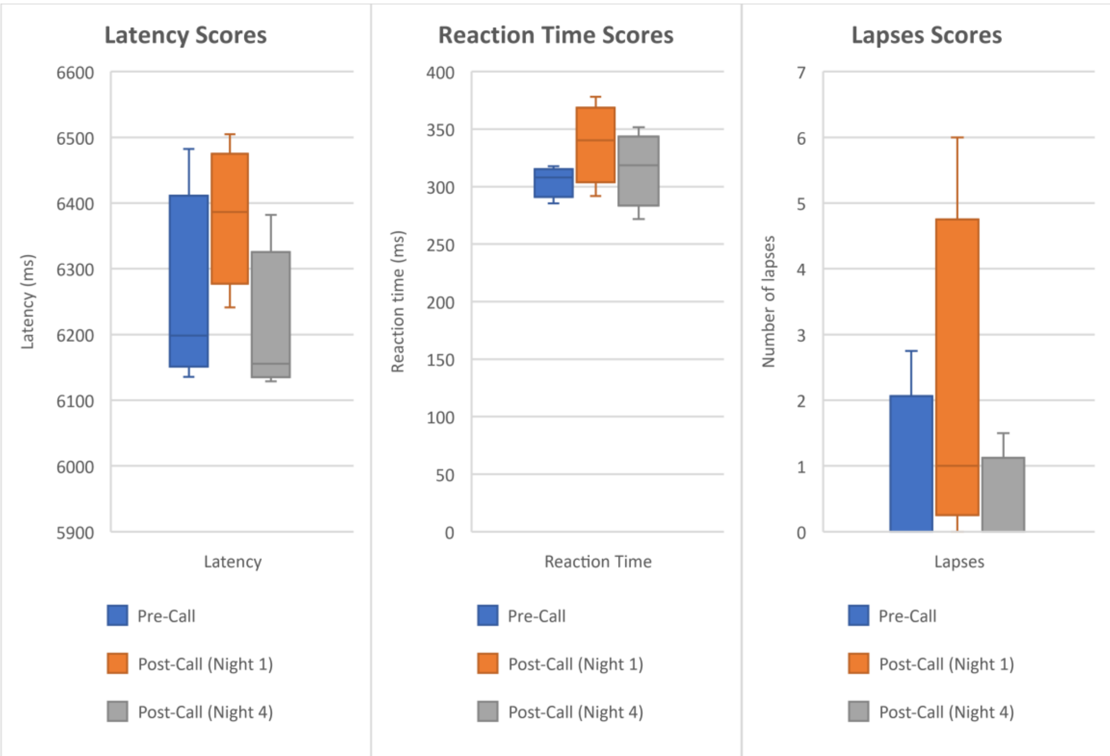


Figure 3.26. Differences in cognitive performance 'latency', 'reaction time' and 'lapses' between pre-call, post-call (Night 1) and post-call (Night 4) assessment showing an upward trend in reaction time in post-call states

3.8. DISCUSSION: POST-CALL FINDINGS

The surgeon after a night on-call in this study experiences significant sleep issues which indicate that current provisions of on-call work are impeding opportunities for sufficient optimisation of sleep quantity and quality.

Greater than baseline levels of early onset sleep latency is reported in post-call states, with associated increased reporting in subjective sleepiness and fatigue. The implications are more detrimental in the cognitive domain of performance, with reduced vigilance noted in post-call states, though aspects of technical performance were also negatively impacted. Interestingly the sleep latency score slightly increased between post-call (Night 1) and post-call (Night 4) states. The time dropped to 164 seconds in post-call (Night 1) before increasing slightly to an average of 204 seconds in post-call (Night 4) states, with strong correlations between pre-call and post-call scores. While circadian disruption was significant in both work-rotas, the group who completed shift-work did have the opportunity to repay the accumulated 'sleep debt' by not completing work after a night-shift, which suggests the potential utility of rest opportunities in post-call states as a means of mitigating longer-term sleep issues.

The post-call levels of sleepiness significantly increased in the post-call (Night 1) and post-call (Night 4) states, and reflects both a state of 'moderate excessive daytime sleepiness' and 'mild excessive daytime sleepiness'. The pattern of reported sleepiness appears to be most significant in post-call (Night 1) with a minor drop in reported sleepiness in post-call (Night 4) states. This may indicate an adaption to a shift-work pattern, as completed by the SHO cohort. In particular, significant increases in reporting of 'lack energy', 'feeling weak', 'difficulties concentrating', 'problems with tiredness', and 'problems starting things' were reported post-call. This reflects components of both physical and cognitive fatigue and has ramifications for increased cognitive load post-call, and the provision of efficient surgical practice. It also links closely with motivational process and could increase risk of longer-term burnout in surgeons. Finally, it reflects the increased physiological demands of sleep deprived states on physical functioning. This may have implications for additional nutritional requirements in on-call work.

There was positive associations between sleepiness and fatigue, supporting previous biased research on the interlinking use of both terms. Perhaps the most distinct difference, was that while sleepiness decreased as the nights progressed, levels of reported fatigue remained consistently high between post-call (Night 1) and post-call (Night 4) states, with particular consistencies in scoring noted in 'cognitive fatigue'. This suggests the necessity to look at other variables which influence fatigue beyond on-call work. Nonetheless, both increased sleepiness and fatigue support arguments on the importance of optimising energy conservation strategies given the regularity of which on-call work is completed. Finally, a low level of baseline sleep quality appeared to exacerbate fatigue levels in post-call states seen in the association between higher PSQI scores and higher post-call CFS scores. Given that registrar and consultant surgeons complete work the day after on-call work, optimising levels of baseline sleep quality in the longer term may elicit beneficial impacts for post-call associated fatigue.

Within post-call assessment, performance showed decrements primarily in the cognitive domain, though aspects of technical performance were also impacted. This would support the literature review from the previous chapter. In post-call (Night 1) states, there was significant decreases in time taken to complete moderately difficult tasks. This task placed little demands on the cognitive system and was largely technical. In the more complex task, which placed additional cognitive strain through the required decision-making processes involved, error scores also reduced between baseline and post-call (Night 1) states. Perhaps most interesting, was the associated reduced efficiency in right pathlength. This was the dominant hand of the surgical cohort and could indicate a potential competition between cognitive processes for resource allocation in dual-transfer tasks. This could also be due to the desire to finish the task as quick as possible, irrespective of precision. The impact of reduced proficiency in movement however was likely offset by left pathlength scores, and combined scores showed overall improved fluidity of instrument motions in the more complex tasks in post-call (Night 1) states.

It was hypothesised that the additional cognitive load associated with shift-work and sub-acute sleep deprivation could have impacted performance, though the findings refute this. There are three potential explanations for the preservation of technical performance. First, some tasks may have become automatic for surgeons with significant experience in laparoscopic skills, thus reducing cognitive load on the working memory. Second, the learning curve effect of the task was likely quite significant, despite efforts to control for it through a pre-study curriculum, and surgeons were likely to have developed and refined strategies for optimising their performance in the task between pre-call and post-call states. From the lens of fatigue, it is also possible that surgeons were able to counteract the time-on-task trajectory from habituation-strain-disengagement, shifting the latter state to that of engagement given the motivational demands for surgical skill. In fact, the competitive nature of the task and surgeons desires to consistently improve each time they performed could have played an important role. Surgeons may have increased subjective alertness to the task as it was of interest to them, leading in some instances to a psychological state of 'flow' (Csikszentmihalyi, 1990). In these states, performance may not negatively impacted by fatigued states (Hockey, 2013, p.127).

Cognitive performance was most noticeably decremented in the surgical cohort, with increased scores in latency and reaction time as well as greater variability in lapses. Vigilant attention was used as a performance metric given its applicability to surgical practice, and the implications it has for variability in responses to different parts of the brain responsible for alertness (Lim and Dinges, 2008), as well as performance indicators such as distraction (Anderson and Horne, 2006). A lower reaction time and latency has implications for surgeons abilities to engage optimally in a fast-paced environment. The most significant finding however, is the greater variability in lapses between the pre-call and post-call states, particularly at post-call (Night 1). This supports previous research that performance decrement is worse on the 1st night of on-call work when compared to subsequent nights (Leff et al., 2008). Lapses are particularly sensitive to sleep pressure (Stepan et al., 2020), and increased variability in performance is thought to occur as a result of low arousal. There are two potential explanations for the decrement of cognitive performance. First, lapses are thought to reflect instinctive cognitive interruptions to allow for momentary respite from the task to regain mental energy (Hockey, 2013, p.82). This is due to the rapid, continuous and repetitive nature of the task which required sustained executive control. Second, the task could be boring for participants given insufficient applicability to their motivations. The homogeneity of the task and sustained time-on-task demand could contribute to a lower level of arousal. The motivational efforts to complete a monotonous task in fatigued states may be reduced which negatively impacts performance (Hockey, 2013, p.83) reflecting the 'disengaged' trajectory of performance .

The performance assessments used were controlled and standardised, but only offer an insight into an aspect of real-life performance. The findings reflect underlying inherent cognitive processes but do not account for the influential role of environment factors. The implications for cognitive performance in real-life settings, which incorporate a myriad of environmental stressors such as teamwork as well as personal motivators such as outcome bias, may offset this performance decrement to an extent. Such complex tasks have been shown to be less susceptible to decrement (Hockey, 2013, p.70), due in fact to the variation in tasks which increases motivations and drives attention (Deci and Ryan, 2004). Similarly, while sleep deprivation has been found to impact on certain cognitive aspects such as vigilant attention, it remains debated whether sleep deprivation impairs other cognitive processes such as executive functions of memory scanning, efficiency and resistance to proactive interference (Tucker et al., 2010), which also have applicability to clinical decision-making practice. Perhaps most concerning is not the primary surgeon, but their assistants in theatre. The repetitive nature and low arousal characteristics of assisting may reduce cognitive performance leading to greater lapses in attention and potential error.

It is difficult to ascertain whether any demographic variables played a significant role on impacting levels of sleep, and subsequent impacts on performance outcomes. There were little gender differences, but experience or professional level could be influential. As previously mentioned, registrars showed the highest level early-onset sleep, followed by SHOs and then consultants pre-call, but in post-call setting this disparity was inequitably reduced. There was strong correlations between pre-call and post-call EEG scores, similarly indicating the potential role of baseline sleep levels on sleep latency in post-call states. While SHOs and registrars did show sleep onset of less than two minutes on average, which is concerning in and of itself from a health and performance perspective, the additional concern lies in the ease of which consultants fell asleep. This is despite having generally more favourable lifestyle factors, such as greater autonomy in their work and more rest opportunities. Consultants remain the ultimate decision-makers in high stake scenarios, and cognitive loads associated with sleep deprivation is likely increased in this state. Could this mean that the final safeguard against fatigue mitigation within surgical teams is prone to performance decrement also? The SHO cohort have the opportunity to rest during the working-day which may allow them to rest sufficiently before going on-call, but doesn't mitigate the significant levels of circadian disruption they face as their body attempts to adjust to a new state of sleep and wakefulness. The timing of participants was standardised throughout, and reflects an upswing in alertness levels on the circadian rhythm pattern which may justify performance and sleepiness maintenance findings. More significant discriminations in levels of sleepiness scores may have been noted in the early morning between groups. This time is also likely to be particularly vulnerable as surgeons will also have poorer social support or other mitigating opportunities. It is also a time when higher levels of mortality in patient groups (Mitler et al., 1987) have been reported. Regarding performance outcomes, level of experience in surgery appeared to protect aspects of technical performance, such as increased precision on pathlength and reduction in error in post-call (Night 1) states. In particular, the additional experience on laparoscopic simulation appeared to further support this mitigation. This may in part be due to aforementioned better sleep opportunities in consultants, but also may reflect the automaticity in completion of technical skill. No such differences were found in cognitive performance, thus refuting hypotheses that experience alone mitigates all aspects of surgical performance.

This study builds on research discussed in the previous chapter for three reasons. It provided objective sleep measurement, controlled rigorously for circadian rhythm influences, and discriminated between sleepiness and fatigue levels in on-call settings and their associated influences on performance. These findings have implications for 'fit-for-duty' status of individuals in post-call states, and could lead to alterations in workflow such as ensuring that surgeons have opportunities for rest post-call, as well as implicating the necessity for improving baseline sleep quality levels for recovery from on-call work. Similarly, work responsibilities in sleep deprived states should be cognisant that circadian influences place surgeons more at risk of decrement in natural lulls of alertness, and that tasks which evoke a greater cognitive load are more likely to be negatively impacted. Stratification of the outcomes according to demographics of age, gender, clinical, and laparoscopic experience amongst allowed greater control of variance and reduction of standard error in the study. Finally, when looking at the sleep quality relationship with the control group of physiotherapists, there was no significant difference which may suggest a broader implication of poorer sleep quality for healthcare professions in general which warrants further investigation. Future research should attempt to use more cognitively demanding surgical tasks to further clarify the role of subjective fatigue on further aspects of cognitive performance and technical performance. Preservation of technical performance may support theoretical assumptions that stressors are less likely to impact primary performance (Hockey, 2013), but aspects of precision were compromised for speed in this study. This could be because the environment is simulated, and thus weighting of performance indicators may differ in real-life settings. In addition, the fidelity of future simulated research could be improved by placing additional environmental demands on surgeons. This may elicit greater levels of performance decrement. Future research should also attempt to explore the role of chronic sleep deprivation, as defined by reduced sleep quantities and disrupted sleep opportunities on performance. This could be through expansion of current studies already looking at sleep and activity tracking devices on surgeons (Mendelsohn et al., 2019), and linking this with performance outcomes both in simulation and real-life.

3.9. LIMITATIONS

This was a single site study which does limit the generalisability of these findings to the greater population of surgeons. A higher numbers for planned recruitment alongside other settings was not possible as the SARS-CoV-2 (COVID-19) pandemic resulted in cessation of all physical testing. Larger scale studies could allow for use of Pearson correlational analysis as an indicator of the effect size of the difference between pre and post-call states on performance, providing more practical importance of the findings to clinical practice.

3.10. CONCLUSION

Surgeons in this study were objectively sleep deprived pre-call, as measured with validated assessment methods. This sleep deprivation increased significantly in post-call states which is a regular feature of standard surgical workflow. Higher levels of self-reported fatigue and daytime sleepiness were associated with post-call reporting which negatively influenced cognitive performance to a greater extent. Technical skill performance was largely preserved in acute and sub-acute sleep deprived states, but may be positively influenced by learning curve effects and experience in surgical tasks. Technical tasks with higher cognitive demands showed greater decrement in performance. Establishing an understanding of the translation of cognitive performance markers to real-life surgical performance is warranted, as well as exploration of higher cognitive loads on executive functions, such as clinical decision-making, which are a staple of clinical practice.

4. Chapter 4 - Establishing understanding of variables associated with clinical decision-making as an aspect of cognitive performance

4.1. BACKGROUND

A key aspect of surgical performance is the ability to make decisions, both in the operating theatre and in other clinical settings, which ultimately benefit patient care. While the fatigue and sleep deprivation research thus far has focused on other aspects of surgeon's cognitive performance, such as vigilance and attention, no research exists on the practical impact of cognitive performance decrement on decision-making in surgeons.

This chapter has four elements summarised in *Figure 4.1*. It establishes an understanding of the most commonly explored decision-making models in healthcare, their applicability to high-stake surgical decision-making, the valid assessment of intuitive models in a realistic surgical scenario, and finally the role of cognitive load on decision-making performance.

Narrative Review	• What are the current understandings of how intuitive decision-making occur in surgery?
Observational Survey	• How do surgeons make clinical decisions in high-stake scenarios and what factors influence that decision-making?
Validation of Simulation	• Can a high-stakes simulated scenario be used for valid assessment of decision-making performance in surgeons?
Observational Simulation	• Can a high-stake clinical scenario evoke differences in decision-making outcomes between surgeons reporting higher and lower cognitive loads?

Figure 4.1. Elements of Chapter 4

4.2. NARRATIVE REVIEW ON CLINICAL DECISION-MAKING WITH FOCUS ON INTUITIVE MODELS

4.2.1. Research Question

What are the current understandings of how intuitive decision-making occurs in surgery?

4.2.2. Objectives

1. To highlight the most commonly used model and patterns of clinical decision-making in medicine
2. To highlight literature relating specifically to surgical decision-making

4.2.3. Methods

4.2.3.1. Search Strategy

The review was conducted utilizing the electronic Medline, Embase and Cinahl using a quasi-systematic review according to modified PRISMA guidelines. The search terms used were 'heuristic', 'cognitive bias', 'tendency', 'preconception', 'rule of thumb', 'problem solving', 'mental processes', 'attentional bias', 'bias', 'metacognition', 'attitude of health personnel', 'behaviour control', 'decision-making', 'clinical decision-making', 'decision theory', 'decision support techniques', 'doctor', 'medical staff', 'surgery', and 'internship and residency'. References, bibliography lists and journal content pages were also hand-searched. All articles which were included were read and a summary of findings reported.

4.2.3.2. Inclusion Criteria

All English language papers including clinical decision-making models and the medical profession were included. Papers with evidence from other healthcare professions were included if medical practitioners were in the study sample.

4.2.3.3. Exclusion Criteria

Papers were excluded if they did not discuss clinical decision-making models. They were also excluded if they did not focus on the medical profession.

4.2.4. Results

A total of 75 references were read and the screening process is elaborated in *Figure 4.2*.

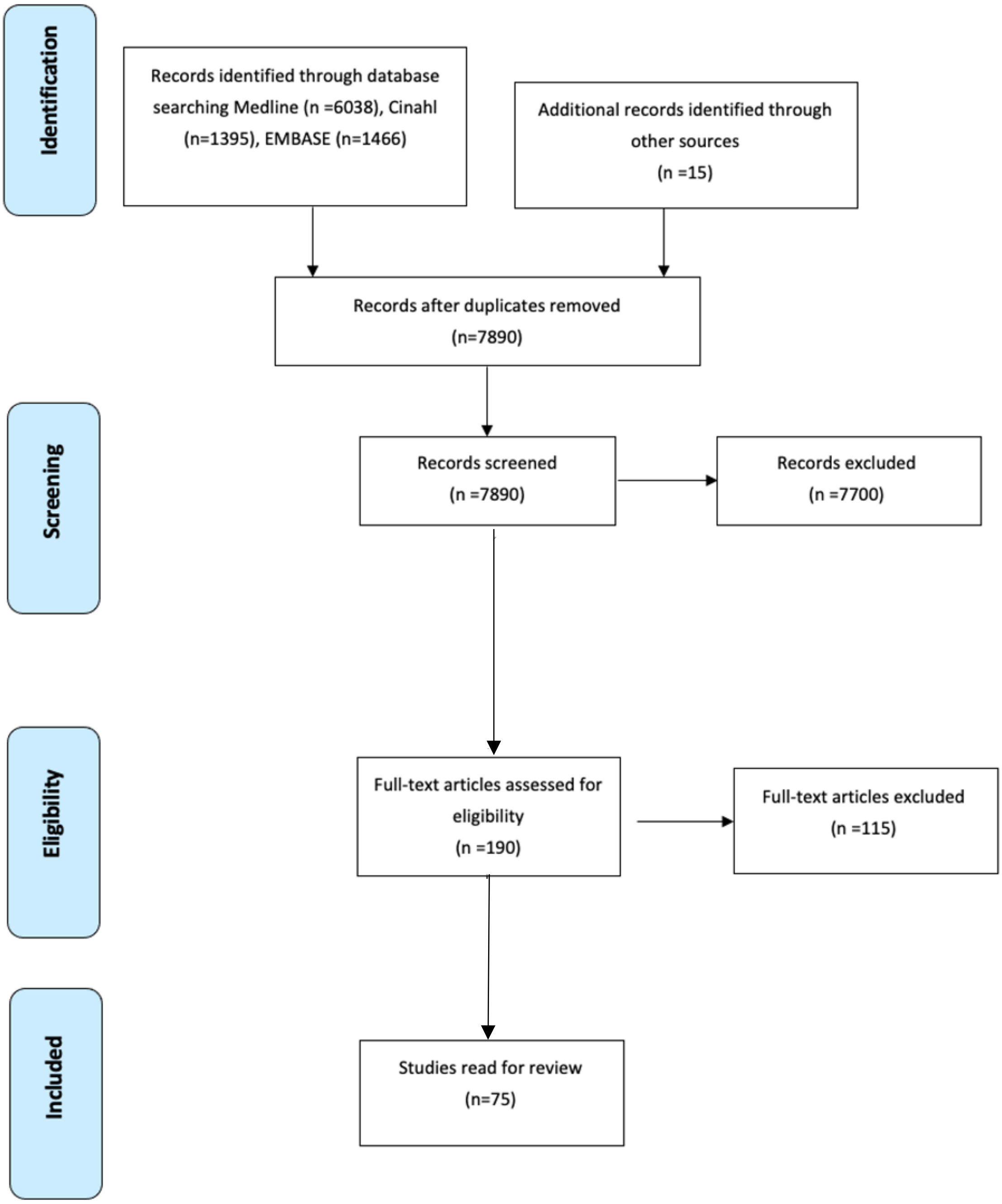


Figure 4.2. Flow diagram of studies read for review

4.2.4.1. Two System of Thinking

The most commonly applied decision-making model in medicine is the 'dual-system' of thinking approach (Croskerry, 2009). An example of this model, seen in *Figure 4.3*, hypothesises that decision-making can be either an 'intuitive' process, which is fast and uses heuristics and cognitive biases, or an 'analytical' process, which is slow and applies the rules or logic and rationality. In the latter, processes are governed by a systematic approach to identify all the variables contributing to a situation, as influenced by knowledge and logic, to inform an evidence-based decision. The context, i.e. the speed at which decisions are made and the weighted outcome of decisions, play an important role in which system is activated. This is particularly important in a profession like surgery, where work contexts, such as theatre and clinics, vary in physical setting and perceived intensity. This model accounts for the systemic and individual factors which can contribute to decision-making processes. However, it suggests it is the calibre of the cognition of the surgeon themselves that ultimately decides the appropriate decision-making process and therefore outcome (Croskerry, 2009).

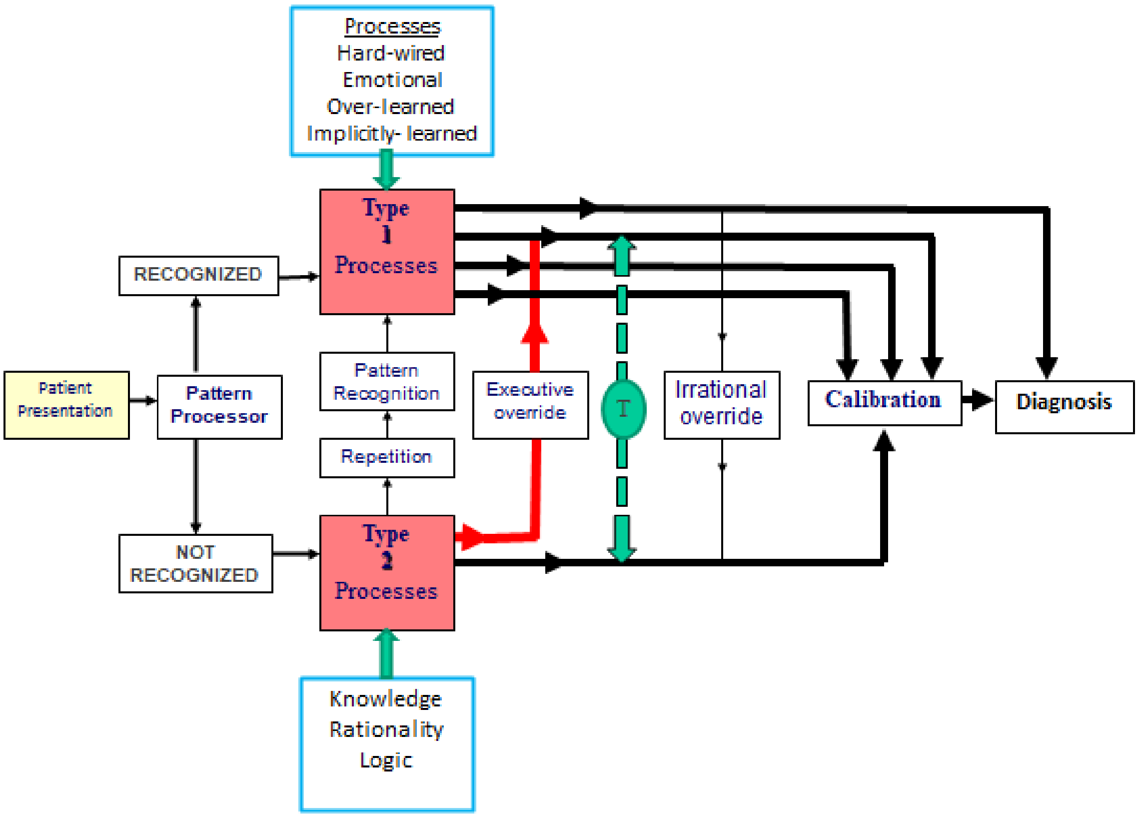


Figure 4.3. Dual process theory applied to diagnostic reasoning with permission granted (Croskerry, 2009)

4.2.4.2. Intuitive Decision-Making

Given the regularity in which surgeons have to make quick decisions as part of daily practice, a focused exploration towards intuitive decision-making which is more error prone is warranted. Within intuitive decision-making, a series of cognitive shortcuts are made through the creation of mental models known as 'heuristics'. Cognitive shortcuts include satisficing (Simon, 1956), which is the judgement of finding an adequate solution rather than the perfect one; elimination by aspects (Tversky, 1972), which is belief that the best solution is achieved through a process of elimination; and fast-and-frugal trees, which involves categorising situations and providing a process-based decision (Gigerenzer and Todd, 1999). In the 'flesh and blood' of clinical practice however, pattern recognition heuristics, informed by previous work experiences are more prominent. It is difficult to arrive at an accurate figure for the true prevalence of heuristic use in the medical profession, with figures ranging from 5.9% to 87.8% in the most comprehensively studied heuristics (Saposnik et al., 2016). These include the availability, representativeness and anchoring heuristics (Tversky and Kahneman, 1974). The availability heuristic, defined as the association of making judgement on the likelihood of an event happening based off previous experience in a similar situation, has been identified in medicine (Mamede et al., 2010; Ogdie et al., 2012; Crowley et al., 2013). Similarly, the representativeness heuristic, reflecting the increased likelihood of a surgeon to utilise a cognitive protocol of stereotyping for diagnosis of a condition which is more common, has been studied (Perneger and Agoritsas 2011). The anchoring heuristic, which can be described as when a diagnosis is biased by specific pieces of information on which a physicians uses to assist their judgement without considering other variables to equal value, has also been explored reported (Ogdie et al., 2012; Crowley et al., 2013). In addition, the confirmation heuristic (Pines, 2006) should be considered as a heuristic model in healthcare as it supports the tunnel visioning of patient assessment and diagnosis. This is more common in resource-constraint and high-pressure environments such as surgery.

By use of these inherent mental processes, individuals are more subject to using their own cognitive biases in influencing decision-making outcomes. Decision-making is influenced by the complex interaction between intrinsic cognitive and extrinsic environmental factors. A list of examples adapted by the author from their reading are provided in *Table 4.1*.

Table 4.1. Intrinsic and extrinsic factors involved in decision-making

Intrinsic Factors
Knowledge
Self-awareness
Experience
Successful use of heuristics previously
Value systems
Personality
Ambiguity
Unrealistic optimism
Source credibility
Priming
Decision fatigue
Extrinsic Factors
Patient-related
Organisational resources
Professional culture
Organisational culture

4.2.4.3. Surgical Decision-Making Approaches

4.2.4.3.1. Dual Process Approach

The dual-process approach marries well with the daily practice of surgery. Within surgery, the operating theatre is a salient setting for clinical practice. A qualitative exploration, with 24 consultant surgeons on critical decision models used in clinical scenarios, found that surgeons identified using a near balance between analytical processes and intuitive processes (Pauley et al., 2011). There are a myriad of environmental influencers in this setting which have implications for which decision-making model is used. The surgeon is often required to make quick rapid decisions based off prior knowledge and experience, which could have significant ramifications for patient mortality and morbidity. The feedback received from decision-making is often quick, indicating a successful or non-successful outcome. Supporting surgeons have varying levels of responsibility within theatre, yet must work cohesively and efficiently to ensure a successful procedure. The ergonomic situation of the room is one which is pressurised, and subject to personal protective equipment which can influence perception and effective communication. Cognisant of these variables, strategies such as pattern matching and chunking of data are commonly utilized for heuristic formation to reduce cognitive load.

There are particular downfalls to applying this model of thinking which could influence optimal decision-making. Top-down dual process approaches impact on a surgeons perception of patients, leading to an increased likelihood of stereotyping. This has negative implications, as profiling of patients can lead to non-optimal care. Sociocultural biases (Hall et al., 2015) may also act as potential mediators affecting this process. A study on 248 surgeons found inconsistencies between explicit and implicit racial and social biases, with surgeons favouring white and upper-class persons (Haider at al., 2014). Other research suggests such biases exist in pre-clinical years, with early-year medical students perceiving patients differently depending on their socioeconomic class (Woo et al., 2004).

4.2.4.3.2. Fast-and-Frugal Approach

A second style of decision-making is that of the 'fast and frugal' heuristic approach (Gigerenzer, 2007). This approach posits that individuals will make intuitive decisions in situations with high levels of uncertainty. It is likely that surgeons may fall into fast-and-frugal approaches in contexts where there is a high workload and more standardised empirical approaches to care, with little impact of outcome associated bias. This may include standardised checklists at the beginning of the operation, or screening for potential pathology. It is assisted through guided use of decision-making trees (Gigerenzer, 2007). It posits that judgements are ultimately determined as the 'first best' approach as a trade-off between optimisation of outcomes and protection of resources. The limitation of the fast and frugal approach is its emphasis on biomedical approaches to decision-making. Given the role of the surgeon is highly influenced by psychosocial factors of the patients presentation, dual process theory is likely to prevail as the dominating model used by surgeons in their day-to-day practice.

4.2.4.4. Impact of Intuitive Decision-Making

Debate on intuitive decision-making is ongoing (Vranas, 2000), but it is hypothesised, by this author, that if heuristic models are used appropriately they have positive benefits in leading to correct choices, as well as resulting in improved efficiency within surgical care. This is particularly the case for reducing cognitive load in thought processes associated with analytical thinking. Such models may be more effectively used by experienced practitioners, who are more risk-averse (Nakata et al., 2000) and who have prior learning to affirm their beliefs about appropriate use. In identifying whether to use these strategies, developing metacognition through employing regular reflective practice is warranted. Metacognition is a higher-order process with cognition as its object, exploring different cognitive processes through critical awareness of thinking processes (Overgaard and Sandberg, 2012).

Antipodally, there are two likely contexts in which they may be used inappropriately. The first context is if preconceived biases dominate the direction of the decision-making resulting in a misconstrued perception of the situation. The second context, which the focus of the latter half of *Chapter 4* will explore, is the role of fatigue on deciphering whether to activate intuitive or analytical thinking processes. This process argues that fatigue activates the cognitive miser function, causing individuals to default to intuitive decision-making processes, in what is known as executive override (Croskerry, 2009), irrespective of the appropriateness of this model of thinking for the situation. Negative impacts on diagnosis, management and treatment, particularly with the use of anchoring and representativeness heuristic use have been found (Saposnik et al., 2016) necessitating further investigation in surgery.

4.2.5. Conclusion

Due to the unpredictable nature of surgical practice, the impacts of intuitive decision-making remain relatively unknown. The majority of medical decision-making research has been in general practice, obstetrics and gynaecology, and oncology (Blumenthal-Barby and Krieger, 2015) which makes generalisabilities to surgery difficult. The use of intuitive decision-making and the associated influencing variables in high-stake surgical contexts remains a gap within the literature and is worth exploring. Similarly, given the complex relationship between analytical and intuitive thinking processes, and the recognition that both modes of thinking occur as part of a surgeon's work-flow, understanding levels of metacognitive practice are subject to further investigations to establish understanding of its use in influencing decision-making.

4.3. OBSERVATIONAL EXPLORATION OF THE VARIABLES INFLUENCING CLINICAL DECISION-MAKING

4.3.1. Research Question

How do surgeons make clinical decisions in high-stake scenarios and what factors influence that decision-making?

4.3.2. Objectives

1. To identify the level of conservative decision-making in high-stake scenarios
2. To identify the influencing factors in decision-making in high-stake scenarios
3. To identify if the use of a 'hook' and prompt to answer quickly evokes heuristic use, resulting in differences in decision-making outcomes
4. To explore relationships between demographic, decision-making outcomes and levels of reflective practice

4.3.3. Methods

This study is reported according to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) guidelines (Eysenbach et al., 2012).

4.3.3.1. Study Design

This was a multi-site observational survey study design, exploring decision-making outcomes in surgical trainees and consultants associated with the Royal College of Surgeons in Ireland (RCSI). The survey was block-randomised, which is a blinded process, as seen in *Figure 4.4*. All participants received three clinical scenarios, while half of the participants received clinical scenarios that present with additional clinically relevant information known as 'the hook' (i.e. a specific phrase to induce an alternative means of thinking), in attempts to evoke use of the respective heuristic being tested. Prompts were also provided i.e. '*you should complete this scenario in under 30 seconds'* to nudge the desired intuitive decision-making. The validity standard was defined as completion of the all sections. A log file analysis method was employed to reduce survey duplication.

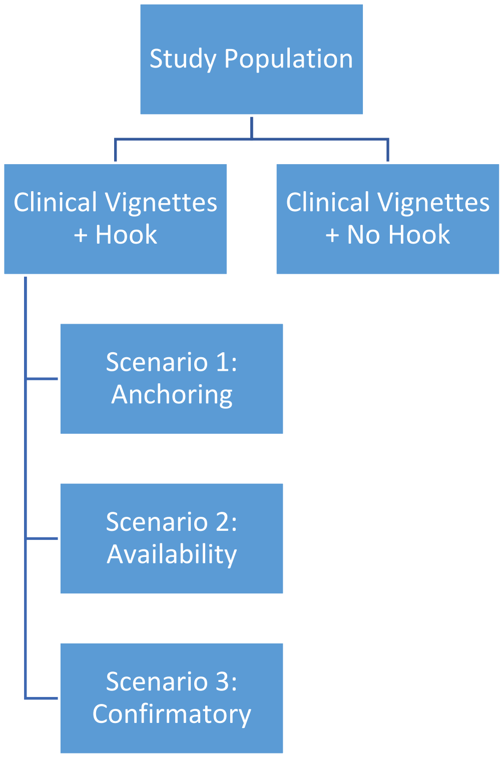


Figure 4.4. The two potential surveys distributed to participants

4.3.3.2. Participants

Participants were recruited between October 2019 – December 2019. Cluster sampling was used and participants were recruited through an email list to surgeons through the department of surgery in RCSI containing an invitation to participate (*Appendix I*), as well as a participant information letter (*Appendix J*). A reminder email was sent after 4 weeks of commencing the study. This sample frame has theoretical and practical experience of biliary tract surgery training as part of their basic surgical training (BST).

Each participant anonymously completed the survey and no financial reward was given for completion. Participants were advised that informed consent was indicative of completion of the survey. The study assessed significance at the level of $p<.05$. Across similar published studies which have explored Irish surgeons, a 36% response rate would be reflective of average survey response in this population.

The inclusion and exclusion criteria are as follows:

Inclusion:

- Surgical trainees and consultants
- Affiliated with the Royal College of Surgeons in Ireland with BST

Exclusion:

- Non-surgical medical professional
- Not affiliated with the Royal College of Surgeons in Ireland with BST

4.3.3.3. Study Instruments

Clinical Decision-Making

Clinical Vignettes: Vignettes (*Appendix K*) were modelled on the theoretical underpinnings of heuristics (Tversky and Kahneman, 1974), and content of the biliary tract procedures was validated by five independent consultant surgeons. The scenarios focused on high-stakes cases involving symptomatic cholelithiasis, an intra-operative bile duct injury, and an abnormal bowel growth. The vignettes offered decision outcomes varying in level of conservative judgements. Participants were also asked to discuss their clinical reasoning for their decision. The survey was piloted amongst non-affiliated members in the Department of Surgery in Tallaght University Hospital, and qualitative feedback regarding accessibility, layout and survey length was sought to reduce number and complexity of the questions.

Reflective Practice

Reflective Practice Questionnaire (RPQ): The RPQ (Priddis and Rogers, 2018) provides scoring for the level of metacognitive activity capacity in surgeons by assessing ten domains - reflective-in-action, reflective-on-action, reflective with others, self-appraisal, desire for improvement, general confidence, communication confidence, uncertainty, stress, and job satisfaction. It has moderate-high reliability (Priddis and Rogers, 2018). It has construct (Rogers et al., 2019) and content validity (Priddis and Rogers, 2018).

Demographics:

Demographic Section: Demographics taken from participants included gender, job specification and years since undergraduate medicine.

4.3.3.4. Statistical Analysis

A protocol of statistical analysis involving tests or normality was used (See *2.3.3.4. Data Extraction and Synthesis* for details). Non-parametric statistics were used. Spearman correlational analysis explored relationships between clinical vignettes, reflective practice and demographics. Mann-Whitney U and Kruskal Wallis testing explored relationships differences between clinical vignette and reflective practice questionnaire outputs. A summative content analysis approach (Hsieh and Shannon, 2005) using magnitude and grammatical coding was used to analyse the open-answer clinical reasoning aspects of the survey to establish weighted influence variables. These were categorised in accordance with previous published research within the department (Bhatt et al., 2016), to three pre-determined domains– disease related factors (e.g. extent of the disease), personal related factors (e.g. experience with clinical scenario), and patient related factors (e.g. outcomes and patient safety).

4.3.4. Results

4.3.4.1. Demographics

A total of 88 surgical trainees and consultants (45% of the overall population) were recruited of which 73 (37.6%) completed the full survey. A participant flow diagram is seen in *Figure 4.5*. The median time spent on each clinical scenario was 50 seconds (20-390). A demographic summary is seen in *Table 4.2.*

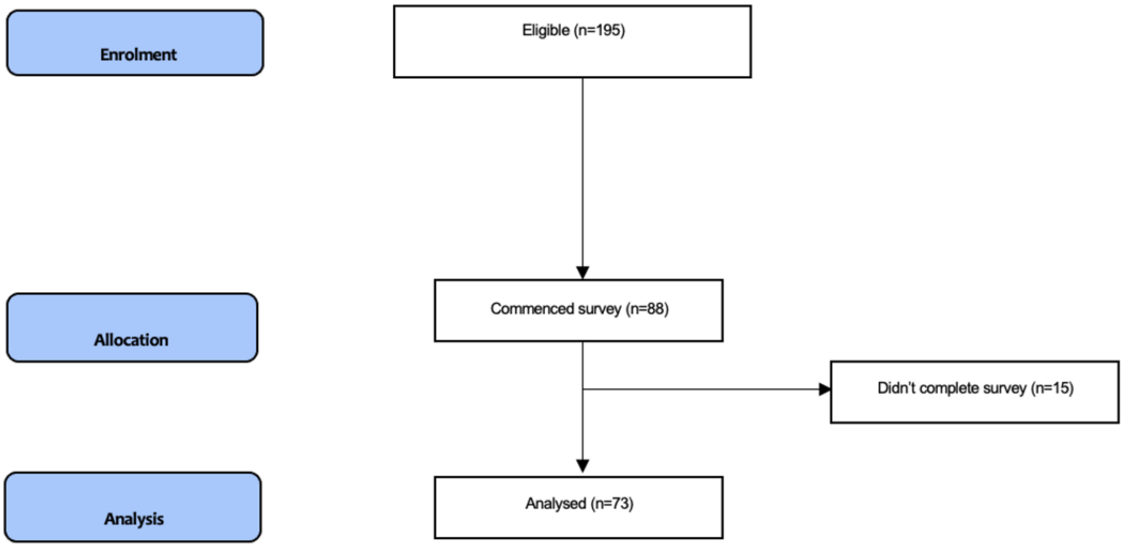


Figure 4.5. Participant flow diagram for Chapter 4 survey study

Table 4.2. Demographics summaries of participants for Chapter 4 survey study

Surgeons	**73**
Gender	
Male	52 (71.1%)
Female	21 (28.9%)
Length Since Undergraduate	
≤ 5 years	10 (14.29%)
6-10 years	22 (28.57%)
11-16 years	17 (23.81%)
17-22 years	5 (7.14%)
≥23 years	19 (26.19%)
Current Job Title	
SHO	9 (12.3%)
Specialist Registrar	37 (51%)
Consultant	27 (36.7%)

4.3.4.2. Reflective Practice

The cohort engaged in a 'moderate' level (Priddis and Rogers, 2018) of reflective practice seen in *Figure 4.6*.

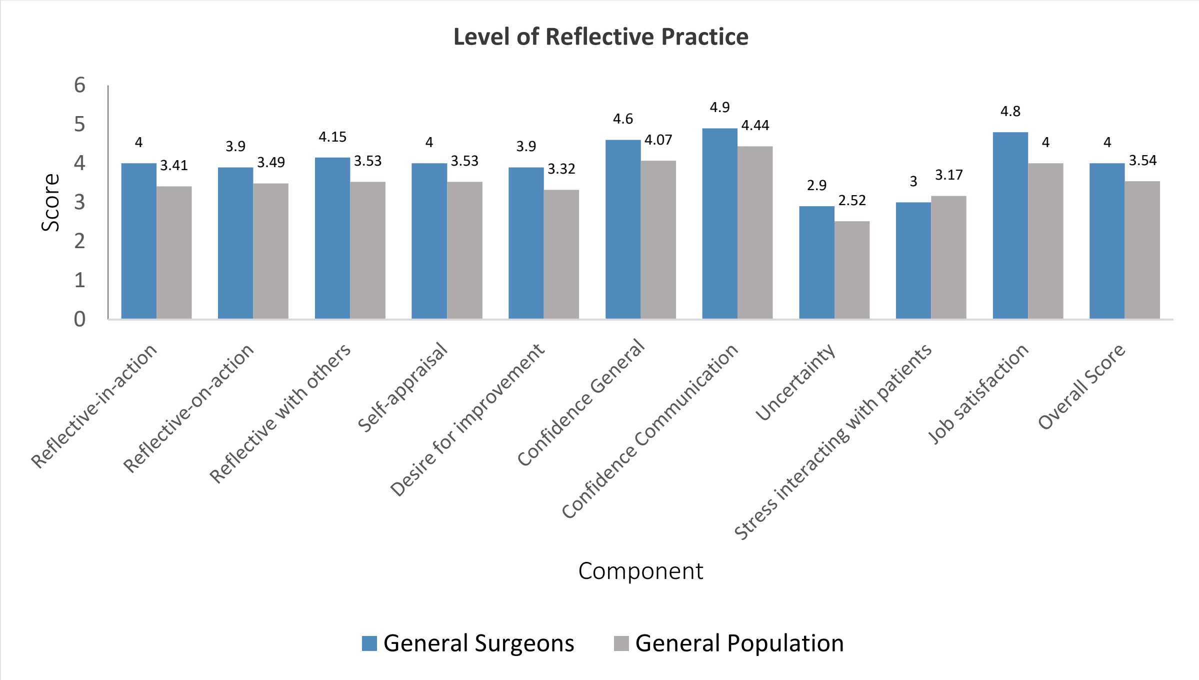


Figure 4.6. Breakdown and comparison of surgeons subscale and overall scores for the RPQ with 'general population' scores (Priddis and Rogers, 2018)

4.3.4.3. First Scenario

71.4% decided to refer this patient to the hepato-pancreato-biliary surgeon. 16.6% decided to perform a laparoscopic cholecystectomy +/- an open procedure. 11.9% decided to conservatively manage the patient. The factors influencing decision-making are seen in *Table 4.3*. There was no significant difference in those presented with the 'hook' with comparable scores (p=.568), seen in *Figure 4.7*. There was no significant demographic differences between the distribution of answers, seen in *Figure 4.8.*

Table 4.3. Factors influencing decision-making in first scenario: symptomatic cholelithiasis

Refer to the Hepato-Pancreato-Biliary surgeon	Perform a laparoscopic cholecystomy +/- an open procedure	Conservatively manage the patient
Patient (25%)	**Patient (0%)**	**Patient (33.3%)**
patients best interest and safety (n=9)		patient will settle (n=2)
risks associated with her comorbidities (n=5)		
Disease (56.4%)	**Disease (0%)**	**Disease (66.6%)**
complexity of the operation (n=19)		decrease morbidity (n=2)
it is protocol (n=12)		more investigations are required (n=2)
Personal (18.6%)	**Personal (100%)**	**Personal (0%)**
lack of experience with this scenario (n=11)	experience (n=11)	
Weighted Overall Factor		
Patient Factors	**Disease Factors**	**Personal Factors**
22%	47.9%	30.1%

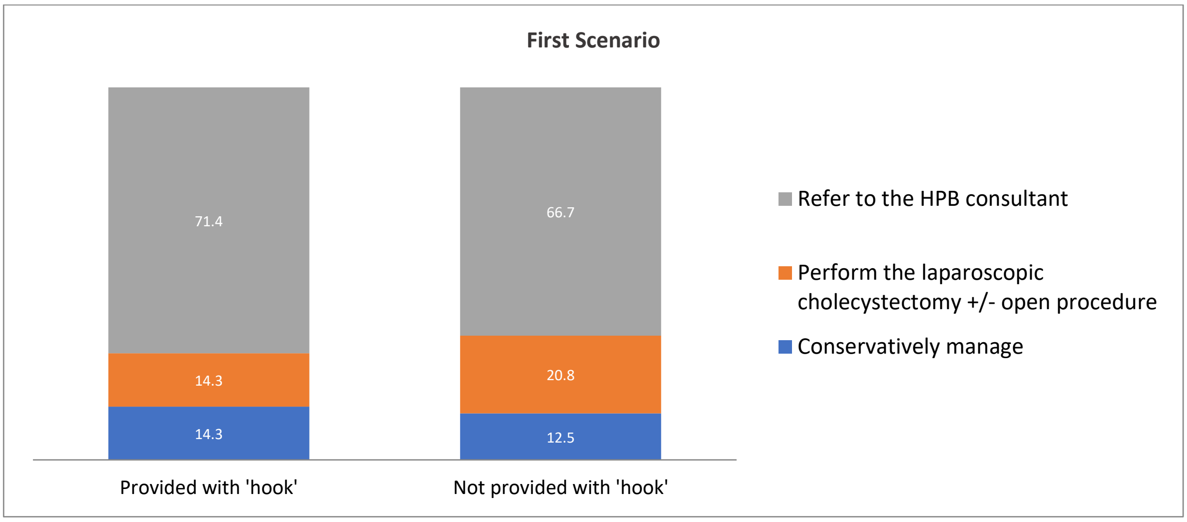


Figure 4.7. Breakdown percentage of decision-choices between 'hook' and 'non-hook' groups in first scenario

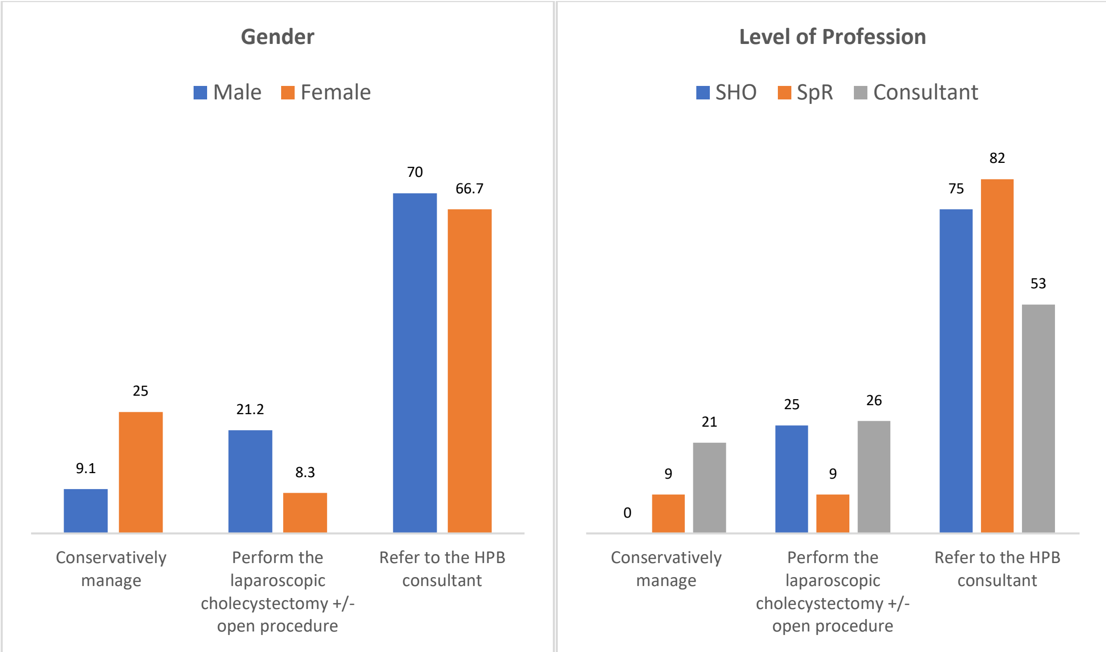


Figure 4.8. Percentage relationship between decisions and demographics on first scenario

4.3.4.4. Second Scenario

73.8% of participants decided to refer this patient to the hepato-pancreato-biliary surgeon. 14.3% decision to perform an intra-operative cholangiography. 11.9% decided to proceed to a primary repair of the injury. The factors influencing decision-making are seen in *Table 4.4*. There was no significant difference in those presented with the 'hook' with comparable scores (p=.496), seen in *Figure 4.9*. There was a significant difference between the distribution of answers between genders (p=.014). There was no statistically significant difference between the distribution of answers on level of profession seen in *Figure 4.10*.

Table 4.4. Factors influencing decision-making in second scenario: intra-operative bile duct injury

Refer to the Hepato-Pancreato-Biliary surgeon	Perform an intra-operative cholangiography	Proceed to a primary repair of the injury
Patient (8.2%)	**Patient (0%)**	**Patient (0%)**
patients best interest and safety (n=5)		
Disease (42.6%)	**Disease (75%)**	**Disease (0%)**
it is protocol (n=23)	assist with diagnosis (n=6)	
complexity of the situation (n=3)		
Personal (49.2%)	**Personal (25%)**	**Personal (100%)**
peer-support (n=10)	experience (n=2)	experience (n=5)
lack of experience with this scenario (n=8)		ease of operation (n=2)
the medicolegal implications (n=6)		
complexity of the situation (n=3)		
outcome bias (n=3)		
Weighted Overall Factor		
Patient Factors	**Disease Factors**	**Personal Factors**
6.6%	42.1%	51.3%

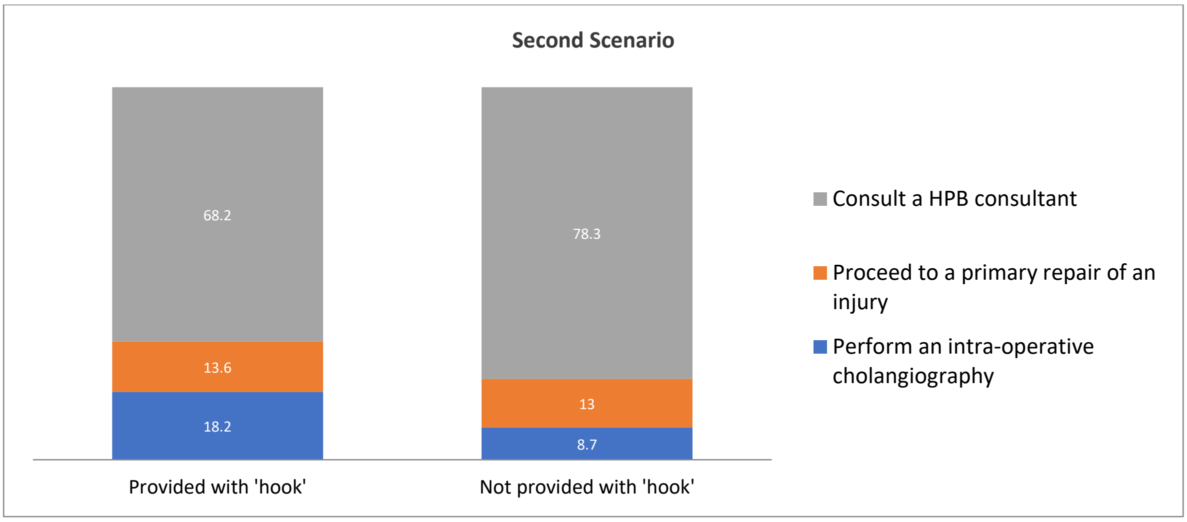


Figure 4.9. Breakdown percentage of decision-choices between 'hook' and 'non-hook' groups in second scenario

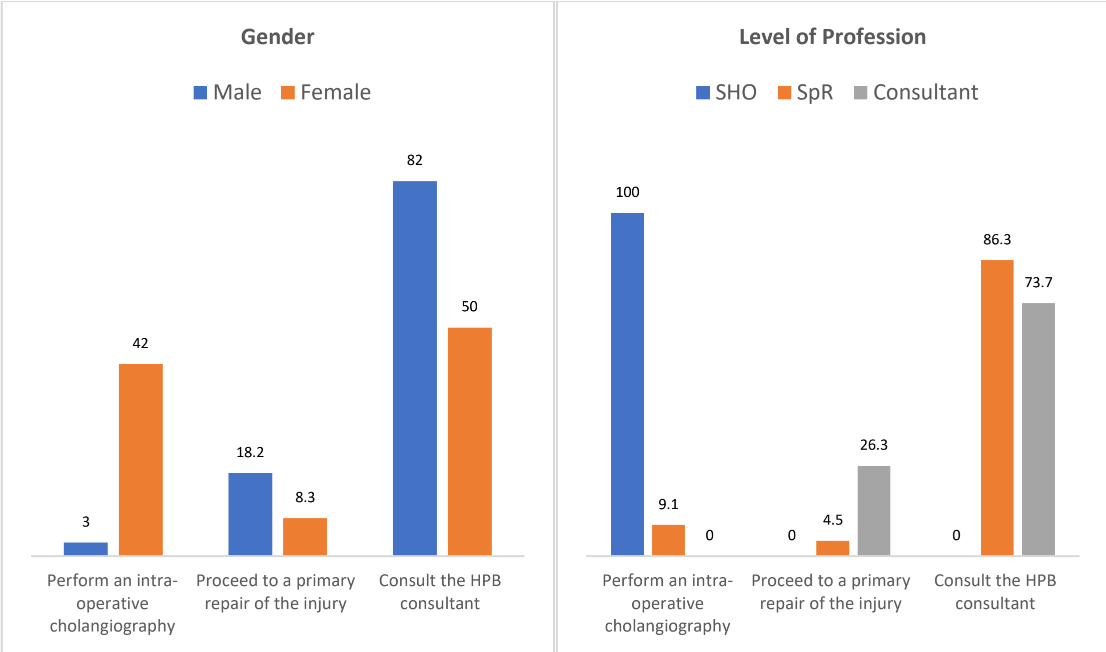


Figure 4.10. Percentage relationship between decisions and demographics on second scenario

4.3.4.5. Third Scenario

78.6% of participants decided to abandon the procedure without a cholecystectomy, and then conduct imaging. 14.3% of participants decided to continue with the laparoscopic cholecystectomy, and conduct imaging post operatively. 7.1% of participants decided to convert to open surgery, recognising that this may involve a wedge resection of the liver. The factors influencing decision-making are seen in *Table 4.5*. There was no significant difference in those presented with the 'hook' with comparable scores (p=.367), seen in *Figure 4.11*. There was no significant difference between the distribution of answers between genders or level of profession seen in *Figure 4.12.*

Table 4.5. Factors influencing decision-making in third scenario: abnormal bowel growth

Abandon the procedure without a cholecystectomy and then conduct imaging.	Continue with the laparoscopic cholecystectomy and then conduct imaging post operatively	Convert to open surgery, recognising that this may involve a wedge resection of the liver
Patient (23.6%)	**Patient (0%)**	**Patient (0%)**
patients best interest and safety (n=9)		
patient didn't provide consent (n=4)		
Disease (30.9%)	**Disease (80%)**	**Disease (42.9%)**
a malignancy diagnosis is needed (n=17)	assist with diagnosis (n=8)	assist with diagnosis (n=2)
	it was safer (n=2)	it is protocol (n=1)
Personal (45.5%)	**Personal (20%)**	**Personal (57.1%)**
they were not prepped (n=12)	unsure why (n=2)	within their scope of practice (n=2)
lack of experience with this scenario (n=9)		conduct if in liver unit (n=2)
outcome bias (n=4)		
Weighted Overall Factor		
Patient Factors	**Disease Factors**	**Personal Factors**
17.6%	40.5%	41.9%

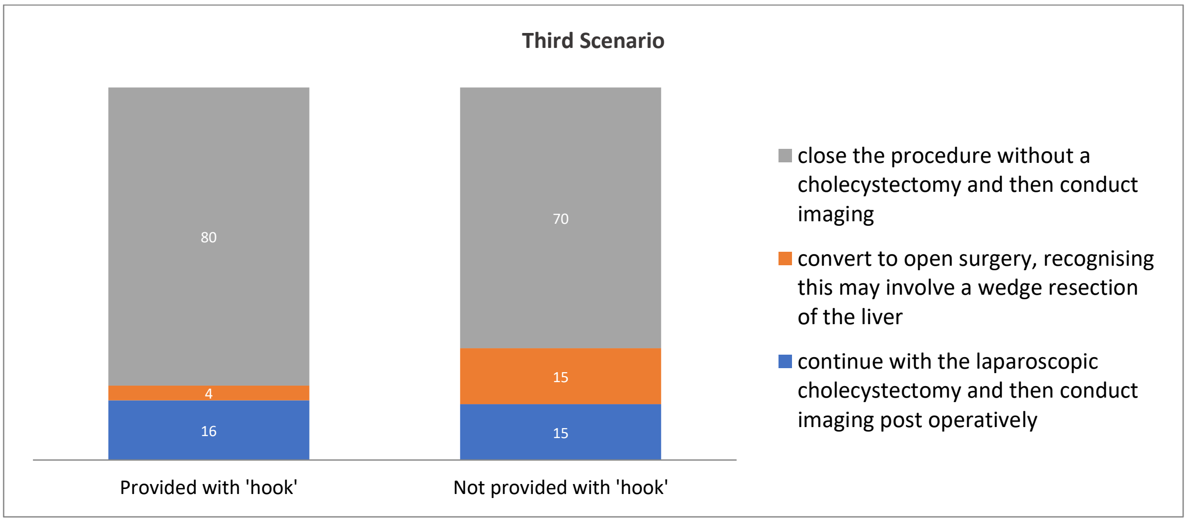


Figure 4.11. Breakdown percentage of decision-choices between 'hook' and 'non-hook' groups in third scenario

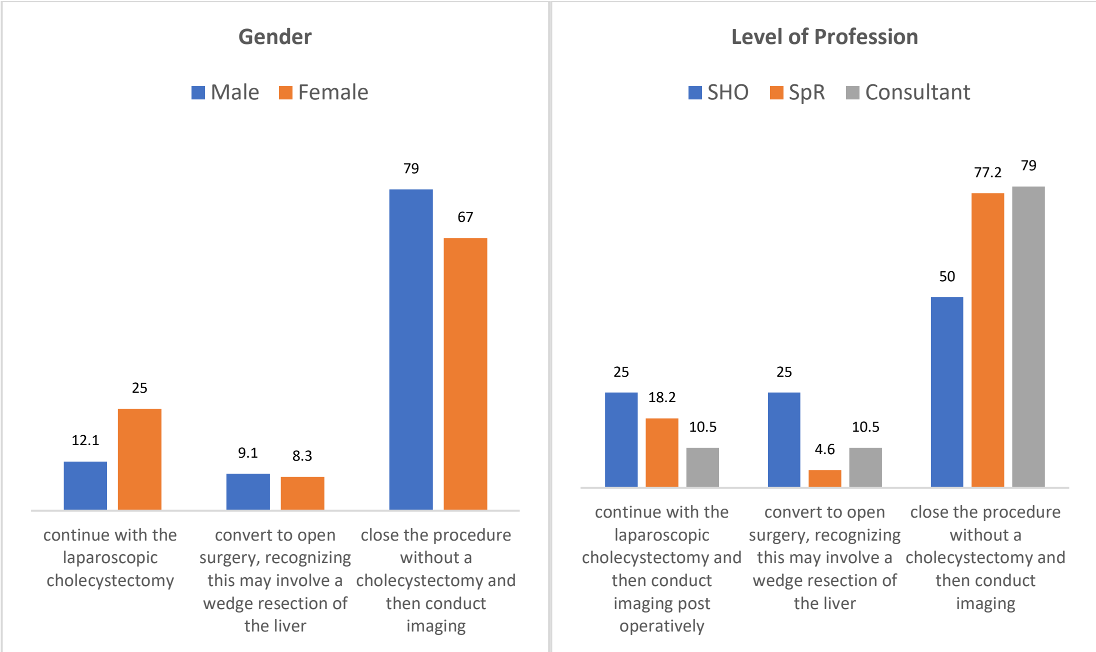


Figure 4.12. Percentage relationship between decisions and demographics on third scenario

A weighted variable factor between the three scenarios ranks order of importance as follows:

- Disease factors (43.5%)
- Personal factors (41.1%)
- Patient factors (15.4%)

4.3.5. Discussion

This study shows surgeons lean towards conservatism by using primarily disease-related, personal-related and patient-related factors, in order of ascending priority, when making decisions in high-stake clinical scenarios.

Conservativism in decision-making was influenced in part by experience. For example, in the first scenario, most participants found the clinical scenario was too complex for their own experience, and felt it was in the patient’s best interest to be referred to a specialist. Those who were more likely to perform the laparoscopic cholecystectomy cited experience as their main rationale for decision-making, highlighting the potential influencing role of years of surgical training on intuitive decision-making. This would support views that heuristics may be best used by experienced practitioners, who are also able to recognise patterns as part of their repertoire of decision-making tools.

The influencing factors associated with decision-making outcomes suggests the potential role of outcome-bias in increasing levels of conservatism. In the second and third scenarios, which involved intra-operative decision-making, outcome bias was recorded by those who opted to make more conservative decisions, and was absent in those who decided to proceed to either an intra-operative cholangiography or primary repair of the injury. This suggests that foresight into potential outcomes, perhaps associated with litigative culture in the profession, prior experience, or fear of the unknown, plays a role in making more liberal decision-making. Interestingly, the first scenario didn't show outcome bias, suggesting the potential differentiation of the bias presence between exo and intra-operative settings. This has implications for performance variability between settings, and could suggest greater emphasis on intra-operative work. Such prioritisation of decision-making may place greater strain on other members of the multi-disciplinary team to mitigate poor decision-making in intensive-care unit and ward settings. The outcome bias may have applicability to the influential role of regret in decision-making processes, leading to defensive-medical practices.

Participants in this study reported greater levels of uncertainty compared to a general population sample (Priddis and Rogers, 2018). Similar survey-style research found that a surgeons perception of operative risk-benefit varies significantly between surgical groups, and is highly predictive (39% of variance) of the decision to operate or not (Sacks et al., 2016). Prospect theory (Kahneman and Tversky, 1980) may explain some variability for how surgeons made judgments in situations of high uncertainty. The first thing they do is make the decision simpler in terms of predicted gains versus potential losses. Ideally, these gains and losses should be in the viewpoint of patients, but oftentimes, it is through the lens of the surgeons best interests. The weighted variables in favour of personal factors would support this hypothesis. They may switch between personal trade-offs and patient trade-offs as part of this process, but when in fatigued states, these shifts in perspectives are less likely to occur. The higher-than-average scoring of self-appraisal, reflective-on-action and reflective-in-action scores which was identified in surgeons could have played a differentiating role in this regard and should be explored further with regards to the importance of metacognition of decision-making outcomes in challenging environments.

The role of experience provides some interesting insights. The hook 'extensive experience' was hypothesised to lead to increased perceived confidence and thus underestimation of evidence which refutes their bias. In fact, the opposite occurred, with those who perceived to have more experience in the setting being more likely to refer. This effect suggests that those who reported little experience in these scenarios could have perceived overconfidence in capabilities which were matched with objective expertise, in a process known as the Dunning-Kruger effect (Kruger and Dunning, 1999). It was previously discussed that older surgeons are more risk-averse in decision-making (Nakata et al., 2000), and this relates once again to level of perceived regret in outcomes.

Resources and settings may also play a determining factor in decision-making. The hook 'long waiting lists' attempted to evoke consideration of resource management. A small difference was noted between groups, but this was not significant. The weighting of resource management as a variable could have been more prevalent when utilising analytical decision-making. Higher levels of conservatism were noted in intra-operative versus exo-operative settings. The high-workload of exo-operative settings including rounds and clinics, which are standardised and process driven, could evoke use of more fast-and-frugal approaches to reduce cognitive burden (Gigerenzer et al., 2007) and should be examined.

This study provides a framework to explore intuitive decision-making in surgery by providing insights into the personal and environmental variables. Future research should explore the influencing role of these variables in a higher-fidelity setting. In the context of heuristics use, each has a potential downfall which warrants further investigation. For example, the availability and confirmation heuristic may result in distorted hypothesis generation, ultimately resulting in premature closure of a diagnosis. The representativeness and anchoring heuristic may result in overemphasis on particular aspects of judgement while missing atypical variants, resulting in misdiagnosis. This study provides insight into the identity of heuristic use but not whether they resulted wrong decisions being taken. A majority of research on heuristics has focused on diagnosis (60%) with less focus on management, which plays a vital role in surgical practice (Saposnik et al., 2016).

4.3.6. Limitations

The participant demographics were predominantly higher BST, which limits generalisability to earlier levels. Similarly, the response rate was reflective of just over a third of the sample frame which limits generalisability. A significant limitation of survey research on decision-making, which dominates the literature (82%) (Blumenthal-Barby and Krieger, 2015), is the lack of exogenous stimuli which are present in real-life decision-making. For example, while surgeons did respond intuitively as determined by time, it is likely that they were not experiencing competition for cognitive resources when completing the survey which is much more prevalent in real-life clinical scenarios. For this reason, these findings reflect surgeons 'perceived' decision-making processes as opposed to 'real' decision-making processes and outcomes.

4.3.7. Conclusion

Surgeons predominantly leaned towards conservatism in perceived decision-making. This was most influenced by disease-related factors, particularly in intra-operative settings. Personal factors such as outcome bias and experience may also play an influential role. Heuristic influence showed greater shifts towards conservatism in intra-operative settings when compared to exo-operative settings, reflecting the potential role of setting in determining intuitive decision-making model use. To further understand perceived and real-life decision-making, alongside decision-making in exo-operative settings, which encompass a large aspect of surgeons work, research in simulated settings is warranted.

4.4. SIMULATED EXPLORATION AND VALIDATION OF CLINICAL DECISION-MAKING PERFORMANCE IN A HIGH STAKES SCENARIO

4.4.1. Research Question

Can a high-stakes simulated scenario be used for valid assessment of decision-making performance in surgeons?

4.4.2. Objectives

1. To compare self-reported clinical decision-making, simulated decision-making, and reflection on-action decision-making processes amongst participants to explore the theory-practice gap
2. To investigate the effectiveness and reliability of the decision-making simulated scenario for examination

4.4.3. Methods

4.4.3.1. Study Design

This was a single site conducted during the European Union Medical Specialist Fellowship Examinations for General Surgery (UEMS) examination for surgeons at the point of transition to junior consultant practice/fellow. There were four points of assessment, summarised in *Figure*

4.13. There were three strands to triangulate and validate the findings - self-reported decision-making, observed assessment of decision-making, and post-hoc evaluation of the station. To reduce associated stress, the simulated scenario was conducted after the formal examination was completed and was not incorporated into summative results.

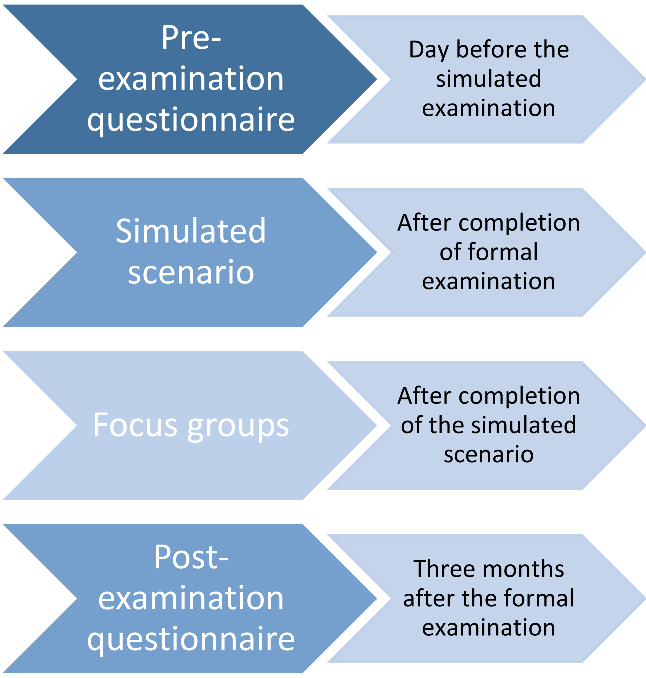


Figure 4.13. Study process including timeframes

4.4.3.2. Participants

Participants were invited and recruited in September 2019 through cluster sampling. Participants were recruited through an email list from the UEMS containing an invitation to participate (*Appendix L*), as well as a participant information letter (*Appendix M*). A reminder email was also sent out after 4 weeks. The participants were considered recruited when they subsequently completed written consent on the day of the study.

The study assessed significance at the level of $p<.05$. Across 30 similar published studies which have explored surgeons performance in simulation examinations the average number of participants has been 35.4. 35 was chosen as an achievable sample size.

There was only one inclusion and exclusion criteria.

Inclusion:

- Surgeons completing the UEMS Fellowship Examinations in General Surgery

Exclusion:

- Surgeons not completing the UEMS Fellowship Examinations in General Surgery

4.4.3.3. Study Instruments

Pre-Examination Questionnaire: A three-item scenario questionnaire on decision-making in an ethical situation was given (*Appendix N*). It provided decision options as well as an option for open responses. The scenario was content-validated by four external surgeons.

Simulated Scenario: A 10-minute simulation, in which participants were tasked with the responsibility of gaining consent from a standardised patient in a critically-ill situation, was given (*Appendix O*). The scenario reflected end of life decision-making, which is a common part of clinical practice of which senior surgical staff have primary responsibility. The assessment tool was designed in collaboration with Dr. Marie Morris (Dublin, Ireland), modelled off the domains of professional practice, and divided into seven sections (Medical Act, 2007) (*Appendix P*).

Focus Groups: Semi-structured interviews were conducted which explored aspects of face-validity of the scenario, and rationale for decision-making in a reflective-on-action approach. Participants were paired in groups of two for a 10-minute discussion (*Appendix Q*).

Post-Examination Questionnaire: A four-item questionnaire on satisfaction, quality enhancement, as well as the level of transferability of the scenario to real-life practice was distributed (*Appendix R*).

Demographic Questionnaire: Two demographics (gender and country of practice) were taken from participants at baseline.

4.4.3.4. Statistical Analysis

A protocol of statistical analysis involving tests or normality was used (See *2.3.3.4. Data Extraction and Synthesis* for details). Parametric statistics were used where possible. Spearman correlational analysis explored the relationship between perceived decision-making on the prequestionnaire and actual decision-making in the simulation as the data was non-continuous. Interviews were transcribed verbatim and a content analysis approach (Hsieh and Shannon, 2005) using magnitude and grammatical coding was used.

Four of the five items of Messick's framework for validity were used (Messick, 1989), seen in *Table 4.6.* Relations with other variables was not explored.

Table 4.6. Aspects and explanations of Messick's validity framework

Aspect	Explanation	Type of Validity	Applicability
Content	Items characterise construct of interest	Content-related	Blueprint of domains of professional practice.
Response process	Data coherence is evident	Construct-related	Standard setting of examiners and actors.
			Inter-rater reliability using kappa statistics.
Consequences	Impact on stakeholders involved	Content-related Construct-related	Establish variance in scoring and categorical scores of black-boxes and failures.
			Comparison of summative anonymised scenario scores to other scores in formal examination.
			Establish predictors of performance using Spearman's correlation.
Internal structure	Psychometric properties	Criterion-related	Reliability using Cronbach's alpha with >0.7 considered acceptable amongst many researchers (Lance et al., 2006).
			Compare categorical checklist scores with ordinal scoring of global rating (Ilgen et al., 2015).
Relations with other variables	Alignment with similar other tools measuring the same subject	Criterion-related	Not explored

4.4.4. Results

4.4.4.1. Demographics

A total of 43 participants were invited and recruited, of which 41 completed the simulated scenario. A participant flow diagram is seen in *Figure 4.14*. The demographic summaries are seen in *Table 4.7.*

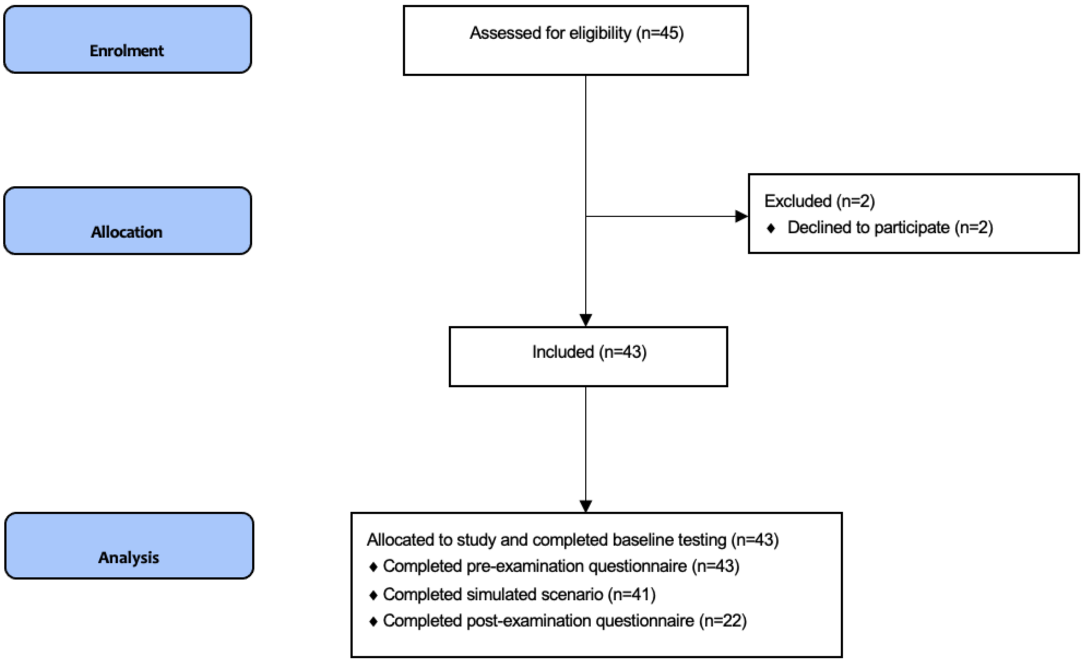


Figure 4.14. Participant flow diagram for Chapter 4 simulation validation study

Table 4.7. Demographics summaries of participants for Chapter 4 simulation validation study

Surgeons	**43**
Gender	
Male	42 (97.7%)
Female	1 (0.3%)
County of Practice	
Sudan	5 (11.6%)
India	4 (9.3%)
Egypt	4 (9.3%)
Pakistan	4 (9.3%)
Oman	1 (2.3%)
Italy	4 (9.3%)
Ireland	6 (14%)
Iraq	3 (7%)
Austria	2 (4.7%)
United Kingdom	5 (11.6%)
Syria	4 (9.3%)
Lebanon	1 (2.3%)

4.4.4.2. *Pre-Examination Questionnaire*

A breakdown of the participants choice in the pre-examination questionnaire is seen in *Figure 4.15*. The 'other' responses are seen in *Table 4.8.* Influencing decision-making factors are shown in *Table 4.9.*

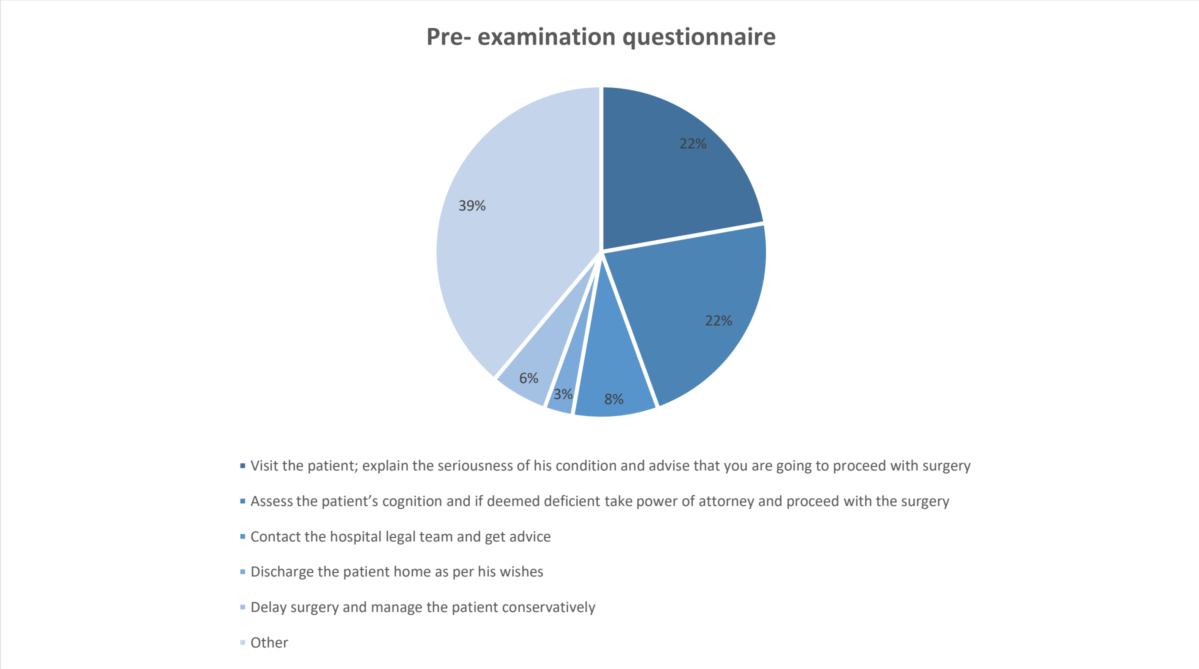


Figure 4.15. Participants responses to the pre-examination questionnaire

Table 4.8. Participants 'other' responses to preferred decision-making

Response	Value (n)
"include family in discussions"	6
"admit and refer to palliative"	3
"explain fatality and contact legal"	2
"discharge with painkillers"	1
"discuss with peers"	1
"take power of attorney if perceived incapacity"	1
"problem solve with patient with the view to having surgery"	1

Table 4.9. Participants influencing factors in decision-making

Response	Value (n)
knowledge-based	12
legal ramifications	10
risk of death with perforation	7
patient autonomy	7
family role	4
patient education	2
comorbidities	1

4.4.4.3. Simulated Scenario

A breakdown in in performance in the simulated scenario is given in *Figure 4.16.*

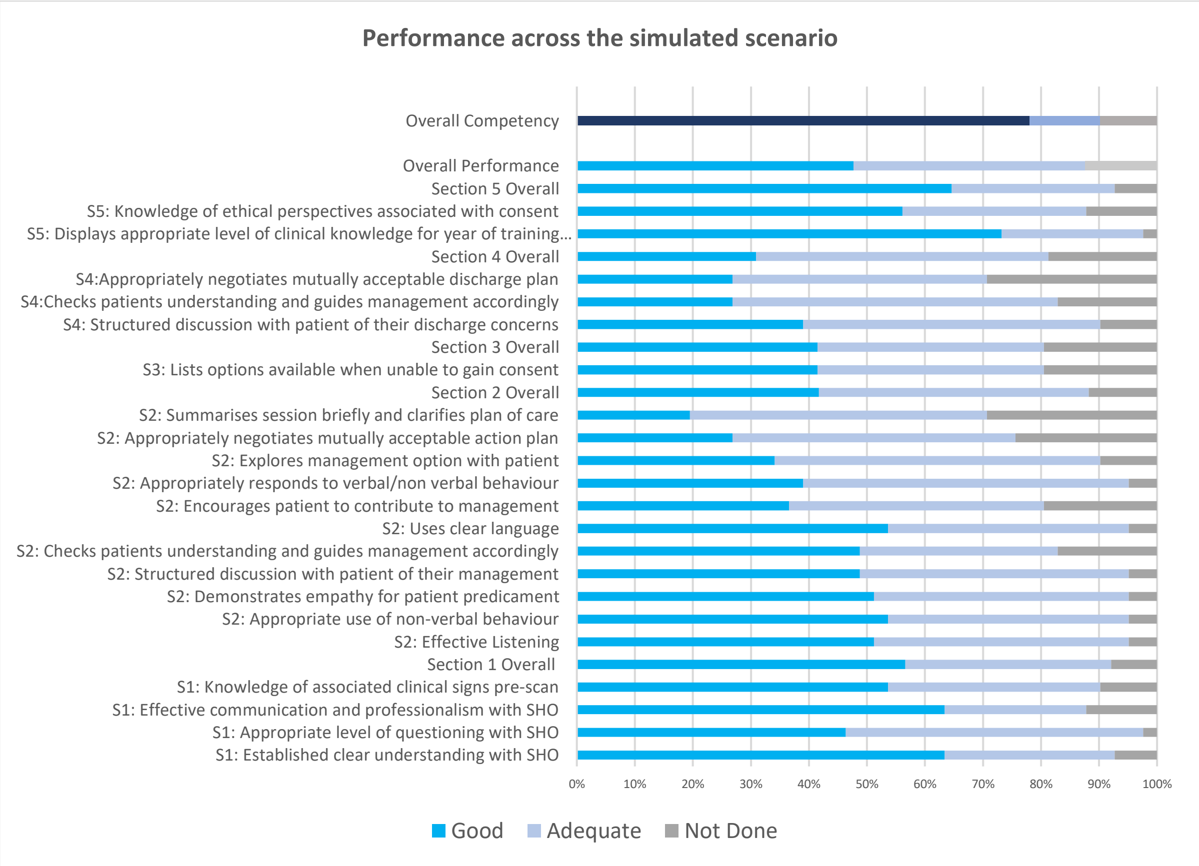


Figure 4.16. Performance of participants across aspects of the simulated scenario

There was no statistically significant correlation between behaviours on the pre-examination questionnaire and performance in the formal examination. Aspects of the stations which were approaching significance were:

- **S4:** Structured discussion with patient of their discharge concerns (r=.315) (p=.062)
- **S2:** Uses clear language (r=.298) (p=.057).

4.4.4.3.1. Content

The blueprint of the station and the competency involved are represented in *Table 4.10.*

Table 4.10. Blueprint mapping of station aspect with domains of good professional practice

Section	Domain of Professional Practice	Communication and interpersonal	Collaboration and teamwork	Professionalism	Clinical Skill	Scholarship	Relating to patients	Patient safety and quality of care	Management
S1	Established clear understanding with SHO	✓	✓						
	Appropriate level of questioning with SHO	✓	✓						
	Effective communication and professionalism with SHO	✓		✓					
	Knowledge of associated clinical signs pre-scan				✓	✓			
S2	Effective Listening	✓							
	Appropriate use of non-verbal behaviour	✓							
	Demonstrates empathy for patient predicament	✓					✓		
	Structured discussion with patient of their management	✓						✓	✓
	Checks patients understanding and guides management accordingly	✓					✓	✓	
	Uses clear language	✓					✓	✓	
	Encourages patient to contribute to management	✓	✓				✓		✓
	Appropriately responds to verbal/non-verbal behaviour	✓		✓					
	Explores management option with patient	✓					✓		✓
	Appropriately negotiates mutually acceptable action plan		✓						
	Summarises session briefly and clarifies plan of care	✓							
S3	Lists options available when unable to gain consent				✓	✓		✓	
S4	Structured discussion with patient of their discharge concerns	✓							
	Checks patients understanding and guides management accordingly	✓					✓		✓
	Appropriately negotiates mutually acceptable discharge	✓	✓				✓	✓	✓
S5	Displays appropriate level of clinical knowledge for year of training and specialty				✓	✓			
	Knowledge of ethical perspectives associated with consent				✓	✓			

4.4.4.3.2. Response Process

The kappa coefficient κ=0.79 indicates substantial level of interrater agreement between the examiners.

4.4.4.3.3. Consequences

The mean score in this station was 2.3 (1.7 – 3.0). 13.3% of participants received black box (i.e. sub-standard) comments. A percentage (9.8%) of participants failed the assessment compared to 12.4% on overall failures in other aspects of the formal examination. A failure in performance was associated with scores in other aspects of the scenario seen in *Table 4.11.*

Table 4.11. Strongest predictors of failed performance in the simulated scenario

Section	Indicator of Failed Performance	Spearman Correlation
S2	Appropriately responds to verbal/non-verbal behaviour	.334 (p<.05)
	Appropriately negotiates mutually acceptable action plan	.382 (p<.05)
S3:	Lists options available when unable to gain consent	.344 (p<.05)
S4:	Checks patients understanding and guides management accordingly	.343 (p<.05)
	Appropriately negotiates mutually acceptable discharge plan	.343 (p<.05)
S5:	Displays appropriate level of clinical knowledge for year of training and specialty	.320 (p<.05)
	Knowledge of ethical perspectives associated with consent	.570 (p<.01)

The strongest associations of aspects of the scenario and overall performance was associated with scores in aspects of the scenario, seen in *Table 4.12*. The following aspects of the examination did not determine overall competence:

- **S1**: Appropriate level of questioning with SHO
- **S1:** Knowledge of associated clinical signs pre-scan
- **S2:** Appropriate use of non-verbal behaviour
- **S2:** Explores management option with patient

Table 4.12. Strongest predictors of overall performance in the simulated scenario

Indicators of Overall Performance	Spearman Correlation
Blackbox scoring	.721 ($p<.01$)
Knowledge of ethical perspectives	.724 ($p<.01$)
Knowledge of clinical aspects	.621 ($p<.01$)

4.4.4.3.4. Internal Structure

Cronbach's alpha scores to other stations in the formal examination are seen in *Table 4.13* and inter-item correlations are seen in *Table 4.14.*

Table 4.13. Cronbach Alpha scores between the simulated scenario and other examination aspects

Station	Cronbach's Alpha Score
Station 1	.909
Station 2	.771
Station 3	.901
Station 4	.898
Station 5	.434

Table 4.14. Inter-item correlations between overall performance and the subsections of the simulated scenario

Sub-section	Inter-item correlation score
S1	.943
S2	.982
S3	.829
S4	.921
S5	.820

4.4.4.4. Focus Groups

- 97.7% agreed they would have regularly encountered this scenario in their work
- 94.5% reported obtaining consent is required before partaking in any surgical procedure
- The most common identified resources for legal information were senior management and guidelines
- Disease-related factors, followed by personal-related factors, and then patient-factors were the order of variables in influencing decision-making.

4.4.4.5. Post-examination Questionnaire

Responses to the post-examination questionnaire are summarised in *Figure 4.17.*

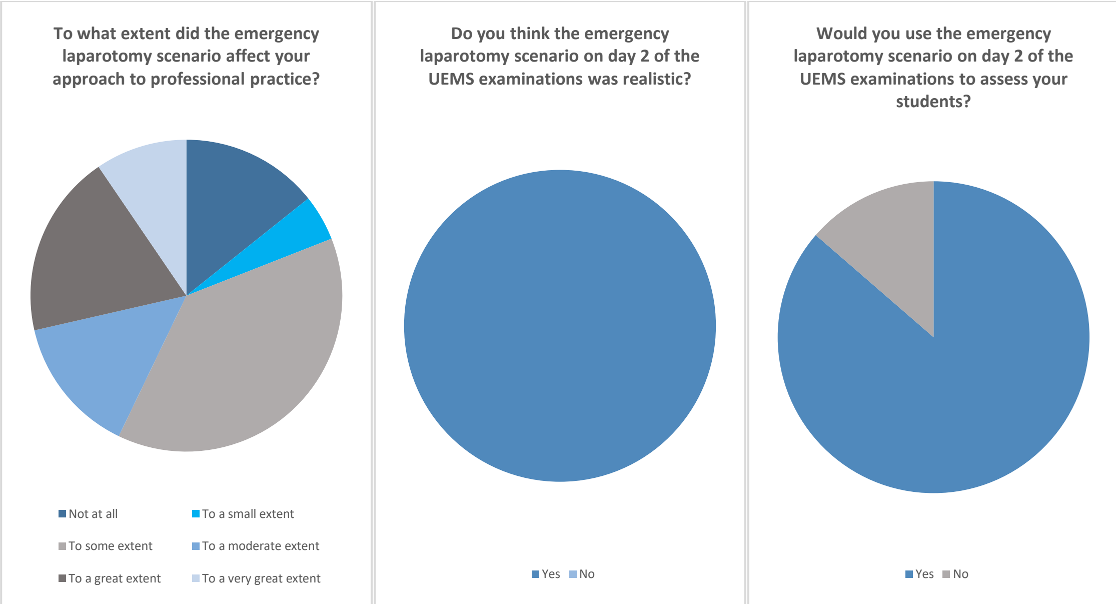


Figure 4.17. Post-examination questionnaire responses

4.4.5. Discussion

The supporting evidence using Messick's model of validity shows that a high-stakes scenario can be used to assess decision-making performance in surgeons. The assessment incorporates a combination of several other non-technical skills associated with the IMC 8 Domains of Good Professional Practice (Medical Act, 2007), and reflects incongruences to that of self-reported decision-making outcomes in a survey-study design.

No relationship could be established between self-reported and simulated performance, indicating a gap between theoretical assumptions and practical implications, as well as potential confidence versus competency awareness in surgeons. The simulated scenario reflected the constructs assessed in the pre-examination questionnaire which assisted in exploring blind spots in self-awareness and perceived overestimation of ability in what is known as the Dunning-Kruger effect (Kruger and Dunning, 1999). There was parallels between the previous study in this chapter, and this studies weighting of variables for decision-making were similarly biased against patient-factors. The implications of this disparity in weighting could be significant. Between 5.5-13.3% of participants made decisions throughout which would have evented in avoidable mortality. These circumstances could have arose when less emphasis was placed on patient-related factors. This may have resulted in a cognitive dissonance in decision-making processing, in which surgeons expectations of how a clinical presentation should go (i.e. surgery will proceed), was incongruent with how the patient responded (i.e. not consenting for surgery).

The simulated scenario was sufficiently proved as an effective way to assess the components of decision-making in a high-stake scenario. Evidence supporting Messick's validity model (Messick, 1989) included a rigorous blueprint of content, a similar passing percentage, and correlation to other aspects of the formal examination which indicates high internal consistency. There was also a strong inter-rater reliability as well as internal structure of the assessment tool suggesting ease of utility. Every participant on follow up reported this scenario was realistic and reflective of real-life, inferring support of aspects of face validity. Finally, the inferences which can be taken from utilising Messick's model triangulated the previous elements of this chapter. Knowledge of ethical and clinical perspectives were two of the highest determining predictors of overall performance, while exploring management with the patient was one of non-determining variables. This provides further triangulation of the hypothesis that effective decision-making is weighted towards disease and personal-related but not patient-related factors, even for surgical examiners.

4.4.6. Limitations

This study was established through the lens of European-based legislation, and while participants were cognisant of this a priori, variance in the findings may be biased against performance of individuals not familiar with these legislative practices. Aspects of inter-item reliability were too high in some instances, meaning revision of assessment criteria is warranted to differentiate non-technical domains further. Similarly, a larger representative sample, incorporating a more diverse demographic, would have assisted in greater validity.

4.4.7. Conclusion

This study validated a high-stakes simulation as a means of assessing decision-making. Surgeons were cognitively forced into intuitive styled decision-making in the simulated scenario, which resulted in differences between perceived and actual decision-making. Taking this as a means of evoking intuitive decision-making more realistically, exploration of the potential role of cognitive-load and fatigue on decision-making outcomes in simulation could be explored.

4.5. PILOT SIMULATED EXPLORATION OF THE ROLE OF COGNITIVE LOAD ON CLINICAL DECISION-MAKING PERFORMANCE IN A HIGH STAKES SCENARIO

4.5.1. Research Question

Can a high-stake clinical scenario evoke differences in decision-making outcomes between surgeons reporting higher and lower cognitive loads?

4.5.2. Objectives

1. To compare decision-making outcomes between higher and lower cognitive loads and sleepiness levels
2. To explore relationships between self-reported sleepiness, circadian rhythm preferences, and cognitive load

4.5.3. Methods

4.5.3.1. Study Design

This was a single site observational study design exploring relationship between subjective measurements of cognitive load and their impact on decision-making in a high-stakes scenario. Participants underwent a 10-minute interview-style performance assessment. The performance assessment was modelled off the previous validated simulation, and was divided into five sections (*Appendix S and T*). Participants were given 30-second time frames to answer each question.

4.5.3.2. Participants

Participants were recruited between March – June 2020 through convenience sampling of surgical trainees and consultants. A similar process of recruitment to *Chapter 3* was employed with an invitation to participate (*Appendix U*), a participant information letter (*Appendix V*) and reminder email. The participants were considered recruited when they subsequently respond by email indicating their interest to participate.

Informed written consent was obtained from participants at recruitment. The rule of thumb of 12 participants for pilot studies was employed (Julious, 2005).

Inclusion:

- Surgeons in the single-site institution
- Surgical trainees (SHO and Registrar)
- Surgical consultants

Exclusion:

- Non-surgical medical professional

4.5.3.3. Study Instruments

Clinical Decision-Making Performance

Simulated Scenario: The scenario was modelled on the theoretical underpinnings of heuristics (Tversky and Kahneman, 1974). Each section offered decision outcomes of 'operate', 'do not operate', or 'don't know' (*with the exception of the last phase*). The correct outcome at the end was 'do not operate'. In each section participants received further relevant and irrelevant 'hooks'. Participants were also asked to list variables for their clinical decision-making. The scenario was designed in conjunction with a consultant surgeon and human factors psychologist to ensure accessibility, content-validity and appropriate layout.

Circadian Preferences

Morningness-Eveningness Questionnaire (MEQ): This 19-item questionnaire (Horne and Östberg, 1976) measures surgeons circadian rhythm through assessing peak alertness categorisation in morning i.e. early birds, evening i.e. night owls or between both i.e. intermediates. It has high reliability (Paine et al., 2006). It has criterion (Taillard et al., 2004) and construct validity (Horne and Östberg 1976).

Cognitive Load

NASA-Task Load Index (TLX): This subjective multidimensional tool rates perceived workload (Hart et al., 1988) through six domains: mental/physical/temporal demand, performance, effort, and frustration. Participants reported their level of cognitive load having completed the scenario, and also hypothetically reported the level of cognitive load completing a similar task during a night on-call (i.e. approximately 1am). It has high reliability (Xiao et al., 2005; Battiste and Bortolussi, 1988). It has criterion (Devos et al., 2020), construct (Ruiz-Rabelo et al., 2015; Sewell et al., 2016), and content validity (Longo, 2018).

Alertness

Karolinska Sleepiness Scale (KSS): This single measurement tool rates subjective sleepiness (Kaida et al., 2006). A cut off of '5' on the scale using semantic reasoning was used to differentiate those experiencing no sleepiness versus some/more sleepiness. Hereafter, these are referred to as 'sleepy' and 'non-sleepy' groups. It has criterion (Kaida et al., 2006) and construct validity (Åkerstedt et al., 2014).

Demographics

Demographic: Demographics taken from participants included gender, job specialty and title.

A summary of reliability and validity measures of the instruments used can be seen in *Appendix F*.

4.5.3.4. Data Analysis

The interviews were audio recorded and transcribed verbatim. A protocol of statistical analysis involving tests or normality was used (See *2.3.3.4. Data Extraction and Synthesis* for details). Non-parametric statistics were used. Kruskal-Wallis and Mann-Whitney U tests explored differences between variables.

4.5.4. Results

4.5.4.1. Demographics

A total of 14 surgical trainees and consultants were recruited, all of whom participated in the observational study from *Chapter 3*. Baseline demographic summaries are seen in *Table 4.15*.

Table 4.15. Demographics summaries of participants for Chapter 4 cognitive load in simulation study

Surgeons	14
Gender	
Male	8 (57.1%)
Female	6 (42.9%)
Specialty	
General	12 (85.72%)
Urology	1 (7.14%)
Vascular	1 (7.14%)
Current Job Title	
SHO	4 (45.3%)
Registrar	7 (33.3%)
Consultant	3 (21.4%)

4.5.4.2. Simulated Scenario

Scores for the summative simulated scenario are presented in *Table 4.16*. A breakdown in NASA-TLX scores for each decision is seen in *Figure 4.18.*

Table 4.16. Median score of decisions in simulated scenario with interquartile ranges

Variable	Median	Interquartile
First-Decision	2	(2-3)
Second-Decision	2	(2-3)
Third-Decision	2	(2-3)
Fourth-Decision	1	(1-2)

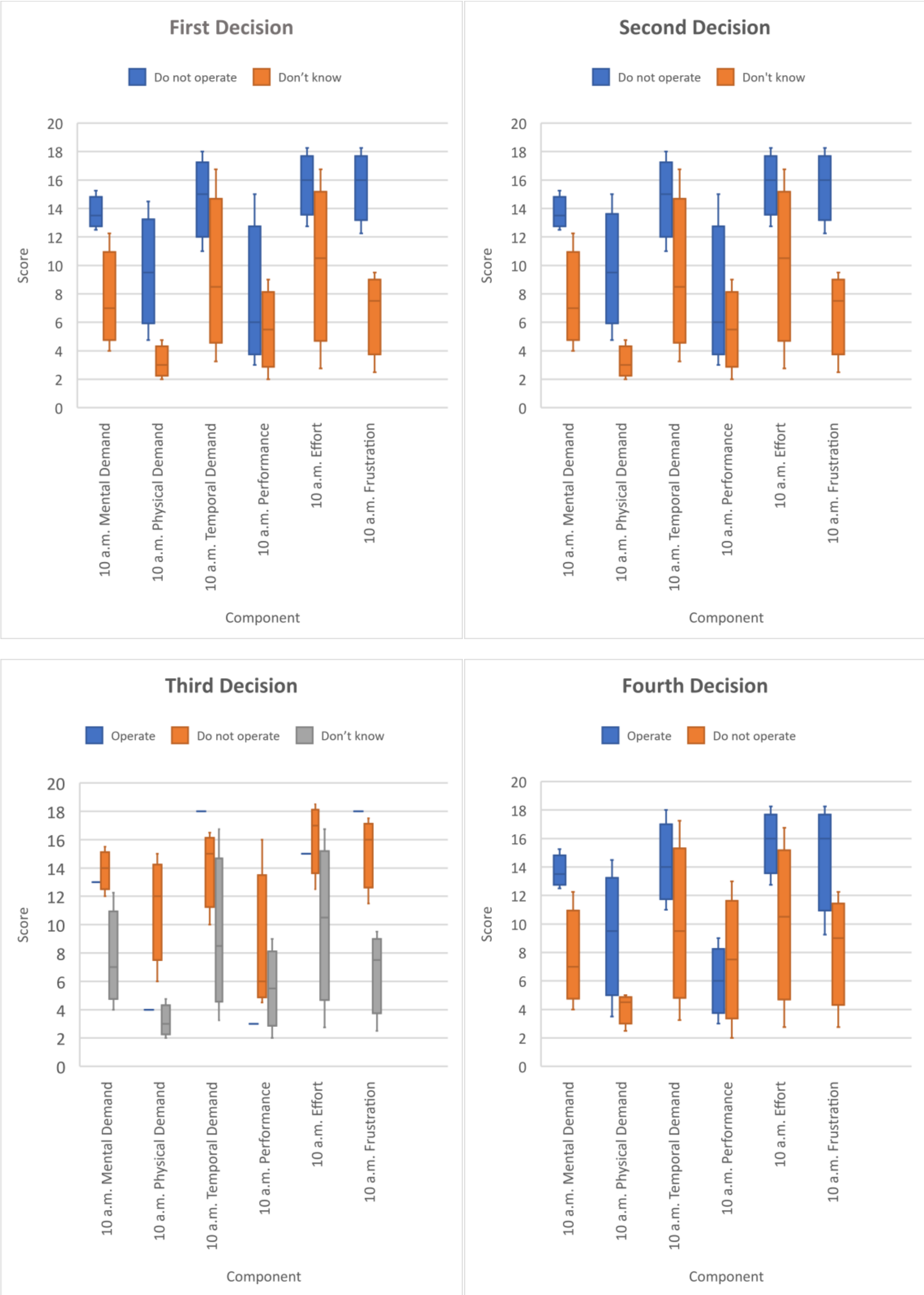


Figure 4.18. Difference in NASA-TLX reporting for each decision showing predominantly lower loads for those reporting ‘don’t know’ in the first three decisions and ‘do not operate’ in the fourth decision

There was statistically significant differences in first-decisions between ‘do not operate’ and ‘don’t know’ in:

- mental demand (p=.030)
- physical demand (p=.031)
- frustration (p=.014)

There was statistically significant differences in second-decisions between ‘do not operate’ and ‘don’t know’ in:

- mental demand (p=.030)
- physical demand (p=.030)
- frustration (p=.010)

There was statistically significant differences in third-decisions between ‘operate’, ‘do not operate’ and ‘don’t know’ in:

- physical demand (p=.040)
- frustration (p=.040)

There was a statistically significant difference in fourth-decisions between ‘operate’ and ‘do not operate’ in:

- mental demand (p=.040)

4.5.4.3. Circadian Preferences

The median global MEQ score was 54, indicative of ‘intermediate types’ (Horne and Östberg, 1976). Scores for the summative component scores are demonstrated in *Table 4.17.*

Table 4.17. MEQ characteristics with median and quartiles

Variable	Median	Interquartile
Get Up	4	(3-4)
Go To Bed	3	(3-4)
Alarm Clock	2	(1-3)
Easy Get Up	3	(2-3)
Alert Half Hour After Waking	3	(1-3)
Appetite Morning	2	(1-3)
Tired Morning	2	(1-2)
Time Go To Bed No Commitment	2	(1-2)
Exercise Morning	3	(2-3)
Time Evening Feel Tired	4	(3-5)
Peak Performance	4	h4-6)
Tiredness At 11PM	3	(2-3)
Gone Bed Late Rise Time Next Morning	1	(1-3)
Remain Wake 4AM What To Do	2	(1-3)
Hard Physical Work Best Time	3	(3-4)
Physical Exercise 10AM	3	(2-4)
Chosen Work Hours Consecutive	3	(3-4)
Time Feel Best Peak	3	(3-3)
Morning Evening Type	4	(2-6)
Global Score	**54**	**(39-68)**

4.5.4.4. *Cognitive Load*

Scores for the NASA-TLX of the scenario at 10 a.m. and 1 a.m. are presented in *Figure 4.19*.

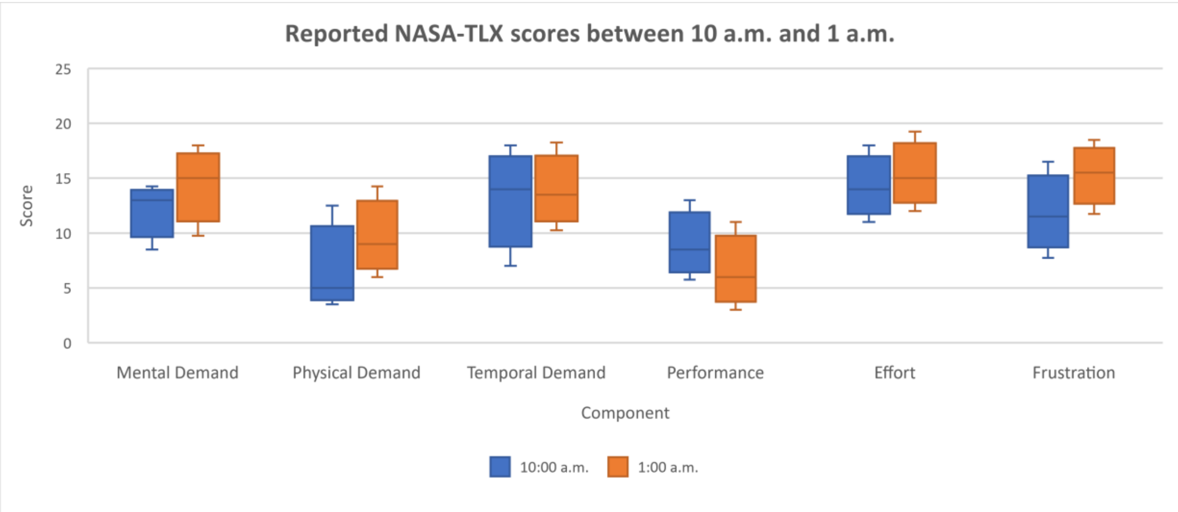


Figure 4.19. Difference in NASA-TLX reporting between 10 a.m. and 1 a.m. reporting showing predominantly increased loads at 1 a.m.

There was statistically significant differences in NASA-TLX scores between 10 a.m. and 1 a.m. in:

- mental demand (p=.042)
- physical demand (p=.041)
- temporal demand (p=.032)
- performance (p=.018)
- effort (p=.046)
- frustration (p=.012)

4.5.4.5. Alertness

The median global KSS score was 6.5 (2.75-7.25). There was a statistically significantly higher self-reported mental-demand on the NASA-TLX in the sleep group compared to the non-sleepy group (p=.038), seen in *Figure 4.20*.

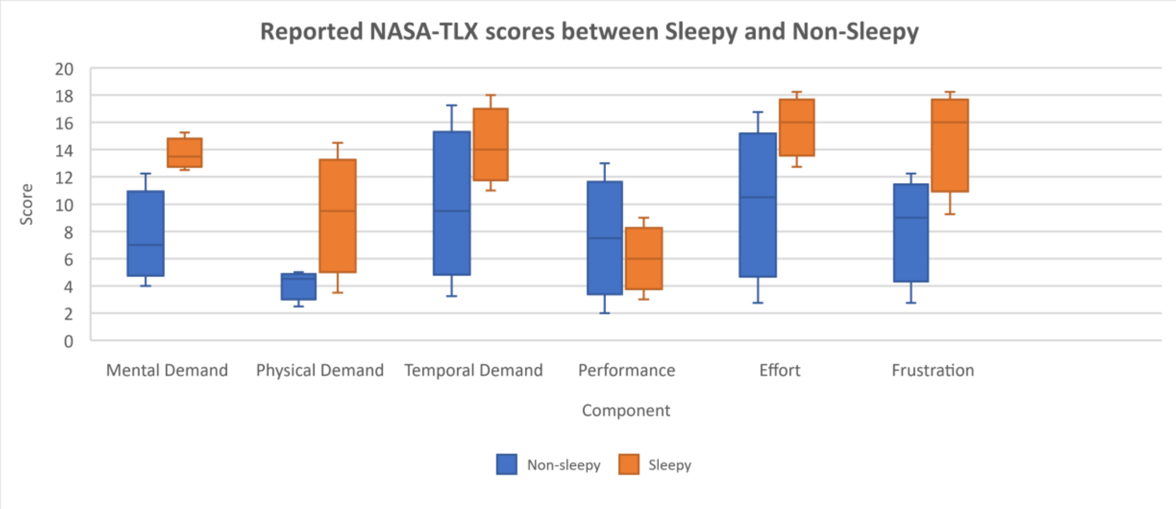


Figure 4.20. Difference in NASA-TLX reporting between sleepy and non-sleepy groups showing predominantly increased loads in the sleepy group

There was a statistically significant difference in fourth decision-making in the simulated scenario between the non-sleepy and sleepy groups (p=.010), seen in *Figure 4.21,* with greater reporting of 'not operating' in the non-sleepy group.

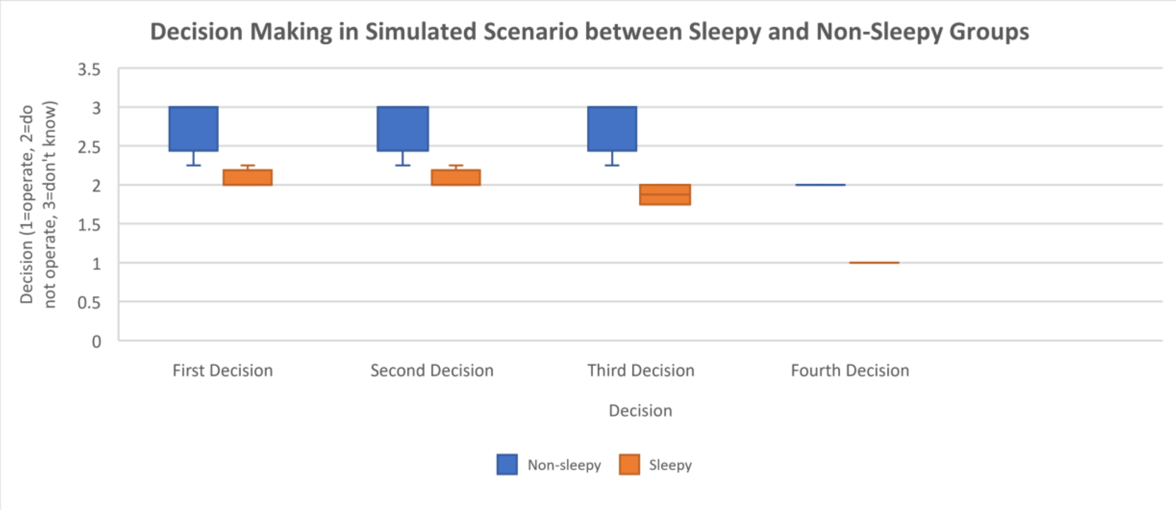


Figure 4.21. Difference in sleepy and non-sleepy groups reporting for each decision showing decision to 'operate' in the sleepy group and 'do not operate' in the non-sleepy group for the fourth decision

4.5.5. Discussion

The study demonstrates significant differences in cognitive load levels between clinical decisions, with higher loads reported in those making premature choices and those choosing to operate. This supports the hypothesis that fatigued surgeons are more likely to use heuristics and intuition ineffectively.

Higher levels of mental and affective demands, as well as sleepiness were reported in surgeons who made premature decisions, such as 'do not operate', and the incorrect conclusion of 'operate'. Even though there was three options available, those reporting higher-load suggest a dichotomy of 'operate' or 'do not operate' mental models. Three reasons could explain this. The previous findings of this chapter established that surgeons can primarily weigh decisions through a biomedical and personal perspectives, and this could have been influential. One study found that surgeons find it difficult to opt for non-operative treatment in high-stake scenarios, even if they know it is in the patient's best interests (Nabozny et al., 2016), suggesting the influence of personal affective processes (Croskerry, 2010). Secondly, surgeons may be deterred from choosing the 'don't know' option for fear of being viewed as incompetent. Finally, it is likely fatigue could play an influential role. Surgeons perceive themselves to perform worse when experiencing higher cognitive load (Lowndes et al., 2020). Working memory models posit that, the central executive will direct and suppress information it deems relevant when complex tasks are ongoing (Baddeley and Hitch, 2001). In fatigued states however, such as on-call or end of the work day, such prioritisation is negatively impacted. This suggests that decision-making in fatigued surgeons may show greater variability from non-fatigued states. This is supported by research which found increased impulsivity in post-call residents (Choshen-Hillel et al., 2021), and the decreased likelihood (33%) of scheduling operations at the end of the work-day, irrespective of patient needs (Persson et al., 2019).

The same ideas apply to surgeons who reported higher levels of sleepiness. Vigilant attention was impaired by sleep deprivation, which may make it more difficult for a surgeon to be able to identify salient and relevant aspects of the presenting condition to guide their management plans. In addition, cognitive load increases in sleep deprived states, as seen through the hypothesised increased reporting of NASTA-TLX scores in an on-call setting. The only reduction in scores in 1 a.m. scoring was a slight decrease in temporal demand, which reflects perception of time pressure. This may be because the night-shift work is slower-paced, or that there is fewer personnel available, leading to a perceived level of non-urgency compared to day-care. While these reports don't provide an objectivity of on-call performance, they do provide insight into how surgeons perceive self-cognitive and affective performance in sleep disturbed conditions. While this is a hypothetical situation, individuals are likely to perceive greater levels of extraneous load in a real-life situation (Sweller and Chandler, 1991). In this instance, individuals may experience even greater loads of cognitive load. Exploration of the genetic predisposition to time of alertness provided interesting insights. It was hypothesised that surgeons nature would be that of 'morning larks' but the findings of the MEQ (Horne and Östberg, 1976) places them in the 'intermediate' cohort. This would suggest that surgeons should typically go to sleep between 10:45 pm – 12:45 am and wake with peak alertness between 6:30 – 8:30 am. If surgeons are regularly completing on-call work, and are working outside these times of peak alertness for high-demand tasks, this could have negative implications for cognitive load.

The final study is novel, informed by a narrative and two observational preceding studies, exploring cognitive load impact on decision making outcomes in a realistic surgical scenario. Consideration for additional objective measurements of cognitive load, such as task-invoked pupillary responses, which has been found to be sensitive to cognitive load may also be useful (Granholm et al., 1996), as well as real-life practice which incorporates additional extraneous stressors. This study was unique in exploring variables such as sleep and circadian rhythm. Further consideration should be given as to the potential role of fatigue on impacting aspects of executive functioning. In this study, it was demonstrated that there was likely impacts on attentional control, but higher-order functions developed in training may assist in mitigating these executive decrements. Training surgeons through deliberate practice in fatigued states could assist in developing 'schemas' (Sweller and Chandler, 1991) to produce greater levels of homogeneity of appropriate decision-making outcomes. This can be complimented through training in reflective practice so as to develop metacognition, and introspection. Introspection, defined as a higher-order process with conscious experience as its object, is used to explore relationships between thoughts and feelings that the individual is currently feeling (Overgaard and Sandberg, 2012). This may assist in identifying and mitigating fatigue.

While exploring surgeons intuition is important, reliance on it alone may not reflect real-life decision outcomes. A review of the literature finds four types of intra-operative decision-strategies - rule-based, intuitive, option comparison and creative (Flin et al., 2007). While the first two of these refer to dual-process (Tversky and Kahneman, 1974) and fast-and-frugal approaches (Gigerenzer, 2007), little understanding on the latter two, and how they might be impacted by fatigue, exists in the surgical literature. Identifying the critical points within a clinical scenario when dysrationalia override should occur, and surgeons switch from an intuitive mode of thinking to an analytical mode of thinking is an important area of future research. A grounded theory study explored the 'slowing down' phenomenon in surgery to identify how surgeons minimise error-making. They state that 'drifting' is to be avoided as this reflects a failure to transition from intuitive to analytical modes in appropriate contexts (Moulton et al., 2010). They also discuss the manifestations of 'stopping', whereby surgeons switched modes of thinking by taking a break from the procedure. The effects of fatigue on these 'slowing down' phenomena warrants further exploration, particularly in contexts which have not been as traditionally explored in surgery such as non-operative settings.

It is finally important to recognise also that cognitive firewalls (Croskerry, 2003), such as standardized approaches, have improved patient outcomes. Surgical safety checklists saw a reduction in rate of death in surgery from 1.5% to 0.8% as well as reduction in postoperative complications from 11% to 7% (Haynes et al., 2009). Technology, through the use of digital clinical decision aids, may be useful as a debiasing technique (Croskerry, 2003), when in conjunction with developing metacognition, to mitigate risk factors for performance decrement which are modifiable. Finally, shared decision-making approaches have been shown to improve patient-centred outcomes (Boss et al., 2016) and while this chapter demonstrates that patient factors don't typically determine clinical decisions, they may be playing an increasingly important role relative to the past.

4.5.6. Limitations

A performance assessment by surgical and human-factor experts was planned for the study using the validated assessment tool from the previous study but resources and time-restrictions of the assessors precluded this opportunity. This applied to the fidelity of the scenario also, which didn't incorporate the use of an actor, due to COVID-19 public health restrictions. Less extraneous load was placed on individuals compared to the previous simulated scenario in *Chapter 4,* apart from a timed-response to make decisions to evoke intuitive decision-making. This is similarly the case for the reporting of increased cognitive load at 1 a.m., which may represent a participant bias, and thus should be considered as an evidence building result as opposed to definitive finding. Greater understanding of the impact of fatigue on other aspects of cognitive performance is warranted. This thesis explored only two aspects – vigilance in *Chapter 3* and, to a degree, intuitive decision-making in *Chapter 4*.

4.6. CONCLUSION

This chapter provides an overview of decision-making models, the variables determining directions of decision-making outcomes, the incongruencies between perceived and actual decision-making, as well as the confounding role of fatigue on clinical decision-making as an aspect of cognitive performance. There is supporting evidence to the hypothesis that surgeons reporting higher cognitive load demands differ in how they make decisions by potential use of ineffective heuristics to guide intuitive decision-making processes. Sleepiness, associated with sleep deprivation, increases levels of cognitive load. Similarly, self-reported performance decrement, coupled with increased cognitive and affective demands, supports the hypothesis that fatigue negatively impacted surgical performance. This was further exacerbated by perceived on-call associated work. It was evident that there was variability between levels of fatigue, and an understanding of the phenomena of fatigue, including its causes, effects and mitigators within individual surgeons is necessitated to further understand potential interventions to optimise performance.

5. Chapter 5 - Qualitative exploration into phenomena of fatigue in surgery

5.1. BACKGROUND

This research has established thus far that fatigue, alongside associated sleepiness, exists in surgery. The increase in associated cognitive load showed decrements in technical and cognitive performance domains. The psychology of fatigue theorises fatigue as an emotional subjective state (Hockey, 2013, p.102). Understanding the phenomena of fatigue is best explored through qualitative exploration. Differentiation between sleepiness and fatigue, as discussed previously, is important as they may have different impacts on performance and be best mitigated by different strategies. By identifying the individual stressors to fatigue levels, tailored approaches to better optimise performance can be established.

This chapter has two elements summarised in *Figure 5.1*. It explores the various aspects of the construct of fatigue as determined by the profession including its impact, causes, and effects, while also having a focused analysis of the impact of the first-wave of the COVID-19 pandemic on the profession from the perspective of fatigue, wellbeing, and performance outcomes.

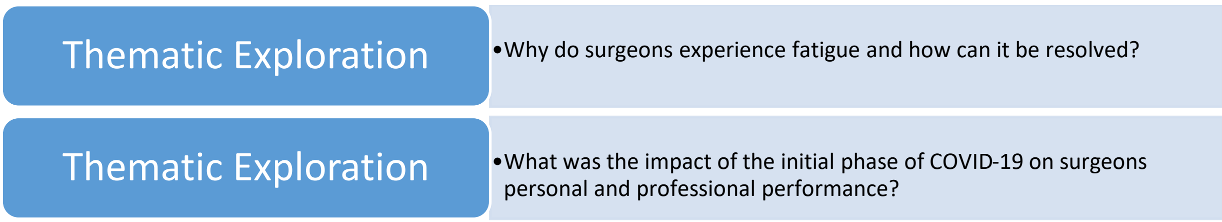


Figure 5.1. Elements of Chapter 5

5.2. THEMATIC EXPLORATION OF FATIGUE IN SURGERY

5.2.1. Research Question

Why do surgeons experience fatigue and how can it be resolved?

5.2.2. Objectives

1. To identify causes of fatigue in surgery
2. To explore effects of fatigue on surgical performance
3. To list mitigators to tackle fatigue
4. To explore acceptability of evidence-based fatigue mitigators

5.2.3. Methods

The research was conducted in accordance with the gold standard Consolidated criteria for reporting qualitative research (COREQ) checklist (Tong et al., 2007).

5.2.3.1. Study Design

This was a single-site qualitative study design using an interpretive, iterative, and then deductive thematic analysis approach (Clarke et al., 2015). Semi-structured, individual interviews were conducted through socially-distanced interviewing or online. Core set questions evolved as interviews progressed in a process called reflexivity, which is a metric of rigour in qualitative research. Reflexivity is described as "an attitude of attending systematically to the context of knowledge construction, especially to the effect of the researcher, at every step of the research process" (Malterud, 2001). The process of reflection on interviews throughout enabled reflexivity of the direction of questioning for subsequent interviews.

The study was approached through initial inductive followed by deductive reasoning. The data was interpreted in two ways:

1. An ontological relativism and epistemological interpretivism; to better understand fatigue in surgery, recognising it to be a subjective experience
2. An ontological realism and epistemological positivism; to use the findings as supporting data for an evidence based intervention in *Chapter 7*

5.2.3.2. Participants

Participants were recruited between February 2020 – May 2020. A similar process of recruitment to *Chapter 3* was employed with an invitation to participate (*Appendix U*), a participant information letter (*Appendix V*), and reminder email. A convenience, followed by purposive sampling strategy was employed to inform theoretical gaps. Data collection was ceased when the research team felt sufficient data was reached on a rolling analysis, and no new codes emerged, which supported the concept of twelve interviews for saturation (Guest et al., 2006). The same inclusion and exclusion criteria to the last study of *Chapter 4* were employed.

5.2.3.3. Study Instruments

Interview Guide: An interview guide (*Appendix W*) was devised based on the objectives of the study, and with collaboration from an expert in qualitative fatigue research (Dr. Taryn Taylor, London, Ontario) to improve accessibility. The questions focused on three main areas in the context of fatigue: 1) influencers 2) impacts and 3) mitigators.

5.2.3.4. Qualitative Analysis

The interviews were audio recorded and transcribed verbatim. NVIVO© (Version 1.1 QSR International Victoria, Australia) was used to support data analysis. Thematic analysis was used, as it is a reflexive analytical approach which aligns with both philosophical approaches employed (Clarke et al., 2015). An additional research team member Dr. Daniel Brown (Portsmouth, United Kingdom), assisted in building qualitative analytical capacity through methodology meetings. This included verifying interpretations by the researcher to reduce limitations of the method of member checking (i.e. ensuring credibility). Theme is defined as patterns within the data with shared meaning across different interviews and underpinned by the central concept (Braun and Clarke, 2019), which in this case was fatigue. The six-phase approach to data analysis (Clarke et al., 2015) is elaborated in *Figure 5.2.*

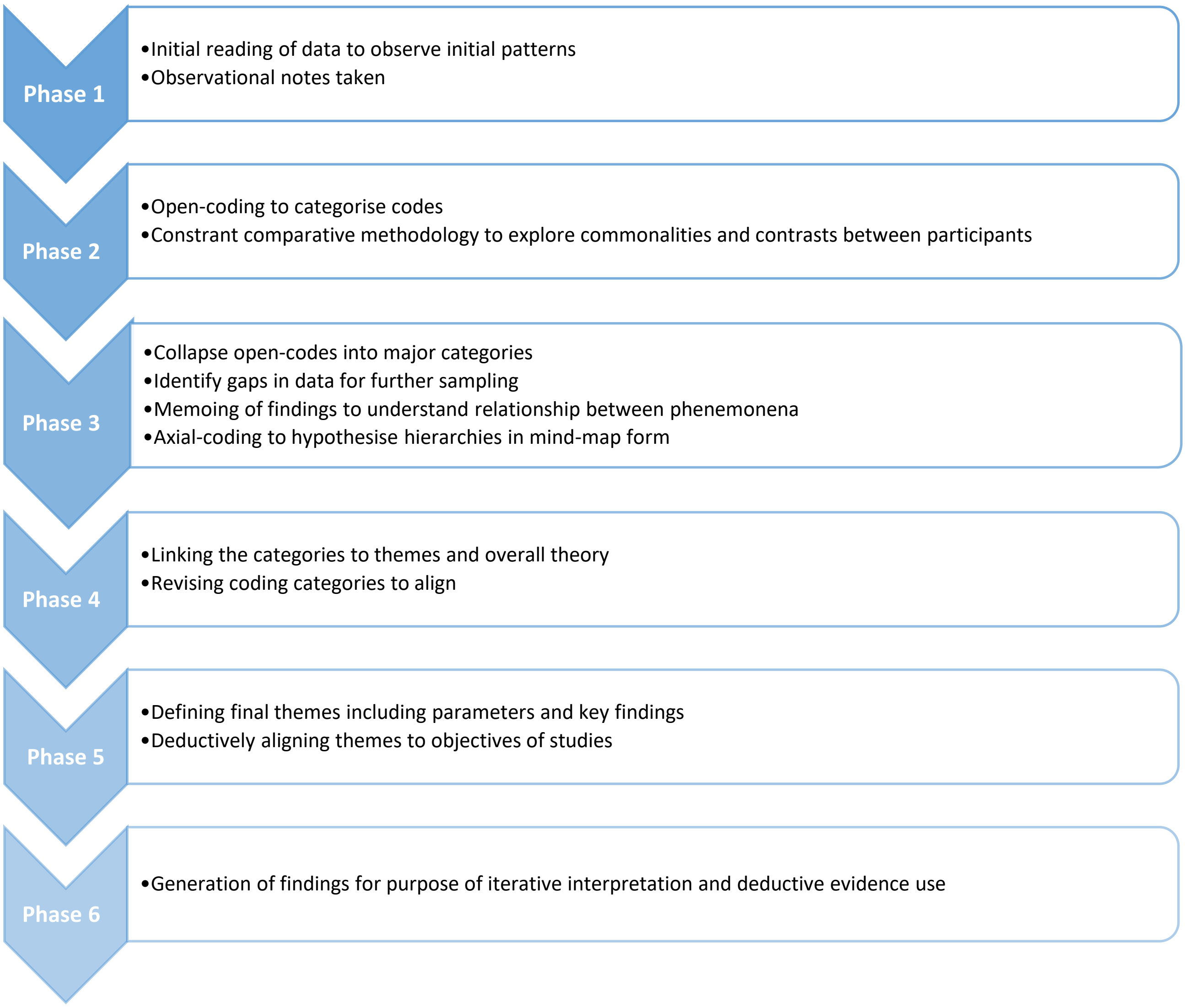


Figure 5.2. Adaption of six-phase approach for thematic analysis (Clarke et al., 2015)

Quality control measures were employed to ensure rigor (Smith and McGannon, 2018) and trustworthiness of the study. This reduces the risk of researcher bias dominating the findings. The four metrics used (Lincoln and Guba, 1985) are discussed in *Table 5.1*.

Table 5.1. Quality control measures employed to ensure rigor and trustworthiness informed by established metrics (Lincoln and Guba, 1985)

Quality Measure	Definition	Actions employed
Credibility	The correct interpretation of the data to ensure accurate representation	➢ Prolonged engagement with participants (>50 minute interviews + other studies) ➢ Triangulation of findings with other studies ➢ Reflection of high-level findings with independent surgeon to provide modified synthesis member checking approach (Birt et al., 2016)
Confirmability	The strategies employed to ensure objectivity and reduce researcher bias	➢ Memo-writing to identify personal biases and explicit disclosure of how perspectives informed research direction (Charmaz, 2014, p.72) ➢ 'Critical friend' (Foulger, 2009) meetings with expert in the field to improve qualitative research skills ➢ Confidentiality and disclosures discussed with participants throughout (Miles and Huberman, 1994 p. 292)
Dependability	The reliability of the data findings	➢ An inquiry audit for detailing changes in coding interpretation ➢ 'Critical friend' who provided alternative interpretations of coded extracts
Transferability	The generalisation that can be extended	➢ Linking quantitative and qualitative findings ➢ Exploring findings in context of established theories ➢ Sampling strategy to ensure diverse engagement

.

Disclosure of research members orientations to the analysis are important to improve transparency in qualitative research. The orientation of the researcher is from the perspectives of behaviour sciences and lifestyle medicine, having worked with surgeons in his capacity as a researcher and physiotherapist. His epistemological leaning is towards post-positivism. The orientation of the supervisor (Prof. Paul Ridgway), has been informed by his experience as director of perioperative care in the hospital to which his offices directive is in enabling personal and professional modifiable changes which can better support surgical staff to provide optimal patient care. His epistemological leaning is towards positivism. The orientation of the fatigue expert (Dr. Taryn Taylor) has been informed by her personal experiences as an obstetrician and gynaecology consultant, and research orientations from qualitative grounded theory. Her epistemological leaning is towards constructivism. The orientation of the methodology expert (Dr. Daniel Brown) has been informed by his research expertise working on thriving states in high performance elite sport industries, having used a thematic analytical approach. His epistemological leaning is towards constructivism.

5.2.4. Results

5.2.4.1. Demographic

A total of 14 surgical trainees and consultants were recruited, all of whom participated in the final study from *Chapter 4*.

5.2.4.2. Fatigue and Sleep Deprivation Influencers

Comparisons of the different influencing factors of higher fatigue and sleep deprivation are provided in *Table 5.2.* There are commonalities in the influencing factors between both fatigue and sleep deprivation, as determined by requisites of *"adapting to the system to become an excellent surgeon"(P5)*. It was identified that often the combination of sleep and non-sleep stressors blurs the line between identifying what is primarily influencing subjective fatigue - *"really busy, over extended and tired makes it all seem like a blur of causes I can't escape from"(P11).* As a result, there is general acceptance of the ambiguity - "*yes I might be fatigued or tired at this stage [and] accept those realities or facts"(P5).* Uniquely, there were a significant amount more personal and work factors that contributed to the fatigued state.

Table 5.2. Influencing factors for fatigue and sleep deprivation

	Fatigue	Sleep Deprivation
Hours of work	• Staying up the day after on-call • Long weekend shifts • Working long days off-call	• Staying up the day after on-call • Sleeping less on-call • Sleeping in the hospital • Not getting to repay 'sleep debt'
Cultural	• Not prioritising rest • Functioning on sleep deprivation • Cult of personality of 'tired surgeon'	• Not prioritising sleep • Functioning on sleep deprivation • Sacrificing sleep for work • Profession-induced insomnia
Specialty	• Patient needs and caseload • Culture of wellbeing • Variation in work	• Patient needs and caseload
Training	• Rest strategies differ in training level	• Sleep strategies differ in training level
Personal	• Ageing • Family • Sleep habits • Commuting • Mental Health • Poor diet • Poor exercise levels	• Ageing • Family • Poor sleep habits
Work Structures	• Inefficient processes and systems • Low resource availability • Low supportive structures or networks • Low job autonomy • Low job security • Low respect for work-life balance • COVID-19 • Physical ergonomics	

5.2.4.3. Impact on Performance

Comparisons of the different impacts on performance are provided in *Table 5.3*. When asked which tasks they preferred to avoid when fatigued, irrespective of whether it was sleep-related, there was unanimous agreement that cognitively demanding performance tasks, such as clinics and administrative clinics, were to be avoided for both personal - *"adds a cognitive load to my day that I don't unnecessarily need"(P34),* and patient interests – *"not going to make good decisions for the patient"(P11).*

There was less agreement on technical performance tasks with some citing they don't like to be fatigued in theatre for personal - *"we are still learning and need to take that all in – so we don't like doing call before theatre"(P4),* and patient interests - *"I would avoid technical procedures as much as possible…I'm more liable to make a mistake and that would adversely impact the patient"(P30).* Interestingly, others found this setting more appropriate for fatigued states because it increases energy - *"you are really switched on you get a good adrenaline rush"(P18),* and is intuitive for more experienced staff – "*automatic muscle based procedure…fall into heuristics and the pattern recognition"(P11).*

There was an appreciation that the perfect storm of personal and environmental stressors could impact patient safety - *"there was a pitch battle going on in the ward outside – people were throwing chairs up and down, and I ended up giving the patient 25,000 units of heparin"(P11).* Such stressors, including repetition, complex decision-making, time pressure, low resources, and poor social supports increased cognitive load and made perceptions of tasks to be more difficult. This culminates towards decrements of affective regulation - *"I find when I'm tired I'm a bit more emotional in the sense that my emotions are a lot more to the surface…anger comes out a lot sooner…sadness or feeling overwhelmed also"(P2),* which had a larger effect on non-technical performance skills such as teamwork, communication, and management.

The link between performance decrement and impact on patient care was less established. While some stated fatigue could impact to the extent of increasing patient morality particularly when overworked - *"we had about 40 patients…and we had about 14 patient deaths, which I know was because I was the only one there"(P2)*; a portion of surgeons felt their moral obligations meant avoidable patient care impact never occurred - *"everyone has their own limits that they push, but in the end it comes to patient care, all of us are the same, all of us try our best to make the right decisions at the right time for the patient"(P5).* When exploring these understandings with other surgeons, some identified that there can be a few reasons for this including:

- Overestimation of ability when tired – *"I think a lot of people overestimate their abilities [when fatigued]"(P30)*
- A lack of insight into the relationship between sleep and performance - *"there is an underestimation and underappreciation of the limits from sleep deprivation"(P30)*
- An inflated ego – *"people don't like to acknowledge fatigue…surgeons think we are able to push through the tiredness and sustain performance"(P34)*

- Cultural expectations within teams – *"I would be seen as not being able to do this [surgery]"(P34)*
- A lack of foresight – *"you need you have cognition of the longer term effects, this is a short term thing like a 3 hour surgery, but the longer term mistake is your career, a lot of surgeons don't think that way"(P30)*

Table 5.3. Impacts of fatigue on performance and patient care

Technical	Cognitive	Affective	Patient Care
• ↓situational awareness • ↓dexterity • ↑reaction time • ↑self-injury	• ↓situational awareness • ↓information processing • ↓attention • ↓error-recognition • ↓information recall • ↑intuition • ↑somnolence • ↑dissonance	• ↓introception • ↓collegiality • ↓communication • ↓motivation • ↓patience • ↓leadership • ↑emotional lability • ↑cynicism	• ↓patient experience • ↓comprehensive assessment • ↓documentation • ↓input to discharge planning • ↓engagement with prolonged-stayers • ↓patient education • ↓interactions with family • ↓MDT communication • ↓progress of care • ↑paternalism • ↑surgery time • ↑ complications • ↑patient death

5.2.4.4. Mitigating impact of fatigue on performance

Comparisons of the different strategies used to mitigate fatigues impact on performance are provided in *Table 5.4*. Participants identified several personal mitigators for aspects of technical and cognitive performance, but relied more heavily on team factors for decision-making, and to mitigate affective issues. Despite acknowledgement of personal fatigue, there was perceptions of fatigue, irrespective of cause, not impacting patient care due to team – "*the consultant gets more rest…which is important as they make the ultimate decisions"(P31),* and institutional safeguards - *"there are nursing staff and you know there is a pharmacist and a physiotherapist, there are so many people who can look at it you know [to prevent error]"(P18).*

Table 5.4. Mitigators of fatigue impacting on performance and patient care

Mitigator	Technical	Cognitive	Affective	Patient Care
Personal	• Slow down • Increase vigilance • Push through • Learning curve • Experience • Adrenaline • Keep active • Food and water • Sleep • Chew gum	• Slow down • Increase vigilance • Push through • Fresh air • Regular breaks • Prioritise work • Write down tasks • Caffeine • Shower	• Cognitive appraisal • Spirituality • Fresh air	• Philosophy of 'do no harm'
Team	• Team support	• Someone double-checks • Standardised communications • Relying on non-sleep deprived staff • Shared decision-making	• Cover call • Collegiality • Caring manager	• More rest for critical decision-makers • Rested colleagues get consent • Rested colleagues write prescription
Institution	• Shift-swapping • Cancelling electives	• Shift-swapping • Safety-checks	• Annual leave	• Safety-checks • MDT perspective

5.2.4.5. Interventions to mitigate fatigue

Comparisons of the different intervention approaches to mitigate fatigue in surgery are provided in *Table 5.5*. The interventions were largely identified as beneficial, including how positive cultures, stress management, effective rest, and sleep could benefit patient care. Three barriers to making change in behaviours which could mitigate fatigue exist. The first is the closed culture within surgery, and the difficulty in making individual change without support from surgical peers – *"if you feel like you're going judged negatively"(P11).* The second is resourcing, and the difficulty in implementing any intervention when significant work pressures are placed on surgeons which they can't ignore – "*we simply do not have the physical capacity or the human resources to change anything major"(P34).* The final barrier is personal inertia to making any changes - "*you can lead a horse to water but you can't make it drink. You could put out all those things but it doesn't mean people would actually avail of them"(P11).*

Identified facilitators of effective interventions involved leadership from senior staff - *"they're meant to be your mentor in all respects, and fatigue and performance comes into that"(P30),* and structural changes within the organisation which can remove environmental impediments – *"I think if there was like even breaks being protected. We're paid for our breaks which means we're supposed to be available for an emergency…that constant leaping and answering phonecalls is a fatigue within itself"(P11).* The pandemic "*brought seismic opportunity and shift in how we work"(P34),* which could suggest it to be an opportunistic time to make significant changes to individuals perceptions and cultures.

Table 5.5. Perceptions on potential interventions to mitigate fatigue

	Culture	Sleep and Rest	Stress	Diet	Exercise
Barrier	**Professional** • Gender • Closed culture • Personality **Personal** • Inertia • Fear of judgement	**Institutional** • Low physical and human resources • Service delivery requirements • Autonomy • Medicolegal issues • Impacts continuity of care • Inefficient systems • Compliancy culture • Fatigue not on risk register • Expectations of profession **Professional** • Training needs • Emphasis on technical skill • Personality • No other interests • Culture • Unpredictable work **Personal** • Inertia • Self-discipline	**Institutional** • High workload **Personal** • Inertia • Anxiety on-call • Rumination	**Institutional** • Facilities access • On-call work **Personal** • Inconsistent eating • Religion • Delivery deals	**Professional** • No off-time **Personal** • Inertia • Poor self-management

Facilitator	**Professional** • Psychological safety • Senior modelling and leadership • Mentorship on self-management	**Institutional** • Increased human and physical resources • Increase lifestyle facilities • In-house training • Policies • Proactive rota design • Compliancy to wellbeing culture • Autonomy in work • Reduce penalties • Comprehensive reporting systems **Professional** • Start with interns • Engagement from senior levels • Objective measurement • Team-based • COVID-19	**Personal** • Sleep hygiene • Exercise • Social life • Gaining insights • Self-compassion	**Personal** • Supportive home • Education • Healthy options • Preparing food	**Professional** • Facilities on-site • Identifying spare-time **Personal** • Education • Value systems
Benefit	**Professional** • Positive culture	**Personal** • Better management • Effective resting • Prioritise wellbeing • Better work-life **Organisational** • Reduces error-risk • Benefits patient care • Provides system approach • Compliancy with EWTD • Work efficiency	**Personal** • Reduced anxiety • Better sleep	**Personal** • Better sleep	**Professional** • Improves collegiality • Positive culture **Personal** • Reduced anxiety • Facilitates work-life • Better sleep

5.2.5. Discussion

The analysis supports the theory of fatigue being a subjective experience, which differs in causes amongst surgeons, and is often blurred in understanding with sleep deprivation. Influenced heavily by sleep states, it is exacerbated by environmental factors such as culture, and work structures. An abundance of strategies are utilised, but it appears there is a consistent discord between opportunity to recover, capability to rest, and motivation to enable effective sustainable behaviour changes to mitigate fatigue. Perceived non-impact on patient care and cultural issues could lead to internalised states of inertia towards fatigue management.

One of the most significant aspects of fatigue in surgery is the regularity in which it is reported and the varied identified causes and effects. The analogy of a perfect storm summarises the sentiment of fatigued states in surgery, while reflecting the theoretical assumptions of fatigue resulting from internal mental processes competing for attentional control (Hockey, 2013, p.107). Theories of fatigue hypothesise the state is more likely to occur in situations where there is perceived external locus of control, rapid successive tasks, and high effort exertion to maintain goals despite environmental distractions (Hockey, 2013, p.34). One of the influencing factors, 'hours of work', was identified, with some discussing the difficulty in mitigating fatigue when they are working during typical times of rest i.e. during the weekend or during the night. In on-call settings, additional cognitive loads, such as covering non-surgical specialties, and less social support, is present which depletes mental resources further. Significant work-demands leaves many without the opportunity to take a break, thus not allowing fulfilling of basic physiological or psychological needs, which ultimately culminates in a 'strain' state characterised by high effort and fatigue (Hockey, 2013, p.123). Work structures was identified as a unique cause of fatigue. In particular, work structures made it difficult for some to establish personal work-life boundaries which impedes opportunities for recovery states. This relates closely to organisational theories such as the demand-control-support (DCS) model (Karasek, 1979). Both a sense of autonomy and feelings of connection to others could buffer the effects of fatigue, but if surgeons perceive little control in how they work, in conjunction with low co-worker support, it is likely the demands of the profession significantly increases fatigue states.

Reference to sleep deprivation as a cause of fatigue was identified by participants throughout, complimenting the previous findings on sleep being a considerable influencer of fatigue in surgery. As previously discussed, the lines between sleepiness and fatigue have been historically blurred. While environmental factors reduced opportunities to maintain a consistent sleep pattern, there was internalised assumptions within the profession that surgeons adapt an immunity to the effects of sleep deprivation. Such in-group ethnocentric perceptions are likely to feed into the cultural milieu, determined in the first instance by Halstedian training (Hughes, 1974), of the necessity to conform to unrealistic physiological adaptions in order to progress through surgical training. These include the sleep habits of being able to "*'sleep well and quickly in any location"(P15),* and beliefs that *"surgeons are morning people"(P34).* On the other hand, incongruencies between surgeons intuitions of biological adaptions from work and objective metrics of sleep exist. Findings from previous chapters indicate early-onset sleep latency in surgeons resulting from the sleep-deprived state, as well as the MEQ finding that refuted the idea of surgeons being unanimously morning larks. Even cognisant of such findings, cognitive dissonance, described as the unpleasant feeling that occurs when an individual has two or more inconsistent cognitions (Festinger, 1957), is likely prevalent for surgeons in their understanding of fatigue and performance. The greater efforts needed by surgeons to pursue their training, irrespective of the environmental, the greater the motivation to continue without changing personal strategies. This is further perpetuated by extrinsic cultural rewards which support current maladaptive performance methods. Distortion of personal choices will reduce the cognitive dissonance between work demands and personal desires, thus leading to over-rationalisation of behaviours which are not optimising performance.

Social variables, such as family responsibilities and ageing, were identified by some participants, and place significant demands on the personal lives of individual surgeons. Research suggests that early-parenthood disproportionally affects sleep quality and performance in women (Insana et al., 2013), and that negative cultures towards pregnancy exist in the profession (Turner et al., 2012), thus contributing to a disparity between genders regarding opportunities for fatigue mitigation (Lim et al., 2021). In addition, older surgeons in this study reported increased difficulty in recovering from on-call work, suggesting the need to evaluate on-call work through the lens of biomathematical modelling. Biomathematical modelling has been shown to predict alertness (Kostreva et al., 2002), and predicted high levels of risk associated with fatigue in healthcare calculating risks (Cumber and Greig, 2019). This would be supported by a qualitative study that found surgeons find reduced opportunities to recover from post-call states (Taylor et al., 2013). Many reported having to make a trade-off between improving physiological depletions through sleep recovery, or improving psychological depletion through engaging in non-work activities.

Fatigue was reported to impact on cognition and affect to a greater extent than technical performance. The implications of this meant, that while aspects of non-technical work could decrement in fatigued states, patient safety in surgery was preserved. The perception of non-technical work being more fatiguing reflects theoretical assumptions that fatigue can result from states of motivational demands (Hockey, 2013, p.10). Surgeons may employ additional executive control strategies in surgical procedures as they place greater value on this aspect of work and thus increased motivation allows increased processing of information and reduced cognitive load. This study found that surgical procedures activated an *"adrenaline rush"(P18)*, particularly in high-stakes scenarios. This draws parallels to descriptions of the 'flow state' (Csikszentmihalyi, 1990) of optimal performance which will be discussed further on. Alternatively, the complex interaction between increasing levels of sleep-associated fatigue could be offset by an upswing in the circadian rhythm which could improve alertness toward the end of on-call associated shifts (Bórbély et al., 2016), and further research is warranted to truly understand how this subjective experience correlates to real-life performance outcomes. Exacerbating fatigue factors however, such as 'intricate surgeries' and 'longer laparoscopic procedures', can reflect the 'strain state' which is characterised by high effort and fatigue (Hockey 2013, p.123). Both flow and strain states are prone to after-effects (Hockey, 2013, p.66), and thus reducing the number of operations within a day to reduce likelihood of delayed-onset fatigue may be warranted, particularly if complex cases are present. In cases where technical skill was perceived to be impacted, it was primarily in tasks which involved cognitive aspects such as reaction time. This would support previous findings in this thesis that fatigued states reduce an individual's vigilance. Interestingly, situational-awareness was also identified as being negatively impacted. The implications of this means surgeons may have decreased conscious recognition of external cues, such as time and support staff. This mirrors non-theatre settings, whereby additional decrements including attentiveness, memory-recall, logical decision-making, and time management were present, which could reduce efficiency of practice.

Whether the fatigue state actually negatively impacts performance is dependent on the transition from the 'strain' state to 'disengagement' state (Hockey, 2013, p.197) due to a mismatch between high environmental demands and personal reduced processing capacity (Wickens, 1991). Surgeons discussed situations where there are similar task demands in rapid succession (i.e. Phase 1 known as 'habituation state'). These situations require an increase in effort (i.e. Phase 2 known as 'strain state') for effortful resistance of attentional focus from environmental demands. In situations which are personally motivating to the surgeon, typically involving technical skill, surgeons are then more likely to sustain this strain (i.e. Phase 3a known as the 'flow state') and maintain performance; whereas in situations where surgeons are not motivated, typically involving non-technical skill or situations of perceived non-autonomy or low resources, surgeons may withdraw effort due to a strategic decision that the effort required does not justify the low-reward (i.e. Phase 3b known as the 'disengagement state'). In the disengagement state, surgeons will operate functions at a suboptimal level. In addition, low physical and human resources were identified by all participants as a cause of fatigue, and while information processing capacity can be increased through engagement in highly-motivating tasks i.e. the flow state, the significant buffering role of sufficient staff is important to allow surgeons the opportunity to recover from high-demand situations effectively. The mismatch is further exacerbated when there is associated sleep deprivation (Baulk et al., 2007), and given the regularity in which surgeons complete on-call work there is fallacy in the belief that current models of work can provide appropriate and sufficient amount of fatigue mitigating opportunities.

There was anomalous conclusions from the participants regarding the translation of performance decrement to patient outcomes. While some participants reported aspects of patient care being impacted, it was felt by many that fatigue in the profession doesn't ultimately translate negatively to patient outcomes. Internalised cognitions from cultural norms of 'do no harm' may contribute to underestimations of self-fallibility from fatigue. The expectation that error is mitigated through a hierarchical system, which involves multi-stakeholder input, may also explain these dissonant perceptions between impacts of fatigue on performance and on patient care. It also highlights understanding of error in surgery, which could be explained by an over-emphasis on error resulting from intra-operative performance, to the neglect of error in other settings. The feedback loop on error-recognition is immediate in the first context, while often imperceptible in the complex multi-input context of the latter. The antipodal argument is that surgeons intuitively are aware of personal errors, but fear retribution for disclosure. One large study of consultants and senior registrars found that major clinical incidents in the workplace are addressed through a culture of blame for the individual involved (Pinto et al., 2013), and thus non-disclosure becomes the default. Further research exploring the link between perceived fatigue and error is necessitated in surgery.

Surgeons employed a series of micro-interventions, and were cognisant of meso and macro-interventions to mitigate the impact of fatigue on performance. Focusing on personal mitigators, the 'slow down' phenomenon, in conjunction with increased vigilance, is often employed as a means to reduce error-making, reflecting a speed-accuracy trade off. Whether such changes in performance are active strategies employed, or are results of an increased cognitive effort associated with the 'strain state' of fatigue, remains unknown. Grounded theory research on surgical expertise describes the 'slow down' phenomenon as a marker of optimising performance in instances of anticipated operation-specific or patient-specific issues (Moulton et al., 2010), though this study's findings provides a counterargument, in that increased cognitive load and associated fatigue may be the primary cause of slowing down in work, irrespective of whether a surgical procedure is perceived as difficult.

Fatigued states acts as a warning signal to surgeons that their current task may be in conflict with their motivational requirements, and that overcommitment to such a task may result in negative impacts on surgical performance. In doing so, the signalling-state increases awareness of neglected personal needs and suggests alternative goals resulting in an appraisal of the benefit-cost of current task demands. Surgeons will typically feel the urge for rest at this point, which allows the opportunity for reappraisal to occur more effectively, and for change in task to occur. Personality factors, not explored in this study, may influence a surgeons decision-making when perceiving a fatigue signal. Some are more likely to preserve cognitive resources by reducing stress associated with high fatigue and high demand situations, while others may increase effort. In the former, cognitive strategies employed in non-theatre settings included delaying decision-making, getting through work quicker, or prioritising workload. The latter approach, categorised by respondent's strategies of 'increasing vigilance' while maintaining task performance, is likely to lead to stronger fatigue after-effects. It is evident that there is no consistent performance management strategies used by surgeons to reduce fatigue impact on performance. Particularly in the case of the latter, prolonged stress responses may be associated with higher levels of error-making. In a large qualitative study design, exploring causes of surgical errors, it was found that there were significantly higher amounts of system failures resulting in error in emergency care situations when compared to non-emergency care (Gawande, 2003), which could mean that performance differs in situations of perceived high stress versus low stress. Positively, taking breaks from tasks can help alleviate fatigue, but transfer to tasks which place similar mental demands may not offer the respite from fatigue as hoped, as similar executive functions are being employed. This means that transferring efforts to mitigate fatigue from learning in the surgical theatre to learning through other means may be futile.

A high reliance on caffeine was identified as a means to mitigate fatigue, supporting previous research (Franke et al., 2015). Caffeine utility is a useful short-term adjunct, but shouldn't be considered the default for fatigue management in surgery as high levels of intake are associated with reduced sleep quality (Clark and Landolt, 2017), and increased neurobiochemical responses (Lane et al., 1990), which could further exacerbate underlying causes of fatigue. The high reliance on stimulants for fatigue management is indicative of the difficulties around capabilities and opportunities for self-regulation of fatigue in surgery. In resource constraint environments where demands exceed information processing capacity, surgeons may resort to use of non-sustainable coping mechanisms.

Acceptability of different interventions to tackle fatigue in surgery were largely positive, with strong interlinks between lifestyle medicine approaches, in conjunction with more systemic environmental changes. There was however barriers for any intervention to overcome. The cultural non-disclosure of fatigue in surgery results in a silent manifestation of its state, further exacerbated by personality differences, insufficient education on performance management, professional expectations of resilience, and individual fears of judgement. The psychological reality of surgeons as a social group can be understood through theories of self-categorisation (Onorato and Turner, 2004). The causes and effects of fatigue discussed by participants were identified as collective experiences for the profession as a whole. There was a sense that the 'social identity' of the surgeon played a more significant role than the 'personal identity' of the individual. This has implications for how individuals have reacted and behaved when confronted with fatigued states. They are more likely to conform to social norms of how their colleagues react, thus reinforcing the stereotypical maladaptive performance strategies previously mentioned. One study exploring principles of fatigue in a cohort of surgical residents identified that there is inconsistent conceptualisations of what fatigue is in the profession, but that there is shared understandings of it being inescapable, better managed through experience, and necessary for future practice (Taylor et al., 2016). Education, followed by establishing psychological safety within departments for fatigue disclosure, was largely welcomed by participants as an important step within the profession to establish a norm of challenging fatigue in a constructive manner. The last barrier is personal inertia to making a change, perhaps due to a feeling of non-necessity, or due to diminished willingness and readiness. In the former, it is possible that the social reality of surgeons has negatively impacted participant's ability to think independently of cultural norms. False self-perceptions that feelings of fatigue are indictive of the requirements to be a surgeon should be challenged at a professional level. Similarly, perceptions of lower error-making, may reflect a level of overconfidence within the profession, with individuals less likely to take personal responsibility for error-making due to ego-defensiveness. One study found that surgeons reported that they were less likely to accept limitations of their own performance due to sleep deprivation (Woodrow et al., 2008). This makes it increasingly difficult to apportion error-mitigation as a personal, as well as a system responsibility. The unwillingness to make change could also be fuelled by a rising litigative healthcare culture and defensive medical practice previously mentioned; while an unreadiness could be due to the significant environmental constraints placed on surgeons which reduces perceived volition, choice and self-regulation (Baumeister and Vohs, 2003).

This study provides a conceptual understanding for the subjective causes, effects, and mitigators of fatigue employed by surgeons. In doing so, it provides understanding of the complex interactions between fatigued states, personal factors and environmental constraints. Future research considerations on fatigue in surgeons should be cognisant of the theoretical underpinnings that it is a subjective state. Nonetheless, there are some areas for future research which have applicability for surgeons as a whole. This study shows individuals may attribute behaviours to the perceived aspects of the context in which they are situated, placing external attribution of cause when in situations of perceived failures. Further exploration of the identified causes of fatigue, and the attribution of those causes may provide insights into how social realities of surgeons experience of fatigue has been constructed.

5.2.6. Limitations

The findings of the study can result in missed pieces of data if the researcher focuses on findings solely through a theoretical vacuum (Clarke et al., 2015). The researcher attempted to explore findings in the context of fatigue theory, motivation theory, as well as social psychological theories to provide a broad conceptualisation of the topic. Inter-coder reliability wasn't used due the time constraints of the research team in the ongoing pandemic to provide prompt and timely coding. Similarly, discourse to support the use of such a metric (Campbell et al., 2013) exists, and so consensus agreement was sought instead. All qualitative research is contextualised to the setting in which the data collection takes place, and this inevitably shapes the research findings, with saturation of the data being recognised as determined by the judgement of the researcher. This means that statistical-probabilistic generalisability is not present or appropriate (Smith, 2018). Instead, this research may provide analytical generalisation (Smith, 2018), by linking of findings to established theories of fatigue and adding to the growing evidence required for triangulation of findings to establish an evidence-based intervention in this cohort.

5.2.7. Conclusion

This study provides understanding of fatigue in surgery as a multifaceted phenomenon. Variation in causes and effects of fatigue are the norm. When exploring effects of fatigue, decremented performance was identified as occurring when task-demands exceeded that of subjective effort capacity, and when compensatory mechanisms could no longer be employed. Maladaptive strategies to mitigate fatigue in surgery are commonly used. Evident is the necessity to view fatigue as a problem which is focused and tailored at an individual level, while being supported by environmental and systemic changes to sustain behaviour changes.

5.3. EXPLORATION OF IMPACT OF COVID-19 ON SURGEONS

During the onset of these interviews, Ireland faced its first ‘wave’ of the COVID-19 pandemic which saw significant changes to the daily lives of surgeons. The COVID-19 pandemic placed significant pressures on healthcare systems worldwide (Adams and Walls, 2020), and significantly impacted on mental states within the general population through increased stress, anxiety and depression (Salari et al., 2020). Traditionally, a surgeon’s work life was predominantly comprised of operative procedures, in-patient clinical care, out-patient management, and administrative duties. The consequences of changes in workflow for surgeons in the acute phase of the COVID-19 pandemic were unknown, though it was said by participants that COVID-19 presented them with a *“seismic opportunity and shift in how we work”(P34)*. In the current study, follow-up interviews with the same participants were employed to explore the impact of this seismic shift on aspects relating to surgical performance and fatigue.

5.3.1. Research Question

What was the impact of the initial phase of COVID-19 on surgeons personal and professional performance?

5.3.2. Objectives

1. To explore the impact of COVID-19 on personal performance and wellbeing of surgeons
2. To explore the impact of COVID-19 on professional performance of surgeons

5.3.3. Methods

5.3.3.1. Study Design

A similar study design to the first study of *Chapter 5* was employed.

5.3.3.2. Study Instruments

Interview Guide: An interview guide was used as the primary study instrument for this study (*Appendix X*). The questions focused on four main areas in the context of COVID-19: 1) work hours and work practice, 2) training and management, 3) system changes, and 4) personal performance and wellbeing.

5.3.3.3. Qualitative Analysis

The methods described for process of qualitative analysis, in accordance with thematic analysis, were utilised. An additional research team member was recruited (Ms. Tara Connelly, Dublin, Ireland), who assisted in verifying interpretations by the researcher to reduce limitations of the method of member checking (i.e. ensuring credibility). Her orientation to the research has been informed personal experiences of working as a surgical trainee during the pandemic.

5.3.4. Results

5.3.4.1. Linked Themes

A number of interconnected themes were explored as summarised in *Figure 5.3.* The pace of work for surgeons significantly reduced, with particular reductions in number of surgical procedures. This reduction caused an increase in mental fatigue at work, as non-technical performance dominated day-to-day practice. Significant changes to the means in which patient care was delivered, including telemedicine, impacted work-flow and engagement. It also afforded some the opportunity to perform meaningful research which they hadn't had the opportunity to do pre-pandemic due to time constraints. All these changes triggered a sense of professional identity crisis for some surgeons. Changes led to reported impacts on technical, cognitive, and affective skill. Younger trainees reported concern that COVID-19 significantly impacted their training progression due to reduced surgical exposure. Despite many personal impacts, including anxiety relating to both acquiring COVID-19 and transmitting it to others, sleep patterns did not change significantly. This is despite a reported increased focus on wellbeing on which they hadn't previously focused on in the past.

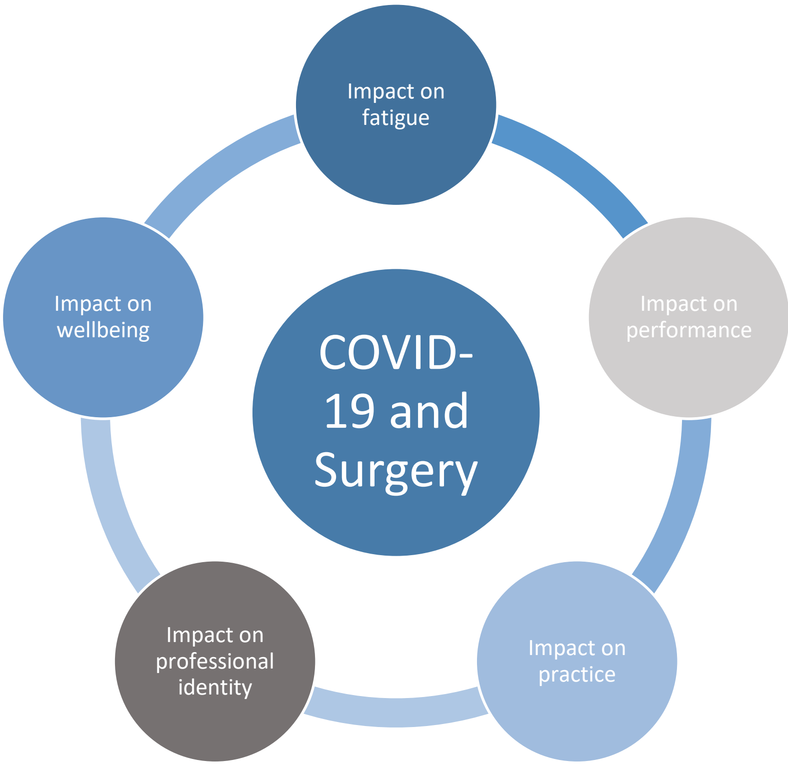


Figure 5.3. Five interconnected themes on the impact of COVID-19 on surgery

5.3.4.2. Practice

The pandemic brought about three significant changes to day-to-day practice – service, provision, additional PPE requirements, and new work rotas. A summary of the findings are given in *Figure 5.4*.

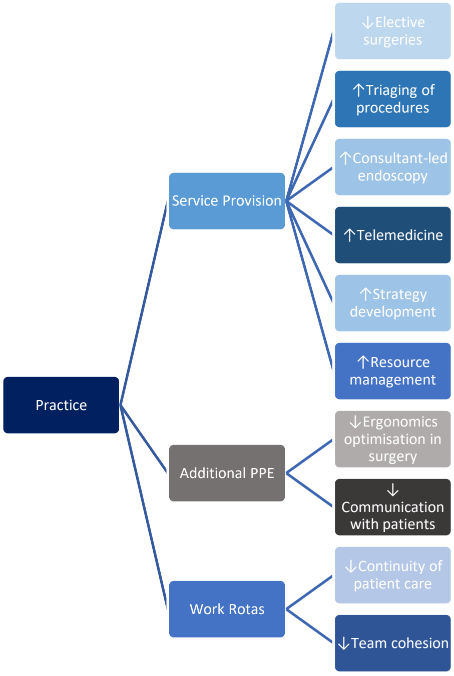


Figure 5.4. Constructed mindmap on impact on practice

5.3.4.3. Fatigue

There was a difference in opinion of the impact on fatigue levels, with some reporting a reduction in fatigue due to an improved work-life balance, while others reported an increase due to additional workplace stressors and reduced motivation – *"In one way I feel less fatigued. Less physically fatigued. Not much is required of me now as the pace is much slower. Mentally however I am finding the* slower *pace much more difficult to deal with. I like to be kept busy and I love operating, which I don't get to do much of now which is frustrating"(P5).* A summary of the findings are given in *Figure 5.5.*

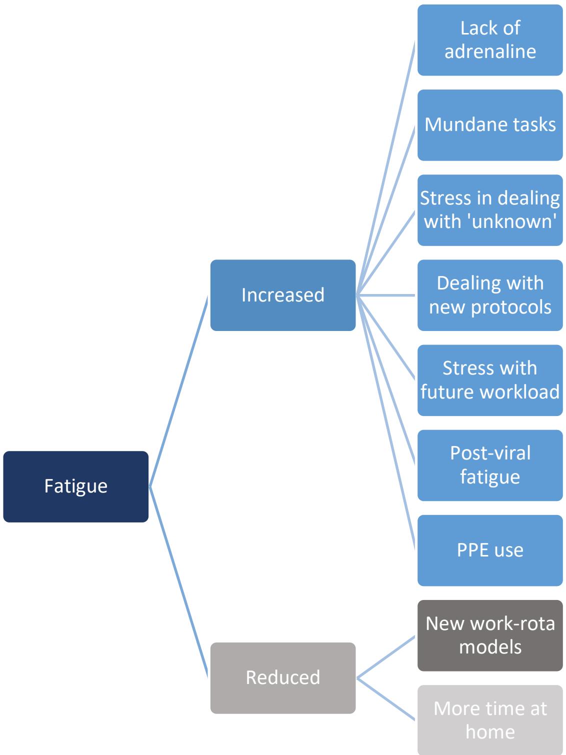


Figure 5.5. Constructed mindmap on impact on fatigue levels

5.3.4.4. Performance

There was a larger consensus that self-reported performance decrements were more likely in the cognitive and affective domain. Technical performance opportunities in earlier trainees were also likely negatively impacted. A summary of the findings are given in *Figure 5.6.*

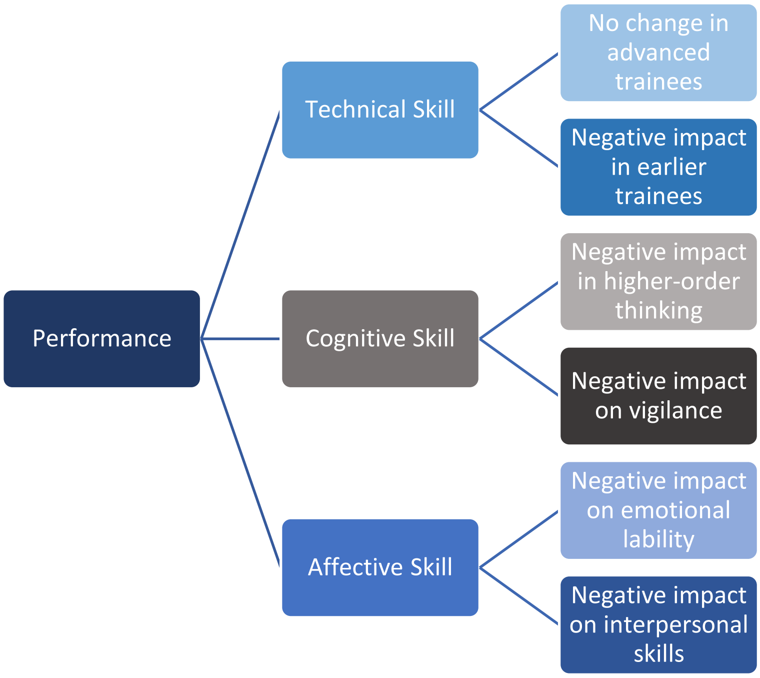


Figure 5.6. Constructed mindmap on impact on performance

5.3.4.5. Professional Identity

The role of professional identity, and the link with work engagement, emerged with some suggesting that the change in work practices has impacted their enjoyment in their workplace – *"maybe because I was enjoying work a little but less than usual, or more happy to take those days off when I usually am itching to get in"(P15)*. A summary of the findings are given in *Figure 5.7.*

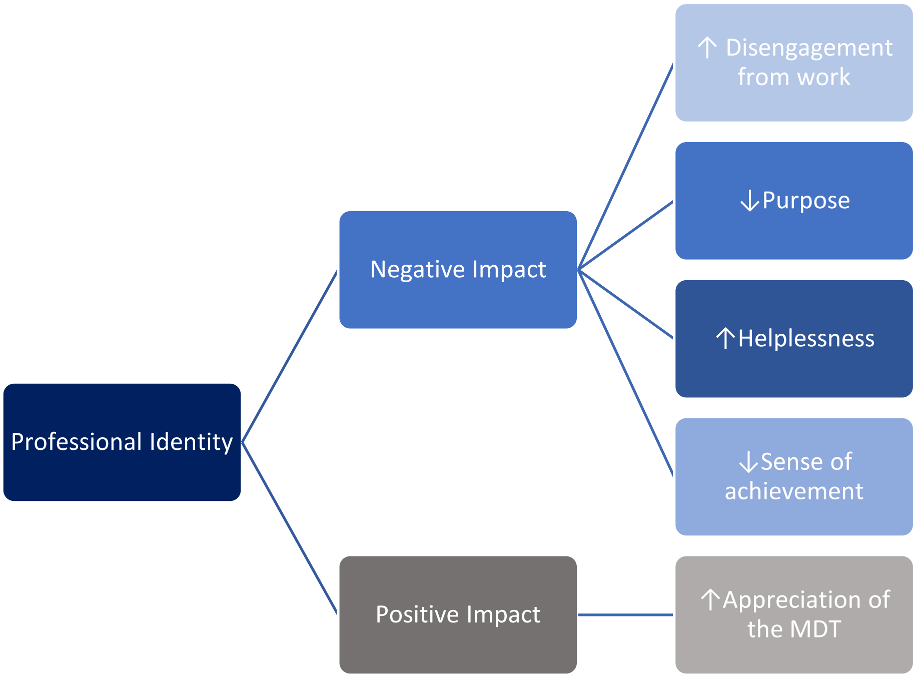


Figure 5.7. Constructed mindmap on impact on professional identity

5.3.4.6. Wellbeing

There was positive and negative impacts associated with wellbeing, coupled with a general appreciation that surgeons experienced a greater impact than the general population – *"it just never feels like you get a break from the virus, and in work you have this heightened exposure to it"(P64).* A summary of the findings are given in *Figure 5.8*.

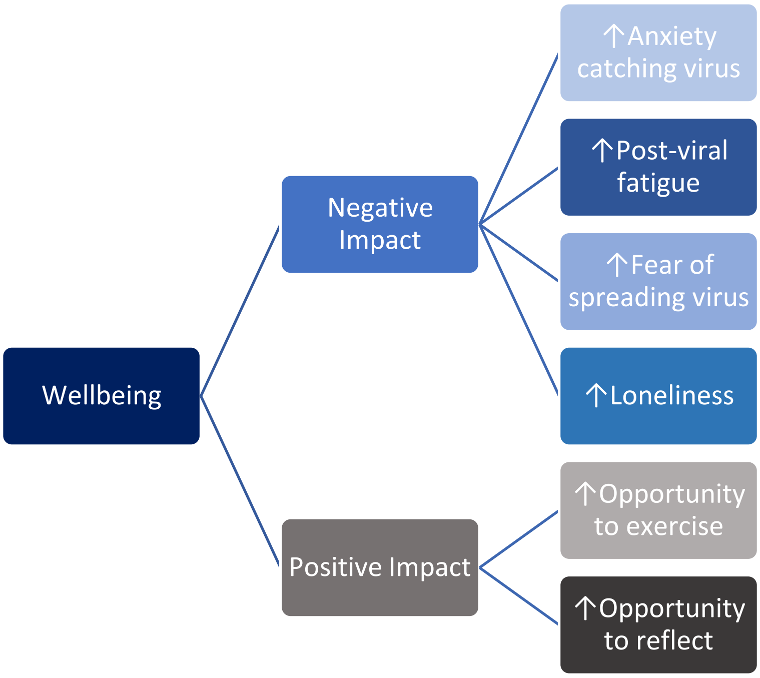


Figure 5.8. Constructed mindmap on impact on wellbeing

5.3.5. Discussion

The initial phase of the COVID-19 pandemic culminated in seismic shifts to the way surgeons work was orientated, with mass-scale cancellation of elective procedures rendering surgeons inoperable for months, and reducing hands-on training opportunities. Such changes had knock on effects for primarily cognitive and affective performance, as well as technical performance in earlier trainees. A loss of professional identity ensued for some, while others flourished with the opportunity to engage in other work activities or non-work activities. The dichotomy of whether an individual perceived benefits or drawbacks differentiated reported fatigue levels.

There are a few explanations for the increase in levels of fatigue during the pandemic. The first relates to the paradoxical findings between increased and decreased fatigue levels by surgeons. This provides insights into the necessity to view fatigue mitigation through a tailored approach, being cognisant of rest opportunities and/or motivational tasks in work, and how they play a role in fatigue manifestation in surgery. Increased effort can be as a result of perceived workload that is too high or too low (Grech et al., 2009), and in this case, the increase in cognitive demands in non-procedural tasks could lead to sustained strain states in surgeons. The previous study found that while surgeons often work long-hours, the challenge was stimulating and motivating. A second reason relates to an increase in levels of burnout. This chronic state is characterised by increased emotional exhaustion (Maslach and Jackson, 1981), which was highly prevalent during the pandemic. The change in workflow was to that of predominantly non-patient care, and this has been previously identified as a predictor of burnout in surgeons (Shanafelt et al., 2009). Senior surgeons also reported significant increases in service delivery changes, and the increase in abstract decision-making could have increased decision-fatigue. The constant 'draining' effect of COVID-19, with heightened exposure and additional stressors in the workforce, is likely to have resulted in the onset of new mental fatigue in surgeons. What is most concerning, is that previous qualitative research conducted on Irish-based doctors highlighted the most significant stressors were that related to quality of healthcare management, feelings of underappreciation, and the difficulty in balancing workplace and personal demands (Hayes et al., 2017). All of these factors have been exacerbated in the context of COVID-19. Healthcare workers can be particularly prone to psychological distress during times of pandemic due to increased exposure (Koh et al., 2003), and the ramifications of subsequent waves of the pandemic on surgeons' physical and mental health is an area of concern. Finally, some surgeons reporting having contracted the virus and developing post-viral fatigue. Known as 'long-COVID' within the emerging literature, this pathological fatigue diagnosis is becoming more prevalent as subsequent waves of the pandemic emerged.

On a positive note, the pandemic afforded surgeons an opportunity for self-evaluation, and increased self-awareness of psychological needs. Surgeons reported an increased focus on wellbeing and exercise to preserve positive mental health during the pandemic. The time off from work, in addition to mandated limitations to personal liberties, afforded some surgeons the opportunity to engage in health-promoting levels of physical activity, which have previously been recorded as below recommended requirements in the profession (O'Keeffe et al., 2019).

Significant changes to service delivery occurred to curb the risk of spreading the virus. As mentioned previously, senior surgeons were challenged to think in higher-order abstract processes, through roll out of new interventions such as telemedicine, as well as the requirement for longer-term strategic direction of patient flow in the hospital. This challenged surgeons, particularly in the cognitive and affective domains of performance. The reduced teamwork element of work had larger implications for performance, with many noticing an increased level of emotional lability and increased cognitive load. Reduced surgical training opportunities presented increasing pressure to surgeons who worried about the implications on their career progression. Such overemphasis on technical skill proficiency, when a myriad of opportunities to develop competencies such as teamwork, communication, leadership and management skills were present, further supports the evidence of over-emphasis on technical skill acquisition as the primary means to achieve progression in the profession.

This study was one of the first conducted during the initial surge of cases in the COVID-19 pandemic. It provides a significant insight into how environmental changes alone, such as reduced work hours alone, do not mitigate fatigue. It sheds light into the strategies employed by some surgeons to optimise wellbeing, but little is known about the utilisation of previously identified maladaptive strategies for fatigue mitigation during the pandemic. Future research should explore the strategies used by surgeons during the subsequent waves of the pandemic to reduce fatigue. Efforts to mitigate fatigue through educating staff on stress management and resilience strategies were introduced in many settings, with evidence-based understandings of the impact of stress on performance (Wetzel et al., 2006), and their efficacy should be investigated. Finally, the emerging evidence on the risk of developing long-COVID is of paramount importance for occupational health of staff. Exploration of the reported levels of prolonged symptoms from viral contraction are warranted in healthcare, given the increased risk of the setting in the spread of COVID-19 (Eyre et al., 2020).

5.3.6. Limitations

The experiences of surgeons working in a 'COVID' status hospital were explored in this study, which allows generalisations within these settings but not others. Had participants been recruited from rural hospital settings, where there are differences in resources and capacity, impacts may have differed. The experiences and perceptions of surgeons in the initial phase of the pandemic is likely to have significantly changed course over the months when subsequent waves of the pandemic arrived, and society as a whole attempted to live the 'new normal', and thus these findings cannot be extrapolated to current contexts.

5.4. DISCUSSION

This chapter provided insight into the causes and effects of fatigue, as perceived by surgeons. The COVID-19 pandemic was a significant opportunity to explore the impact of drastic environmental change to support or refute the role of external factors towards influencing fatigue and performance. A complex and contrasting relationship emerged, with some reporting improved outcomes, and others deterioration. The outstanding question remains – is environmental intervention or personal intervention likely to elicit the greatest impact? This chapter highlighted individual responsibility to tackling fatigue is only part of the equation, with environmental restructuring required in order to facilitate individuals behaviour change efforts. Similar contextually relevant research on Irish doctors, which explored priority interventions for reduction of stress and burnout, identified that system-focused interventions were the most highly rated amongst participants. Establishing basic work entitlements such as leave and on-call rotas as areas requiring immediate attention is therefore important (Walsh et al., 2019).

A significant portion of the required changes to mitigate fatigue have theoretical underpinnings associated with the self-determination theory (Deci and Ryan, 2004). This theory holds that the basic psychological needs (BPN) of the surgeons i.e. their perceived levels of competence, relatedness, and autonomy, must be fulfilled in order to make motivation autonomous and sustain required behaviour changes. Current environmental structures constrain autonomy, yet the environmental changes alone may not translate across to improved performance outcomes. In a large representative survey study, on multivariate analysis the frequency of on-call work and number of hours were not predictors of error-making (Shanafelt et al., 2010), suggesting the necessity for consideration of non-environmental factors also.

A reductionist one-size-fits-all approach to mitigating fatigue through environmental intervention is antithetical to theories of fatigue being a subjective experience (Hockey, 2013). The deployment of effort, which increases risk of fatigued states, is a voluntary process and thus perceived external locus of control results in many surgeons perceiving fatigue to being an unavoidable state. This reflects an error of absolute attribution of fatigue causes. Similarly, variability in tolerances of effort (Dornic, et al., 1991), as well as motivational commitments to goal achievement (Hollenbeck and Klein, 1987) are the norm. Compliancy with EWTD has been discussed previously, and violation of the work hour regulations has been previously found in residents (Taylor et al., 2017), despite participants knowledge of the importance of such mandates for ensuring patient safety, and improving wellbeing of workers. Irrespective of whether they had over-worked or not, participants felt they were upholding the principles of 'do no harm'. The participants stated that non-compliance was driven by educational pursuits, as well as cultural expectations within the workplace of compliance with working-hour regulations (Taylor et al., 2015), which resonates with the findings of this study. With that in mind, both inertia and cultural issues barriers are best facilitated by senior leadership within the profession. Leaders should highlight the fallibility of their own performance due to fatigue, and the importance of recognising fatigue as a significant risk to error-making, and thus patient safety. This helps foster 'relatedness' in accordance with self-determination theory (Deci and

Ryan, 2004), as individuals begin to develop a shared experience of fatigue and a collective understanding of how to address it. Developing perceived 'competence' can be facilitated by educational intervention to increase knowledge and thus capability to make change (Michie et al., 2011), in conjunction with a formal mentorship or coaching programme, to track changes in behaviours in a psychologically safe manner.

5.5. CONCLUSION

The causes and effects of fatigue in surgery are multifaceted and were significantly impacted during 2020. While emphasis was placed strongly on environmental stressors, such as poor resourcing and being over-worked, as leading causes of fatigue in surgery, it became evident in the context of COVID-19 that these stressors alone were not causing fatigue in the profession. In fact, some surgeons reported increased levels of fatigue associated with COVID-19 even though they were working less hours. All of these findings would support evidence that surgeons are a heterogenous group with individual stressors and mitigating strategies for fatigue.

Nonetheless, the combinatory role of personal lifestyle measures, as well as professional changes were highly valued by all surgeons as a broad framework to improve fatigue levels in the profession. Establishing an understanding of the influence of these identified measures, with regards to their relationship to reported levels of health, wellbeing, fatigue, and professional performance, is warranted to enable a prioritised evidence-based intervention for performance optimisation in surgery.

6. Chapter 6 – Investigating trends between health, wellbeing and modifiable factors on surgical performance

6.1. BACKGROUND

In the previous chapter, it was established that a variety of personal and professional factors impacted on self-reported fatigue. While research has found higher levels of alcohol consumption, and lower levels of health enhancing physical activity (O'Keeffe et al., 2019) in surgery, the link between lifestyle behaviours, wellbeing, and reported surgical performance remains unknown. Identification of the significant associations between the outcomes of fatigue levels, health and wellbeing, and performance outcomes with lifestyle behaviours and work factors, provides further quantitative evidence to inform an evidence-based intervention to optimise surgical performance.

6.2. RESEARCH QUESTION

What lifestyle and work factors are associated with surgeons self-reported levels of health, wellbeing, fatigue levels and performance measures?

6.3. OBJECTIVES

1. To investigate trends between overall health, wellbeing, levels of fatigue and surgical performance
2. To explore adherence to guidelines on healthy lifestyle factors
3. To explore surgeons self-reporting of work-related factors
4. To explore differences between the primary cohort used in this study versus an international sample

6.4. METHODS

This study is reported according to the CHERRIES guidelines (Eysenbach et al., 2012).

6.4.1. Study Design

This was a multi-site observational survey study design conducted in collaboration with the Association of Surgeons in Training (ASIT) in Ireland and the United Kingdom. On survey completion, participants responses were recorded, and they could not complete the survey again on that device to reduce the risk of survey duplication.

6.4.2. Participants

Participants were recruited between June 2020 – August. 2020. Cluster sampling was used, and participants were recruited through an email list through ASiT containing an invitation to participate (*Appendix Y*), as well as a participant information letter (*Appendix Z),* explaining the study thoroughly. Additionally, tweets were sent from the ASiT twitter account with an approved graphic, as well as a website page.

Each participant anonymously completed the survey and no financial reward was given for completion. Participants were advised that completion of the survey was indicative of informed consent. Eligibility was assessed through membership of ASiT as a prerequisite question on the survey. The study assessed significance at the level of $p<.05$. Across similar published studies which have explored surgeons, a response rate of between 800-1000 responses is reflective of survey responses from surgeons in this geographic domain, when collaborating with affiliate bodies (Harries et al., 2016).

The inclusion and exclusion criteria are as follows:

Inclusion:

- Surgical trainees and consultants from Tallaght University Hospital (primary cohort)
- Affiliated with the ASiT (international sample)

Exclusion:

- Non-surgical professionals
- Surgeons not affiliated with the ASiT

6.4.3. Study Instruments

A survey (*Appendix AA*) was developed and validated in accordance with the Burns criteria on design and conduct of self-administered surveys on clinicians (Burns et al., 2008).

(i) *Item generation:* The survey was designed surrounding themes which emerged from the findings of *Chapter 5,* as well as literature review of the identified variables in *Chapter 2.* Thereafter the relevant constructs were framed as seen in *Figure 6.1*.

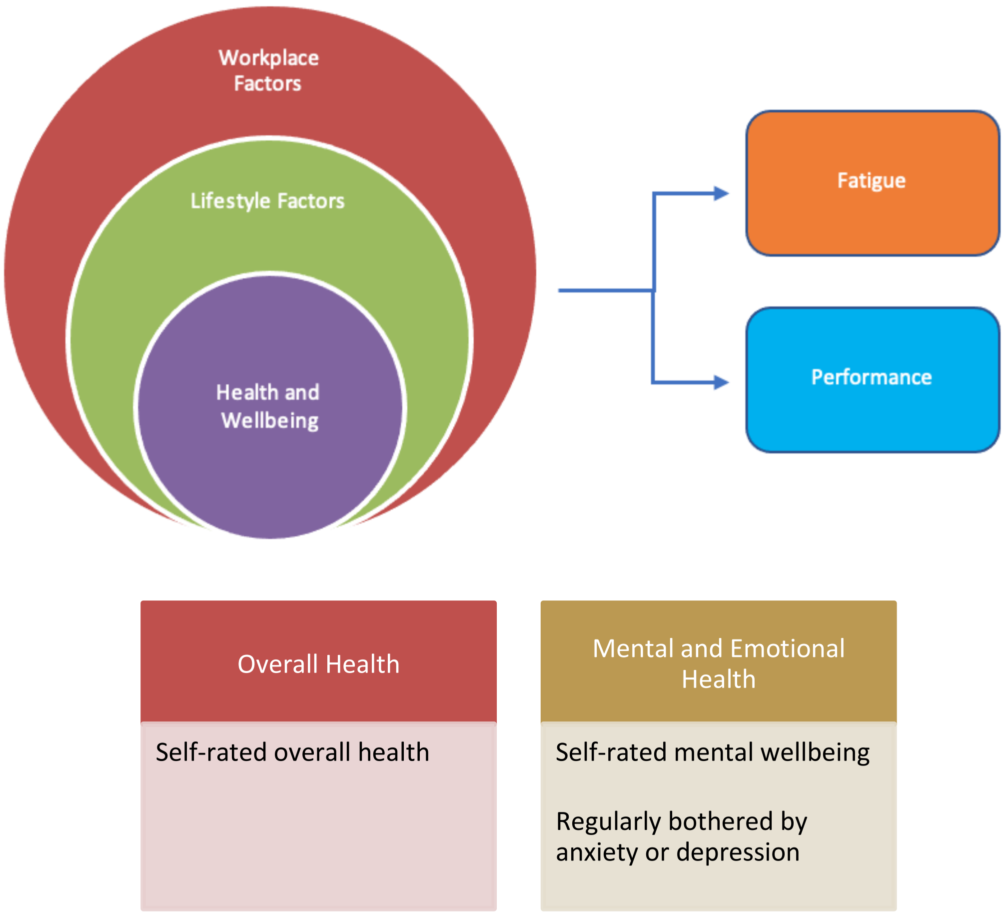


Figure 6.1. Relationship between the constructs

(ii) Item reduction: An item reduction process reduced the number of questions, through a binary process (include/exclude), culminating in the relevant constructs and question domains (*Tables 6.1* and *6.2).* The survey received input from surgical (Ms. Tara Connelly) and psychology researchers (Prof. Eva Doherty, Dublin, Ireland) to consider accessibility of the survey questions. A simplified clinical sensibility testing measure was then conducted to provide a final overview regarding survey and research objective cohesion. The questions focused on the extent to which the survey measured the desired constructs, the extent to which the survey items were relevant or redundant, and the likelihood of the survey to elicit useful information (*Appendix AB*).

Table 6.1. Work factors with performance outcomes and associated questions

Culture	Q42 Staff treated fairly	Q44 Honesty patients sleep	Q45 Error disclosure promoted					
Resources	Q43 Enough staff							
Commute	Q18 Commute to work	Q19 Commute from work						
On-call Work	Q5 Often on call	Q8 On call sleep hours	Q10 After call sleep hours					
Performance	Q7 Performance off call	Q9 Performance on-call	Q13 Fatigue with surgical tasks	Q14 Fatigue with non-surgical tasks	Q39 Disruptive Social Activities	Q40 Disruptive Professional Activities	Q46 Minor errors from fatigue	Q47 Major errors from fatigue

Table 6.2. Lifestyle factors and associated questions

Smoking Alcohol Caffeine	Q2 Smoker/Non smoker	Q25 Weekly alcohol intake	Q3 Daily caffeine intake						
Hydration	Q4 Daily water intake								
Sleep and Fatigue	Q6 Average sleep hours	Q11 Consistent sleep pattern	Q15 Manage fatigue effectively	Q12 How often fatigue					
Stress	Q16 Often stress at work	Q17 Easy to switch off	Q41 Supported feel at home						
Physical Activity and Exercise	Q20 Light activity	Q21 Moderate activity	Q22 Strenuous activity	Q23 Amount of exercise	Q24 Importance of exercise				
Diet	Q26 Often breakfast	Q27 Often lunch	Q28 Often dinner	Q29 Often fast-food	Q30 Often readymade meal	Q31 Often sugary drinks	Q32 Often sweet things	Q33 Portions fruit	Q34 Portions vegetables
Health Checks	Q35 Last time doctor	Q36 Last time dentist							

(iii) Survey formatting: Attempts to reduce ceiling and floor effects of survey questions was conducted through modelling statement ranks from other surveys (Jenkinson et al., 1993; Godwin et al., 2008; Dupuy 1984). Attempts were used to use previously validated question to match the desired construct. A combination of nominal and ordinal measurements were used.

(iv) Pre-testing and pilot testing: The survey was pretested on a cohort of physiotherapists (n=30) based in the primary research setting whereby feedback on clarity and interpretation was sought. The survey was then piloted on a cohort of surgeons (n=29) in the primary research setting.

(v) Reliability: Ordinal association between construct items was assessed using Kendall's-tau correlations (*Appendix AC*).

(vi) Validity: Content-related validity was assessed by establishing aspect of face validity with the population sample during clinical sensibility testing, as well as expert input. Criterion-related validity was supported through use of clinical guidelines for lifestyle factors, and informed by the literature. Construct-related validity was considered when making comparisons with the international surgical sample, and the physiotherapy cohort as described in *Chapter 8*. The validity standard for the survey was defined as completion of the all sections.

6.4.4. Statistical Analysis

A protocol of statistical analysis involving tests or normality was used (See *2.3.3.4. Data Extraction and Synthesis* for details). Non-parametric statistics were used. Kruskal Wallis testing explored differences in groups. Reliability tests i.e. Kendall's-tau correlations were applied to measure associations between variables.

6.5. RESULTS

6.5.1. Demographics

A total of 120 surgical trainees and consultants (4.3% of the overall population) were recruited, of which 95 (2.7%) completed the full survey. A participant flow diagram is seen in *Figure 6.2.* Some demographics were not collected of participants, due to the inclusion of results from the 29 surgeons involved in the pilot group, for whom extensive demographics were not collected. A demographic summary is seen in *Table 6.3.*

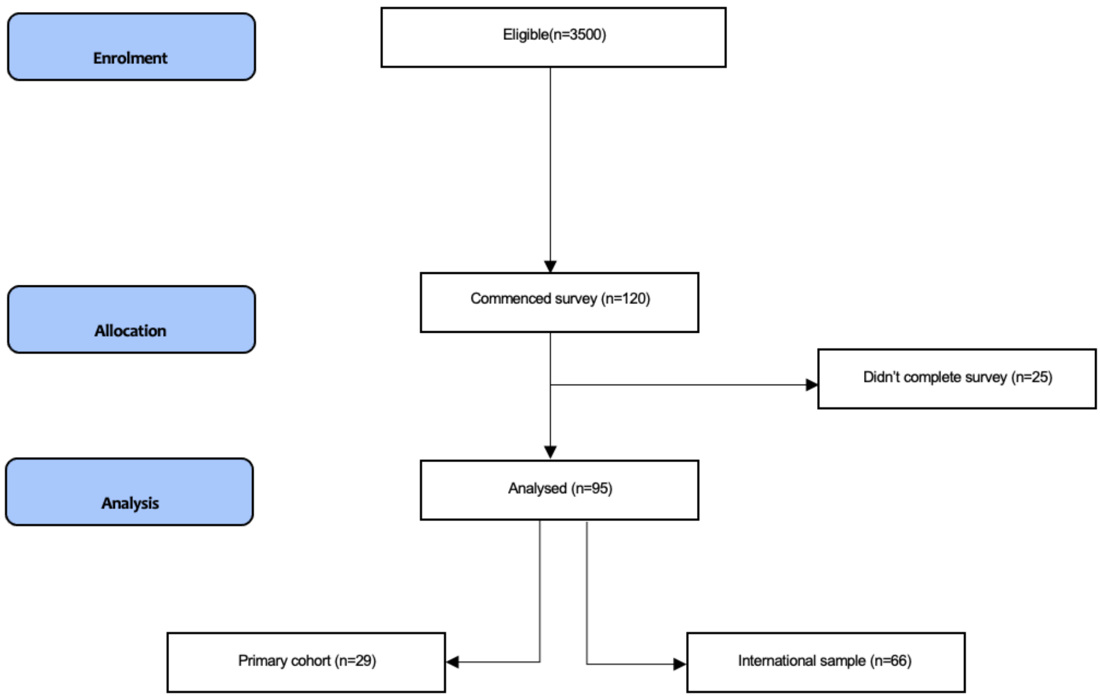


Figure 6.2. Participant flow diagram for Chapter 6 survey study

Table 6.3. Demographic summaries of participants in Chapter 6

Surgeons	**66 I 95**
Gender	
Male	32 (48.5%)
Female	34 (51.5%)
Age	
18-24	1 (1.5%)
25-34	31 (47%)
35-44	26 (39.4%)
45-54	8 (12.1%)
Length Since Undergraduate	
≤ 5 years	16 (24.2%)
6-10 years	19 (28.8%)
11-16 years	17 (25.8%)
17-22 years	9 (13.6%)
≥23 years	5 (7.6%)
Current Job Title	
Intern	8 (8.4%)
SHO	15 (15.8%)
Registrar	37 (38.9%)
Consultant	28 (29.5%)
Research Fellow	7 (7.4%)
Sector of Employment	
Public	90 (94.7%)
Private	5 (5.3%)
Specialty	
General	65 (68.4%)
Oral and maxillofacial	5 (5.3%)
Otolaryngology	1 (1.1%)
Plastic	4 (4.2%)
Orthopaedics	11 (11.6%)
Urology	5 (5.3%)
Vascular	3 (3.2%)
Gynaecology	1 (1.1%)
Region of Work	
England	23 (24.2%)
Wales	3 (3.2%)
Scotland	2 (2.1%)
Northern Ireland	1 (1.1%)
Republic of Ireland	62 (65.3%)
Other	4 (4.2%)

6.5.2. Overall Health

A large majority (94%) reported overall health that was at least good. No-one reported poor overall health as seen in *Figure 6.3*. The variables trending in association with overall health are seen in *Table 6.4.*

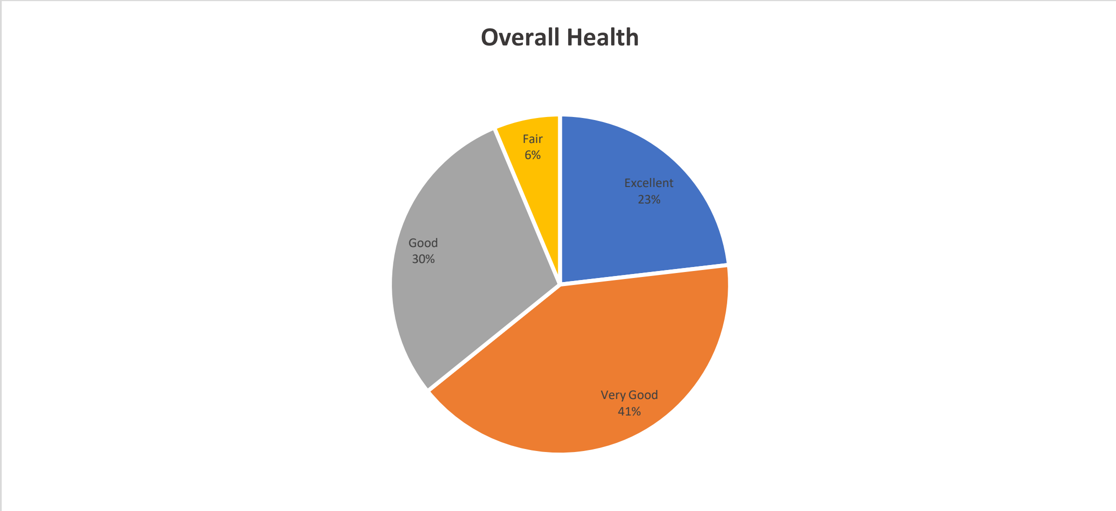


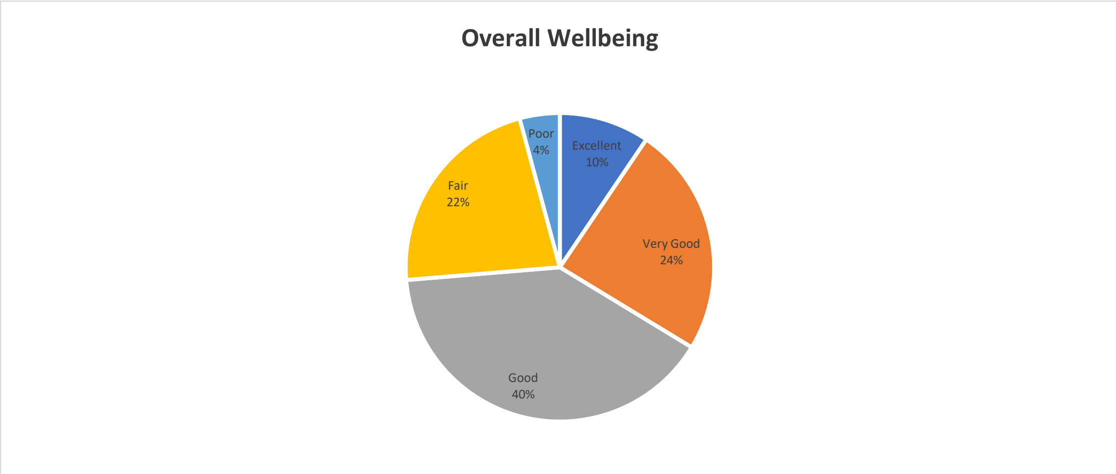
Figure 6.3. Self-reported overall health in surgeons

Table 6.4. Variables trending in association with overall health

Determining Variable ↑Overall Wellbeing (p<.001) ↓Often Fatigue (p=.021)				**Work Factor: Performance Management** ↓Disruptive Professional (p=.008) ↑Performance Off-Call (p<.001) ↑Performance On-Call (p=.012) ↓Fatigue Non-Surgical (p=.031)
Lifestyle Factor: Sleep ↑Consistent Sleep (p=.033)				
Lifestyle Factor: Stress ↑Supported Feel (p=.042)				
Lifestyle Factor: Exercise and Physical Activity ↑Light Activity (p=.038) ↑Moderate Activity (p=.021) ↑Amount Exercise (p=.048)	⇋	**↑Overall Health**	→	
Lifestyle Factor: Diet ↓Fast Food (p=.028) ↓Ready-made Meal (p=.030) ↑Portion Vegetable (p=.007)				
Work Factor: Culture ↑Staff Treated Fairly (p=.022) ↑Error Disclosure Promoted (p=.033)				

6.5.3. Overall Wellbeing

A large majority (74%) reported overall mental and emotional wellbeing that was at least good. Nearly two-thirds (64.2%) reported being bothered by feelings of anxiety and/or depression at least somewhat. A summary of findings are seen in *Figure 6.4*. The variables trending in association with overall wellbeing are seen in *Table 6.5.*



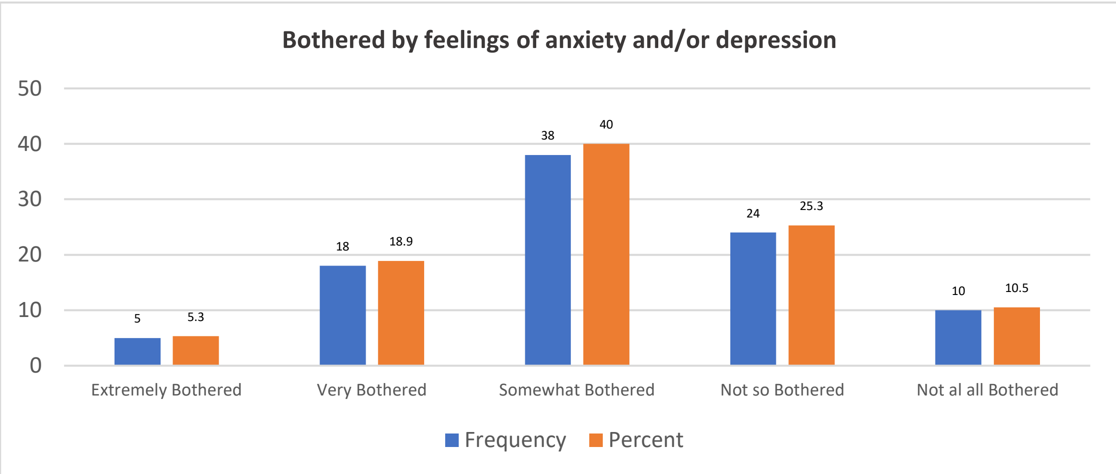


Figure 6.4. Self-reported overall wellbeing in surgeons

Table 6.5. Variables trending in association with overall wellbeing in surgeons

Determining Variable ↑Overall Health (p<.001) ↓Bother Anxious Depression (p<.001) ↓Often Fatigue (p=.006)	⇋	↑**Overall Wellbeing**	→	**Work Factor: Performance Management** ↓Disruptive Social (p=0.39) ↓Disruptive Professional (p=.010) ↑Performance Off-Call (p=.001) ↑Performance On-Call (p=.014) ↓Fatigue Non-Surgical (p=.002)
Lifestyle Factor: Sleep ↑Consistent Sleep (p=.047)				
Lifestyle Factor: Stress ↑Supported Feel (p=.015)				
Lifestyle Factor: Exercise and Physical Activity ↑Amount Exercise (p=.041)				**Work Factor: Culture** ↑Honesty Patients (p=.033)
Lifestyle Factor: Diet ↑Dinner (p=.014) ↓Fast Food (p=.006)				

6.5.4. Overall Fatigue Levels

Nearly two-thirds (62%) reported feeling fatigued at least half of the time. Over half (52%) disagree to managing fatigue effectively. A summary of findings are seen in *Figure 6.5.* The variables trending in association with overall fatigue levels are seen in *Table 6.6.*

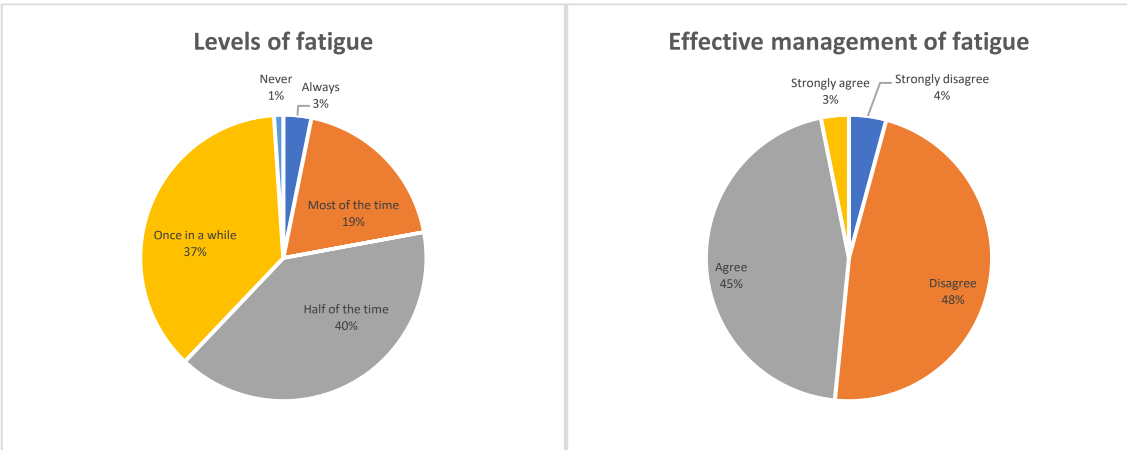


Figure 6.5. Self-reported levels of fatigue and effective management of fatigue in surgeons

Table 6.6. Variables trending in association with level of fatigue in surgeons

Determining Variable ↑Overall Health (p=.014) ↑Overall Wellbeing(p=.006) ↓Bother Anxious Depression (p=.001)				**Work Factor: Performance Management** ↓Disruptive Social (p=.031) ↓Disruptive Professional (p=.001) ↑Performance On-Call(p=.034) ↓Fatigue Surgical (p<0.001) ↓Fatigue Non-Surgical (p<0.001) ↓Major Fatigue Errors (p=.021)
Lifestyle Factor: Sleep ↑Consistent Sleep (p=.001) ↑Manage Fatigue Effectively (p<0.001)	⇋	↓**Level of fatigue**	→	
Lifestyle Factor: Stress ↓Often Stress Work (p=.017) ↑Easy Switch Off (p=.010) ↑Supported Feel (p=.041)				**Work Factor: Culture** ↑Honesty Patients (p=.023)
Work Factor: Culture ↑Error Disclosure Promoted (p=.046)				

6.5.5. Lifestyle Factors

6.5.5.1. Smoking and Alcohol

A majority (94.7%) reported not smoking. A majority (96.8%) reported not exceeding thirteen units of alcohol on a weekly basis, as seen in *Figure 6.6*.

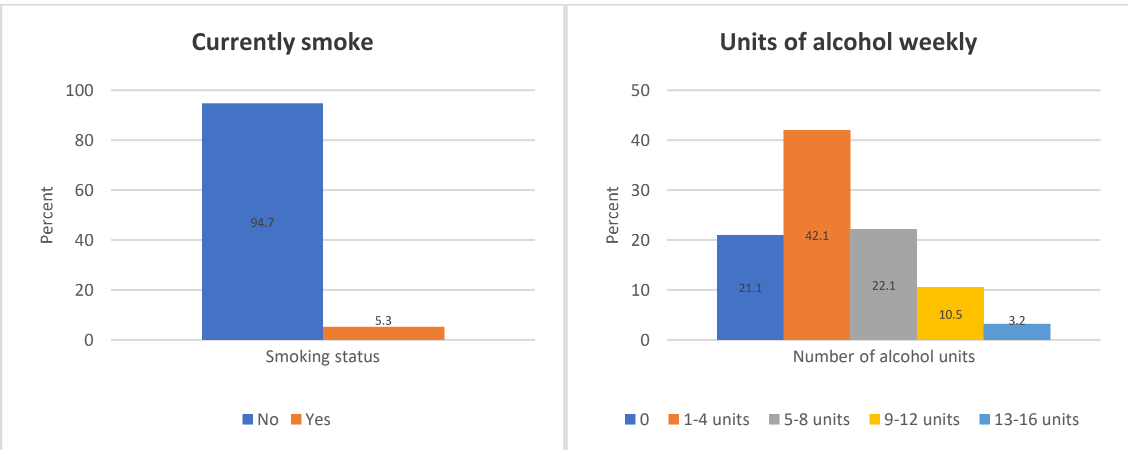


Figure 6.6. Smoking and alcohol factors in surgeons

6.5.5.2. Caffeine Intake

A majority (95.8%) reported drinking more than 4 caffeine drinks daily, as seen in *Figure 6.7*.

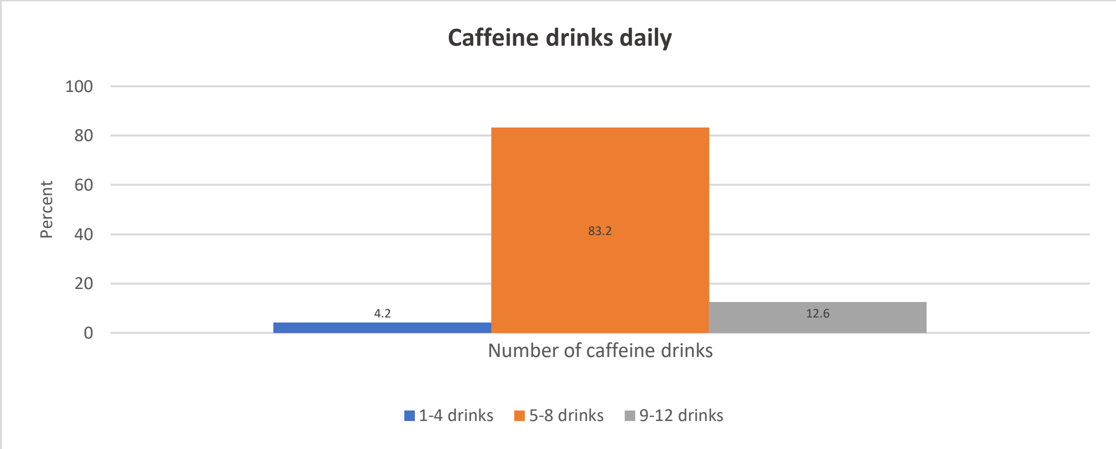


Figure 6.7. Caffeine intake factor in surgeons

6.5.5.3. Hydration

A majority (92.6%) reported drinking less than two litres of water daily, as seen in *Figure 6.8*.

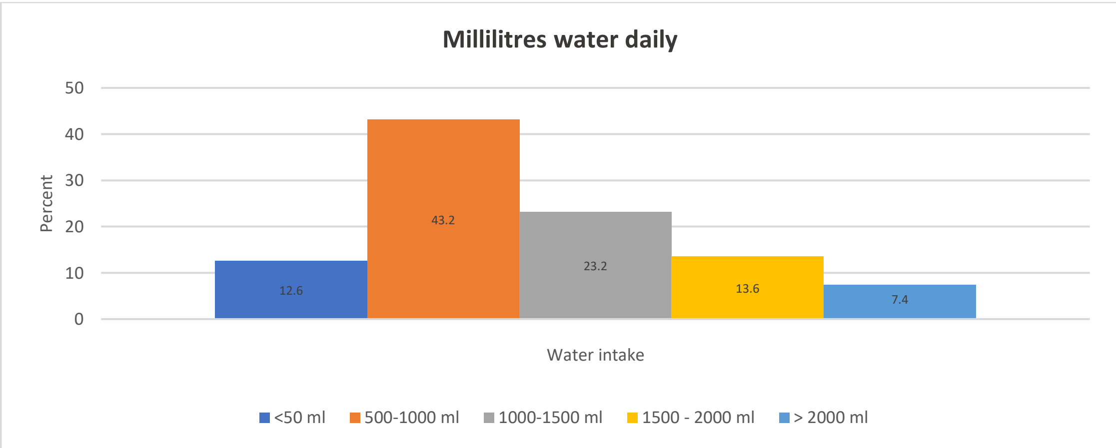


Figure 6.8. Hydration factor in surgeons

6.5.5.4. Sleep

Over three-fifths (61.1%) reported sleeping an average of seven or more hours a night when not on-call. Less than half (45.3%) reported having a consistent sleep pattern, as seen in *Figure 6.9*.

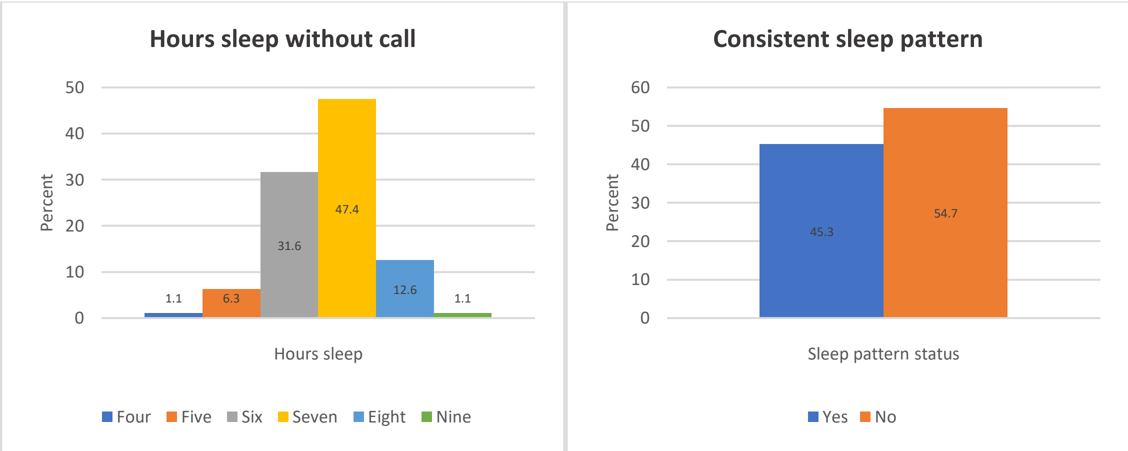


Figure 6.9. Sleep factors in surgeons

6.5.5.5. Stress

Three-fifths (60%) reported feeling stressed either 'once in a while' or 'never'. Over two-fifths (41%) agreed it is easy to switch off after work. Three-quarters (76.8%) reported feeling a level of support at work or at home, as seen in *Figure 6.10.* Female surgeons were more likely to report feeling regularly stressed at work (94% vs 43.8% in males, p=.010).

There was a significant difference between the primary cohort and international sample scores with the primary cohort reporting greater levels of:

- 'often stressed at work' (p=.023)
    - primary cohort: 4(4-4)
    - international sample: 4(3-4)
- 'easy to switch off after work' (p=.011)
    - primary cohort: 3(3-4)
    - international sample: 2.5(2-4)
- 'feeling supported' (p=.032)
    - primary cohort: 2(2-3)
    - international sample: 3(2-4)

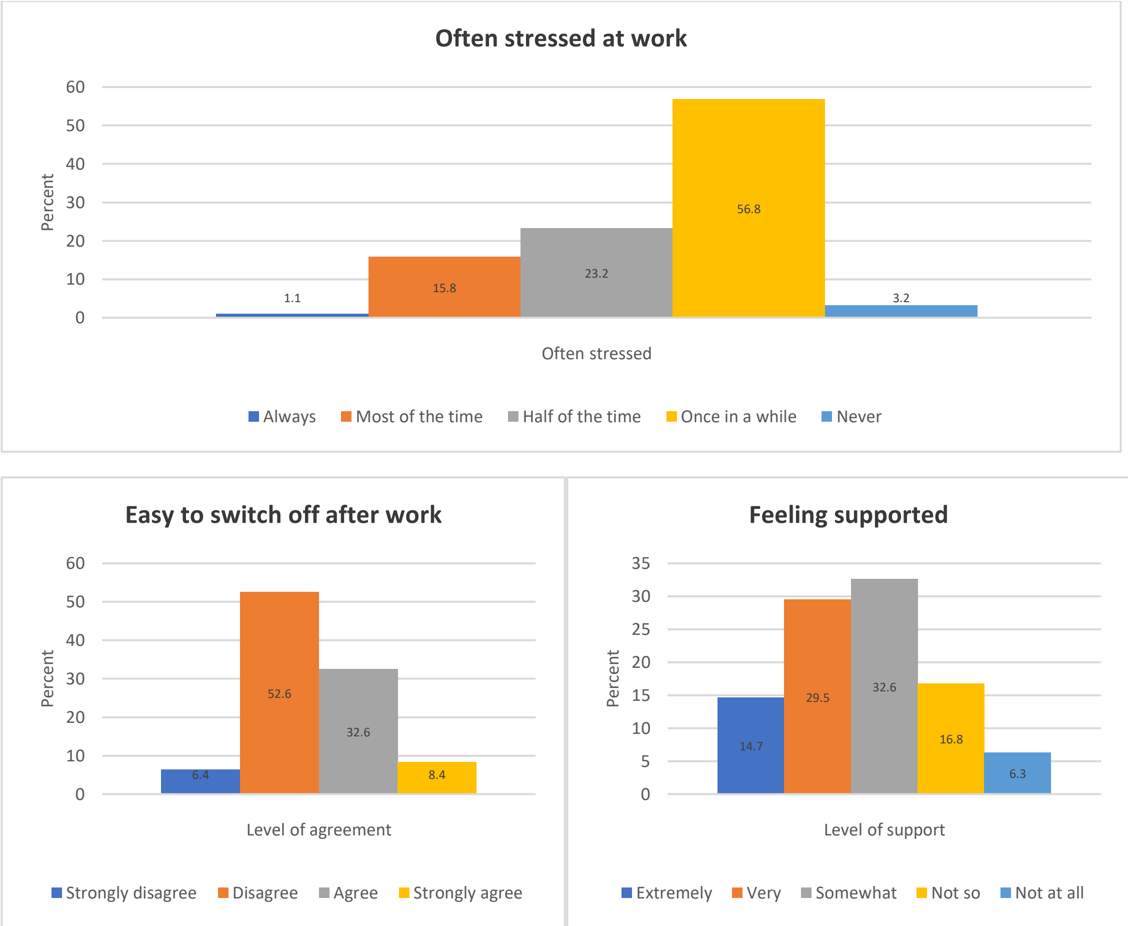


Figure 6.10. Stress factors in surgeons

6.5.5.6. Physical Activity and Exercise

A minority reported engaging in light activity (23.2%) or moderate activity (11.6%) five times or more a week. A minority (21.1%) reported engaging in strenuous activity three times or more a week. A majority (84.1%) report getting not getting enough exercise. A majority (91.6%) reported exercise is at least somewhat important to them. A summary of findings are seen in *Figure 6.11*.

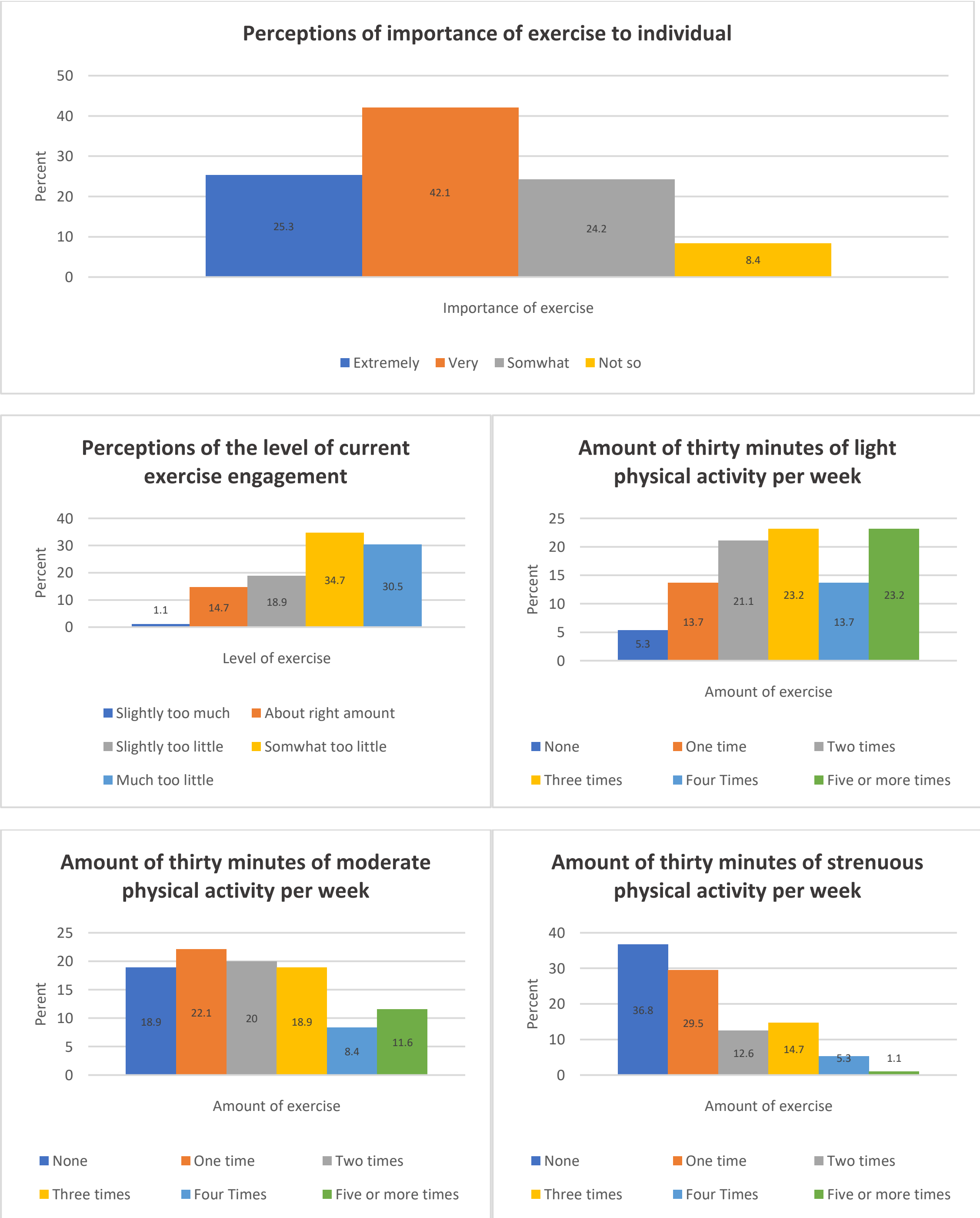


Figure 6.11. Physical activity and exercise factors in surgeons

6.5.5.7. Diet

About half (49.5%) reported eating breakfast daily. Over half reported eating lunch (52.6%) and dinner (81.1%) daily. A minority (7.4%) reported not eating fast food. Nearly three-quarters (74.7%) reported not eating microwavable or ready-made deals daily. A quarter (25.3%) reported not drinking sugar-carbonated beverages. A minority (1.1%) reported not eating sweet things such as sweets, chocolates or crisps. Over half (52.8%) of participants reported eating two or more fruits a day. Over three fifths (63.2%) reported eating two or more vegetables a day. A summary of findings are seen in *Figure 6.12*.

Figure 6.12. Diet factors in surgeons

6.5.5.8. Health Check-ups

Less than half (44.2%) reported getting a medical check-up on a yearly basis. A third (33.7%) reported getting a dental check up on a yearly basis, as seen in *Figure 6.13.*

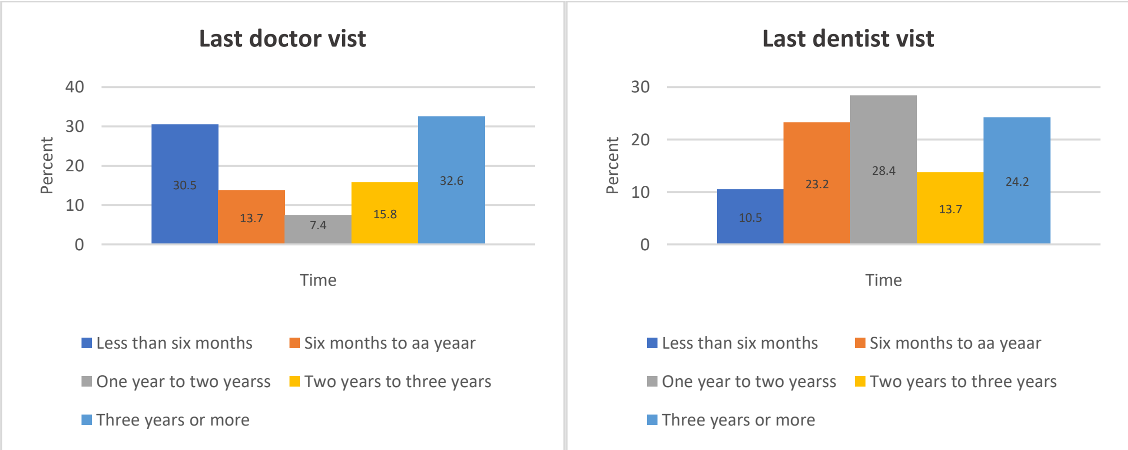


Figure 6.13. Health check-ups factors in surgeons

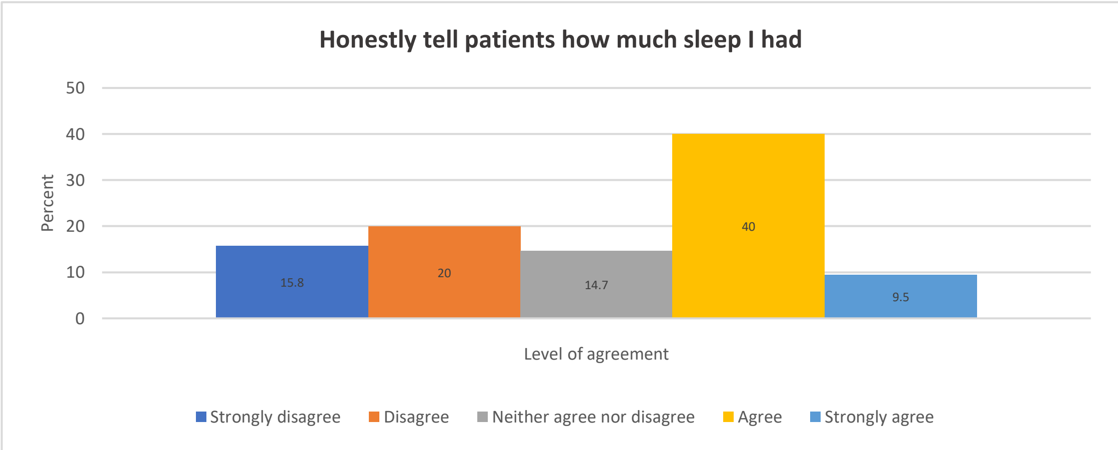
6.5.6. Work Factors

6.5.6.1. Culture

Over a quarter (26.4%) agree to being treated fairly when they make mistakes. Half (49.5%) agree to being honest telling patients how much sleep they had before surgery. Less than a third (29.6%) agree to error disclosure being promoted and implemented effectively in surgery, as seen in *Figure 6.14.*

There was a significant difference between the primary cohort and international sample scores with the primary cohort reporting greater levels of:

- 'staff treated fairly' ($p<.001$)
  - primary cohort: 4(3-4)
  - international sample: 2(2-3)
- 'error disclosure promoted and implemented effectively' ($p=.022$)
  - primary cohort: 3(2.5-4)
  - international sample: 3(2-3.25)



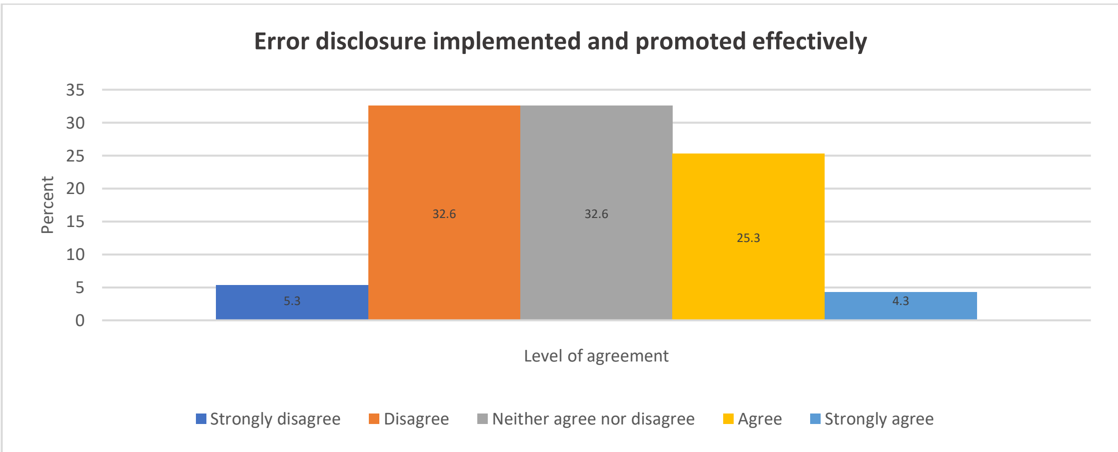


Figure 6.14. Work culture factors in surgeons

6.5.6.2. Resources

Less than a third (29.5%) agree to having enough staff to handle the workload, as seen in *Figure 6.15.*

There was a significant difference between the primary cohort and international sample with the primary cohort reporting greater levels of:

- 'enough staff to handle workload' (p=.001)
    - primary cohort: 3(2-4)
    - international sample: 2(1-3)

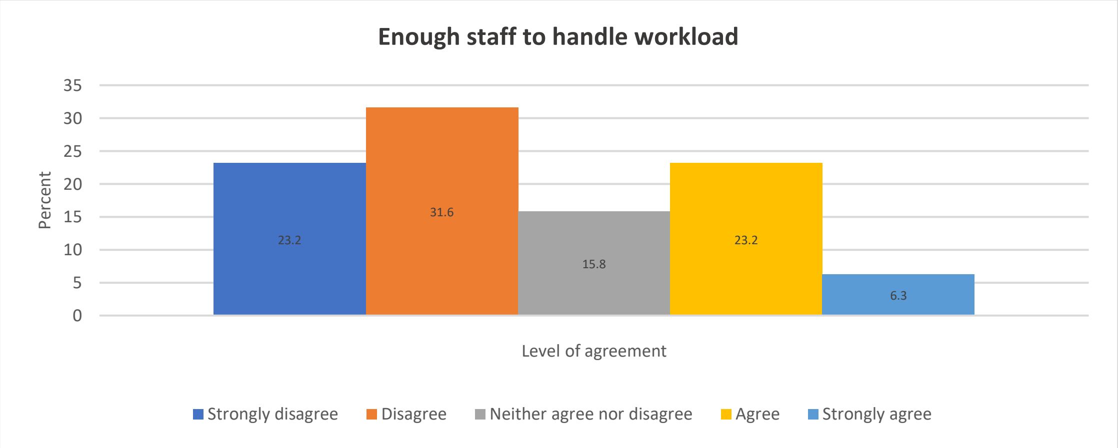
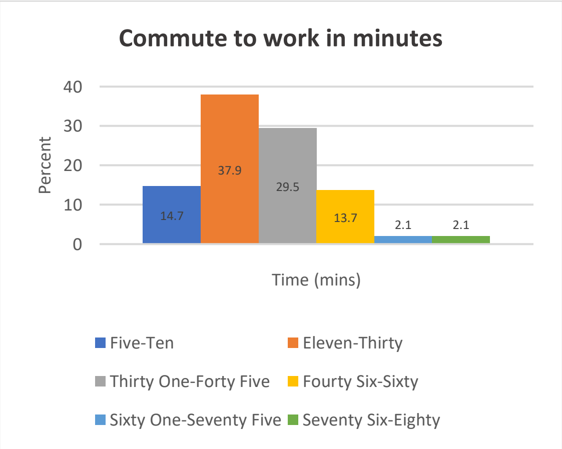


Figure 6.15. Resource factor in surgeons

6.5.6.3. Commuting

About half report commuting less than 30 minutes to work (52.6%), and from work (50.5%), as seen in *Figure 6.16.*



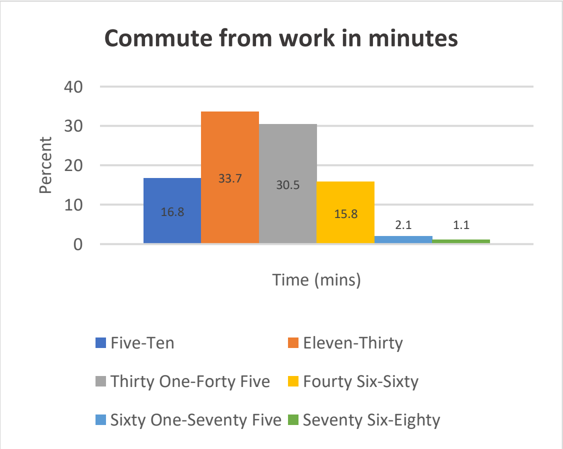


Figure 6.16. Commuting factors in surgeons

6.5.6.4. On-call work

Over three-quarters (77.9%) reported completing on-call work weekly. Over two-thirds (70.4%) reported sleeping five hours of less when on-call. Over half (57.1%) reported sleeping at least seven on average after on-call, as seen in *Figure 6.17*. There was variation regarding regularity of on-call work, depending on the specialty, with general surgery and vascular reporting the greatest amount of weekly on-call work, while oral and maxillofacial surgery reported the least (once a week vs one in three weeks, p=0.019). Professional title influenced levels of sleep on-call with interns sleeping the least (3.5 hours), while consultants slept the most (6 hours).

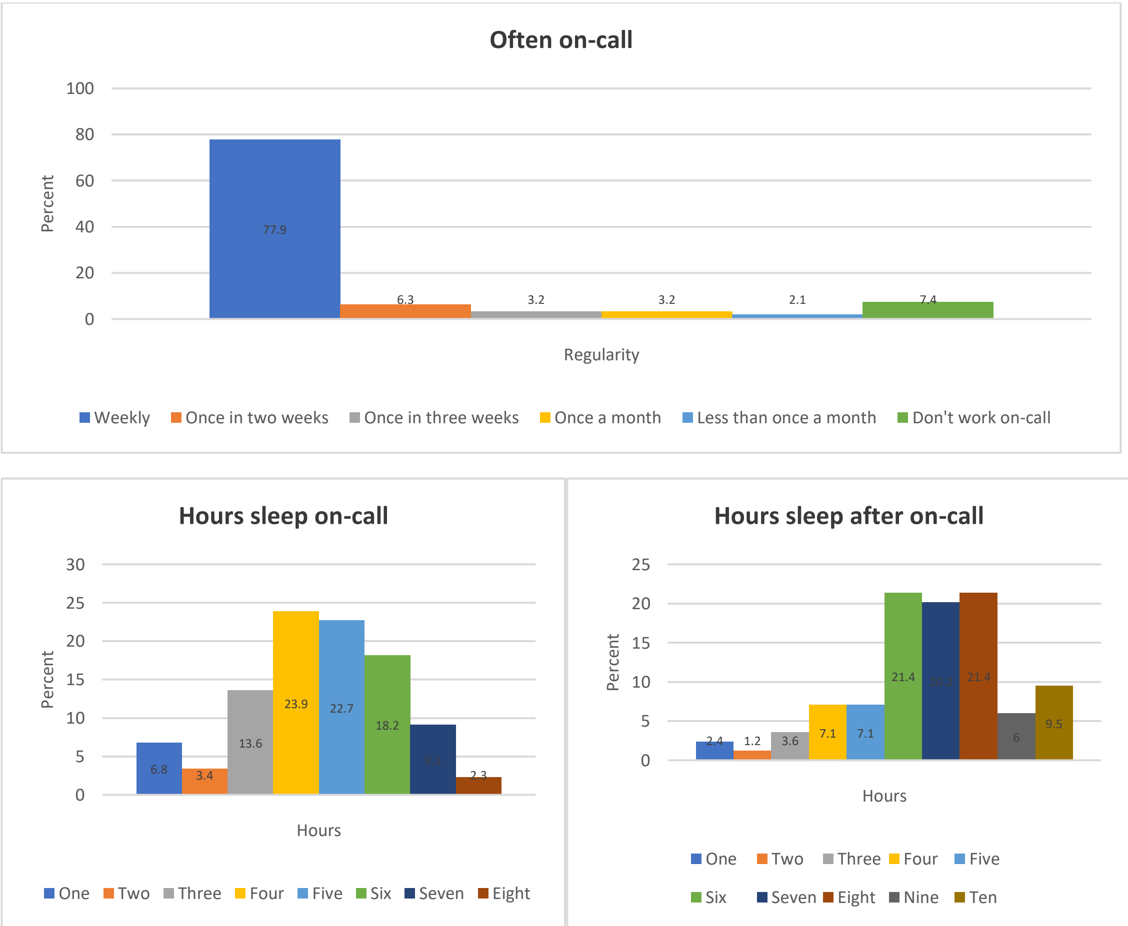


Figure 6.17. On-call factors in surgeons

6.5.7. Performance Outcomes

The minority reported their physical health or emotional problems at least somewhat disrupted their social activities (40%) or professional activities (30.6%). The majority reported their work performance at least good when not on-call (95.8%), and when on-call (84.3%). A minority reported that at least half of the time fatigue negatively impacts their ability to perform surgical tasks (20%) or non-surgical tasks (31.6%) optimally. Over two-thirds (67.4%) agree to having made minor work-errors as a result of fatigue. A minority (10.7%) agree to having made major work-errors as a result of fatigue. A summary of findings are seen in *Figures 6.18 and 6.19*.

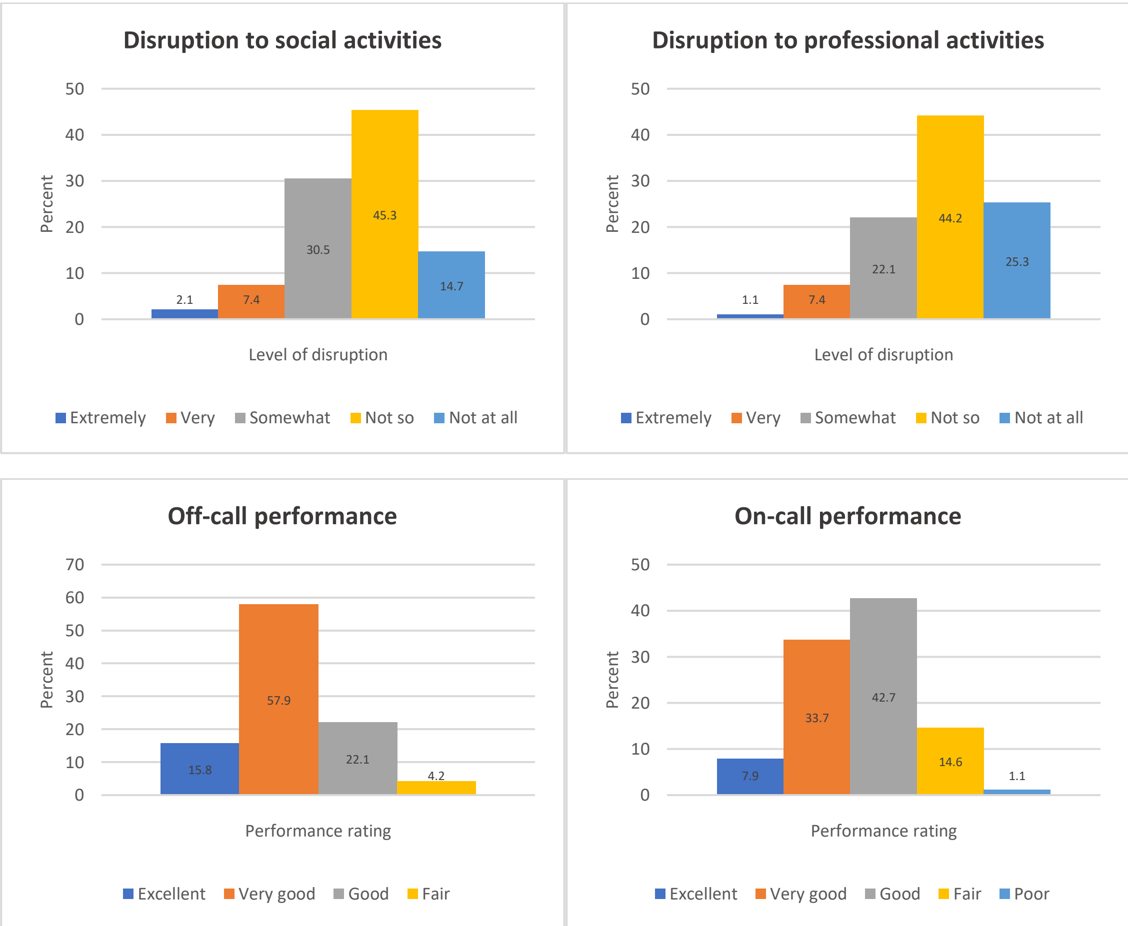


Figure 6.18. Performance outcomes in surgery

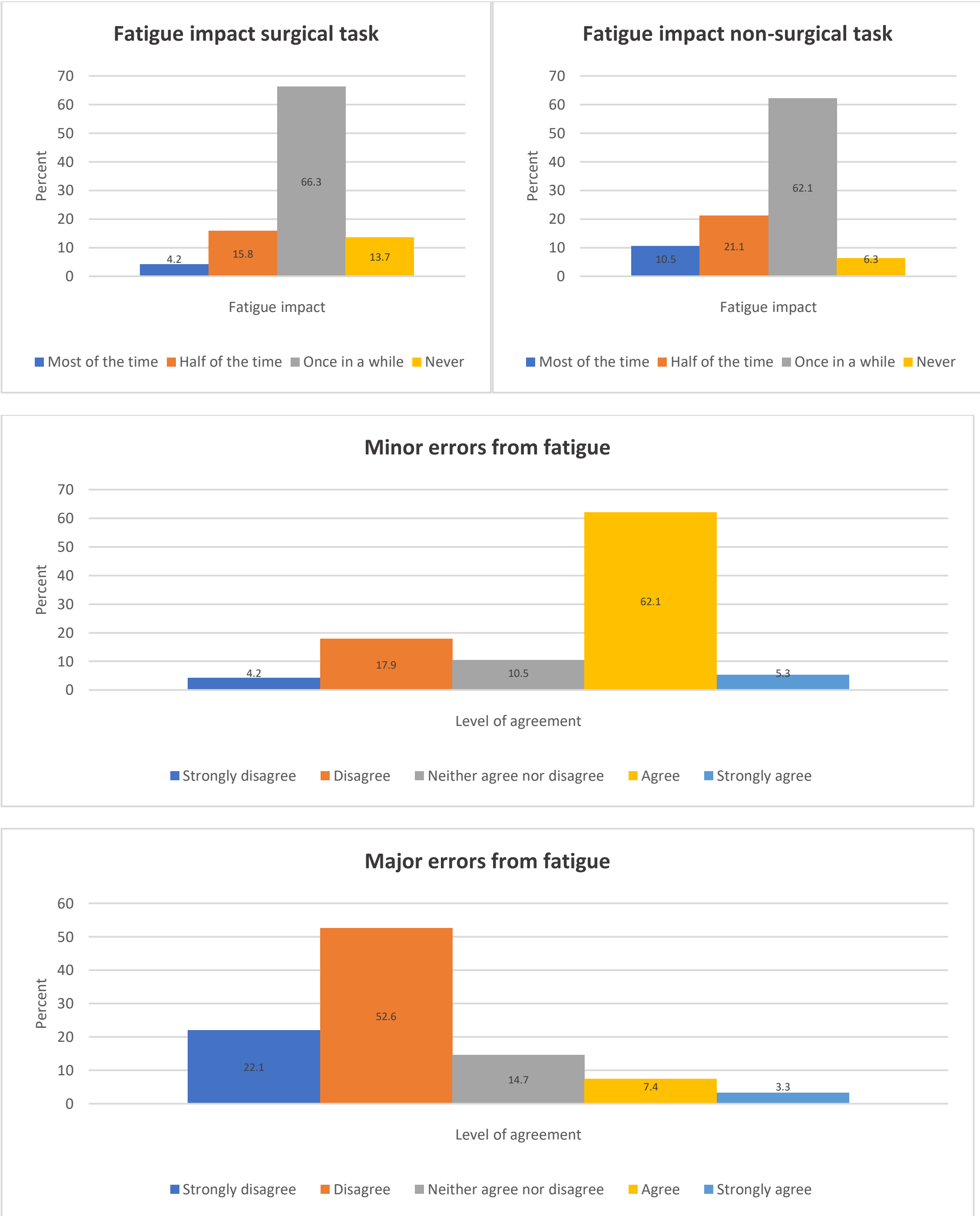


Figure 6.19. Fatigue-related performance outcomes in surgery

6.6. DISCUSSION

The surgeons in this study reported positive levels of overall health, with nearly a quarter reporting excellent health. However, such findings are not as established in overall wellbeing, with a shift downwards to just a tenth reporting excellent wellbeing, and a majority reporting being bothered at least somewhat by feelings of anxiety and/or depression. While overall wellbeing scores were higher than previous research conducted on Irish doctors (Hayes et al., 2017), psychological distress measures were higher in this study. There was a combination of lifestyle and work factors associated with these measures.

Surgeons demonstrated variable levels of self-reported compliance with healthy behaviours. Positively, a majority of surgeons reported high levels of compliance with non-smoking and acceptable alcohol weekly alcohol consumption (Kalinowski and Humphreys, 2016). This is much lower than previous reported research, which found 15.4% of surgeons have alcohol dependency issues (Oreskovich et al., 2012). With regards to recommendations on daily caffeine intake (Nawrot et al., 2003), there was very low compliance (4.2%), suggesting an issue of caffeine overuse in the profession. Similarly, irregular eating patterns were present, with only half of participants regularly eating breakfast and lunch. While most did not compromise their dietary intake with regular processed food or fast food, recommended vegetable and fruit intake was also low (FSA, 2011). The combination of these factors suggest that caffeine could be used as a substitute for meal intake, leading to insufficient calorific and nutrient intake which could impact energy levels.

While nearly two thirds of surgeons reported meeting the National Sleep Foundation guidelines (Hirschkowitz et al., 2015) of at least seven hours of sleep, less than half (45.3%) report having a consistent sleep pattern. Alongside this, nearly two thirds reported feeling regularly fatigued, and while, in part, this could be due to other physiological processes, such as insufficient hydration (90% non-compliance), a majority of participants reported they were not managing their own fatigue effectively. This supports the hypothesis that sleep quality must be considered in conjunction with sleep quantity for performance optimisation. Irregular sleep patterns could be related to mindsets of negative appraisal towards stress and challenge leading to states of insomnia. In this study, 40% of surgeons reported regularly stressed at work while 59% reported finding it difficult to switch off after work, indicating a potential inability to establish personal and work-life boundaries in the profession. This was significantly higher in female surgeons (94%

reporting regularly feeling stressed), and could reflect increasing demands on female surgeons in their personal lives including outstanding cultural expectations of the women to be the primary caregiver, as well as internalised cognitions to work harder to perform, as previously discussed.

There was a strong link between recognition of the importance of exercise, as well as the perception of not meeting recommended exercise guidelines. This however did not translate across to high levels of compliance with physical activity guidelines. Less than a quarter of respondents met recommended physical activity guidelines in moderate and strenuous activity for health enhancing physical activity (HEPA) benefits (WHO, 2012), which mirrors previous research on Irish-based doctors (19.1%) (O'Keeffe et al., 2019), but is significantly lower than reported findings of American surgeons, where over half (55%) engage in aerobic, and over a third (36.3%) engage in strengthening exercise (Shanafelt et al., 2012). Given that surgeons identified exercise as an important activity for them, it could be a potential behaviour change worth exploring within individuals to improve stress responses, work-life balance, and sleep levels, if done in conjunction with improved dietary intake. This could be facilitated by engaging with other healthcare practitioners to establish a plan for behaviour change. Currently, a significant portion (55.8%) of surgeons were not regularly checking in on their own health, which mirrors paralleled survey research on general surgeons in New England (54%) (Yoo et al., 2017) and America (53.6%) (Shanafelt et al., 2012). Such screening offers practitioners opportunities to increase self-awareness of health status and develop preventive habits.

Work related factors also provided insights into the day-to-day life of a surgeon. On-call work has been previously identified previously as particularly unique to surgery. Over three-quarters of surgeons reported completing on-call work on a weekly basis, with only 11.4% meeting the recommended sleep guidelines (Hirshkowitz et al., 2015) when doing so. Sleep levels were particularly lower in interns when compared to consultants, as well in the general and vascular disciplines. Poor resource availability is highly reported in this surgical cohort with over 70% reporting that they are working with insufficient human resources to fulfil their professional duties. Overworked and fatigued staff could lead to higher burnout amongst staff, as well as contribute to negative work cultures. It would appear that the regularity of the on-call work is intrinsically linked with insufficient staffing, which is thus contributing to reduced opportunities for surgeons to engage in healthy behaviour compliance.

Low levels of positive culture appear to be present in the profession. Nearly three-quarters of participants felt there was poor culture towards error-making in the profession, with similar findings suggesting that staff are not treated fairly if mistakes are made. Parallel qualitative study findings on surgeons in the United Kingdom found that institutional support responses to major clinical incidents were inadequate due to strong blame cultures (Pinto et al., 2013). Closed-cultural norms in the profession also led to non-disclosure to patients about hours of sleep prior to surgery. This makes it difficult for reporting systems to identify fatigue within surgeons. Previous research has shown, in anonymous survey study design, that higher fatigue was independently associated with higher levels of self-perceived medical error amongst internal medicine residents (West et al., 2009). This is supported in this study with regards to reported minor error-making but not with major error-making. This difference could reflect the differences in what is perceived as 'error-making' in the surgical profession as discussed previously. Cultural expectations of non-disclosure, perceived perfectionism, and unrealistic expectations of performance could lead to hostile work environments and lower cohesiveness amongst disciplines and between disciplines. These ultimately have negative ramifications for individual performance, as well as provision of quality of care.

Higher overall health and lower levels of fatigue were associated with better wellbeing and performance outcomes. When exploring the trends associated with health and wellbeing as joined measures, a series of lifestyle factors were found. Physiologically, consistent sleep patterns, engaging in the right amount of physical activity, and consistent eating patterns including increasing vegetable intake, while reducing fast food and ready-made meal consumption, all positively trended with better overall health. In addition, a psychological need of feeling supported was also associated with better overall health. These trends would support the theoretical underpinnings of Maslow's hierarchy of needs (Maslow, 1943), that perceived senses of physiological and psychological safety are associated with improvements in reporting of esteem factors such as overall wellbeing, reduced psychological stressors, and improved performance outcomes.

Higher levels of fatigue were reported by those who felt they were not managing fatigue effectively, those with greater levels of stress at work, and those who struggle to establish work-life boundaries. This has particular associations with the motivational theory of fatigue, which implicates fatigue states resulting from poor perceived self-management to adapt to high-effort and stressful situations (Hockey, 2013, p.127). While there were less work-place factors associated with the aforementioned outcomes, supportive cultures were associated with better overall health and lower fatigue. Positive cultures may have particular implications for surgeons self-determination (Ryan and Deci, 2004), whereby they may feel an increased sense of psychological need fulfilment in the areas of perceived relatedness, competence and autonomy. This is likely to increase their motivation levels, and reduce associated fatigue from competing demands (Hockey, 2013). Perceived high social support has also been found to be a predictor of high resilience (Sarkar and Fletcher, 2014), further supporting the idea of fatigue being influenced by a combination of personal and work relate factors.

Stress responses are an area of concern for surgeons wellbeing as well as performance. Prolonged negative appraisals to stressful conditions is associated with high negative affect, and may explain the finding that the majority of participants reported being bothered by feelings of anxiety and/or depression. Similar research, amongst general surgery residents in New England, found that a majority reported work-related stress negatively affected their overall wellbeing (72%) (Yoo et al., 2017), suggesting these behaviours are professionally influenced. Stress responses may also be implicated with regards to mediating the reporting of performance outcomes. A systematic review on the relationship between intra-operative stress and performance suggests that both non-technical and technical performance can be negatively impacted by stress states (Arora et al., 2010). Acute and chronic stress have also been implicated in reducing working memory capacity (Arnsten, 2009), which could lead to increased cognitive load and early-onset fatigue in tasks. This doesn’t necessarily mean that they are cognisant of this however. While nearly all surgeons report performing well off-call, this decreased when reporting on-call performance. Resilience in work can be defined in relation to the ability to perform under pressure, and has been divided into robust (i.e. perform under pressure and maintain wellbeing), and rebound resilience (i.e. bounce back from minor decrement to performance and wellbeing) states (Fletcher and Sarkar, 2016). This study’s findings suggests how a significant portion of surgeons have not developed resilience in their work, as supported in part by the implications of work on reported wellbeing measurements.

Interestingly, the differences between the primary cohort and the international sample may provide insights into how such stress responses are manifested in the profession. In particular, two work factors may predict stress responses – work cultures and resources. Overall, the surgeons in the primary cohort reported lower levels of stress at work, finding it easier to switch off after their work, and feeling more supported in their work. This shows the potential role of ‘relatedness’ in the BPN theory (Ryan and Deci, 2004), to mitigate stress impacts on individuals, as well as develop better coping strategies. The primary cohort felt staff were treated more fairly, and that error-disclosure was better promoted. This reflects the potential role of positive psychological safety cultures in mitigating stress levels. Lower levels of perceived resource constraints could also reduce negative stress responses, as differences between the two cohorts was also found. While this trend isn't fully verified, it does add further evidence of the necessity for sufficient human and physical resources to mediate stress responses.

This study provides novel insights into the myriad of lifestyle and work factors which could impact on influencing factors for health and performance outcomes in surgery. In particular, insights into the levels of exercise and diet are new to the research domain, as supported by findings in *Chapter 5.* The study provides results which indicate a mismatch in perceptions of surgeons of health and wellbeing measures, as well as providing further evidence that fatigue states are influenced by both personal and environmental factors.

Future research should explore the role of mandated breaks, and how such time would be utilised by surgeons. In particular, surgeons identified that exercise was important to them, and *Chapter 5* identified work-constraints as being a significant barrier to engaging in sufficient exercise. Active recovery strategies may be warranted in surgery, and could tip the balance away from use of maladaptive fatigue mitigators such as high caffeine consumption. Nearly a fifth of surgeons who responded to our survey are commuting for 90 minutes or longer each day, suggesting that non-work opportunities are not being utilised for recovery from work. Exploration of these higher-level strategic policy decisions on work-life balance are warranted.

Future research should explore the cultural norms in surgery towards fatigue responses, and performance outcomes related to error-making. If fatigue is not disclosed, and if error is not reported in a systematic way, with casual association between the two variables, it could become difficult to establish the relationship between them in real-life settings. Should systemic efforts to mitigate fatigue within healthcare settings be implemented, they should be done in conjunction with increasing reporting of error-making. This can be facilitated by developing a culture of psychological safety within the profession and hospital setting (Nembhard et al., 2006). Strong senses of team collegiality play an important role in sustaining emotional resilience (Murden et al., 2018), and this study would suggest that poor-collegiality may be playing a potential influential role in overall health of surgeons.

Future research should also explore surgeons capacity for self-awareness of the contributing factors to optimising their perceived health, wellbeing and performance outcomes. While a high percentage of respondents reported good health and wellbeing, there were several lifestyle factors which would suggest that they could be optimised further. A previous study on exploring surgeons awareness of wellbeing levels relative to their peers found that 89.2% of participants believed themselves to have similar wellbeing to their colleagues (Shanafelt et al., 2014). The authors also reported inconsistencies between self-reported levels of distress and objective measurements validated by the research team. Such findings could reflect an incongruent understanding of what wellbeing is, and how it is experienced by surgeons as a professional cohort. Internalised responses to norms of fatigue may suggest that surgeons believe wellbeing is optimal, when in fact it could be improved.

6.7. LIMITATIONS

While the study provides insight into the potential relationship between lifestyle, work, health and performance indicators, this was an opt-in survey which was distributed during the peak of the first wave of the COVID-19 pandemic, which significantly impacted recruitment and thus generalisability of the findings beyond the primary cohort. This study only investigated trends in associations, using box plots, between the different constructs of which there was significant differences between reported scoring. Further research should explore the relationships found in this study with more complex statistical modelling, such as regression analyses. Since the measurements were largely non-continuous, non-parametric regression analysis would be warranted. This requires larger sample sizes than parametric equivalents as the data doesn't assume a predetermined model structure or parameter, and thus this must be derived from the data collected.

Given the small sample size, efforts to reduce error warrants discussion. The reduction of random error was assisted through triangulation of the findings of this study with previous chapters. Specific factor error was considered in the study design, as the survey was piloted and tested for clinical sensitivity. Stratification and sub-group analysis of the findings in accordance with key demographic variables allowed control of the extent of variance, and thus reduction of standard error. Nonetheless, establishing test-retest reliability to control for variance was not possible given the anonymity of the data. Even if possible, the timing of the survey during a significant shift in work and life for individuals would have likely elicited different responses. In this regard, conclusions of the relationship between the variables in this study can only be given to the point of the first wave of the pandemic.

Finally, this survey provides subjective reporting by surgeons into lifestyle, work and performance related outcomes. It was established in previous chapters that incongruity between self-reported outcomes versus objective real-life outcomes can be present in the profession. Efforts to explore these metrics in an objective manner are thus warranted to establish the levels of similarity between perceived and actual outcomes.

6.8. CONCLUSION

This study reported trends between modifiable lifestyle and work factors, on self-reported health behaviours, and surgical performance. Addressing individual surgeons' lifestyles, in conjunction with occupational stressors, may improve self-reported health, wellbeing, fatigue levels, and ultimately optimise surgical performance. Evidence from this study, in conjunction with previous chapters, justifies the necessity for interventions to optimise surgical performance to utilise an individualised approach, with consideration of environmental conditions which can enable or impede behaviour change.

7. Chapter 7 - Changing the narrative: exploring thriving in surgery and examining the factors associated with optimising surgical performance

7.1. BACKGROUND

Thriving, broadly defined as the "joint experience of development and success" (Brown et al., 2017), captures the experience of full functioning, and can be observed via the concurrent subjective perceptions of high-level performance and wellbeing. It is influenced by two dimensions – a sense of learning and a sense of vitality (Spreitzer et al., 2005). The state has been linked to improvement in performance (14%), commitment to organisations (32%), satisfaction in work (46%), and reduction in burnout (125%) (Spreitzer and Porath, 2012).

While surgeons are likely to experience daily learning opportunities given the nature of the profession, exploration of vitality levels in the profession may offer an insight into how to optimise thriving states in the profession. In particular, vitality, by definition, is characterised by feelings of enthusiasm and increased energy (Ryan and Frederick, 1997), which could be the inverse of the fatigued state. Changing the narrative from 'surviving' to 'thriving' in surgery may elicit meaningful re-evaluation of what is required to optimise surgical performance. Thriving is therefore the construct through which optimising surgical performance will be explored.

This chapter has three elements summarised in *Figure 7.1*. It explores the phenomena of the thriving construct, as determined by the profession, including its meaning, enablers, and inhibitors; followed by the design, pilot and, evaluation of a bespoke evidence-based, and theoretically driven individualised behaviour-change intervention.

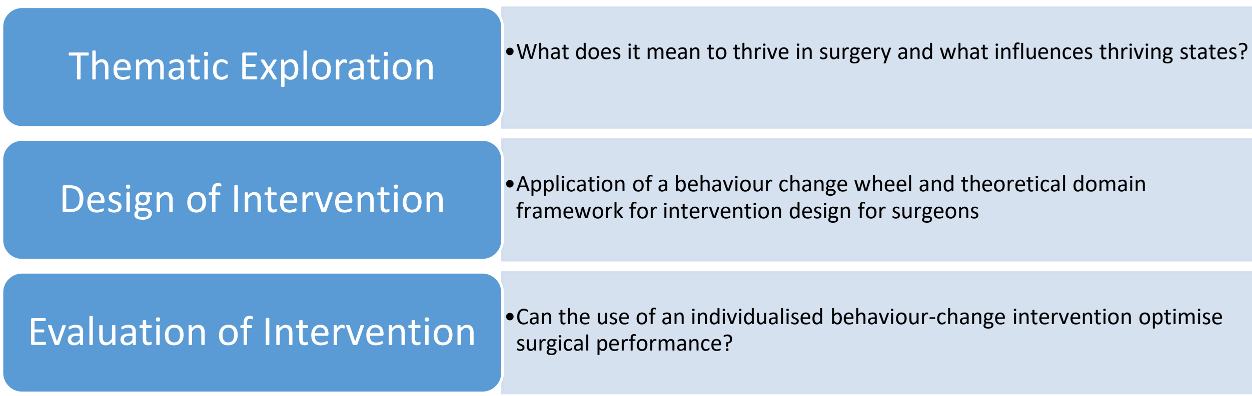


Figure 7.1. Elements of Chapter 7

7.2. THEMATIC EXPLORATION OF THRIVING IN SURGERY

7.2.1. Research Question

What does it mean to thrive in surgery and what influences thriving states?

7.2.2. Objectives

1. To identify the self-reported meaning of thriving in surgery
2. To explore the enablers of thriving in surgery
3. To understand the inhibitors of thriving in surgery

7.2.3. Methods

The research was conducted in accordance with reporting of standards of the American Psychological Association (Levitt et al., 2018) and the COREQ guidelines (Tong et al., 2007).

7.2.3.1. Participants

Participants were recruited between February 2020 – May 2020. This study took place in conjunction with the first study in *Chapter 5,* and thus the same recruitment call was utilised.

7.2.3.2. Study Instruments

Interview Guide: An interview guide (*Appendix AD*) was devised based on the objectives of the study, and with input from an expert in thriving in high-performance industries (Dr. Daniel Brown) to improve the researchers ability to ask appropriate follow-up questions. The questions focused on three main areas in the context of thriving: 1) meaning 2) enablers and 3) inhibitors.

7.2.3.3. Qualitative Analysis

The methods described for process of qualitative analysis, in accordance with thematic analysis, are discussed in *5.2.3.4. Qualitative Analysis*.

7.2.4. Results

7.2.4.1. Demographics

A total of 14 surgical trainees and consultants were recruited, all of whom had previously participated in the studies in *Chapter 5.*

7.2.4.2. Meaning of Thriving in Surgery

When asked to discuss the meaning of 'thriving' in surgery, it was evident from the participants' responses that this was "*difficult to conceptualise"(P31),* yet occasionally recognisable during surgical practice. It was described as being linked with a "*sense of achievement"(P32)* or excitement in work, which ultimately increased vitality. While not explicitly discussed as a meaning of thriving, the ability to sustain "*high-performance"(P15)* work was mentioned several times by surgeons. The sense of thriving is implicitly influenced by fragmented moments of hedonia or "*adrenaline rush"(P18),* which was largely in theatre settings. Most notably, in the context of COVID-19, the lack of opportunities for technical skill resulted in reduced vitality.

7.2.4.3. Enablers of Thriving in Surgery

Participants described a series of 'personal' and 'environmental' factors which enabled thriving, as seen in *Figure 7.2.*

Personally, various motivations within work were identified as enablers of thriving including learning, improving in their profession, competition between peers, and making a meaningful difference to help patients and trainees – *"there is a wanting there…to do something and always contribute to helping"(P4).* Having a core set of perceived competencies to support the surgical culture was another enabler, including an awareness of the resilience required for surgery, the grit required, and the necessity to have a growth mindset as surgeons are expected grow from the difficulties endured in training –*"you expect a certain amount of hardship, you expect it, you know it, and you grow for having gone through it"(P2)*. Similarly, adapting to non-optimal physiological states is important – *"you learn to function on six or less hours"(P30).* Finally, engaging in co-curricular activities, such as research and professional societies, also facilitates access to thriving states.

Environmentally, the promotion of a positive and supportive culture enabled thriving – "*you're not going to be judged...if something goes wrong it is okay"(P11)*. This was facilitated by modelling from those in power – "*you were up all night with them [consultant], and they would say they found it really tough and always have...that is powerful"(P4).* It was identified that the changing demographics, with a greater number of females progressing to leadership in surgery, has facilitated a shift towards better performance regulation. This shift resulted in better examples of maintaining a work-life balance, and associated regulatory adaptions. Finally, removal of environmental impediments, such as giving surgeons more autonomy in their workflow, was important as it also helped develop social supports outside of work – "*control of our rotas so we can organise when to meet family, friends, go on vacation"(P32).*

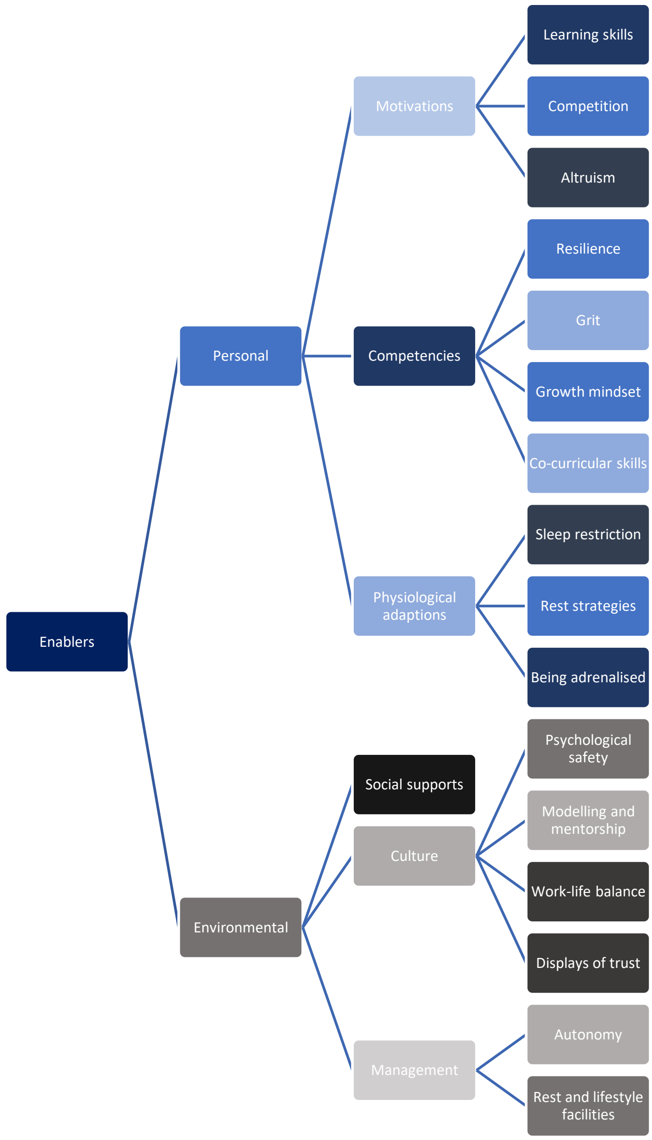


Figure 7.2. Constructed mindmap on enablers of thriving in surgery

7.2.4.4. Inhibitors of Thriving in Surgery

Participants described a series of 'personal' and 'environmental' factors which inhibited thriving, as seen in *Figure 7.3*.

Personally, the most marked inhibitor was sleep deprivation and fatigue, with surgeons perceiving themselves to be regularly *"suffering"(P4)* because of the state. They identified modifiable and non-modifiable aspects to the state, but spoke of internalised cognitions of being perceived as *"weak"(P32)* if they didn't push through the state, meaning wellbeing is not prioritised for performance optimisation. This meant their social reality was often dominated by cultural norms within the profession - *"I probably wasn't like that when I started off in surgery, but you get used to or adapt to the system"(P5),* due in part to overattachment, which often means placing unrealistic expectations on themselves – "*like I'm really trying to be the same person, or same level I was before…and yet I feel like a failure on both fronts"(P2).*

Environmentally, cultural norms within the profession of the "*old boys club"(P2),* enabled by peer-pressure, as well the system of "*don't complain…just comply"(P32),* meant negative norms remain. This culture, in part, is fuelled by insufficient resourcing, which reduces training opportunities for staff, as well as the significant work demands of a surgeon, which makes it difficult to rest – "*so Ireland has a completely backwards approach…you can never really be 'off' – you always have this feeling that there is a possibility you could be called for something"(P5).*

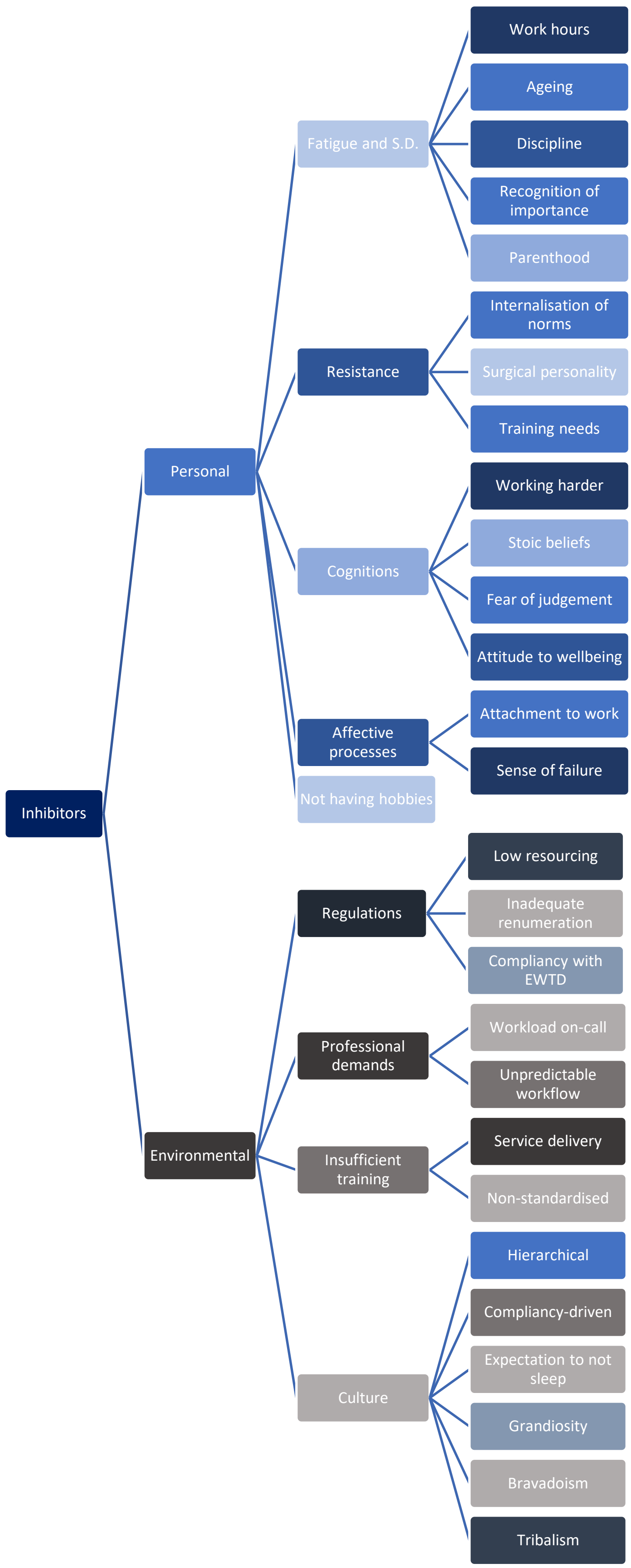


Figure 7.3. Constructed mindmap on inhibitors of thriving in surgery

7.2.5. Discussion

Surgeons identified experiences of thriving in surgery as being similar to fragmented moments of hedonia. Most markedly, sleep deprivation and fatigue were identified as barriers to achieving states of thriving, likely reducing vitality levels in surgeons. While difficult to identify on a regular basis, thriving in surgery can be influenced by a series of personal and environmental factors. Thriving was intrinsically linked to fragmented moments of achievement, predominantly in technical performance. This may relate to the 'flow state', which might only be present in operative settings (Csikszentmihalyi, 1990). No surgeons identified eudemonic experiences, which could in part be influenced by the predominant role that work plays in their lives.

Fatigue and sleep deprivation were identified as inhibitors to thriving in surgery. While such issues are highly influenced by environmental constraints, there were internalised processes relating to professional and organisational norms within the profession which created a level of inertia towards making meaningful change. High levels of self-stigma (68.4%) have been previously reported in Irish-based doctors (Hayes et al., 2017), and previous grounded theory study research on surgical residents found that residents felt the need to conform to surgical stereotypes at the expense of personal wellbeing (Patel et al., 2013). The difficulty in changing these perceptions draws reference to self-categorisation theory (Onorato and Turner, 2004), whereby parlance in the profession focuses on surviving and not thriving. These limiting cognitions have negative implications for opportunities to access thriving. In accordance with the hierarchy of needs (Maslow, 1943), if deficits in physiological needs such as sleep cannot be fulfilled then individuals cannot reach states of higher self-esteem, which is important for positive behaviour change. It is also important to access states of self-actualisation, which is important for thriving. Many of these internalised processes reflect a cognitive dissonance (Festinger, 1957), between the perceived requirements to thrive in surgery, and the personal effects on psychological wellbeing and physiological processes as a result of trying to reach these demands. This cycle becomes even more difficult to break as surgeons regularly rotate between different settings. This means that they must continually access and integrate with new social agents (Harris et al., 2012), who may support of impede access to states of thriving.

There were additional barriers to thriving including perceived non-fulfilment of the BPN. Feelings of non-autonomy lead surgeons to perceive an external locus of control which reduces self-control of wellbeing. Particular to trainees, insufficient training exposure reflects non-fulfilment of the 'learning' component to access states of thriving, which reflects feelings of non-competence. Finally, while tribalism was identified as being present in the profession, the precarious foundations of acceptable domains of conversation may inhibit feelings of connectedness to others. Specifically, participants reported a lack of willingness to discuss their own wellbeing with others. Similarly, lack of opportunity to spend time away from work, due to professional demands, means surgeons find it difficult to detach from work, and thus feel connected with family and friends.

One of the enablers which was identified as being important to accessing thriving states was beliefs about capabilities of overcoming adversity. The perception that thriving in surgery requires a core set of resilient psychological competencies, which all surgeons must develop in order to conform to norms, indicates the difficulties within the profession to identify their own individualised experience of thriving. In addition, the necessity to adapt to non-optimal conditions indicates that significant structural constraints impede access to the thriving experience. The combination of cultural and environmental demands culminates in increased stress load, of which surgeons have to "*learn to function"(P30)* through employing coping strategies. This relates to the stress appraisal theory (Lazarus and Folkman, 1984), which posits that positive reaction to stressors can be formed by an individual. The internalised process then facilitates a belief of situational control, leading to desensitisation to similar subsequent stressors, and the 'bounce back' (Carvar, 1998) required in order to access states of thriving following adverse events. This can involve developing capacity to activate baseline performance with ease, and suggests the necessity for resilience or grit traits to be prerequisites to thriving states in surgery.

Additional enablers to thriving states included contexts where the BPN of autonomy, competence and relatedness were promoted. This is supported by the literature, whereby developing feelings of relatedness, and the importance of trust to enable connectivity, has been identified as important to thriving (Carmeli and Spreitzer, 2009). The presence of cohesive surgical teams can facilitate this. This includes surgeons recognising the importance of high quality relationships with colleagues, to allow for personal development through learning from feedback on performance (Carmeli and Gittell, 2009). Relatedly, developing social support, a known enabler of thriving (Feeney and Collins, 2015), by recognising that your peers also experience fatigue, breaks down cultural norms of masochism within the profession. In the context of surgery, consultants act as 'social agents' for change, and offer the most meaningful opportunity to model positive cultural norms within the profession. In situations where surgeons perceive greater control in their work, as facilitated through resourcing and workload modelling, a greater level of autonomy is fulfilled. Finally, surgeons are exposed to learning-rich environments on a daily basis, and facilitating curiosity in learning helps to fulfil the need of competence.

7.2.6. Limitations

Similar limitations to qualitative research discussed previously are applied to this study. The meaning of thriving meaning was less understood by participants, suggesting the use of positive psychological experiences is not commonly discussed in the profession. Nonetheless, this research does have analytical generalisation (Smith, 2018), as findings married many of the preestablished variables associated with thriving in the organisational and elite sport thriving literature. A greater sample size would allow identification of discipline-specific factors associated with thriving in surgery.

7.2.7. Conclusion

The surgical profession, as a high-performance industry, is limited in both its conceptualisation of, and opportunities to, thrive, primarily due to the dominant influence of fatigue and sleep deprivation, internalised cognitions, and non-fulfilment of the BPN. Addressing the issues of negative cultural norms and personalised fatigue management in surgery through a multifaceted approach is warranted. Establishing a perceived sense of internal locus of control, which will allow surgeons to have a sense of increased autonomy in their work will drive intrinsic motivation to mitigate fatigue. This is best established through behaviour-based interventions to challenge individual cognitive processes, and complimented through group-based efforts to tackle environmental barriers. This may shift surgeons from focusing on shorter-term hedonic to longer-term eudemonic wellbeing approaches, eliciting thriving states and optimising performance within the profession.

7.3. FRAMEWORK FOR INTERVENTION TO OPTIMISE SURGICAL PERFORMANCE

Recognising the constraints of environmental adaptions in healthcare settings, this research focused on optimising performance through self-determination, in the form of an individualised behaviour-based intervention. The intervention follows a theoretically-informed and evidence-based design process to improve efficacy.

7.3.1. MRC Framework

The MRC framework for complex interventions was used to guide process for intervention design (O'Cathain et al., 2019; Craig et al., 2008). A multi-disciplinary research team was assimilated to guide intervention development, implementation, and assessment over a series of months. A summary of the research team and their expertise is provided in *Table 7.1.*

Table 7.1. Intervention team members and expertise

Member	Expertise
Mr. Dale Whelehan	PhD researcher
Prof. Paul Ridgway	Supervision and performance assessment
Dr. Daniel Brown	Positive psychology and elite sport
Prof. Eva Doherty	Human factors
Dr. Taryn Taylor	Fatigue
Lt. Col Niall Buckey	Fatigue risk management and systems
Prof. Andrew Baillie	Psychometrics

An evidence-based approach was used for design. Assimilation of the data findings from previous studies was conducted to triangulate relationships between concepts. Identification of the influencing personal and environmental factors for surgeons which would impact behaviour change was conducted (*Appendix AE*). Relevant outcome measurements were then linked with broader intervention constructs, and the relevant stakeholders to consider, in ensuring effective intervention, were listed (*Appendix AF*). To select the targeted behaviour for intervention, an exhaustive list of potential behaviours was created which were prioritised according to the APEASE criteria, an acronym for affordability, practicability, effectiveness, acceptability, side-effects and equity (Michie et al., 2014) (*Appendix AG*). This culminated in a proposed framework for personal and professional interventions for optimising surgical performance as the map for intervention success (*Figure 7.4*). The identified behavioural focus of the intervention was belief in principles to optimise surgical performance.

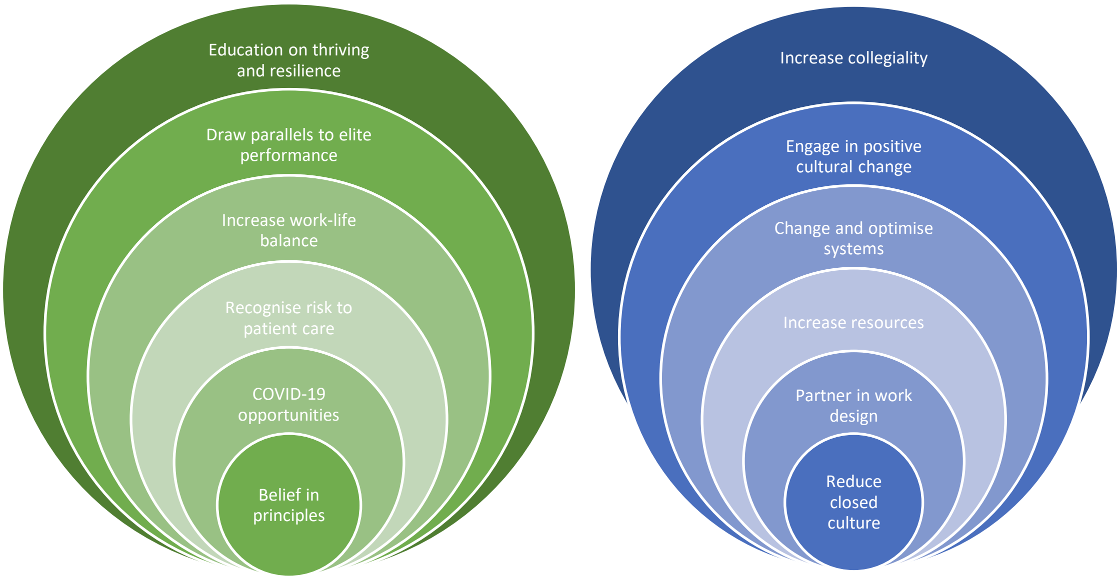


Figure 7.4. Personal and professional intervention framework devised by researcher

7.3.2. Application of Theoretical Frameworks

The intervention was designed using two theoretical frameworks – the Behaviour Change Wheel (BCW) theory (Michie et al., 2011), which allowed for behaviour change diagnosis and macro-level intervention design, and the Theoretical Domain Framework (TDF) (Atkins et al., 2017), which allowed for micro-level intervention design (*Figure 7.5*).

Given the complex setting of healthcare systems, these two theories were identified as the most appropriate means to optimise surgical performance. It was decided to use the BCW over other behaviour change theories due to the methodological approach in which it was designed. The BCW was developed from a systematic review of pre-existing theories of behaviour change (Michie et al., 2011). It identified gaps within current behaviour change theories according to three criteria – comprehensiveness, coherence, and link to overarching model of behaviour. At a microlevel, the TDF is an evidence based implementation theory framework, synthesised from 128 theoretical constructs from 33 theories (Atkins et al., 2017). It comprises of fifteen domains, and aligns with the COM-B model to assist in providing an evidence-based micro-level intervention study design. It provides individual-level changes such as knowledge and skills; social-level changes such as support; and environmental resource level changes. It allows identification of the barriers and facilitators to change through the lens of cognitive, affective, social, and environmental influencers (Atkin et al., 2017).

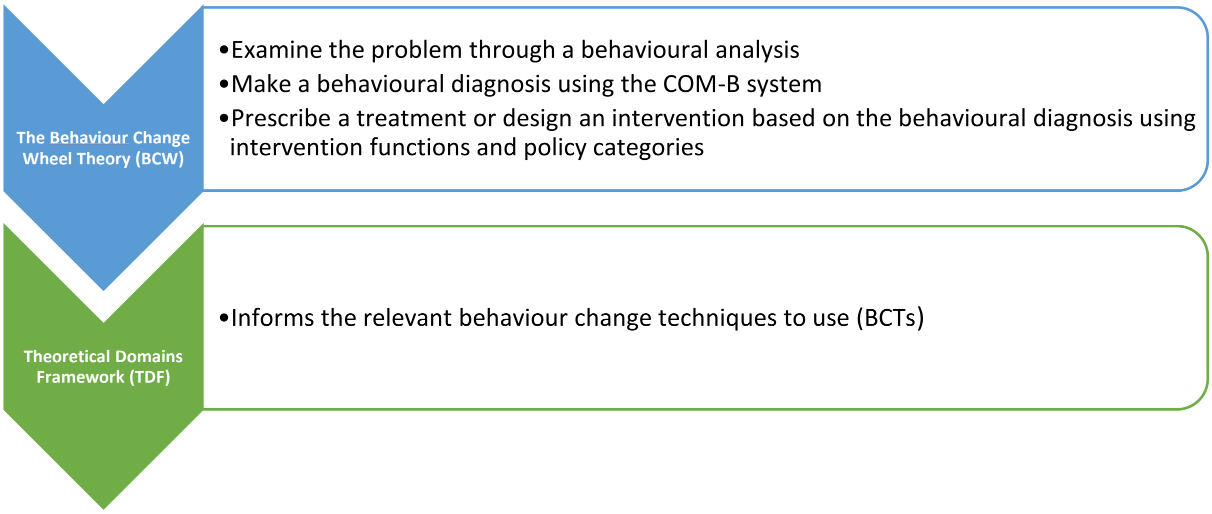


Figure 7.5. Theoretical approach of intervention study design

7.3.2.1. Behaviour Change Wheel Theory

At a macrolevel, the COM-B model is used, adapted in *Figure 7.6* (Michie et al., 2011). It states that capability and opportunity influence behaviour outcomes through mediation of levels of motivation.

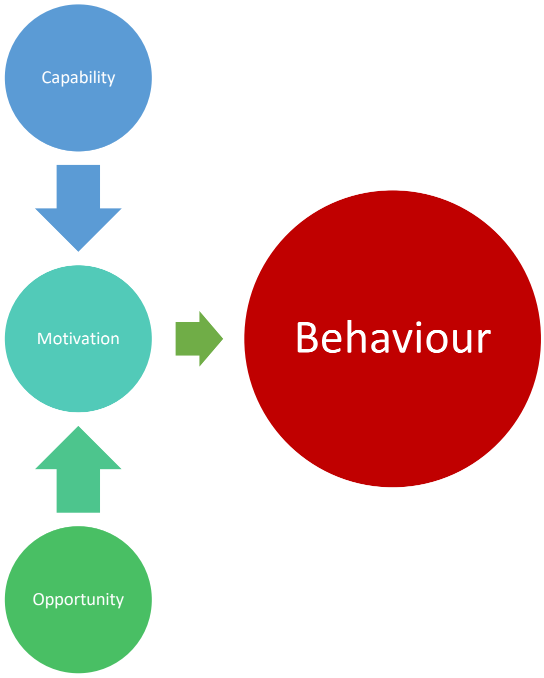


Figure 7.6. COM-B model of behaviour change

Matched with each of the components of the COM-B are nine intervention functions which address deficits in one or more of the conditions of the model. Supporting these intervention functions are seven policy categories which enable and support such interventions to occur. This creates the BCW seen in *Figure 7.7.*

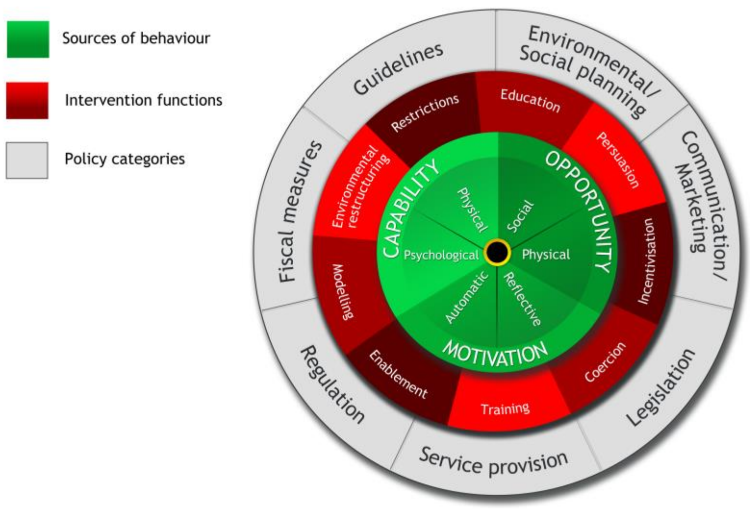


Figure 7.7. Behaviour Change Wheel with permission granted (Michie et al., 2011)

A seven step process of behaviour diagnosis for surgeons (*Appendix AH*) culminated in the macro-level intervention design seen in *Table 7.2.*

Table 7.2. Summary of macro-level study intervention design

Strongly Recommended Intervention Functions
1. Education
2. Environmental Restructuring
3. Modelling
4. Enablement
5. Training
Moderately Strong Recommended Intervention Function
1. Persuasion
2. Incentivisation
Supported by Policies in
1. Guidelines
2. Service Provision
3. Communication/Marketing
And longer-term planning towards:
Regulation

7.3.2.2. Theoretical Domain Framework

At a microlevel, the selected behaviour change intervention is mapped to the fifteen domains of the TDF (*Figure 7.8*).

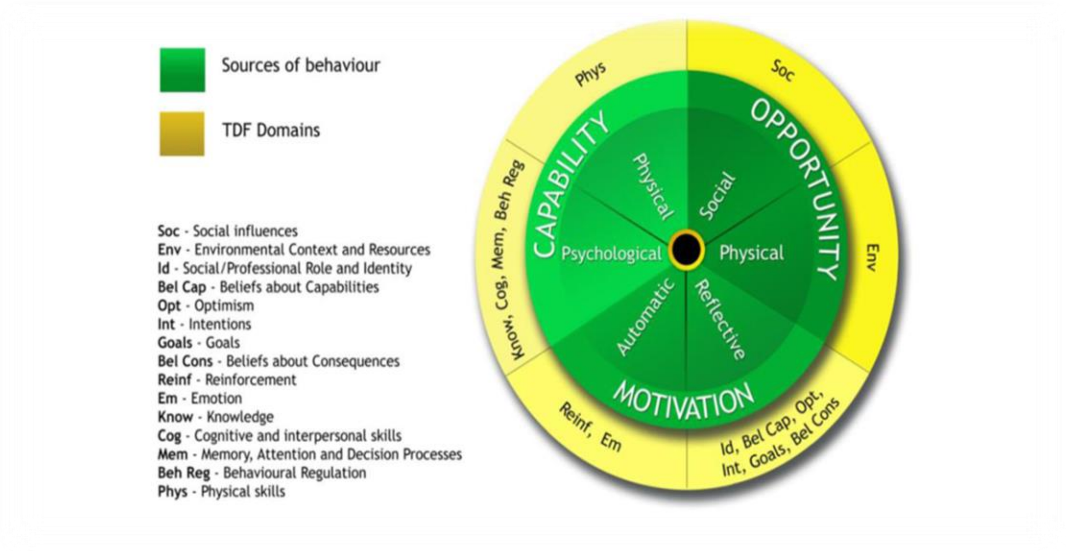


Figure 7.8. Theoretical Domain Framework with permission granted (Atkins et al., 2017)

Thereafter, appropriate BCTs are selected to maximise effectiveness of the intervention. BCTs are groups of activities that can be utilised to target specific patterns of behaviour (Michie et al., 2011). The Behaviour Change Techniques Taxonomy (BCTT) (Michie et al., 2013) provides 93 distinctive BCTs which are clustered into 16 groups listed in *Table 7.3*.

Table 7.3. List of distinctive BCT groups

Behaviour Change Techniques Taxonomy
Goal Planning
Feedback and monitoring
Social support
Shaping knowledge
Natural consequences
Comparison of behaviour
Associations
Repetition and substitution
Comparison of outcomes
Reward and threat
Regulation
Antecedents
Identity
Scheduled consequences
Self-belief
Covert learning

Deciding to focus on areas of COM-B system which were determined most amenable on behavioural diagnosis in surgeons (i.e. psychological capability, motivation automatic and motivation reflective), a four step process of BCT matching and prioritisation occurred (*Appendix AI*), resulting in the chosen BCTs seen in *Table 7.4.*

Table 7.4. BCTs used for intervention study

BCT			Definition
Goal planning	1.1.	Goal planning: goal setting	Set or agree on a goal defined in terms of the behavior to be achieved
	1.4.	Action planning	Prompt detailed planning of performance of the behaviour in terms of context, frequency, duration, and intensity
Feedback and monitoring	2.2.	Feedback on behaviour	Monitor and provide informative or evaluative feedback on performance of the behaviour
	2.4	Self-monitoring of outcome of behaviour	Establish a method for the person to monitor and record the outcome of their behaviour as part of a change strategy
Natural consequences	5.1.	Information about health consequences	Provide information about health consequences of performing the behaviour
	5.2.	Salience of consequences	Use methods specifically designed to emphasise the consequences of performing the behaviour with the aim of making them more memorable
	5.3.	Information about social and environmental consequences	Provide information about social and environmental consequences of performing the behaviour
	5.6.	Information about emotional consequences	Provide information about emotional consequences of performing the behaviour
Comparison of outcomes	9.1.	Credible source	Present communication from a credible source in favour or against the behaviour
	9.2.	Pros and cons	Advise the person to identify and compare reasons for wanting and not wanting to change the behaviour
Reward and Threat	10.4.	Social reward	Arrange reward if and only if there has been effort in performing the behaviour
	10.7.	Self-incentive	Plan to reward self in future if and only if there has been effort in performing the behaviour

7.3.2.3. APEASE Criteria

In order to assist in prioritisation of the intervention functions, policy categories and behaviour change techniques, the APEASE criteria (Michie et al., 2014) were used. These are six criteria, explained in *Table 7.5*, which encompass all aspects of consideration when implementing an intervention.

Table 7.5. Explanation of the APEASE criteria

Criterion	Description
Affordability	An intervention is affordable if within an acceptable budget.
Practicality	An intervention is practicable to the extent that it can be deliver as designed through the means intended to the target population.
Effectiveness	Effectiveness refers to the effect size of the intervention in relation to the desired objectives in a real world context.
Acceptability	Refers to the extent to which an intervention is judged to be appropriate by relevant stakeholders.
Side-effects/Safety	An intervention may have unwanted side effects or unintended consequences.
Equity	An intervention may reduce or increase the disparities in standard of living, wellbeing, or health between different sectors of society

7.3.3. Intervention Components

The findings culminated in a two phase behaviour change intervention seen in *Figure 7.9*.

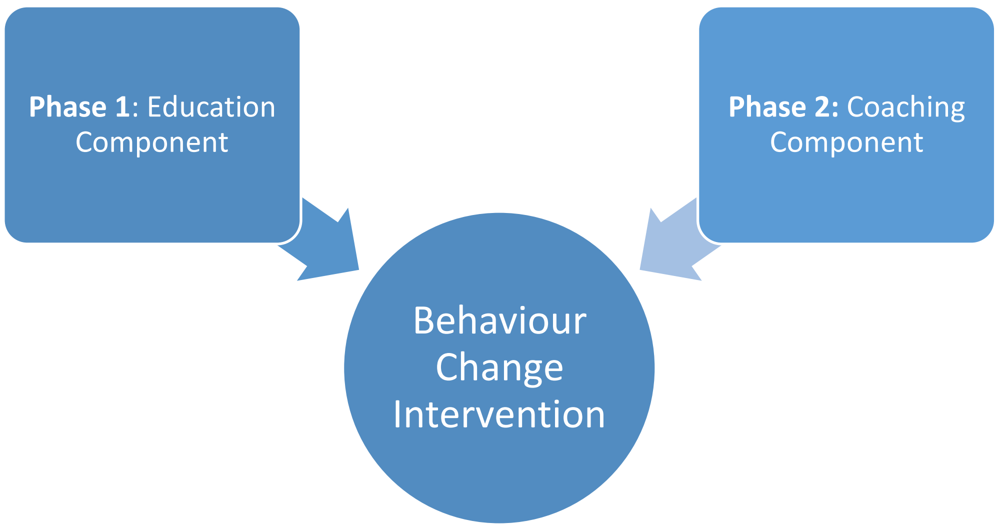


Figure 7.9. Components of behaviour change intervention

7.3.3.1. Phase 1: Education Component

This intervention functions **education** and **training** were used. The bespoke intervention sought to increase surgeon's confidence, and establishment of goals, for behavior change using the principles of three areas of performance science *[BCT 1.1].* An hour-long educational session involved testimony from key experts *[BCT 9.1].* As part their presentations, the experts showcased examples *[BCT 5.2]* within their own sectors, where the application of evidence-based principles has led to positive outcomes, as well as examples of poor practice, and examples of significant error resulting from non-application of the principles. Their discussion focused on health consequences *[BCT 5.1]*, social, environmental, [*BCT 5.3]* and emotional consequences, such as wellbeing, stress, and success *[BCT 5.6].* The researcher worked in conjunction with the experts, utilising the findings informed from this research, to assist in improving accessibility and relevance to the surgical cohort.

7.3.3.2. Phase 2: Coaching Component

The intervention functions **enablement** and **persuasion** were used**.** This phase focused on individualised guidance, using the GROW (Goals, Reality, Options, Will) model of coaching (Whitmore, 1996), from a certified external coach to make behaviour change. This model of coaching focuses on a process of identifying the problem, creating, and then implementing goals to remove the problem.

Coaching is a deliberate practice activity which seeks to invoke knowledge attainment and self-awareness. It draws parallels to philosophies of humanistic psychology (Stober, 2006), and positive psychology (Linley and Harrington, 2008), while using goal-orientated learning and experiential learning (Whitmore, 1996). These approaches are important for surgery, given they have either not been previously studied, or that they utilise already embedded approaches to learning in the profession. The behaviour change goal was focused on for the duration of the intervention, which lasted for at least two months as recommended for habit formation (Lally et al., 2010). As part of coaching, surgeons discussed the pros and cons of behaviour change *[BCT 9.2]* in terms of health [BCT 5.1], social, environmental *[BCT 5.3*], and emotional consequences [*BCT 5.6].* An individualised action plan *[BCT 1.4]* was then conducted, and feedback from the coach was given in subsequent sessions *[BCT 2.2]* through a supportive coaching model.

7.3.3.3. Sustainability

The policy category **of service provision** was used. The coaching process was already established and independently funded within the research setting. Coaching was conducted on a tailored and regular basis, asking surgeons to review their desired goals and actual outcomes, and identify what went well and not so well to encourage self-monitoring of achievement *[BCT 2.4].* This is facilitated through the common practice of 'coaching logs', whereby individuals record their thoughts and emotions in situations where desired behaviour change is required. In doing so, they begin to develop self-awareness of the interplay between emotion, thought, and behaviour, which leads to new learning. Ensuring regular application of the behaviour change was facilitated by embedding a series of self-identified incentives, which involved having the surgeon self-reward if they were adhering to the behaviour change *[BCT 10.7],* as well as using coaching strategies or social rewards *[BCT 10.4*]. The role of the coach has also been shown to influence motivation levels in individuals (Theeboom et al., 2014), but the process also encourages developing intrinsic reinforcement within individuals to sustain goal-direction behaviour changes. Specific barriers for surgeons engaging in coaching were identified from the literature (Byrnes et al., 2021; Valanci et al., 2020; Lin and Reddy, 2019; Mutabdzic et al., 2015). Efforts to overcome these barriers are described in *Table 7.6*.

Table 7.6. Barriers to surgeons engaging in coaching and mitigating strategies used

Barrier	Mitigation
Limited time and logistics	• Online and flexible timing for completion of both phases
Concern about reputation	• Participant anonymity and coaching occurred independent of research team
Loss of control	• GROW approach is a participant-led coaching process
Culture	• Engagement from consultants in process, and word-of-mouth dissemination of value • Language of intervention focus on 'optimising surgical performance' including operative settings

7.3.4. Outcome Measurement and Process Evaluation

A study protocol was established, which is attached in *Appendix AJ*. The intervention feasibility and pilot was evaluated using a process evaluation framework (Moore et al., 2015) (*Figure 7.10*), as well as a series of validated outcome measurements. A questionnaire was formed from an exhaustive list of relevant outcome measurements which were minimised by consideration for length, relevance, public availability, psychometric properties, and expert input. In addition, outcome measurements designed by the researcher to assess relevant clinical performance indicators were used. Engagement with the SOAR programme regarding logistics occurred throughout.

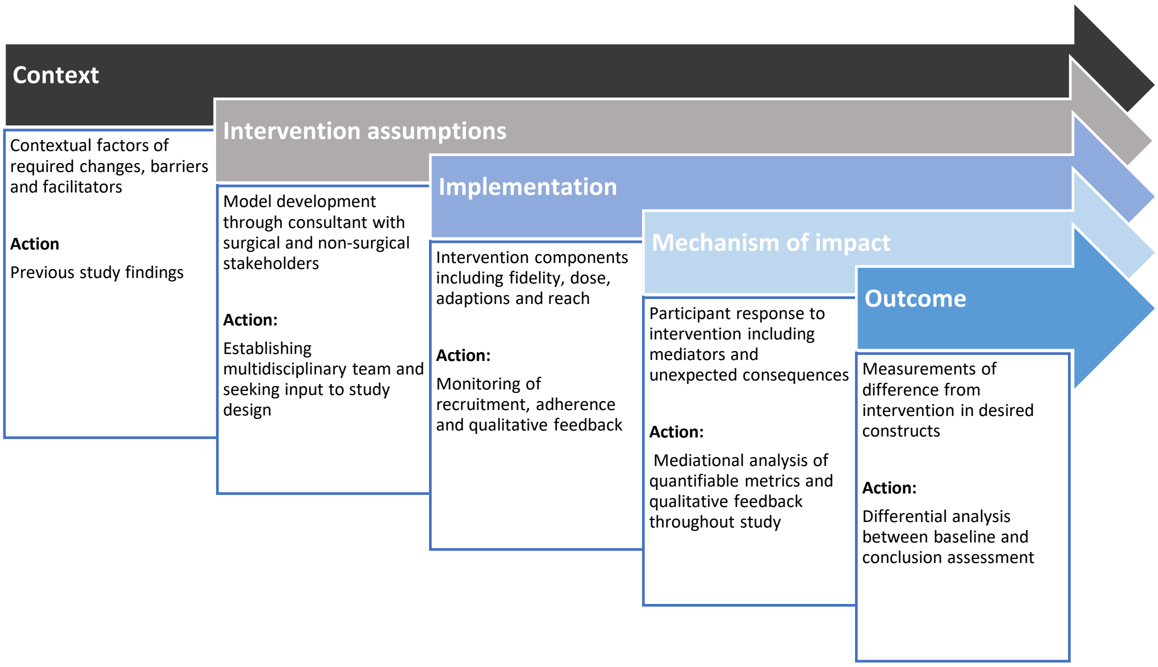


Figure 7.10. Key functions for process evaluation of the study

7.4. EVALUATION OF THE INTERVENTION

7.4.1. Research Question

Can the use of an individualised behaviour-change intervention optimise surgical performance?

7.4.2. Objectives

1. To explore the feasibility of a two phase intervention study design in eliciting behaviour change
2. To pilot investigate if the intervention impacts self-reported fatigue and thriving levels
3. To identify if the intervention impacts on self-reported clinical and psychological performance markers
4. To identify surgeon-specific barriers to engaging in behaviour change

7.4.3. Methods

This study is reported according to the TRENDS guideline statement (Des Jarlais et al., 2004).

7.4.3.1. Study Design

This was a feasibility and pilot intervention study design, whereby surgeons short-term behaviour change was evaluated. Feasibility allows the researchers to establish with confidence that a study is comprehensive and effective to elicit desired changes. A study flow diagram is seen in *Figure 7.11.* Participants received baseline assessments followed by an education session of one hour (*Appendix AK)*. Then participants had an opportunity to identify a personalised behaviour and self-refer to complete an average of three coaching sessions, for a minimum of two months. Each session was between 60-90 minutes in length.

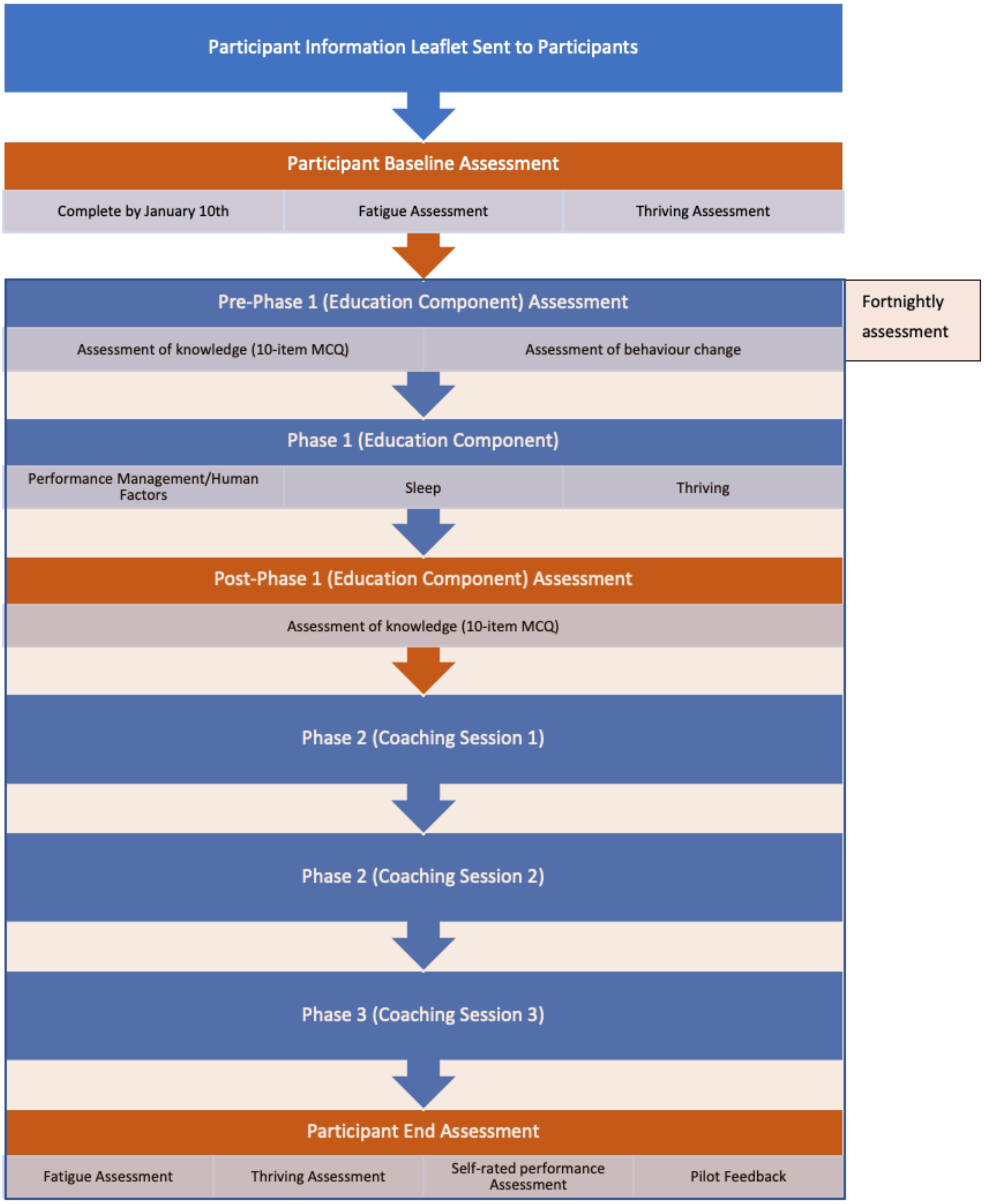


Figure 7.11. Study intervention flow

7.4.3.2. Participants

Participants were recruited between December 2020 – February 2021 through convenience sampling. A personalised email containing an invitation to participate (*Appendix AL*), as well as a participant information letter, was sent (*Appendix AM*). A reminder email was also sent out to individual emails between 3-5 weeks after the study commenced. The participants were considered recruited when they subsequently respond by email indicating their interest.

Informed written consent was obtained from participants at recruitment through postal or electronic signature. All specialties of surgical trainees and consultants were invited. Since this was a feasibility study, the aim was to recruit between 8-10 participants. This allowed the researcher to explore issues on feasibility, but also provides preliminary data on the potential effectiveness of the intervention and theoretical assumptions also.

The inclusion and exclusion criteria are as follows:

Inclusion:

- Surgeons from the single-site institution
- Surgical trainees
- Surgical consultants
- Control cohort of physiotherapists

Exclusion:

- Non-surgical medical professional, with the exception of a control group of physiotherapists
- Surgeons in a hospital that isn't the identified single-site institution

A cohort of ten physiotherapists were recruited as a control group. These were conveniently sampled from within the institution, and attempts were made to have similar demographic characteristics of the surgical cohort regarding professional level and age brackets. They completed the baseline reporting of measurements and fortnightly tracking of fatigue levels only. Their data was also used, in addition to the surgeons, to inform theoretical understandings between the identified constructs discussed in the next chapter.

7.4.3.3. Study Instruments

A questionnaire was sent to participants at baseline, and at the conclusion of the intervention (*Appendix AN*). Participants also completed fortnightly fatigue assessment distributed through their preferred method of communication (*Appendix AO*).

The timeframes in which each assessment were completed are provided in *Table 7.7*.

Table 7.7. Timeframes of each aspect of the assessment for study duration

Instrument	Recruitment	During Study	Conclusion
Clinical performance encounters	✓		✓
Clinical performance markers	✓		✓
Test of Performance Strategies Short Form (TOPS-2-SF)	✓		✓
Thriving at Work (TAW)	✓		✓
Positive and negative affect schedule (PANAS)	✓		
Physician wellbeing index (PWBI)	✓		
Psychological capital questionnaire (PCQ)	✓		✓
Single-Item Measures of Personality (SIMP)	✓		
Workplace Climate Questionnaire (WCQ)	✓		
CFS	✓		✓
3D fatigue inventory (3DFI)	✓	✓	✓
Recovery, revised from the Occupational Fatigue Exhaustion Recovery (OFER)	✓		✓
PSQI	✓		
ESS	✓		✓
Behaviour change prediction	✓		
Behaviour change actual			✓
Multi-choice questionnaire (MCQ)	✓	✓	

7.4.3.3.1. Performance Assessment

Clinical Performance Encounters: Participants identified three tasks i.e. 'clinical performance encounters' that they found themselves in over the past month in which they perceived there to be a 'load or strain' associated with the task (i.e. experienced fatigue either before, during, or after completing the task). Modelled off stress appraisal theory (Lazarus and Folkman, 1984), participants appraised primary level of stress within these tasks using a 6-item Likert scale. Using a 7-item Likert scale, secondary appraisal was assessed by asking to rate level of agreement that the encounters were a 'positive challenge' or a 'threat'. Definitions of these were provided in the questionnaire. This approach has been used to assess stress appraisal for similar encounters in other high-performance industries (Brown et al., 2017).

Clinical markers of technical, cognitive, and affective performance were assessed using confidence and satisfaction with the domains of good professional practice (Medical Act, 2007). Performance was assessed by participants rating of their performance on an 11-point scale of 'totally dissatisfied' to 'totally satisfied', and 'not confident at all' to 'totally confident'. Teamwork and collaboration was amalgamated with communication and interpersonal skills.

Psychological Performance Assessment: A modified version TOPS-2- SF (Kumar et al., 2020; Hardy et al., 2010) was used to assess a range of psychological skills during clinical performance encounters. The scale was reduced from 51 items to 19 items. The identified subscales are self-talk, emotional control, automaticity, goal setting, imagery, activation, relaxation, negative thinking, and attentional control. It has high reliability (Kumar et al., 2020). It has criterion (Thomas et al., 1999) and construct validity (Kumar, 2020).

7.4.3.3.2. Thriving Assessment

A summary of the instruments used for thriving are seen in *Table 7.8.*

Table 7.8. Summary of the instruments used in Chapter 7 for thriving measurement

Instrument	Purpose	Measures	Advantages	Disadvantages	Altered
TAW (Porath et al., 2012)	Thriving at work	Vitality Learning	High reliability (Porath et al., 2012) Criterion, construct, and content validity (Porath et al., 2012)	Lengthy (24-items) May be sensitive to time in which test is taken or poor understanding in participants	Yes - A 6-item scoring instead of 7
PANAS (Watson et al., 1988)	Affect	Positive affect Negative affect	High reliability (Crawford and Henry, 2004) Content (Zevon and Tellegen, 1982), construct, and criterion validity (Crawford and Henry, 2004)	No test-retest reliability Only provides affect and not implications of such	No
PWBI (Dyrbye et al., 2013)	Wellbeing	Cut-off greater than or equal to 4 on the statements indicates potential psychological distress.	High reliability (Dyrbye et al., 2010) Content validity (Dyrbye et al., 2010)	No test-retest reliability No construct or criterion validity	Yes – additional questions on thriving/flow included and suicidal ideation removed
PCQ (Luthans et al., 2007)	Psychological capital	Hope Optimism Resilience Self-efficacy	High reliability (Luthans et al., 2007) Built on four previous resources self-efficacy (Parker, 1998), optimism (Scheier and Carver, 1985), hope (Snyder et al., 1996) and resilience (Wagnild, 2009). Criterion (Luthans et al., 2007), content validity (Parker, 1998, Scheier and Carver, 1985, Snyder et al., 1996; Wagnild, 2009)	No test-retest reliability Further examination of construct validity required (Luthans et al., 2007) Aspects were reduced for participant fatigue which may reduce overall psychometrics.	Yes – change to adapt to questionnaire

7.4.3.3.3. Confounding Assessment

Two potential confounding factors were identified throughout the research which could impact on individual behaviour change efforts. These were individual personality styles and the organisational workplace environment.

Personality: The SIMP (Woods and Hampson, 2005) was used to measure the variability in the five commonly identified personality traits: neuroticism (i.e. emotional instability and irritable behaviours), openness (i.e. inquisitiveness and thoughtfulness behaviours), conscientiousness (i.e. sense of duty and responsibility behaviours), extraversion (i.e. assertive and energetic behaviours), and agreeableness (i.e. empathetic and sympathetic behaviours). These traits were used to understand variability within individual surgeons, and to predict if particular traits influenced the outcomes of this intervention. It has high reliability (Woods and Hampson, 2005; Gosling et al., 2003). It has criterion validity (Woods and Hampson, 2005).

Workplace Environment: A shortened version of the WCQ (Kirby et al., 2003) was used to measure three constructs: 'choice-independence', 'workload' and 'supportive-receptive'. This shortened version has been previously validated in healthcare (McManus et al., 2004), and assists in understanding work-variables beyond the scope of this intervention.

7.4.3.3.4. Fatigue Assessment

A summary of the instruments used for fatigue are seen in *Table 7.9.*

Table 7.9. Summary of the instruments used in Chapter 7 for fatigue measurement

Instrument	Purpose	Measures	Advantages	Disadvantages	Altered
CFS (Chalder, 1993)	Subjective fatigue	11-item Severity of tiredness or fatigue	Moderate-high reliability (Chilcot et al., 2016; Cella and Chalder., 2010) Construct (Cella and Chalder, 2010), content (Morriss et al., 1998; Fong et al., 2015), and criterion validity (Fong et al., 2015)	Ceiling effect Higher baseline scores	Yes - asked to rate their subjective feelings in the context of 'during or after work' .
3DFI (Frone and Tidwell, 2015)	Effects of fatigue	Physical Mental Emotional	High reliability (Frone and Tidwell, 2015) Content, discriminant, and convergent validity (Frone and Tidwell, 2015)	No test-retest reliability Construct validity not determined	Yes – 3 items used and aggravating and mitigating factors were identified in fortnightly assessment in an experience-sampling method approach (Csikszentmihalyi and Larson, 2014).
Recovery revised from the OFER (Winwood et al., 2005)	Recovery processes	Opportunities and engagement for recovery BPN recovery (competency, relatedness, autonomy).	High reliability (Winwood et al., 2005) Criterion and content validity (Winwood et al., 2005)	Lower test-retest reliability (Winwood et al., 2005) May be biased to interpretation of 'after-work' recovery	Yes – questions were adapted from original and focused on recovery with BPN incorporated
PSQI (Buysse et al., 1989)	Subjective sleep	19-item Subjective sleep quality	Moderate-high reliability (Spira et al., 2012; Backhaus et al., 2002) Criterion (Grandner et al., 2012; Spira et al., 2012) and content validity (Mollayeva et al., 2016)	Bias toward work-day	Yes – only involved sleep quality and sleep patterns
ESS (Johns, 1991)	Subjective sleep	8-item Daytime sleepiness	High reliability (Hagall et al., 2007; Gibson et al., 2006; van der Heide et al., 2015) Criterion (Johns, 2000; Spira et al., 2012), and construct validity (John, 1991)	No prediction of risk Confounding influences	No

7.4.3.3.5. Behaviour Change Assessment

Predictability of behaviour change: Behaviour change likelihood was evaluated by asking participants to rate on a 6-item Likert scale their willingness, belief, and readiness to make behaviour change. These were modelled off the motivational interviewing technique (Rollnick and Miller, 1995).

Post-coaching intervention reporting: A 9-item Likert scale was used at the end of the intervention to assess behaviour change resulting from the coaching intervention.

7.4.3.3.6. Feasibility Assessment

Feasibility was evaluated using a process evaluation framework (Moore et al., 2015) (*Figure 7.10*). The four metrics of implementation – fidelity (i.e. whether the intervention was delivered as intended), dose (the quantity of intervention that was delivered), adaption, and reach, were informed by the qualitative and quantitative findings.

Qualitative findings: Participants were asked seven open-ended questions at the conclusion of the study including overall experience, impact on fatigue levels, impact on clinical performance, biggest learning, any positive changes, revisions to the study, and longer-term impacts.

Quantitative findings: Study metrics to evaluate the successful feasibility of the intervention were used including attrition, changes in tracking of fatigue, and change in outcome measurements. Using a modified experience-sampling methodology, tracking of fatigue levels, their stressors, and mitigators, on a fortnightly basis during the intervention study allowed patterns to be established in understanding the variable impact of fatigue.

7.4.3.3.7. Knowledge Assessment

MCQ: A 10-item questionnaire was used to assess levels 1 and 2 of Blooms Taxonomy (Bloom, 1956) of scientific principle knowledge upon completion of Phase 1 (Education).

7.4.3.3.8. Demographics

Demographic questionnaire: Demographics taken from participants included age, gender, speciality, job specification, and years since undergraduate medicine.

7.4.3.4. Statistical Analysis

A protocol of statistical analysis involving tests or normality was used (See *2.3.3.4. Data Extraction and Synthesis* for details). Non-parametric statistics were used. Kruskal-Wallis and Mann-Whitney U tests were conducted to explore differences between variables of independence. Wilcoxon-Signed ranks test were used to explore differences in related groups at different times.

7.4.4. Results

7.4.4.1. Demographics

A total of 16 surgical trainees and consultants were recruited, of which 10 completed the baseline assessment. A participant flow diagram is seen in *Figure 7.12*. The demographic summaries alongside the control group of physiotherapists are seen in *Table 7.10.*

Table 7.10. Demographic summaries of participants and control group for Chapter 7 intervention study

Surgeons	10		Physiotherapists	10
Age				
≤30			≤ 30	5 (50%)
31-40	5 (50%)		31-40	3 (30%)
41-50	4 (40%)		41-50	1 (10%)
51-60	1 (10%)		51-60	1 (10%)
Gender				
Male	7 (70%)		Male	2 (20%)
Female	3 (30%)		Female	8 (80%)
Length since Undergraduate				
≤5 years	1 (10%)		≤5 years	3 (30%)
6-10 years	1 (10%)		6-10 years	2 (20%)
11-16 years	4 (40%)		11-16 years	2 (20%)
17-22 years	2 (20%)		17-22 years	3 (30%)
≥23 years	2 (20%)		≥ 23 years	
Current Job Title				
Registrar	2 (20%)		Staff Grade	3 (30%)
Specialist Registrar	3 (30%)		Senior	6 (60%)
Consultant	5 (50%)		Clinical Specialist	1 (10%)
Specialty				
Otolaryngology	1 (10%)		Outpatients	4 (40%)
Urology	1 (10%)		Surgery	2 (20%)
General	4 (40%)		Neurology	1 (10%)
Paediatric	1 (10%)		Orthopaedics	3 (30%)
Vascular	1 (10%)			
Neurosurgery	1 (10%)			
Orthopaedics	1 (10%)			

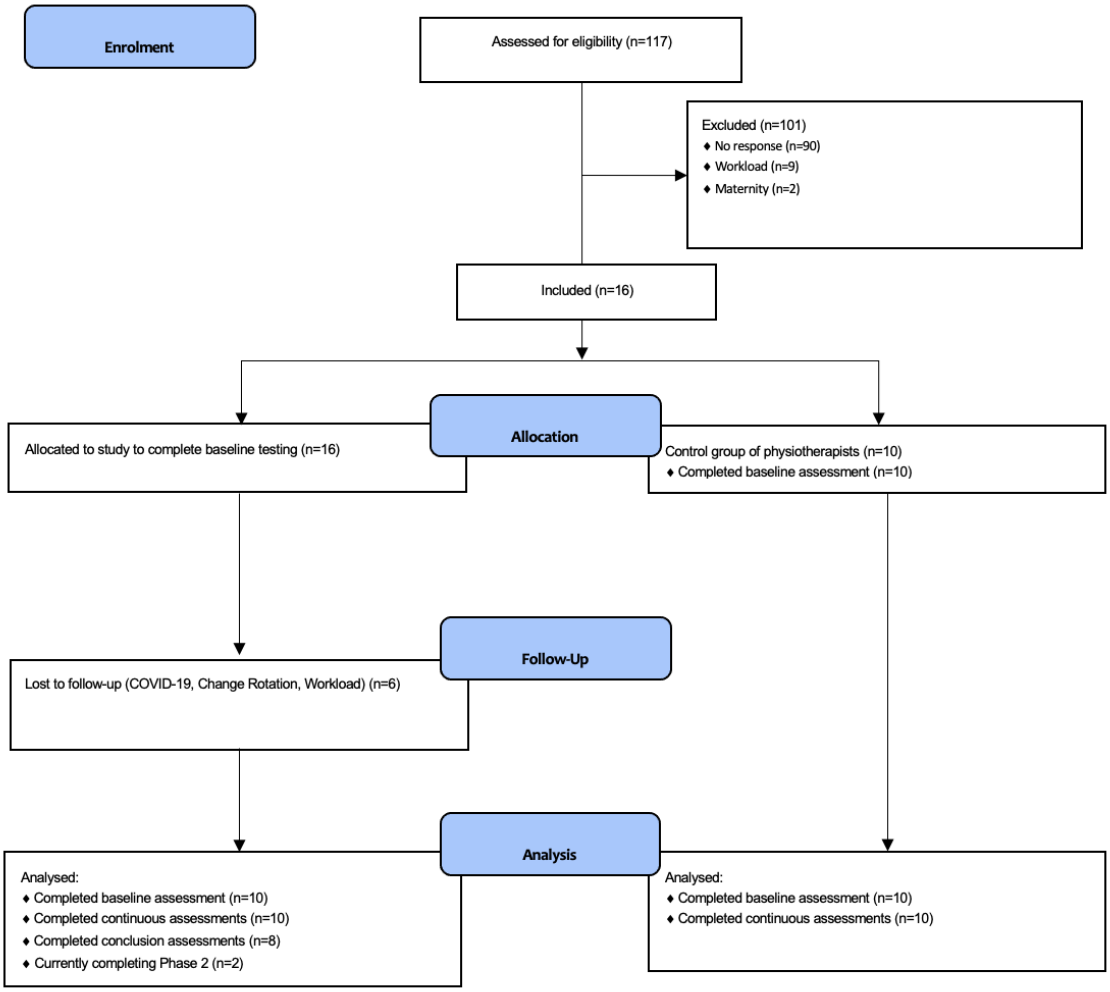


Figure 7.12. Participant flow diagram for Chapter 7 pilot and feasibility study

7.4.4.2. Baseline Performance Results

7.4.4.2.1. Clinical Performance Encounters

The reported clinical performance encounters are categorised in *Table 7.11.* The median global stress appraisal score of the cohort was 4 (2.5 – 4). The median global coping appraisal score was 5 (5 – 5.5). The median global positive challenge response score was 6 (4.5 – 6.5). The median global threat response was 2 (1.5 – 3).

Table 7.11. List of clinical performance encounters reported by surgeons and physiotherapists

Surgeons	Physiotherapists
Afternoon rounds	Clinics
Overnight call	Patient expectations
Elective clinic	Technically tasks
Operating	Administration
OPD/Clinics	Training
Administrative meetings	Rehabbing complex patients
Family meeting	Motivating patients
Long ward round pre-weekend	Working day after on-call, even if not called in
Following day on-call rounds and surgery	Administration
Gaining informed consent	Discharge planning

The median reported satisfaction and confidence in aspects of clinical performance is demonstrated in *Table 7.12*. The correlation between both was >0.85 in all domains.

Table 7.12. Satisfaction and confidence in clinical performance indicators with median and interquartiles

	Surgeons	Physiotherapists
Relating to patients		
Satisfaction	8 (6.5 – 9)	8 (6.25 – 8.75)
Confidence	8 (7.5 – 9)	8 (6.25 – 9)
Possessing the necessary clinical skills		
Satisfaction	8 (7 – 9)	7.5 (5.5 – 9)
Confidence	7 (6.5 – 9)	8 (5.5 – 9)
Demonstrating professionalism		
Satisfaction	9 (8.5 – 9)	9 (8.25 – 9.75)
Confidence	9 (8.5 – 9)	9 (8.25 – 10)
Possessing the necessary communication and interpersonal skills		
Satisfaction	9 (8 - 9)	8.5 (7.25 – 9.75)
Confidence	9 (8 – 9)	8.5 (7.25 – 9.75)
Possessing management and self-management skills		
Satisfaction	7 (5.5 – 7)	7 (4.5 – 8.75)
Confidence	7 (5.5 – 8)	7 (3.75 – 8.75)
Demonstrating scholarship		
Satisfaction	7 (4 – 8)	6.5 (4.25 – 8.5)
Confidence	8 (5 – 8)	6.5 (4.5 – 8.50)
Providing patient safety and quality of care		
Satisfaction	8 (7.5 – 9)	8.5 (8 – 9.75)
Confidence	8 (7.5 – 8.5)	9 (8-9)

7.4.4.2.2. Psychological Performance

The reported psychological performance across subscales are seen in *Table 7.13.* Physiotherapists scored statistically significantly higher than surgeons in aspects of self-talk, relaxation, and attentional control.

There was a statistically significant difference between current job title scores, with consultants scoring higher in scores of:

- 'whole skill no concentration': registrar – 2.5 (2-2.5) ; SpR - 1.5 (1-1.5) ; consultant – 3 (3-3) (p=.044)
- 'talk positively to get most out of performance': registrar - 2 (1-2) ; SpR – 2(1-2) ; consultant – 4 (4-4) (p=.032)

There was a statistically significant difference between gender scores, with males scoring higher in using:

- 'goal setting': male - 3 (2.75 -4) ; female - 2 (2-2) (p=.048)

Table 7.13. Psychological performance scoring in the TOPS-2-SF with median, interquartiles and statistically significant differences

	Surgeons	Physiotherapists	P-value
Self-talk	**4 (2.5 – 6.5)**	**8 (3.5 -9)**	
Say Things To Self	2 (1 – 3)	2.5 (1-3)	
Say Things Help Performance	1 (0.5 – 2)	2.5 (1.25 – 3)	**.046**
Talk Positively Get Most Out Of Performance	1 (1 – 1.5)	3 (1.25 – 3)	
Emotional control	**5 (2.5 – 6)**	**4.5 (4.5 – 5.75)**	
Control Emotions Not Going Well	3 (2 – 3)	2.5 (2.5 -3)	
Performance Suffer Something Upset	2 (0.5 -3)	2 (2-2.75)	
Automaticity	**6 (3.5 – 6)**	**5.5 (3.25 – 6)**	
Whole Skill No Concentration	3 (2 – 3)	2.5 (1.25 – 3)	
Able To Trust Body Perform Well	3 (1.5 – 3)	3 (2-3)	
Goal setting	**6 (4 – 6.5)**	**5 (5 – 6.75)**	
Goal Setting	3 (2 – 3.5)	3 (3-3.75)	
Get Goal Intensity Levels Right	3 (2 – 3)	2 (2-3)	
Imagery	**4 (3 – 6)**	**5.5 (2.25 – 6)**	
Past Performance	2 (1.5 – 3)	2.5 (1.25 – 3)	
Rehearse Performance	2 (1.5 – 3)	3 (2-3)	

Activation	**3 (1.5 – 3)**	**3 (2-3)**	
Psych Myself Perform Well	3 (1.5 – 3)	3 (2-3)	
Relaxation	**3 (1 – 4.5)**	**5.5 (1 – 7.5)**	
Take Time Relaxation	1 (0 – 2)	3 (0.75 – 3.75)	**.036**
Start Lose It	2 (1 – 2.5)	2.5 (0.25 – 3.75)	
Negative thinking	**5 (2.5 – 6)**	**2.5 (1.25 – 5.5)**	
Self-Talk Negative	2 (1.5 -3)	3.5 (0.25 – 4)	
Thoughts Failure	3 (1 -3)	2 (1-3.5)	
Attentional control	**6 (5 -8)**	**9 (5.25 – 10.5)**	
Attention Wanders	1 (1 -2)	3 (2.25 – 3)	**.001**
Control Distract Thoughts	3 (2 – 3)	2 (1-2.75)	
Can Get Myself Up Feel Flat	2 (2 -3)	2 (2.75)	
Overall score	**42 (25.5 - 52.5)**	**48.5 (28 – 60)**	

7.4.4.3. Baseline Thriving Results

7.4.4.3.1. Thriving

The reported levels of vitality and learning subscales are seen in *Table 7.14.* Physiotherapists scored statistically significantly higher than surgeons in aspects of vitality and learning.

There was a statistically significant difference between gender scores, with males scoring higher in:

- ‘experiencing considerable personal growth’: male - 3 (3-4.25) ; female - 2 (1-2) (p=.024)
- ‘growing positive way’: male - 4 (3-4.25) ; female - 2 (2-2) (p=.048)
- ‘enjoy seeing views progress’: male - 4 (3.75 -5.25) ; female - 3 (3-3) (p=.048)

Table 7.14. Thriving performance scoring in the TAW with median, interquartiles and statistically significant differences

	Surgeons	Physiotherapists	P-value
Vitality			
Alive And Vital	4 (3-4.5)	5 (5-6)	**.015**
Want To Burst	2 (2-2.5)	3 (2.25 – 4.75)	**.046**
Energy Spirit	3 (3-4)	5 (4.25 – 5.75)	**.011**
Look Forward Each Day	4 (3-4)	4.5 (4-5.75)	**.046**
Feel Energised	3 (2-4.5)	5 (4-5.75)	**.021**
Alert And Awake	4 (3-4.5)	5 (4.25 – 5)	
Not Feel Very Energetic	3 (1.5 – 5)	5 (3-5)	
Feel Depleted	3 (2-4.5)	5 (4.25 -5.75)	**.036**
Lethargic	3 (2-4.5)	5 (4.25 -5.75)	**.021**
Lack Energy	3 (2-4.5)	5 (4-5)	**.015**
Vitality Score	**32 (23.5 – 43)**	**47.5 (39.75 – 54.5)**	
Learning			
Experiencing Considerable Personal Growth	3 (2 – 3.5)	4 (2-4)	
Growing Positive Ways	3 (2.5 – 4)	4 (4-4)	
Not Grown Much Recently	4 (2.5 – 4.5)	4.5 (3-5)	
Stagnating	4 (3-5)	5 (5.25 – 5)	**.027**
Enjoy Seeing Views Progress	4 (3 – 4.5)	5 (5-6)	**.043**
Continue Learn More Time Goes By	4 (4-5)	5.5 (5-6)	**.046**
Finding New Ways Develop	4 (3.5 – 4.5)	5.5 (5-6)	**.015**
Not Learning	4 (3.5-5)	5.5 (5-6)	
Developing A lot As Person	3 (3 – 4)	4 (4-5)	
Not Moving Forward	3 (2.5 – 4)	2 (1-2)	**.015**
Finding Myself Learning Often	4 (3.5 – 5)	5 (4.25 – 5.75)	
See Myself Continually Improving	4 (3 – 4)	5 (4-5)	
Continuing To Develop	4 (3.5 – 5)	5 (5-6)	**.036**
Failing To Progress	4 (3-5)	6 (5-6)	**.011**
Learning Score	**52 (42.5 – 63)**	**66 (57.5 – 71.75)**	

7.4.4.3.2. Feelings and Emotions

The reported positive affect and negative affect subscales are seen in *Table 7.15.* Physiotherapists scored statistically significantly higher than surgeons in aspects of positive affect i.e. ‘excited’, ‘enthusiastic’, and ‘active’.

Table 7.15. Positive and negative affect in the PANAS with median, interquartiles and statistically significant differences

	Surgeons	**Physiotherapists**	**P-value**
Positive Affect			
Interested	3 (2.5 – 4)	4.5 (3.25 – 5)	
Excited	2 (1.5 – 3.5)	4 (3-4)	**.036**
Strong	2 (2-4)	2.5 (1-4.75)	
Enthusiastic	3 (2-4)	4 (3.25 – 5)	**.046**
Proud	2 (2-3)	4 (2.5 – 5)	
Alert	3 (2-3.5)	4 (2.2.5 – 4.75)	
Inspired	3 (2-3)	3.5 (3 – 4.75)	
Determined	3 (2.5 – 4.5)	4 (3.25 – 5)	
Attentive	3 (2.5 -4)	4 (4 – 4.75)	
Active	2 (2-3.5)	4 (3.25 – 4.75)	**.011**
Negative Affect			
Distressed	1 (1-2.5)	1.5 (1-2)	
Upset	2 (2-2)	1 (1-2)	
Guilty	2 (1.5 – 2.5)	1 (1-2)	
Scared	1 (1-2)	1 (1-2)	
Hostile	2 (1-2)	1 (1-1.75)	
Irritable	2.5 (2-4)	2.5 (2 – 4)	
Ashamed	1 (1-1.5)	1 (1 – 1)	
Nervous	2 (1-2.5)	2.5 (1.25 – 3.75)	
Jittery	1 (1-1.5)	1.5 (1-2)	
Afraid	1 (1-2)	1.5 (1-2)	

7.4.4.3.3. Physician Wellbeing

Scores are seen in *Table 7.16.* The most statistically significant differences in reporting 'yes' and 'no' to flow, thriving, and burnout states, are seen in *Figures 7.13, 7.14* and *7.15*.

Table 7.16. Wellbeing scores with median and interquartiles

	Surgeons	Physiotherapists
Thriving	1 (1-2)	1 (1-1.75)
Flow	1 (1-2)	1 (1-1.75)
Emotional hardening	1 (1-2)	1 (1-2)
Overwhelmed	1 (1-1.5)	1 (1-1.75)
Anxiety, depression or irritability	2 (1-2)	1 (1-2)
Interference	2 (1-2)	2 (1.25 – 2)
Burnout	1 (1-2)	1.5 (1-2)

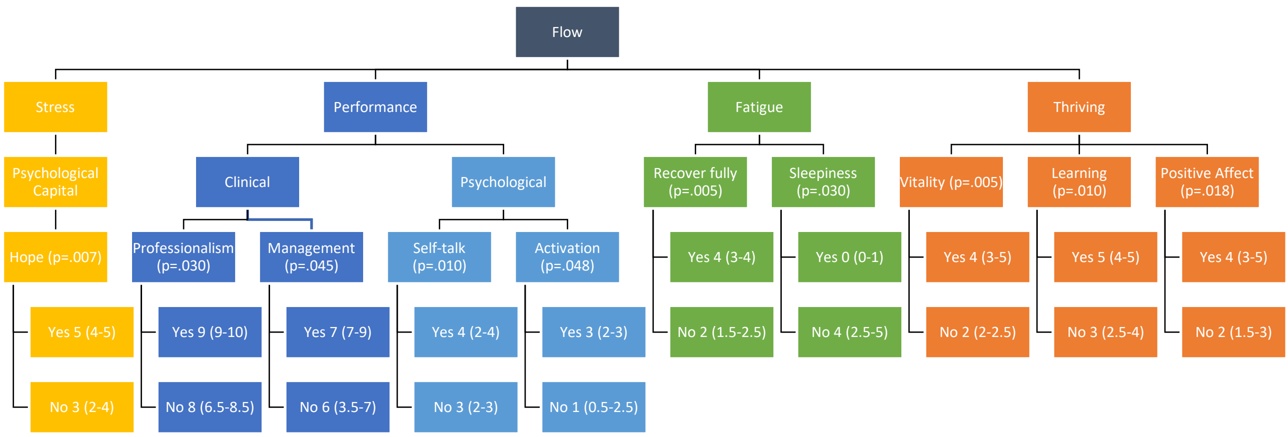


Figure 7.13. Statistically significant score differences between those answering 'yes' and 'no' in experiencing flow

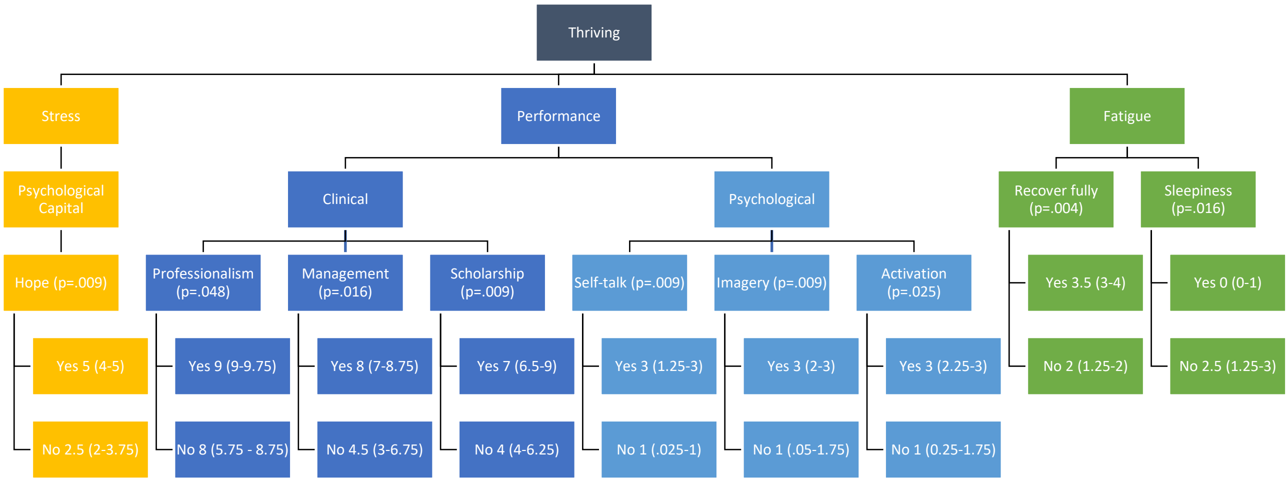


Figure 7.14. Statistically significant score differences between those answering 'yes' and 'no' in experiencing thriving

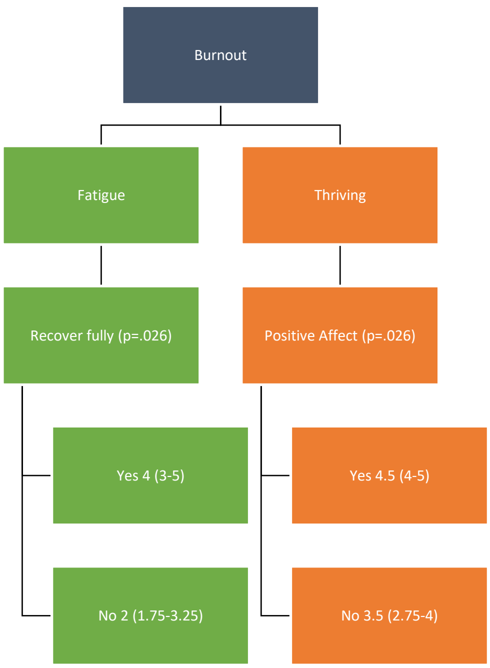


Figure 7.15. Statistically significant score differences between those answering 'yes' and 'no' in experiencing burnout

7.4.4.3.4. Psychological Capital

The reported levels of self-efficacy, optimism, hope, and resilience subscales are seen in *Table 7.17.* Physiotherapists scored statistically significantly higher than surgeons in aspects of hope and while surgeons scored higher in aspects of resilience.

Table 7.17. Psychological capital scoring in PCQ with median, interquartiles and statistically significant differences

	Surgeons	**Physiotherapists**	**P-value**
Self-efficacy	**15 (13 – 16)**	**13.5 (10.5 – 17.5)**	
Feel Confident Analysing Long Term Problem	5 (4-5)	4 (3-5.5)	
Feel Confident Helping Set Target Goals	5 (4-5)	4 (4-6)	
Feel Confident Presenting Information To Group	5 (5-6)	5.5 (3.5 – 6)	
Hope	**25 (18- 29)**	**27.5 (21.25 – 32.75)**	
Find Myself Jam At Work Many Ways Get Out	5 (4-5)	5 (3.25 – 6)	
Present Time Energetically Pursuing Work Goals	4 (2-5)	5 (2.75 – 6)	**.048**
Lots Ways Around Problems	5 (4-5)	5 (4-5.75)	
Right Now See Myself Successful Work	4 (3-4.5)	4.5 (4-5)	
Can Think Many Ways To Reach Goals	4 (2.5 – 5)	4 (4-5)	
At Time Meeting Work Goals Set For Myself	3 (2.5 - 4)	4.5 (3.25 – 5)	**.046**
Resilience	**22 (17 – 25)**	**21.5 (16.25 – 25.75)**	
Have Trouble Recovering Moving On	4 (3-5)	4.5 (2.25 – 5.5)	
Usually Manage Difficulties One Way Another	5 (4-5)	5 (4-5.75)	
Usually Take Stressful Things Stride	4 (2.5 – 4.5)	3.5 (3-4.75)	
Can Get Through Difficult Times Experienced Difficulty Before	5 (4.5 – 5.5)	3.5 (3-4.75)	**.046**
Feel Can Handle Many Things At Time	4 (3-5)	5 (4-5)	
Optimism	**17 (13 – 22)**	**19.5 (26.51 – 24.5)**	
Things Uncertain Usually Expect Best	3 (2-4)	3 (1.25-4)	
Something Go Wrong It Will	4 (3-5)	5 (4.25-5.75)	
Look Brighter Side	3 (2.5 – 4)	4 (2.25-5)	
Optimistic What Happen Future Pertains Work	4 (3.5 – 5)	4.5 (4-5)	
Approach Job As Every Cloud Silver Lining	3 (2-4)	3.5 (3 - 4.75)	
Overall score	**19.75 (15.25 – 23)**	**20.5 (18.63 – 25.13)**	

7.4.4.4. Baseline Confounding Results

7.4.4.4.1. Personality

The median scoring on the subscales of the SIMP are seen in *Table 7.18.* Physiotherapists scored statistically significantly higher than surgeons in extraversion.

There was a statistically significant difference between gender scores, with females scoring higher in:

- 'agreeableness': male - 4.5 (2.75 – 7) ; female - 8 (7-8) (p=.048)

Table 7.18. Personality scoring with median, interquartiles and statistically significant differences

	Surgeons	Physiotherapists	P-value
Neuroticism	5 (3-7)	3 (2-4.75)	
Openness to experience	4 (2.5 – 4)	3.5 (1.25 – 7.25)	
Conscientiousness	5 (3.5 – 7)	6 (3-7)	
Extraversion	5 (4-7)	3 (2-4.75)	**.021**
Agreeableness	7 (3.5 – 7.5)	6 (5-8)	

7.4.4.4.2. Workplace Environment

The reported levels of the subscales are seen in *Table 7.19.* Physiotherapists scored statistically significantly higher than surgeons in aspects of 'supportive-receptive'.

Table 7.19. Workplace environment scoring in WCQ with median, interquartiles and statistically significant differences

	Surgeons	Physiotherapists	P-value
Choice independence	**3.7 (3.3 – 5)**	**4.5 (2.5 – 5.9)**	
Decide How Work	4 (4-5)	5 (3-6)	
Opportunity Choose Particular Things	4 (4-5)	4.5 (2.25 – 5.75)	
Choice In Work	3 (2-4.5)	4 (2.25 – 5)	
Workload	**4 (3.2 – 4.8)**	**3.8 (2.4 – 5.2)**	
Workload Too Heavy	4 (3-5.5)	3.5 (2-4)	
Position Too Many Things	4 (4-5.5)	5 (3-6)	
Too Much Work	4 (2.5 – 4.5)	3 (2.25 – 5.5)	
Supportive-receptive	**4 (3 – 4.7)**	**5 (4.25 – 5.92)**	
Co-workers Supportive	5 (4-5.5)	6 (5.25 – 6)	**.027**
Colleagues Get To Know Each Other	4 (3-4.5)	5 (4.25 – 6)	**.046**
People Understand Difficulties	3 (2.5-4)	4 (3.25 – 5.75)	

7.4.4.5. Baseline Fatigue Results

7.4.4.5.1. Self-reported Fatigue

The reported physical and cognitive fatigue subscales are seen in *Table 7.20.*

Table 7.20. Fatigue scoring in CFS with median and interquartiles

	Surgeons	**Physiotherapists**
Physical Fatigue	**2.43 (2 – 2.94)**	**2.14 (2- 2.64)**
Problems Tiredness	3 (2-3)	2 (2-2.75)
Rest More	3 (2-3)	2.5 (2-3)
Sleepy Drowsy	3 (2-3)	2 (2-3)
Problem Start Things	2 (2-3)	2 (2-2.75)
Lack Energy	2 (2-3)	2.5 (2-3)
Less Strength Muscles	2 (2-3)	2 (2-2)
Feel Weak	2 (2-2.5)	2 (2-2)
Cognitive Fatigue	**2 (1.88 – 3)**	**2 (2-2)**
Difficulties Concentrating	2 (2-2.5)	2 (2-2)
Slips Of Tongue	2 (1.5-3)	2 (2-2)
Difficulty Find Right Word	2 (2-3.5)	2 (2-2)
How Is Memory	2 (2-3)	2 (2-2)
Overall score	**2.22 (1.94 – 2.97)**	**2.07 (2 – 2.32)**

7.4.4.5.2. Impact on Performance

The reported physical, cognitive and emotional impact scores are seen in *Table 7.21.*

Table 7.21. Impact of fatigue scoring in 3DFI with median and interquartiles

	Surgeons	**Physiotherapists**
Physical Exhaustion	2 (1.5 – 2.5)	2.5 (2-3.75)
Cognitive Exhaustion	2 (1.5 – 2.5)	2 (1.25 – 2)
Emotional Exhaustion	3 (2-3)	2.5 (2—3.75)

7.4.4.5.3. Fatigue Recovery

The reported components are seen in *Table 7.22.* Physiotherapists scored statistically significantly higher than surgeons in aspects of recovery from fatigue.

Table 7.22. Recovery from fatigue scoring with median, interquartiles and statistically significant differences

	Surgeons	Physiotherapists	P-value
Spare time to recover	4 (2-4.5)	3 (2-4.75)	
Don't get enough time	3 (2-4)	1.5 (1-2.75)	**.042**
Feel fully relaxed	2 (1-3)	3 (2.25 – 4)	**.048**
Recover my energy getting home	2 (2-2.5)	3.5 (2.25 – 4)	**.021**
Fully rested starting work	2 (2-3)	3 (2 – 4)	

The median psychological needs recovery subscales are seen in *Table 7.23.* Physiotherapists scored statistically significantly higher than surgeons in levels of competency and autonomy in recovery states.

Table 7.23. Psychological needs recovery scoring with median, interquartiles and statistically significant differences

	Surgeons	Physiotherapists	P-value
Competence	3 (2-5)	5.5 (5 – 7)	**.021**
Relatedness	5 (3-5.5)	5 (4.25 – 6)	
Autonomy	3 (2-5.5)	7 (4 – 7)	**.015**

7.4.4.6. Baseline Sleep Results

7.4.4.6.1. Sleep Quality

The median sleep quality score for surgeons was 'fairly poor', compared to physiotherapists 'fairly good'. The median numbers of sleep hours for surgeons was 5.5 hours, compared to physiotherapists 7.5 hours (<.001).

7.4.4.6.2. Daytime Somnolence

The median ESS score of the cohort was 7, indicative of 'higher normal daytime sleepiness'. The reported levels of each component are seen in *Table 7.24.*

Table 7.24. Daytime somnolence in ESS scoring with median and interquartiles

	Surgeons	**Physiotherapists**
Sitting and reading	1 (1-2)	1 (1 – 3)
Watching TV	2 (1-2)	1 (1 – 2.75)
Sitting, inactive in a public place (e.g. a theatre or a meeting)	0 (0-1.5)	0.5 (0 – 1)
As a passenger in a car for an hour without a break	1 (0-3)	0.5 (0 – 1.75)
Lying down to rest in the afternoon when circumstances permit	2 (1-3)	1 (0.25 – 1.75)
Sitting and talking to someone	0 (0-0.5)	0 (0 – 0)
Sitting quietly after a lunch without alcohol	1 (0.5 – 1.5)	0 (0 – 1)
In a car, while stopped for a few minutes in the traffic	0 (0-0)	0 (0 – 0.75)
Overall score	**7 (3.5 – 13.5)**	**4 (2.25 – 11)**

7.4.4.7. Baseline Behaviour Change Results

The median scores of the behaviour change predictability were:

- 'willingness': 5 (4-5)
- 'belief': 4 (4-5)
- 'readiness' 4 (4-5)

Associated factors with behaviour change are seen in *Figure 7.16*. Increased likelihood of behaviour change correlated positively with aspects of:

- Higher BPN fulfilment
- Higher psychological skill use (i.e. emotional control and goal setting), and lower negative psychological skill use (i.e. negative thinking)
- Higher psychological capital
- Higher thriving

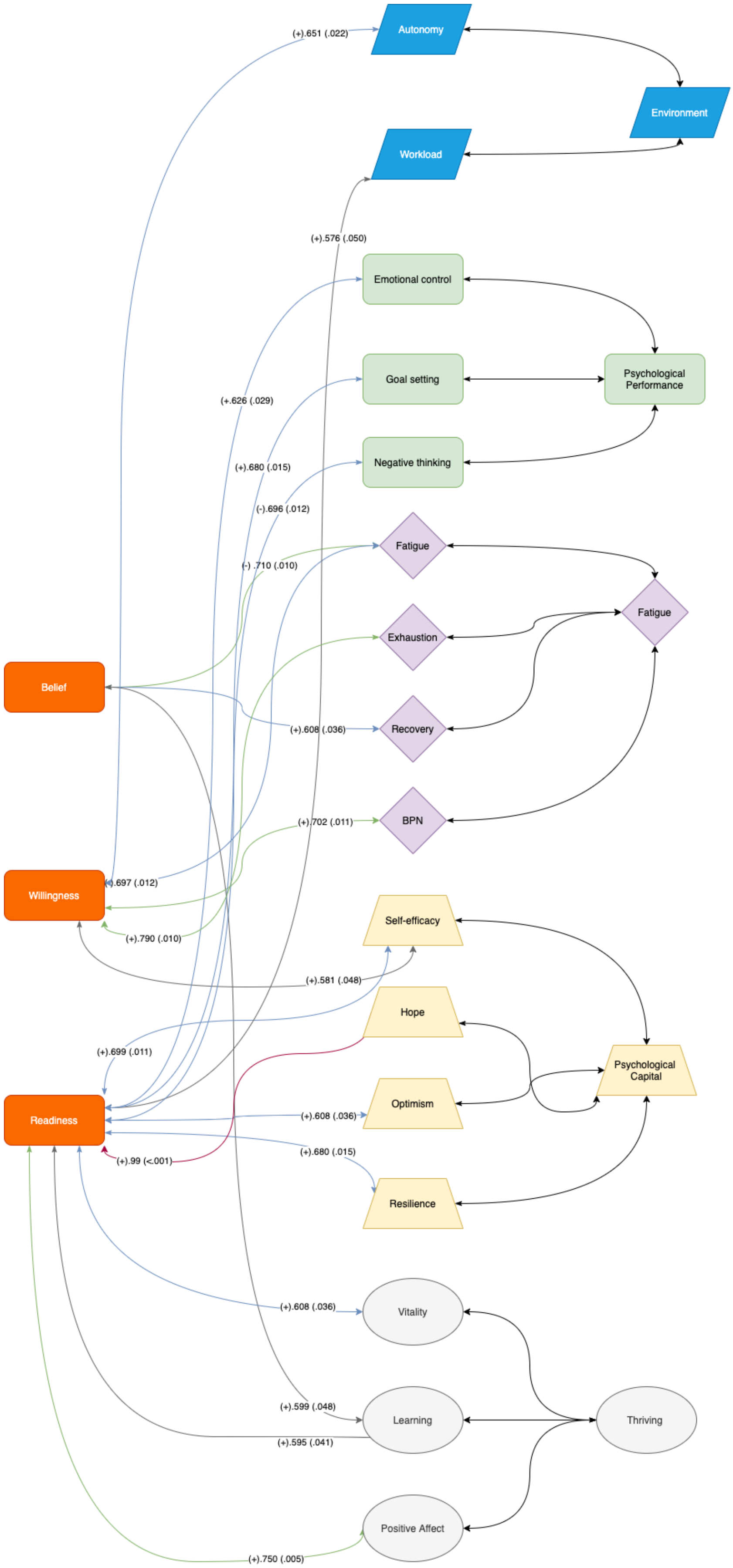


Figure 7.16. Statistically significant associations between behaviour change predictors and other modifiable factors

7.4.4.8. Baseline Knowledge Results

7.4.4.8.1. MCQ

The median correct answers in the MCQ was 4.

7.4.4.9. Post-intervention Performance Results

7.4.4.9.1. Post-intervention Clinical Performance Encounters

The median global stress appraisal score of the cohort decreased to 3 (3-4). The median global coping appraisal score of the cohort increased to 5 (5-6). The median global positive challenge response score of the cohort increased to 6 (5-7). The median global threat response was 2 (1-3).

The median reported satisfaction and confidence in aspects of clinical performance are demonstrated in *Table 7.25*. There was a non-statistically significant decrease in median scores between baseline and post-intervention in 'possessing the necessary communication and interpersonal skills'. There was a non-statistically significant increase in median scores between baseline and post-intervention in aspects of:

- 'Relating to patients'
- 'Possessing the necessary clinical skills'
- 'Possessing management and self-management skills'
- 'Demonstrating scholarship'
- 'Providing patient safety and quality of care'

Table 7.25. Post-intervention satisfaction and confidence in clinical performance with median, interquartiles and paired data p-values

	Baseline	**Post-intervention**	**P-value**
Relating to patients			
Satisfaction	8 (6.5 – 9)	8 (8-9)	.334
Confidence	8 (7.5 – 9)	9 (8-9)	.414
Possessing the necessary clinical skills			
Satisfaction	8 (7 – 9)	9 (8-9)	.453
Confidence	7 (6.5 – 9)	9 (7-9)	.180
Demonstrating professionalism			
Satisfaction	9 (8.5 – 9)	9 (7-9)	.516
Confidence	9 (8.5 – 9)	9 (7-9)	.257
Possessing the necessary communication and interpersonal skills			
Satisfaction	9 (8 - 9)	8 (7-9)	.317
Confidence	9 (8 – 9)	8 (8-9)	.180
Possessing management and self-management skills			
Satisfaction	7 (5.5 – 7)	9 (6-9)	.072
Confidence	7 (5.5 – 8)	9 (7-9)	.102
Demonstrating scholarship			
Satisfaction	7 (4 – 8)	8 (6-9)	.057
Confidence	8 (5 – 8)	9 (6-9)	.102
Providing patient safety and quality of care			
Satisfaction	8 (7.5 – 9)	9 (9-9)	.340
Confidence	8 (7.5 – 8.5)	9 (9-9)	.498

7.4.4.9.2. Post-intervention Psychological Performance

The overall psychological performance score increased from a median of 42 (25.5-52.5) to 45.5 (33-57). The reported psychological performance across subscales are seen in *Table 7.26.*

Table 7.26. Post-intervention psychological performance scoring in the TOPS-2-SF with median, interquartiles and paired data p-values

	Baseline	**Post-intervention**	**P-value**
Self-talk	**4 (2.5 – 6.5)**	**6 (4-9)**	
Say Things To Self	2 (1 – 3)	2 (2-3)	.589
Say Things Help Performance	1 (0.5 – 2)	2 (1-3)	.257
Talk Positively Get Most Out Of Performance	1 (1 – 1.5)	2 (1-3)	.157
Emotional control	**5 (2.5 – 6)**	**5 (4-6)**	
Control Emotions Not Going Well	3 (2 – 3)	3 (2-3)	.564
Performance Suffer Something Upset	2 (0.5 -3)	2 (2-3)	.739
Automaticity	**6 (3.5 – 6)**	**6 (5-6)**	
Whole Skill No Concentration	3 (2 – 3)	3 (2-3)	.317
Able To Trust Body Perform Well	3 (1.5 – 3)	3 (3-3)	.180
Goal setting	**6 (4 – 6.5)**	**6 (4-6)**	
Goal Setting	3 (2 – 3.5)	3 (2-3)	.655
Get Goal Intensity Levels Right	3 (2 – 3)	3 (2-3)	.90
Imagery	**4 (3 – 6)**	**4 (3-6)**	
Past Performance	2 (1.5 – 3)	2 (1-3)	.577
Rehearse Performance	2 (1.5 – 3)	2 (2-3)	.655
Activation	**3 (1.5 – 3)**	**3.5 (2-4)**	
Psych Myself Perform Well	3 (1.5 – 3)	3.5 (2-3)	.059
Relaxation	**3 (1 – 4.5)**	**3 (2-6)**	
Take Time Relaxation	1 (0 – 2)	0 (0-2)	.458
Start Lose It	2 (1 – 2.5)	3 (2-4)	.414
Negative thinking	**5 (2.5 – 6)**	**6 (4-6)**	
Self-Talk Negative	2 (1.5 -3)	3 (2-3)	.102
Thoughts Failure	3 (1 -3)	3 (2-3)	.194
Attentional control	**6 (5 -8)**	**6 (5-8)**	
Attention Wanders	1 (1 -2)	1 (1-2)	1
Control Distract Thoughts	3 (2 – 3)	3 (2-3)	1
Can Get Myself Up Feel Flat	2 (2 -3)	2 (2-3)	1
Overall score	**42 (25.5 - 52.5)**	**45.5 (33-57)**	

7.4.4.10. Post-intervention Thriving Results

7.4.4.10.1. Post-intervention Thriving

The overall vitality score increased from a median of 32 (23.5-43) to 37 (27-51). The overall learning score increased from a median of 52 (42.5-63) to 72 (62-81).

There was statistically significant differences, seen in *Figure 7.17,* between baseline and post-intervention scoring, with higher scores in:

- ‘growing positive ways’: (p=.059)
- ‘not grown much recently’: (p=.039)
- ‘continue to learn more as time goes by’: (p=.046)
- ‘finding new ways to develop’: (p=.059)
- ‘not learning’: (p=.041)
- ‘developing a lot as a person’: (p=.034)
- ‘finding myself learning often’: (p=.046)
- ‘see myself continually improving’: (p=.014)
- ‘failing to progress’: (p=.039)

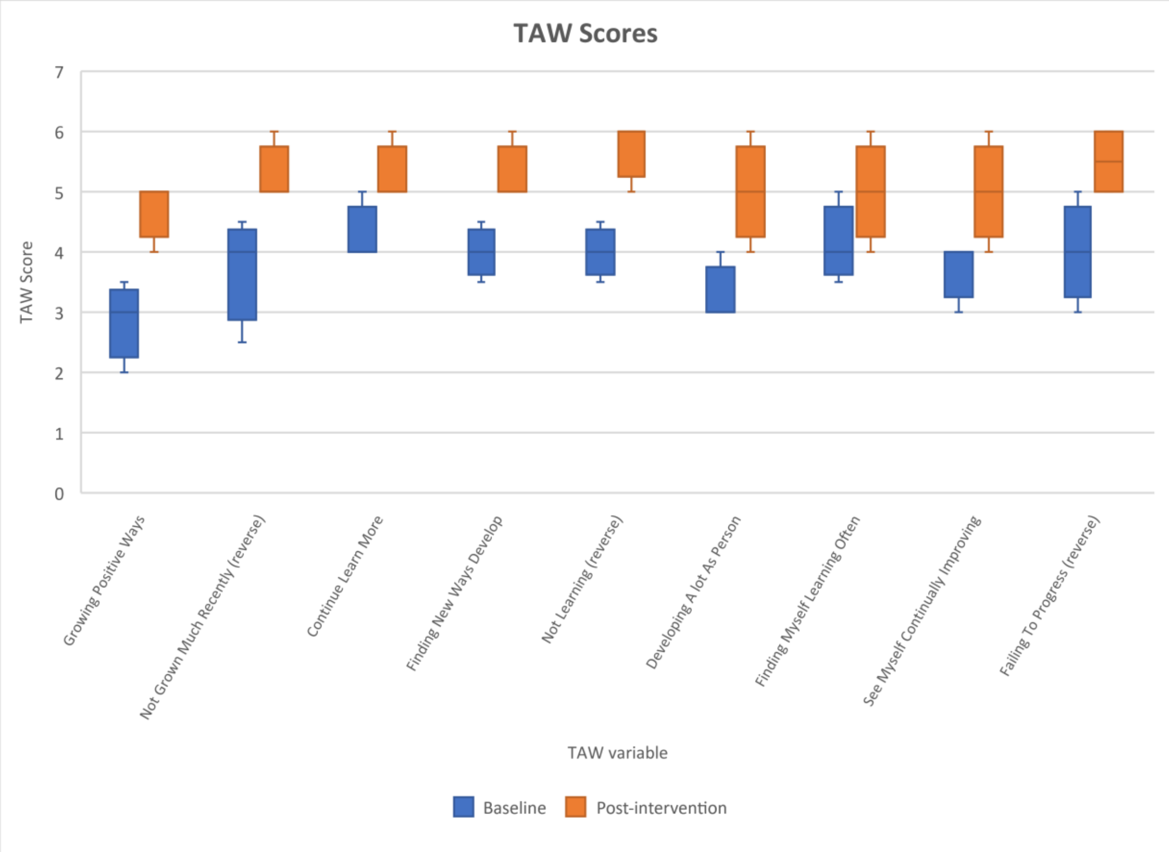


Figure 7.17. Scoring aspects of the TAW which significantly increased between pre and post-intervention

7.4.4.10.2. Post-intervention Feelings and Emotions

There was statistically significant differences, seen in *Figure 7.18,* between baseline and post-intervention scoring with higher scores in:

- 'inspired' (p=.038)
- 'determined' (p=.046)
- 'attentive' (p=.046)

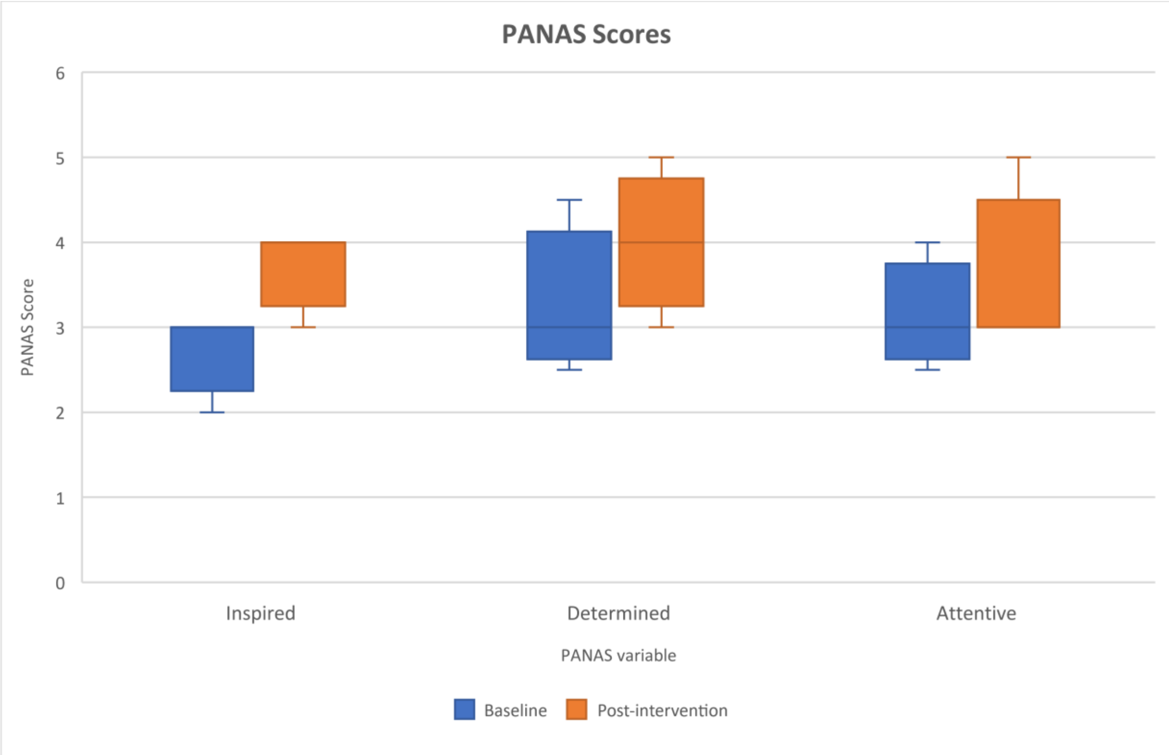


Figure 7.18. Scoring aspects of the PANAS which significantly increased between pre and post-intervention

7.4.4.10.3. Post-intervention Physician Wellbeing

The component scores are seen in *Table 7.27.* The median shifted from 'yes' at baseline to 'no' post-intervention in reporting of:

- Emotional hardening
- Feeling overwhelmed
- Burnout

Table 7.27. Post-intervention wellbeing scores with median, interquartiles and paired data p-values

	Baseline	Post-intervention	P-value
Thriving	1 (1-2)	1 (1-2)	.157
Flow	1 (1-2)	1 (1-1)	.317
Emotional hardening	1 (1-2)	2 (1-2)	.180
Overwhelmed	1 (1-1.5)	2 (1-2)	.317
Anxiety, depression or irritability	2 (1-2)	2 (1-2)	1
Interference	2 (1-2)	2 (2-2)	.083
Burnout	1 (1-2)	2 (1-2)	.564

7.4.4.10.4. Post-intervention Psychological Capital

The overall PCQ score increased from a median of 19.75 (15.25-23) to 21.75 (17-26.5). The overall hope score increased from a median of 25 (18-29) to 28 (22-35). The overall optimism score increased from a median of 17 (13-22) to 21 (16-25). The overall resilience score increased from a median of 22 (17-25) to 23 (18-28). The overall self-efficacy score didn't change from a median of 15 (13-16) to 15 (12-18).

There was statistically significant differences, seen in *Figure 7.19,* between baseline and post-intervention scoring, with higher scores in:

- Hope: 'right now see myself successful at work': (p=.038)
- Hope: 'at present time, I'm meeting the work goals set for myself': (p=.034)
- Optimism: 'approach my job as every cloud has a silver lining': (p=.049)

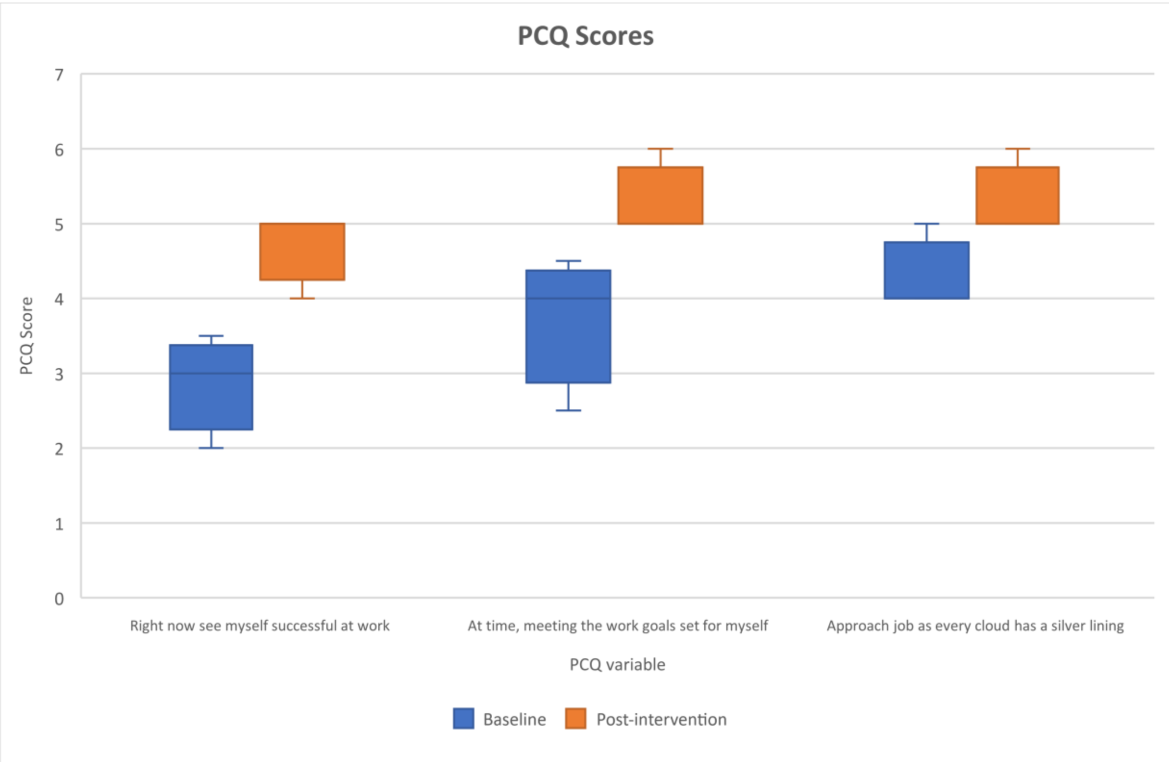


Figure 7.19. Scoring aspects of the PCQ which significantly increased between pre and post-intervention

7.4.4.11. Post-intervention Fatigue Results

7.4.4.11.1. Post-intervention Self-reported Fatigue

The overall CFS score decreased from a median of 2.22 (1.94-2.97) to 2.07 (1.81-2.93). The overall physical fatigue score decreased from a median of 2.43 (2-2.94) to 2.14 (1.86-2.86). The overall cognitive fatigue score didn't change from a median of 2 (1.88-3) to 2 (1.75-3).

There was one statistically significant difference between baseline and post-intervention scoring, with a lower score in:

- 'Need to rest more' (p=.046)

7.4.4.11.2. Post-intervention Impact on Performance

The overall median physical, cognitive and emotional exhaustion scores didn't change, as seen in *Table 7.28.*

Table 7.28. Post-intervention impact of fatigue in 3DFI scoring with median, interquartiles and paired data p-values

	Baseline	Post-intervention	P-value
Physical Exhaustion	2 (1.5 – 2.5)	2 (2-3)	.317
Cognitive Exhaustion	2 (1.5 – 2.5)	2 (2-3)	.083
Emotional Exhaustion	3 (2-3)	3 (2-4)	.180

7.4.4.11.3. Post-intervention Fatigue Recovery

The 'feel fully relaxed' score increased from a median of 2 (1-3) to 3 (1-4). The 'recover my energy getting home' score increased from a median of 2 (2-2.5) to 3 (1-4). The reported components are seen in *Table 7.29.*

Table 7.29. Post-intervention recovery from fatigue scoring with median, interquartiles and paired data p-values

	Baseline	Post-intervention	P-value
Spare time to recover	4 (2-4.5)	4 (2-5)	.655
Don't get enough time	3 (2-4)	3 (1-4)	.480
Feel fully relaxed	2 (1-3)	3 (1-4)	.157
Recover my energy getting home	2 (2-2.5)	3 (1-4)	.180
Fully rested starting work	2 (2-3)	2 (2-4)	.785

The median psychological needs recovery subscales are seen in *Table 7.30.* There was one statistically significant difference between baseline and post-intervention scoring, with a higher score in:

- Autonomy (p=.044)

Table 7.30. Post-intervention psychological needs recovery scoring with median, interquartiles and paired data p-values

	Baseline	**Post-intervention**	**P-value**
Competence	3 (2-5)	3 (3-5)	.336
Relatedness	5 (3-5.5)	5 (4-5)	.680
Autonomy	3 (2-5.5)	5 (3-6)	**.044**

7.4.4.11.4. Longitudinal tracking of fatigue

The median levels of overall fatigue severity decreased from 6 at the first assessment to 2.5 at the last assessment. Physical fatigue decreased from 'at least once a week' at the first assessment, to 'at least once a month' at the last assessment. Mental fatigue decreased from 'at least once a week' at the first assessment, to 'at least once a month' at the last assessment. Emotional fatigue remained at 'at least once a month' at the first assessment and last assessment, while trending towards 'less than once a month'. A summary of the median scores across each data point are provided in *Figure 7.20*.

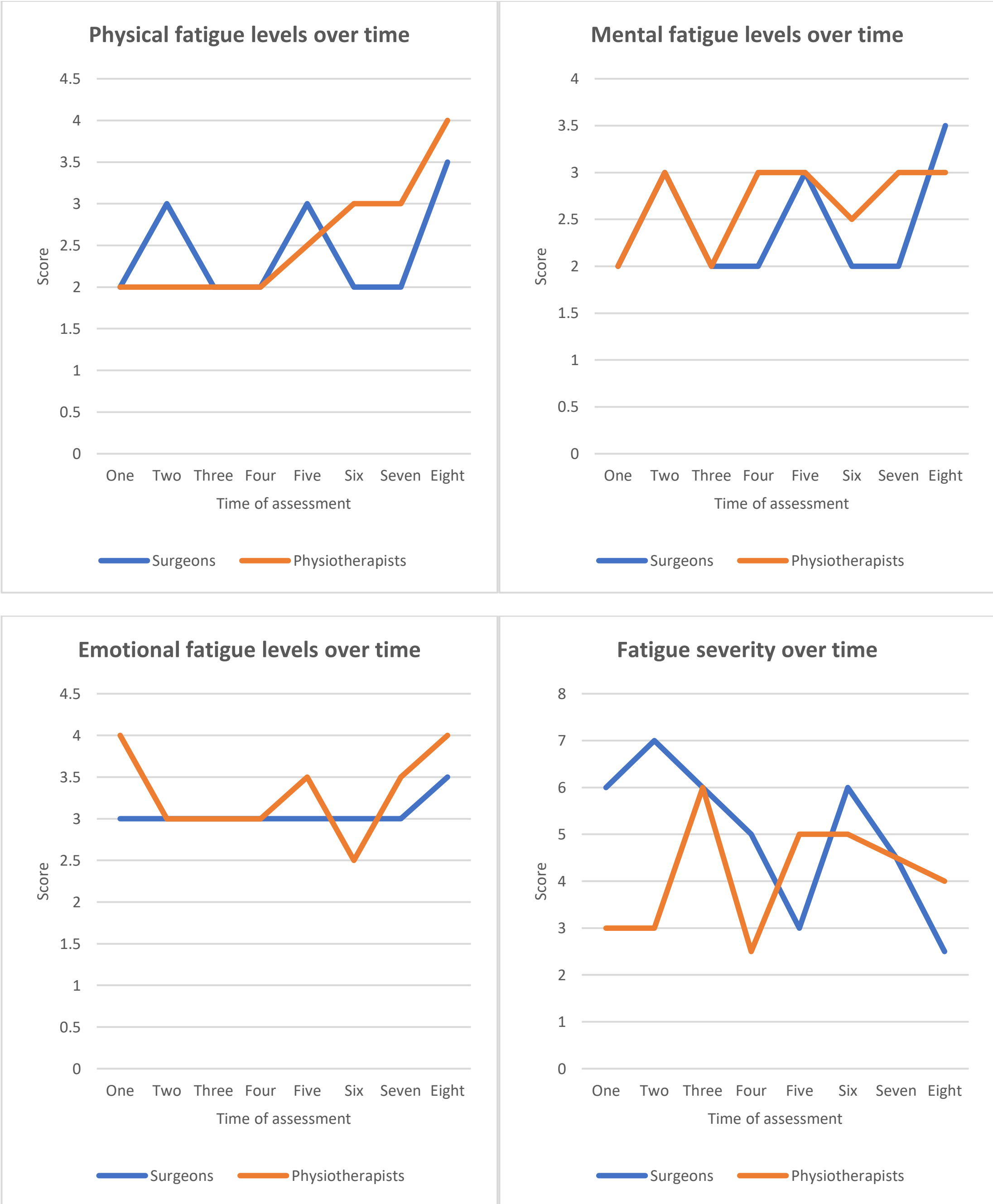


Figure 7.20. Changes in overall fatigue throughout study duration assessed on a fortnightly basis showing gradual decrease in fatigue severity over time, as well as less frequent physical, mental and emotional fatigue on last assessment

7.4.4.12. Post-intervention Sleep Results

7.4.4.12.1. Post-intervention Sleep Quality

The median sleep quality score of the cohort was 'fairly poor'. The median numbers of sleep hours of the cohort was 6 hours. This was statistically significantly higher than the baseline scoring of 5.5 hours (p=.026).

7.4.4.12.2. Post-intervention Daytime Somnolence

The overall median ESS scores didn't change, as seen in *Table 7.31.*

Table 7.31. Post-intervention daytime somnolence in ESS scoring with median, interquartiles and paired data p-values

	Baseline	**Post-intervention**	**P-value**
Sitting and reading	1 (1-2)	1(1-2)	1
Watching TV	2 (1-2)	2 (1-2)	1
Sitting, inactive in a public place (e.g. a theatre or a meeting)	0 (0-1.5)	0 (0-2)	.85
As a passenger in a car for an hour without a break	1 (0-3)	1 (0-3)	1
Lying down to rest in the afternoon when circumstances permit	2 (1-3)	2 (1-3)	.8
Sitting and talking to someone	0 (0-0.5)	0 (0-0)	.564
Sitting quietly after a lunch without alcohol	1 (0.5 – 1.5)	1 (1-2)	.157
In a car, while stopped for a few minutes in the traffic	0 (0-0)	0 (0-1)	.564
Overall score	**7 (3.5 – 13.5)**	**7 (4-15)**	

7.4.4.13. Post-intervention Behaviour Change Results

7.4.4.13.1. Self-reported effectiveness of intervention

The median self-reported effectiveness scores are seen in *Table 7.32*.

Table 7.32. Self-reported effectiveness of intervention with associated change level label

	Post-intervention	Change level
I changed my priorities about what is important in life	3 (1-3)	Moderate change
I developed new interests	2 (1-3)	Small change
I more clearly see that I can count on people in times of trouble	1 (0-3)	Very small change
I have a greater sense of closeness with others	1 (0-3)	Very small change
I am more willing to express my emotions	1 (1-2)	Very small change
I know that I can handle difficulties	2 (2-3)	Small change
I have more compassion for others	2 (1-3)	Small change
I am more likely to try and change things which need changing	3 (2-4)	Moderate change
I feel more vital or energetic	2 (1-4)	Small change

7.4.4.14. Post-intervention Knowledge Results

7.4.4.14.1. Post-intervention MCQ

The median correct answers in the multi-choice questionnaire was 4 at baseline and 8 after Phase 1 (p=.035).

7.4.4.15. Post-intervention Feasibility Results

The feasibility findings suggest an appropriate dose and adaption level, as subjectively determined by the researcher. There was acceptable level of fidelity and reach, with further aspects to consider, as seen in *Table 7.33.*

Table 7.33. Evidence for feasibility of intervention study

Feasibility Measure	Evidence
Fidelity	85% of the tracking of fatigue levels was returned.
	100% of desired recruitment.
	100% completed consent forms and baseline assessment.
	80% completed Phase 1.
	80% completed Phase 2.
	80% completed the post-intervention assessment.
Dose	Positive appraisal of the process by 90% of those who completed the intervention. Suggestions: ➢ more targeted coaching by surgeons ➢ more coaching sessions across a longer period ➢ incorporate into formal training ➢ increase focus on younger trainees
	1. a majority (90%) reported positive changes. 2. 40% reported changes with reduced fatigue 3. 50% reported improved performance outside of work and 60% inside of work
	1. Improved knowledge transfer noted in Phase 1 2. Changes at the level of 'very small' change-'moderate' change noted in Phase 2
Adaptions	Identified largest changes were: ➢ time management ➢ stress appraisal ➢ conflict resolution in work ➢ leadership building ➢ building healthy behaviour habits ➢ better recovery ability
	Identified facilitators to successful completion were: ➢ online format and time flexibility ➢ regular engagement from the researcher ➢ autonomous engagement
	Identified barriers to successful completion were: ➢ external coach with non-specific focus ➢ expectations within the profession ➢ length of coaching session ➢ timeframe to completion ➢ rotations
	The project was cost-neutral
	The project material for Phase 1 was available online
	Promotion by senior management
	Ongoing third wave of pandemic didn't impact outcome according to 80% of participants
Reach	1. Sufficient reach and low attrition from pilot number. 2. Attrition of six more individuals for personal reasons 3. Discussion with coaching service identified three further surgeons are now utilising the service 4. Insufficient engagement from younger trainees

7.4.5. Discussion

This study showed that a two-phase intervention study is a feasible way to elicit behaviour change in surgeons towards optimising their own performance. Using quantitative and qualitative metrics, there was sufficient evidence to support the markers of dose and adaptions, with further considerations necessitated for fidelity and reach. In pilot testing, there was significant improvements in aspects of stress appraisal, thriving, positive affect, psychological capital, fatigue, psychological needs fulfilment in non-work activities, and hours of sleep.

Feasibility

There was sufficient evidence to suggest that a two-phase intervention is a feasible intervention for optimising performance in surgeons. There was an overall high level of adherence to the study protocol showing high fidelity, but higher adherence to fortnightly assessment and Phase 1 should be considered in scaled-up efforts. Participants fatigue levels were tracked according to their preferred date and time, and flexibility in which they could complete Phase 1 and Phase 2 of the study was given as it allowed them to engage in the project at their own convenience. These likely helped with fidelity during a context which faced higher than normal barriers for engagement.

Participants identified that the dose of the intervention was satisfactory. There was improvements in knowledge transfer during Phase 1, and participants identified, in qualitative feedback, a combination of improvements in the domains of self-regulation and interpersonal relationships. Executive summaries of the education session principles may be an area for improvement, and engagement of education in group cohorts may overcome cultural barriers discussed previously. The coaching programme was positively rated by 90% of participants who completed the process, and given the expertise used to offer the service, felt that the timeframes between sessions were largely in line with their intended behaviour change goals. This supports a systematic review of coaching interventions studies on surgeons, which found that positive satisfaction was always above 80% in participants (Valanci et al., 2020).

Within adaptions, a memorandum of understanding and open communication lines, between the researcher and the independently resourced SOAR programme, occurred, allowing the project to be cost-neutral. One of the difficulties in the study was the change in work-settings for some participants in early January. The online nature of the intervention allowed adaptability of the intervention in this regard. Similar barriers and facilitators to engagement previously discussed were identified in this study. Cultural barriers were addressed through engagement from consultants in the process. Similarly, the independent process of Phase 2 of the intervention was appreciated by participants as it offered them anonymity from any surgical colleagues. The largest changes individuals identified were a combination of managing time more effectively, improved stress management, and better interpersonal relationship. These parallel similar findings of prioritised behaviour change in US surgeons (Shanafelt et al., 2014). In their study, work-life balance (39%), improving career satisfaction (34%) , reducing burnout (30%), and reducing fatigue (27%) were the most prominent areas for making behaviour change.

While recruitment of the desired pilot number of surgeons was difficult, including a large non-response rate and attrition of six additional surgeons, the reach was deemed sufficient for the purposes of pilot and feasibility testing. Significant efforts were made to engage SHO's in the process, however only one engaged formally in the process, and then didn't complete the process. Further exploration of barriers to engagement in this cohort are required, as it may lead to more sustainable professional behavioural change. Reach may have been greater if there was in-house group education components and input from professional leaders. Language used in promotion of the study was tailored towards high performance optimisation. This was to assist in overcoming cultural barriers of engagement in projects which historically focus on ill-health concepts, and to foster their inherent interests in learning. It is likely that the communication strategies and mechanisms were subject to the phenomena of out-group bias (Turner, 1979), which could have limited value placed on the research project, given the non-surgical background of the researcher. It is also likely that the high level of self-stigma, previously identified in Irish doctors (Hayes et al., 2017), was a significant barrier. Future efforts to recruit larger cohorts may better be facilitated by leadership of the project by a senior surgical member with expertise in coaching. This approach has been trialled and proved effective elsewhere (Greenberg et al., 2018). The multidisciplinary perspective which informed the intervention could have had unintended consequences for beliefs in the efficacy by potential participants. The cultural milieu of supporting fatigue within the profession, as opposed to actively discouraging it, implicates aspects of self-verification theory (Swann et al., 2003). This theory posits that individuals prefer their behaviours to perceived in a particular way, such as the tired surgeon, irrespective of whether they're presented with information which refutes its effectiveness. While coaching challenges these verifications, it is likely that this was a significant barrier of engagement for other surgeons in the process. A screening process, prior to recruitment, may assist in creating a cognitive dissonance to challenge these strongly held beliefs. Such a process has been explored elsewhere (Shanafelt et al., 2014), whereby surgeons were screened and provided with immediate feedback regarding their wellbeing relative to other staff. Less than half (47%) of participants stated they would make a behaviour change based off the feedback, but most importantly, this incorporated those who scored lowest in wellbeing relative to physician norms.

Fatigue

There was a non-statistically significant shift downwards in reported physical fatigue levels post-intervention, as well as a significant reduction in reported levels of required rest from fatigue. The level of fatigue that was reported by participants using the modified experience sampling method (Csikszentmihalyi and Larson, 2014) showed decreases in severity of fatigue as the intervention progressed, as well as reduced levels in physical, cognitive, and emotional fatigue trends between baseline and conclusion assessments. The resulting impact on performance scores showed a downward non-statistically significant quartile trend to being less exhausted in all three domains, albeit these differences were not statistically different. Interestingly, levels of recovery showed increased non-statistically significant trends to feeling more relaxed, and recovering energy more quickly. More apparent, was the increased reporting of perceived autonomy in recovery states, adding weight to the importance of BPN in fatigue level management (Deci and Ryan, 2004). This improvement could have been assisted through the coaching process, whereby participants developed more control and thus self-regulation. The level of sleepiness and sleep quality showed no differences between the two time frames, but there was an improvement in reported sleep hours by an average of 30 minutes. This improvement in sleep quantity could have arose as a side-effect from engaging in the intervention, or through other uncontrolled variables.

Thriving

There were statistically significant improvements in thriving scores, positive affect, and psychological capital. In particular, significant increases in aspects of learning and positive affect were identified, as well as aspects of hope and optimism. Finally, the median scores of those reporting they felt emotionally hardened, burned out, or feeling overwhelmed shifted from 'yes' to 'no' on conclusion assessment. The combination of these findings supports the meta-analytical finding that psychological interventions have proven effective for wellbeing (Koydemir et al., 2020). One study, exploring the effects of an individualised coaching programme in optimising wellbeing in physicians (Dyrbye et al., 2019), showed significant decreases in absolute rates of burnout (17.1%) after six months, with improvement in quality of life and resilience scores. This intervention, while much shorter in length, has identified additional variables which could contribute to these longer-term changes.

This study identified significant differences between individuals reporting experiencing thriving in work and those who do not. Higher reported levels of hope, professionalism, self-management, and scholarship, alongside lower levels of sleepiness from better recovery opportunities were associated with those reporting thriving in their work. This would support the framework that thriving states only occur when there are concurrent experiences of cognitive and affective excellence (Spreitzer et al., 2005). Psychological activities, identified as significant associations, which may facilitate this state were self-talk, imagery, and activation, which will be later discussed.

While this intervention couldn't identify significant improvements in levels of self-efficacy, the quartile ranges suggest an upward trend post-intervention. These findings provide some interesting insights into the already published literature on the importance of self-efficacy for performance and wellbeing. Higher self-efficacy has been previously found to be negatively predictive of emotional exhaustion (i.e. a marker or burnout), and positively predictive of personal accomplishment (i.e. a marker of work engagement) and general psychological wellbeing (Milam et al., 2019). Coaching could be considered a version of applied positive psychological practice, with a focus on developing positive aspects of the human condition, and thus self-efficacy. Participants did identify moderate likelihoods of making change when required, as well as the majority reporting making some form of positive change from the intervention, which does suggest a level of improved self-efficacy. In coaching, positive emotions are emphasised to inspire individuals to make concrete actions towards goal attainment (Whitmore, 1996) and progressing this can be a steady endeavour. These findings suggest that they may have improved belief in the process, and further improvements may have been identified if the coaching process was longer.

Coaching also promotes engagement with work in such a way that it will optimise an individual's performance, and thus could assist in promoting strategies to promote flow in work. This is done through advising on environmental changes to induce flow states, as well as establishing clear goals, providing immediate feedback, and finding a balance challenge-skills ratio (Fong et al., 2015). To facilitate development of the 'challenge skill ratio', coaches typically use a technique called 'scaffolding' (Beed et al., 1991), related to the zone of proximal development theory which posits that you assist individuals in their learning only at the point of which the capability is beyond their control. You subsequently remove that support once learning has occurred to keep challenge in the learning process consistently (Shabani et al., 2010; Vygotsky, 1980, p. 84). This too, can be a steady process, as identifying appropriate goals and challenges involves in the first instance developing self-awareness.

There were some interesting insights into the relationship between fatigue and thriving. Improvements were noted in aspects of psychological needs recovery for fatigue reduction, and increasing levels of thriving. Autonomous motivation is the outcome of fulfilling the BPN, and could assist in facilitating thriving states. The improvement in thriving and fatigue scores indicates a potential relationship between fatigue recovery and accessing states of thriving. While it is likely that fatigue impacts on the 'learning' aspect of thriving, with research showing reduced memory in fatigued states (Jain and Nataraja, 2019), it could be possible that fatigued states are counteracted due to the ongoing daily learning in trainee surgeons which motivates them. On the other hand, vitality scores slightly increased throughout the intervention, but to a lesser extent that learning.

The most startling insight is the comparison of surgeons with physiotherapy scores. Both groups reported similar baseline levels of fatigue and sleepiness, but physiotherapists reported statistically significantly higher thriving scores, particularly in the vitality domain. When exploring other variables, physiotherapists reported higher sleep hours, abilities to recover quickly, and fulfilment of the BPN of competency and autonomy (Deci and Ryan, 2004). The post-intervention scoring of surgeons, which showed statistically higher thriving scores, particularly in the learning domain, similarly showed statistically significant improvements in sleep hours and reported autonomy. There was non-statistically significant improvements in recovering more quickly as well. Willpower is depleted in states of non-autonomy (Muraven, 2008), which will impact motivation for behaviour change and perceived performance. These findings suggests that fatigue and thriving states can co-exist, but that recovery states, inclusive of getting sufficient sleep and fulfilment of psychological needs, influences the relationship between the existence of thriving when fatigued. In addition, physiotherapists were more likely to set goals in their work, to report supportive work settings, possess extravertive personality traits, and to use psychological skills of self-talk, relaxation, and attentional control in their work. All of these variables may play an additional role in abilities maintain motivation in fatigued states.

Performance

While there was no statistically significant differences, there was unanimous reported improvements in all clinical performance domains, with the exception of professionalism and communication, which could suggest the intervention improved improve perceived performance in some aspects, while perhaps increasing awareness of overconfidence in other domains. Interestingly, there was no difference in baseline between perceived self-management skills between physiotherapists and surgeons, but this was the area that the latter rated their performance lowest in. Coincidentally, this was then also the area which had the largest reported improvement between baseline and post-intervention assessment, suggesting its importance in optimising performance. When exploring clinical encounters which evoked a level of strain on surgeons, the predominant themes were non-technical tasks, on-call related duties, and interpersonal encounters. This is in comparison to physiotherapists who reported a combination of work-specific tasks, and more general work activities, such as training. These stressors are largely in line with the work-factors which influence fatigue levels and wellbeing levels discussed previously. An exploration of the stressors in healthcare (Shanafelt et al., 2005) previously conducted identified balancing professional and personal duties, mastering specialty, sleep deprivation, and administration as stressors. These support the findings of this research. In addition, Shanafelt and colleagues identified additional stressors, including keeping up with evidence, dealing with patient death, finding meaning in work, pressure to publish, and finance which were not identified in this study.

Surgeons perceived situations to not be too stressful, and evoked a high level of coping strategies with positive challenge appraisals. Psychological, affective, or personality traits could have contributed to this. Surgeons reported normal levels of positive affect, and lower negative affect. This may have assisted in appraisal of situations. The perceived high level of coping counteracts the hypothesis that fatigue results from failure of coping in conditions of low control (Hockey, 2013, p.127), and this could reflect a situation of disparity between perceived reactions in situations versus actual mental processing in stressful situations. There was shifts towards improvement in the percentile levels of perceived stress levels, coping ability, and positive challenge appraisal on conclusion assessment. This supports the idea that coping behaviours which result in cognitive and emotional processing, can reduce levels of stress. This is likely to have wider ramifications for prevalence of fatigued states, given that fatigue can be often preceded by anxiety about meeting task demands, and fear of failing, within stress states (Schönpflug, 1983). This may translate across to better performance, as employing coping mechanisms have been associated with better technical performance (Hull et al., 2012). Debate exists as to whether coping is a trait or a state (Krohne, 2002), and thus the findings of stress appraisal within this context may vary depending on the environment that the surgeons are in. Other research has found psychological interventions, such as mental skills training (Arora et al., 2011; Stefanididis et al., 2017), have been successful in protecting performance of surgeons in stressful environments. Some surgeons may focus on more general behaviour change towards stress, while others may focus on particular contexts in which they perceive there to be high pressures. It has been advocated by stress experts that the effective use of coping strategies must account for not only the individuals appraisal of situations but also the alignment of individuals goals and situational contexts (Folkman and Moskowitz, 2004). This has implications for levels of fatigue in surgery. If a surgeons personal goals are not aligned with the tasks they are performing, or if they are working within settings of little control, whereby they must use passive and emotion-focused coping strategies, then they are more likely to elicit negative stress responses which will influence fatigue levels.

The psychological performance of an individual has been defined as a key differentiator between expert and non-expert performance (Ericcson and Pool, 2016). Development of the basic psychological skills to a level of proficiency has been found predict success in performance (Kudlackova et al., 2013; Tod et al., 2011). Surgeons predominantly used automaticity, goal setting, and activation, as their performance excellence markers in this domain, but were in large not near expert levels in any domain. There was non-statistically significant shifts upwards in use of self-talk, and activation, as well as lower negative thinking, on conclusion assessment. This adds evidence to the hypothesis of psychological skill use for performance optimisation. Targeted coaching efforts on particular aspects of surgical performance may have elicited higher rating scores that were statistically significant. On the other hand, physiotherapists on average scored higher than surgeons in psychological performance, with statistically significantly higher scores in domains of attentional control, relaxation, and self-talk. As previously mentioned, development of these skills, may assist surgeons further in facilitating thriving states by promoting rest strategies to regain vitality, and to focus attention for effective learning. They may also assist in mitigating fatigue. Fatigue results from increasing difficulty in controlling attention and effort to a particular task, encouraging reappraisal as a mitigator. Developing these skills in non-fatigued states could assist in the development of psychological traits which can assist in fatigued states. While there was little improvement in these scores between baseline and post-intervention testing, this study identified statistically significant differences between individuals reporting experiencing flow in work and those who do not. Those who experience the state reported having higher levels of hope, self-management skills, professionalism, higher vitality, learning, and positive affect, alongside lower sleepiness. The additional activities associated with the flow state were greater levels of self-talk and activation, as well as higher recovery states. Such areas may be particularly useful to focus on to increase access to flow states in healthcare, and speak to the importance of psychological skill use as part of that implementation process.

Previously mentioned benefits to coaching on perceived improvements in performance show how it can assist in accessing thriving states. Other research has shown that developing a philosophy to work, having active recovery opportunities, having an optimistic perspective in the workplace, and establishing balance between work and life are all associated with higher wellbeing in oncology (Shanafelt et al., 2005). All of these behaviour changes are within the remit of this intervention, and when asked what the most significant differences the coaching intervention made, participants identified time management and better recovery which match these findings. From an objective performance perspective, psychological skill enhancement has been proven to improve both technical and non-technical skill (Stefanidis et al., 2017), with improvements noted in laparoscopic suturing (Palter et al., 2016), as well as non-technical performance, such as interpersonal skills (Pradarelli et al., 2020), which shows the potential multi-faceted benefit of psychological based interventions in surgery.

Behaviour Change

In exploring the relationship between the three predictors of behaviour change, and the variables associated with them, there may be some modifiable factors at a personal and environmental level which could improve engagement in larger-scale roll out of the project. The use of the Hill's criteria of states that the larger the association, the more likely there is a casual inference between variables (Hill, 1965). All of the variables associated with behaviour predictors were greater than 0.5 and a majority moderately related. In both belief and willingness, an increase in access to learning opportunities and capabilities may increase both predictors. Reported high self-efficacy was more likely to lead to willingness and readiness to engage, while readiness was also associated with traits of hope and positive affect. In exploring determinants, higher levels of emotional control, goal setting, lower negative thinking, and having an appropriate workload could predict readiness to make behaviour changes.

On conclusion assessment, participants reported 'moderate change' in life priorities and likelihood to make required changes in their lives when ranking the effectiveness of the intervention. The questions involved questions of affect, as well as personal views on life changes. This questionnaire explored aspects of relevance self-efficacy theory (Bandura, 1977), assessing human agency in the surgeons abilities to self-regulate and mitigate their own fatigue. A higher baseline self-efficacy score was predicted to improve success in the intervention, as the state encouraged beliefs of capabilities (Bandura, 1977) of performing behaviour changes to mitigate fatigue, which was one of the core aspects identified for intervention in the COM-B model. This was somewhat supported by the findings of this study though further research is warranted.

There are several strengths and recommendations based on this study, one of which is that an individualised approach to coaching allows targeted intervention in the development of areas relevant to individual surgeons. This supports the psychological theory of SDT (Deci and Ryan, 2004) by facilitating a transfer of extrinsically motivated factors for behaviour change to intrinsically motivated drives associated with individual perceived sense of enjoyment and importance. For example, the development of self-awareness strategies may be particularly important for early-career surgeons, while the focus on optimising aspects of clinical performance, such as leadership, may be more important in older-career surgeons. This differentiation between acquisition of performance skills and optimisation of performance skills has been advocated for in the surgical literature (Cocks et al., 2014). In addition, the coaching process targets executive functions by having surgeons engage in reflective motivation processes which can override intuitive habitual behaviours.

One of the difficulties in research on fatigue is the difficulty in recruiting individuals who may need intervention but do not engage. While this study explored willingness for change, a significant portion of surgeons are likely to have not engaged because they felt the issue of fatigue is not one which they should take responsibility for. In these instances, future studies should explore targeted communication tailored to provoke the ‘precontemplation phase’ of the behaviour change cycle (Prochaska et al., 1992), which focuses on exploring cognitive dissonance in their beliefs and attitudes, and the reality of the environment in which they are situated.

Surgeons scored lower in the ‘competency’ and ‘autonomy’ aspects of BPN recovery, relative to ‘relatedness’. The former may be improved through active recovery strategies (e.g. exercise which is highly valued by the profession), while the latter involves the necessity to look at what are the barriers to perceived independence in recovery opportunities, including over-working, and additional life stressors, such as parenthood. This is particularly true for gender differences, as some aspects of vitality and learning were much lower in female surgeons, and thus warrants further investigation to explore demographic specific barriers. Interestingly, disparities between demographics were not evident on conclusion assessment, suggesting that coaching may be an equitable intervention for all surgeons.

While most of the surgical coaching literature has focused on technical skill proficiency, this research focused on other aspects of surgical performance, including cognitive and affective performance. Self-regulated interventions, with goal-driven feedback which is important for sustainable behaviour change, is a novel way to address fatigue in surgery. This lifestyle approach to coaching recognises that known factors, such as fatigue, impact on surgical performance. It views that the self-regulation of lifestyle factors are the bedrock on which to enable sustainable performance growth and optimisation in all domains of surgical performance. For this reason, coaching was identified as the best approach over mentoring, given its increased focus on autonomy and performance outcomes. Mentoring focuses on more directive advice for personal development with hierarchical relationships which can further perpetuate cultural norms. Future research should explore fidelity of the coaching intervention from the perspective of the other stakeholders involved such as the coach, occupational health, and the SOAR programme staff as these may offer further insights into improving appropriate dose and adoptions (Moore et al., 2015).

Research error was mitigated through careful study design. The experience-sampling method, with longitudinal tracking of fatigue, allows strong test-retest reliability to be established and for greater inferences to be made about fatigue levels and perceptions within individual participants in the study. Since fatigue, thriving, and performance are constructs which have variable understanding amongst surgeons, attempts to reduce specific factor error in reporting of these constructs was established through the participant information leaflet which provided a level of theoretical understanding of these phenomena.

7.4.6. Limitations

The primary purpose of this intervention was to explore feasibility, and given the sample size, ascertaining definitive conclusions to effectiveness of the two phase intervention is difficult. Sustainability of any behaviour change was not formally assessed, given the time and resource constraints, and the difficulty in following up when regular staff rotate in and out of the hospital. A systematic review on behaviour maintenance found that consideration for five variables is important for sustaining changes. These are motives, self-regulation, habits, resources, environmental and social influences (Kwasnicka et al., 2016). While this study did assess internal resources such as psychological skills and psychological capital, which may have had positive influences on volitional behaviour, establishing strong predictive value of these outcomes for behaviour success was not possible. Variability with regards to successful change in behaviour is the norm given individuals variability in tolerance of efforts (Dornic et al., 1991), and motivational commitments to goal achievement (Hollenbeck and Klein, 1987). Finally, behaviour change typically goes through periods of lapses to prior behaviours (Kwasnicka et al., 2016), and there is large variability in timeframes to which particular behaviours become automatic, though models of habit formations suggests at least two months (Lally et al., 2010). These factors should be accounted for in future studies.

BCT is a comprehensive theoretical approach to behaviour change, but it does fail to provide empirical evidence to describe the specific conditions for sustainability of particular types of behaviour change. It is difficult to ascertain if behaviour change led to objective performance changes, which could have been explored through simulation or observation. This would have allowed the researcher to assess perceived locus of control in managing personally identified modifiable factors for performance optimisation, while also assessing application of learned strategies from the coaching intervention to generate performance management changes.

Self-rating of performance is a perceptual marker which is important for assessing thriving, but shouldn't be used as a valid marker for objective performance. Previous research has found surgeons are prone to overconfidence, with those who over-rate their performance correlating to higher leak rates in complex procedures (Varban et al., 2020). Further empirical evidence to assess objective performance markers in behaviours is warranted in surgery. While efforts were made to ensure constructs were rigorously assessed, alterations to some validated questionnaires were undertaken which may have altered the psychometric properties of the instruments.

Finally, the engagement in the project may have been hampered by the 'out-group' status of the researcher (Turner et al., 1979), making culture a significant barrier for individual behaviour change opportunities. The cultural inertia within the profession may require further intervention also, and increasing access of vicarious experiences for surgeons, such as modelling from senior members of staff on fatigue mitigation, may improve self-efficacy and willingness to engage in the project.

7.4.7. Conclusion

Individualised behaviour-change interventions evokes self-identified positive changes in aspects of fatigue, thriving, and performance . A theoretically-informed intervention is a feasible way to optimise surgical performance when additional considerations are given to fidelity and reach. There remains professional and institutional barriers to effective engagement in behaviour change, that likely restrict opportunities for optimal performance management. Exploration of these higher-level interventions, and their broader applicability to other healthcare professions, may provide further insight into areas that require further consideration prior to larger scale implementations.

8. Chapter 8 – Exploring fatigue and associated factors on performance variables in healthcare professions: drawing comparisons with physiotherapy

8.1. BACKGROUND

It has been established throughout that there is a high prevalence of fatigue within surgery, but are such states comparable to other professions within healthcare system as a whole? In using physiotherapists as a parallel professional group throughout, it became evident that fatigue exists amongst physiotherapists also, even if they aren't subject to the same professional cultural norms or on-call expectations.

This chapter has three elements, summarised in *Figure 8.1,* to explore if similar issues of modifiable factors on performance, identified in surgeons, are comparable to other healthcare professions. A national exploration of sleep-related issues within the physiotherapy profession was conducted, followed by a paralleled study to *Chapter 6* on a physiotherapy cohort. Finally, this chapter concludes by providing a theoretical foundation for understanding the transition from 'surviving' to 'thriving' in healthcare professions, such as surgery and physiotherapy, using a theory-building exploration of combined data of surgeons and physiotherapists from *Chapter 7*.

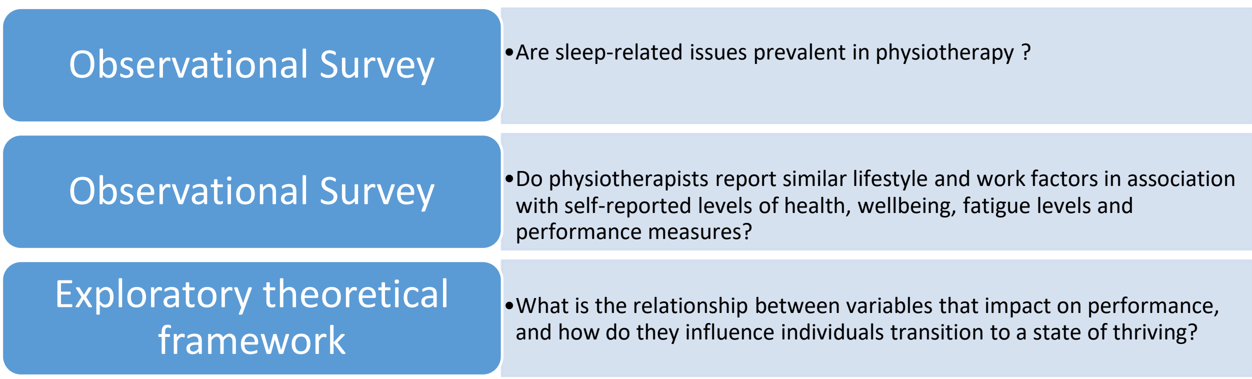


Figure 8.1. Elements of Chapter 8

8.2. EXPLORING SLEEP DEPRIVATION IN A PARALLEL HEALTHCARE PROFESSION

8.2.1. Research Question

Are sleep-related issues prevalent in physiotherapy ?

8.2.2. Objectives

1. To identify levels of self-reported sleep deprivation in physiotherapy
2. To identify if sleep deprivation impacts on self-reported performance
3. To highlight self-reported causes of sleep deprivation in physiotherapy

8.2.3. Methods

This study is reported according to the CHERRIES guidelines (Eysenbach et al., 2012).

8.2.3.1. Study Design

This was a multi-site observational survey study design conducted in collaboration with the Irish Society of Chartered Physiotherapists (ISCP). The validity standard for the survey was defined as completion of the all sections of the survey. On survey completion, participants responses were recorded, and they could not complete the survey again on that device to reduce the risk of survey duplication.

8.2.3.2. Participants

Participants were recruited between October 2019 – December 2019. Clustered sampling was used and participants were recruited through an email list through the ISCP containing an invitation to participate, as well as a participant information letter (*See Appendix AP*) explaining the study thoroughly. A reminder email was also sent out after 4 weeks.

Each participant anonymously completed the survey and no financial reward was given. Participants were advised that informed consent was indicative of completion of the survey. The study assessed significance at the level of $p<.05$. Across similar published studies which have explored Irish physiotherapists, a response rate of between 520-615 (20-22% of a 3000 membership database) responses is reflective of survey responses from Irish physiotherapists (McMahon and Connolly, 2013; McGowan and Stokes, 2015).

The inclusion and exclusion criteria are as follows:

Inclusion:

- Physiotherapists
- Member of the ISCP

Exclusion:

- Non-physiotherapists
- Non-ISCP members

8.2.3.3. Study Instruments

Personal View Statements: Participants were asked if they feel their work as a physiotherapist impacts on their level of sleep, and if sleep deprivation impacts on their work performance. If so, they were asked to disclose what particular tasks they find most impacted.

Sleep Quality: The PSQI (Buysse et al., 1989) was completed to assess sleep quality and sleep patterns.

Daytime Somnolence: The ESS (Johns, 1991) was completed to assess subjective sleepiness during daytime activities.

Demographics: Demographics were taken from participants including gender, age bracket, length since undergraduate, job specification, sectoral area, and specialty (*Appendix AQ*).

8.2.3.4. Statistical Analysis

A protocol of statistical analysis involving tests or normality was used (See *2.3.3.4. Data Extraction and Synthesis* for details). Parametric statistics were used where possible. Spearman correlational analysis was used to examine relationships variables as the data was non-continuous. Independent t-tests and ANOVA explored differences between variables of independence. A summative content analysis approach (Hsieh and Shannon, 2005), using magnitude and grammatical coding, was used to analyse the open-ended exploration of reasons for self-reported sleep deprivation.

8.2.4. Results

8.2.4.1. Demographics

A total of 613 physiotherapists (20.4% of the overall population) were recruited, of which 559 (i.e. 18.6%) completed the full survey. A flow diagram is seen in *Figure 8.2*. A demographic summary is seen in *Table 8.1.*

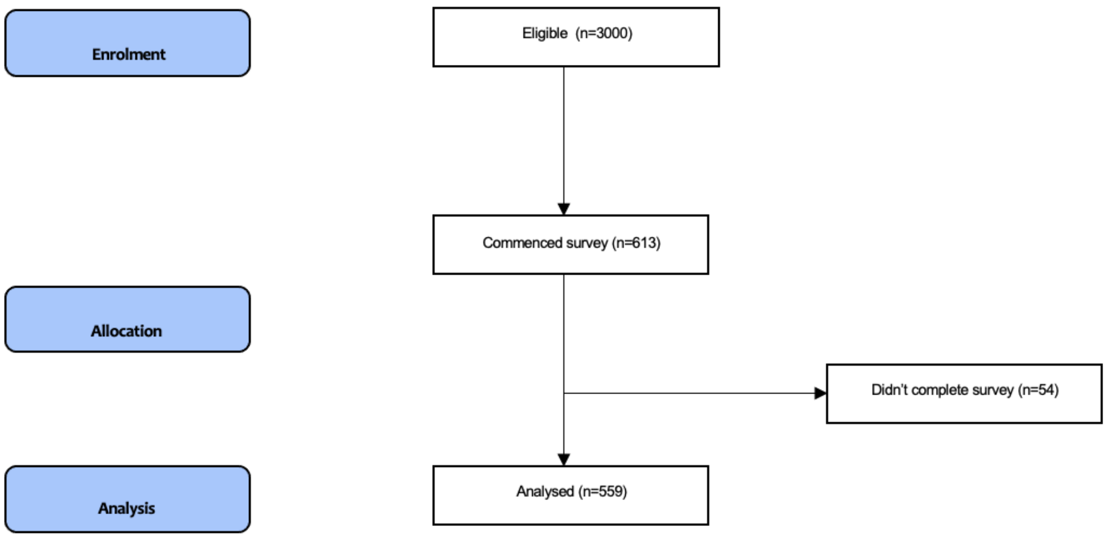


Figure 8.2. Participant flow diagram for Chapter 8 sleep survey study

Table 8.1. Demographics summaries of participants for Chapter 8 sleep survey study

Physiotherapists	**559**
Gender	
Male	98 (17.5%)
Female	461 (82.5%)
Age Bracket	
18-24	45 (8.05%)
25-34	143 (25.6%)
35-44	207 (37%)
45-54	107 (19.1%)
55-64	52 (9.3%)
≥65	5 (0.9%)
Length Since Undergraduate	
≤ 5 years	96 (17.2%)
6-10 years	100 (17.9%)
11-16 years	115 (20.6%)
17-22 years	107 (19.1%)
≥23 years	141 (25.2%)
Current Job Title	
Staff Grade	110 (19.7%)
Senior Physiotherapist	209 (37.4%)
Clinical Specialist	31 (5.6%)
Advanced Physiotherapy Practitioner	12 (2.2%)
Private Practitioner	147 (26.3%)
Other	50 (8.9%)
Sector of Employment	
Public	350 (62.6%)
Private	209 (37.4%)
Work Setting	
Hospital – Inpatient	112 (20%)
Hospital – Outpatient	101 (18.1%)
Primary Care	110 (19.7%)
Private Practice	158 (28.3%)
Other	78 (14%)
Specialty	
Cardiology	5 (0.9%)
Respiratory	32 (5.7%)
Intellectual Disability	2 (0.4%)
Musculoskeletal and Orthopaedics	271 (48.5%)
Neurology	43 (7.7%)
Gerontology	49 (8.8%)
Oncology	6 (1.1%)
Paediatrics	53 (9.5%)
Rheumatology	8 (1.4%)
Gender Health	12 (2.2%)
Sports and Exercise Medicine	16 (2.9%)
Other	62 (11.1%)

8.2.4.2. Levels of sleep deprivation and relationship with performance

Almost two thirds (63.3%) reported their professional practice did not impact their sleep. The reported causes of sleep deprivation are seen in *Figure 8.3*.

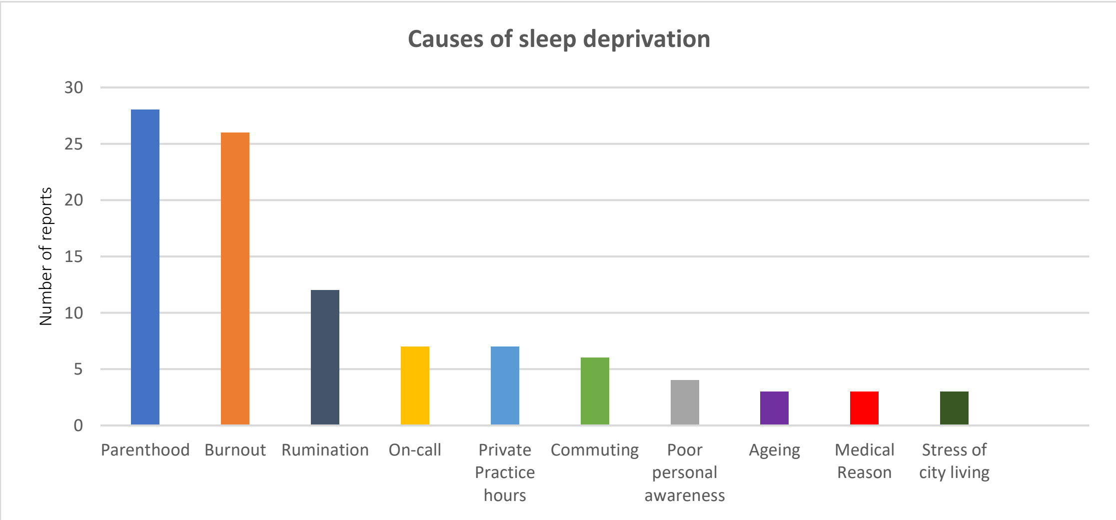


Figure 8.3. Activities causing sleep deprivation in physiotherapy

Half of participants (50.1%) reported sleep deprivation impacted on their professional practice. The most affected activities are seen in *Figure 8.4*.

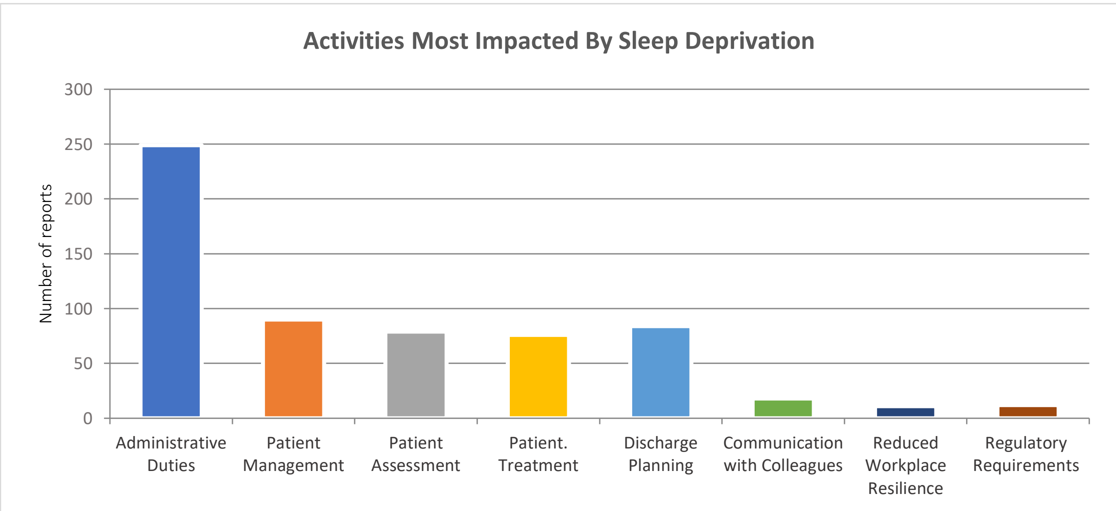


Figure 8.4. Performance activities affected by sleep deprivation

More females worked in the public sector (67.3%), compared to males (39.8%) (p=.030). More females worked in hospital outpatients (20%), while more males worked in private practice

(46.9%) (p=.040). There was a statistically significant difference between percentages of those who reported 'yes' to sleep deprivation impacting on performance in:

- Age groups (p=.034)
  - 18-24 (66.8%) and 25-34 (60.8%)
  - 35-44 (49.8%), 45-54 (43%) and 55-64 (25%)
- Job title (p=.044)
  - Staff grade (60.9%)
  - Senior (47.4%) and private practitioners (46.9%)

8.2.4.3. PSQI

The mean global PSQI score of the cohort was 5.6, which is indicative of poor sleep quality. Scores for the summative component scores are shown in *Table 8.2*.

Table 8.2. PSQI characteristics with means and standard deviations

Variable	**Mean**
Subjectively Sleep Quality	1.07 ± 0.67
Sleep Latency	1 ± 0.72
Sleep Duration	0.5 ± 0.58
Habitual Sleep Efficiency	1 ± 0.46
Sleep Disturbances	1 ± 0.79
Sleep Medication	0.1 ± 0.54
Daytime Dysfunction	1 ± 0.72
Global score	5.6 ± 0.64

8.2.4.4. ESS

The mean global ESS score of the cohort was 6, which is indicative of higher normal daytime sleepiness. Scores for the summative component scores are demonstrated in *Table 8.3*.

Table 8.3. ESS characteristics with means and standard deviations

Variable	Mean
Sitting and reading	1 ± 0.94
Watching TV	1.2 ± 0.92
Sitting inactive in a public place	0.5 ± 0.71
As a passenger in a car for an hour without a break	1 ± 0.93
Lying down to rest in the afternoon when circumstances permit	1.6 ± 1.1
Sitting and talking to someone	0.1 ± 0.31
Sitting quietly after lunch without alcohol	0.4 ± 0.69
In a car, while stopped for a few minutes in the traffic	0.2 ± 0.29
Global score	**6 ± 0.74**

8.2.5. Discussion

Physiotherapists report sleep quality scores similar to that of surgeons. While physiotherapists do complete on-call work, primarily identified as the cause of reduced sleep in surgeons, they do not complete it as regularly and often can achieve the recommended sleep hours irrespective of on-call status. Parenthood was ranked as the highest cause of sleep-related issues in physiotherapy, followed closely by burnout.

While a majority of participants reported their work didn't impact of their sleep levels, the PSQI scoring was higher than that reported in the primary cohort setting for both surgeons and physiotherapists in previous chapters. In particular, lower scoring on sleep duration was noted in the national cohort. This would suggest that the primary cohorts based within Tallaght University Hospital, whom were researched in this thesis, may sleep better compared to a national population of healthcare staff. Poorer sleep quality has been reported in healthcare personnel (Alami et al., 2018), indicating this may be a wider issue in the healthcare sector.

Half of participants identified that, when sleep deprived, there was impacts on many aspects of performance, and in particular administrative duties. This percentage is much higher than percentage reporting of fatigue impacting performance by surgeons in previous chapters. Administrative duties can be cognitively demanding, and could involve competition for motivational demands leading to fatigued states and perceived impacts on performance.

Parenthood was the highest ranked cause of sleep deprivation in the profession, highlighting the stark differences between a predominantly male and female healthcare profession. Parenthood was previously identified as a cause of fatigue in surgery, but they were largely gender-specific issues which were highlighted. While efforts to establish gender-balance are being implemented in organisations to improve work cultures and new professional norms and expectations, vestiges of old paternalistic milieu of the primary role of a women as the caregiver of the family is likely still prevalent. Closely followed to parenthood was high levels of burnout impacting sleep. Given the complex understanding that burnout results from increased exhaustion, cynicism and inefficacy (Maslach and Jackson, 1981), it may be that psychological states are intrinsically linked with sleep levels in healthcare professions. This appears to be particularly problematic amongst younger staff, which parallels findings on younger surgical trainees experiencing greater sleep disturbances also.

8.2.6. Limitations

The survey is reflective of the distribution of work settings for physiotherapy, with nearly half of physiotherapists working in musculoskeletal medicine and orthopaedics. This is also a limitation however, as it fails to provide greater generalisability to hospital settings alone as a potential influencer of sleep levels. Greater response rates above 60% would provide a greater reflection of true levels of sleep deprivation in the population sample frame. The survey provides a snapshot of the sleep levels of a parallel profession, but further rigorous study design is required to identify the underlying mechanisms causing sleep-related issues in healthcare.

8.2.7. Conclusion

Sleep-related issues exist within physiotherapy and are caused by non-work related factors, such as parenthood, as well as work-related factors which contribute to reported levels of burnout. Some of these causes parallel findings in surgery, but some also differ. This study suggests that sleep-related issues may be a broader issue within healthcare professions. Further investigation on areas of difference and overlap between surgery and physiotherapy may offer insights into shared organisational and professional culture factors which contribute to fatigue and sleep-related issues in healthcare professions.

8.3. COMPARING TRENDS BETWEEN HEALTH, WELLBEING AND MODIFIABLE FACTORS ON PERFORMANCE IN A PARALLEL HEALTHCARE PROFESSION

8.3.1. Research Question

Do physiotherapists report similar lifestyle and work factors in association with self-reported levels of health, wellbeing, fatigue levels and performance measures?

8.3.2. Objectives

1. To investigate trends between overall health, wellbeing, levels of fatigue and physiotherapy performance
2. To explore adherence to guidelines on healthy lifestyle factors
3. To explore physiotherapists self-reporting of work-related factors
4. To explore differences between surgeons and physiotherapists at the primary cohort level

8.3.3. Methods

This study is reported according to the CHERRIES guidelines (Eysenbach et al., 2012).

8.3.3.1. Study Design

A similar study design to *Chapter 6* was employed (See *6.4. Methods* for details).

8.3.3.2. Participants

Participants were recruited between June 2020 – August 2020. The same process of recruitment and eligibility criteria to the first study in this chapter was employed (see *8.2.3.2. Participants* for details). Participants also indicated if they were working within the primary cohort setting for further sub-group analysis.

8.3.3.3. Study Instruments

A similar survey instrument to that validated in *Chapter 6* on the surgical cohort was used. Minor amendments to the survey were made to make it applicable to physiotherapists. Reference to 'surgical performance' was changed to 'physiotherapy performance', while the reference to being honest to patients regarding sleep levels removed reference to the latter half of the sentence which said ‘before surgery’.

8.3.3.4. Statistical Analysis

A protocol of statistical analysis involving tests or normality was used (See *2.3.3.4. Data Extraction and Synthesis* for details). Parametric statistics were used where possible. Independent t-tests and ANOVA explored differences between variables of independence. Kruskal Wallis and Mann-Whitney U testing was used when comparing physiotherapists and surgeons as the homogeneity assumption between both groups could not be assured.

8.3.4. Results

8.3.4.1. Demographics

A total of 370 physiotherapists (i.e. 12.3% of the overall population) were recruited, of which 320 (10.6%) completed the full survey. A flow diagram is seen in *Figure 8.5*. A demographic summary is seen in *Table 8.4*.

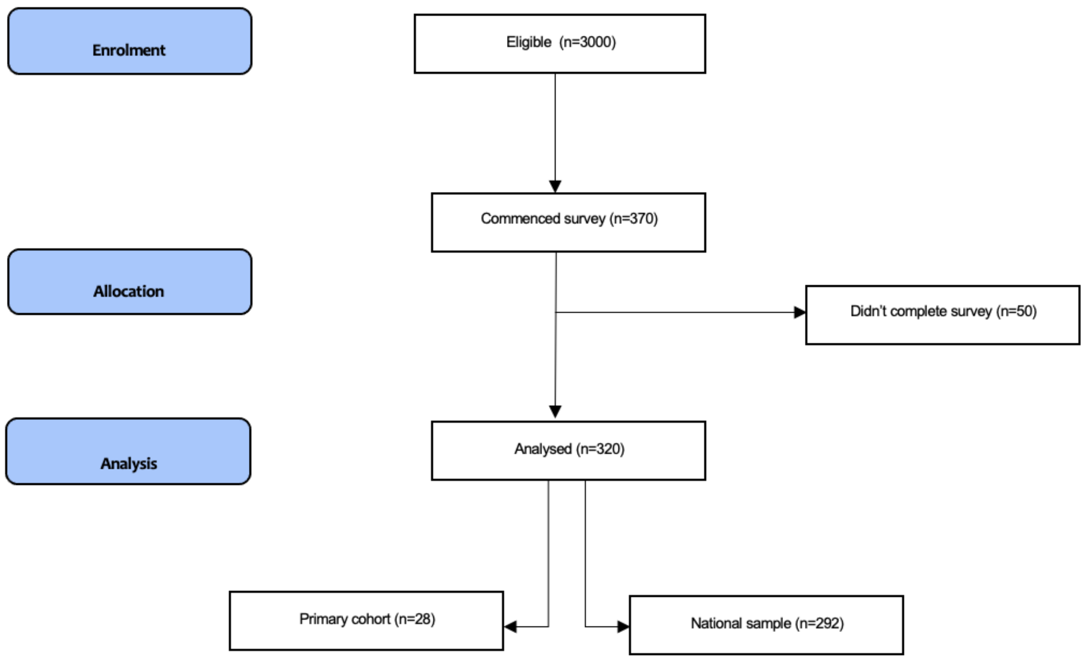


Figure 8.5. Participant flow diagram for observational modifiable factors study

Table 8.4. Demographics summaries of participants for Chapter 8 modifiable factors survey study

Physiotherapists	320
Gender	
Male	48 (15%)
Female	272 (85%)
Age Bracket	
18-24 years old	10 (3.1%)
25-34 years old	75 (23.4%)
35-44 years old	111 (34.7%)
45-54 years old	96 (30%)
55-64 years old	25 (8%)
≥65 years old	3 (0.8%)
Length Since Undergraduate	
≤ 5 years	35 (10.7%)
6-10 years	44 (13.8%)
11-16 years	74 (23.2%)
17-22 years	59 (18.4%)
≥23 years	108 (33.9%)
Current Job Title	
Staff Grade	43 (13.5%)
Senior Physiotherapists	143 (44.8%)
Clinical Specialist	23 (7.2%)
Private Practice	83 (26%)
Research	5 (1.3%)
Management	15 (4.7%)
Other	8 (2.5%)
Specialty	
Cardiology	2 (0.6%)
Respiratory	26 (8.1%)
Intellectual Disability	2 (0.6%)
Musculoskeletal and Orthopaedics	159 (49.7%)
Neurology	26 (8.1%)
Gerontology	26 (8.1%)
Oncology	5 (1.6%)
Paediatrics	27 (8.4%)
Rheumatology	3 (0.9%)
Gender Health	7 (2.2%)
Sports and Exercise Medicine	11 (3.5%)
Other	26 (8.2%)
Work Setting	
Hospital – Inpatient	70 (21.9%)
Hospital – Outpatient	47 (14.9%)
Primary Care	61 (19.1%)
Private Practice	97 (30.2%)
Academia	7 (2.1%)
Other	38 (11.8%)

Female physiotherapists were more likely to find it difficult to switch off (p=.022), be bothered by feelings of anxiousness and depression (p<.001), engage in lower levels of moderate physical activity (p=.023), and eat breakfast less regularly (p=.038).

Younger physiotherapists reported drinking more caffeine (p<.001), completing more on-call work (p=.001), feeling more fatigued (p=.001), managing their fatigue less effectively (p=.036), and engaging in higher levels of strenuous physical activity (p=.013).

Lower sleep hours (p=.024), poorer self-reported work performance (p=.010), higher emphasis on the importance of exercise (p=.028), and higher levels of anxiety and depression (p=.017) were trending in association with lower professional grades. Lower grade physiotherapists were also less likely to feel error disclosure is promoted in the workplace (p=.018), or that there is sufficient staff for the service needs (p<.001).

8.3.4.2. Overall Health

The majority (98%) reported overall health that was at least good. Two respondents reported poor overall health, as seen in *Figure 8.6*. The variables trending in association with overall health are seen in *Table 8.5.*

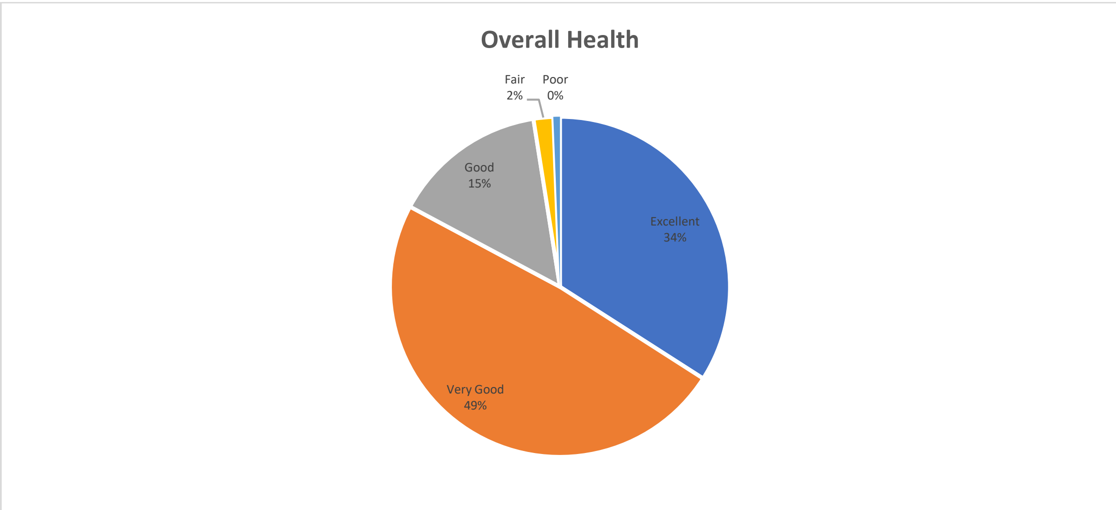


Figure 8.6. Self-reported overall health in physiotherapists

Table 8.5. Variables trending in association with overall health in physiotherapists

Determining Variable				**Work Factor: Performance Management**
↓Often Fatigue (p<.001)				↑Performance Off-Call (p<.001)
↑Overall Wellbeing (p<.001)				↓Fatigue Physiotherapy Task (p<.001)
↓Bother Anxious Depression (p<.001)				↓Fatigue Non-Physiotherapy Task (p<.001)
Lifestyle Factor: Sleep				↓Disruptive Social Activities (p<.001)
↑Average Sleep Hours (p=.034)				↓Disruptive Professional Activities (p<.001)
↑Consistent Sleep (p=.002)				
↑Manage Fatigue Effectively (p<.001)				
Lifestyle Factor: Stress				
↓Often Stress (p<.001)	⇋	**↑Overall Health**	→	
↑Easy Switch Off (p<.001)				
↑Supported Feel (p=.011)				
Lifestyle Factor: Exercise and Physical Activity				
↑Light Activity (p=.007)				
↑Moderate Activity (p=.004)				
↑Strenuous Activity (p<.001)				
↑Importance Exercise (p<.001)				
Lifestyle Factor: Diet				
↑Lunch (p=.030)				
↓Sugar Drinks (p=.027)				
↑Portion Vegetable (p=.008)				
Lifestyle Factor: Health Checkups				
↓Last Time Doctor (p<.001)				

8.3.4.3. *Overall Wellbeing*

The majority (85%) reported overall mental and emotional wellbeing that was at least good. Nearly two-thirds (63.6%) reported being bothered by feelings of anxiety and/or depression at least somewhat. A summary of findings are seen in *Figure 8.7*. The variables trending in association with overall wellbeing are seen in *Table 8.6.*

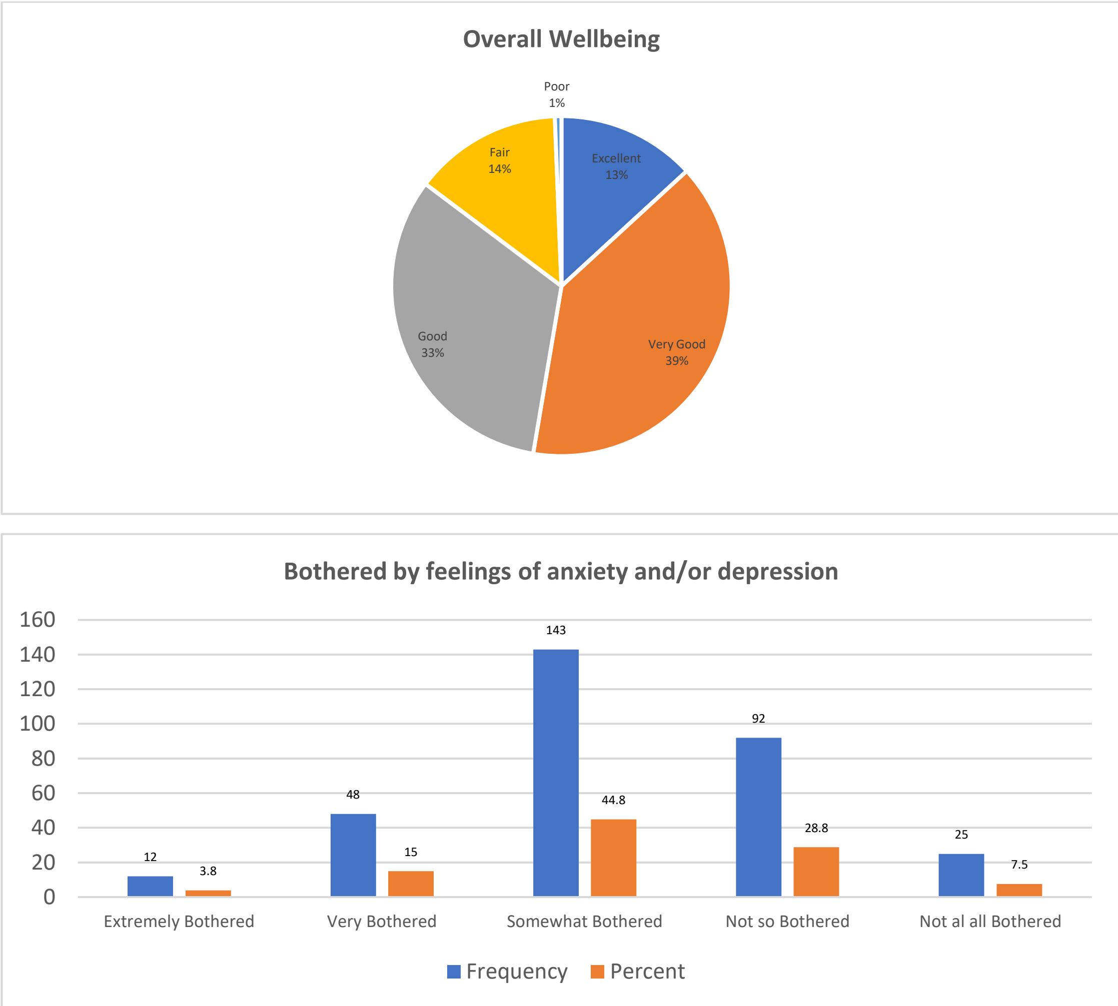


Figure 8.7. Self-reported overall wellbeing in physiotherapists

Table 8.6. Variables trending in association with wellbeing in physiotherapists

Determining Variable				**Work Factor: Performance Management**
↓Often Fatigue (p<.001)				↑Performance Off-call (p<.001)
↑Overall Health(p<.001)				↓Fatigue Physiotherapy Task (p<.001)
↓Bother Anxious Depression (p<.001)				↓Fatigue Non-Physiotherapy Task (p<.001)
Lifestyle Factor: Sleep				↓Disruptive Social Activities (p<.001)
↑Average Sleep Hours (p<.001)				↓Disruptive Professional Activities (p<.001)
↑Consistent Sleep (p<.001)				↓Minor Fatigue Errors (p=.019)
↑Manage Fatigue Effectively (p<.001)				↓Major Fatigue Errors (p=.046)
Lifestyle Factor: Hydration				
↑Water Intake (p=.024)				
Lifestyle Factor: Stress				
↓Often Stress (p<.001)				
↑Easy Switch Off (p<.001)	⇋	**↑Overall Wellbeing**	→	
↑Supported Feel (p<.001)				
Lifestyle Factor: Exercise and Physical Activity				
↑Light Activity (p=.030)				
↑Strenuous Activity (p=.002)				
↑Amount Exercise (p=.004)				
↑Importance Exercise (p=.017)				
Lifestyle Factor: Diet				
↑Breakfast (p=.019)				
↑Lunch (p<.001)				
↑Dinner (p=.019)				
↓Sugar Drinks (p=.048)				
↓Sweet Things (p=.036)				
↑Portion Vegetable (p=.048)				
Lifestyle Factor: Health Checkups				
↓Last Time Doctor (p<.001)				
Work Factor: Culture				
↑Error Disclosure Promoted (p=.002)				

8.3.4.4. Overall Fatigue Levels

Over two-fifths (43%) reported feeling fatigued at least half of the time. The majority (70%) reported managing fatigue effectively. A summary of findings are seen in *Figure 8.8*. The variables trending in association with overall fatigue levels are seen in *Table 8.7.*

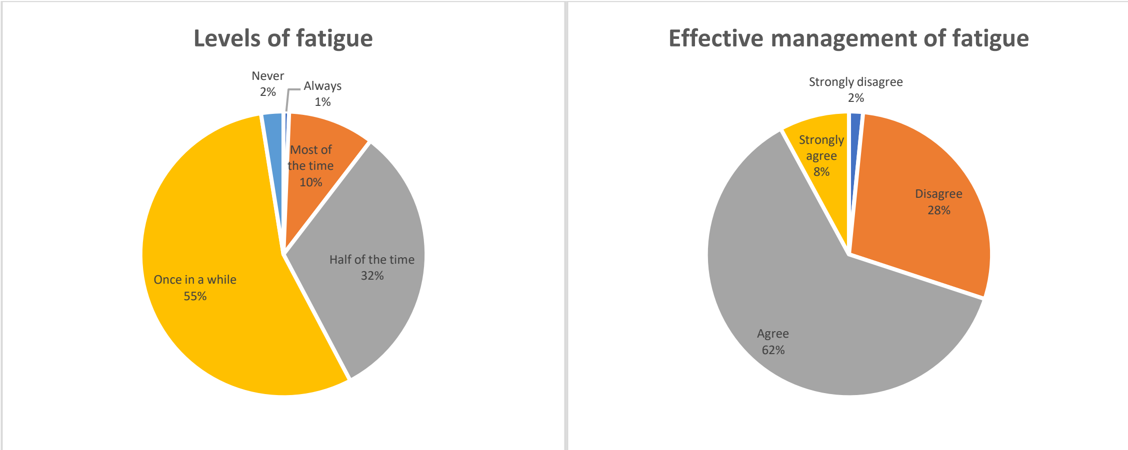


Figure 8.8. Self-reported levels of fatigue and effective management of fatigue in physiotherapists

Table 8.7. Variables trending in association with level of fatigue in physiotherapists

Determining Variable				**Work Factor: Performance Management**
↑Overall Wellbeing (p<.001)				↑Performance Off-Call(p<.001)
↑Overall Health(p<.001)				↓Fatigue Physiotherapy Task (p<.001)
↓Bother Anxious Depression (p<.001)				↓Fatigue Non-Physiotherapy Task (p<.001)
Lifestyle Factor: Sleep				↓Disruptive Social Activities (p<.001)
↑Average Sleep Hours (p<.001)				↓Disruptive Professional Activities (p<.001)
↑Consistent Sleep (p<.001)				↓Minor Fatigue Errors (p=.001)
↑Manage Fatigue Effectively (p<.001)				
Lifestyle Factor: Stress				
↓Often Stress (p<.001)				
↑Easy Switch Off (p<.001)				
↑Supported Feel (p<.001)				
Lifestyle Factor: Exercise and Physical Activity				
↑Light Activity (p=.010)				
↑Amount Exercise (p<.001)		**↓Level of fatigue**		
Lifestyle Factor: Diet	⇋		→	
↑Lunch (p<.001)				
↑Dinner (p=.020)				
↓Sugar Drinks (p=.044)				
↓Fast Food (p=.028)				
Work Factor: Commute				
↓Commute To Work (p=.003)				
↓Commute From Work (p=.002)				
Work Factor: On-call work				
↓Often On-Call (p=.031)				
Work Factor: Culture				
↑Error Disclosure Promoted (p=.034)				
↑Staff Treated Fairly (p=.053)				

8.3.4.5. Lifestyle Factors

8.3.4.5.1. Smoking and Alcohol

A majority (94.8%) reported not smoking. A majority (97.8%) reported not exceeding thirteen units of alcohol on a weekly basis.

8.3.4.5.2. Caffeine Intake

A majority (88.9%) reported drinking less than 4 caffeine beverages daily.

8.3.4.5.3. Hydration

A majority (89%) reported drinking less than two litres of water daily.

8.3.4.5.4. Sleep

A majority (84.3%) reported sleeping an average of seven or more hours a night when not on-call. Over three-quarters (77.4%) reported having a consistent sleep pattern, as seen in *Figure 8.9.*

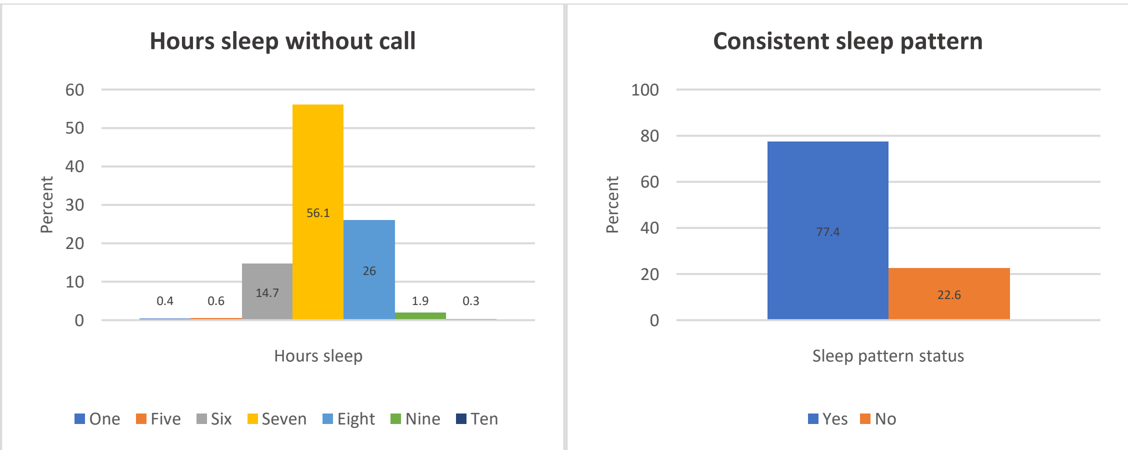


Figure 8.9. Sleep factors in physiotherapists

8.3.4.5.5. Stress

Over half (52.4%) reported feeling stressed either 'once in a while' or 'never'. Over half (56.3%) agreed it is easy to switch off after work. A majority (85.3%) reported feeling a level of support at work or at home as seen in *Figure 8.10.*

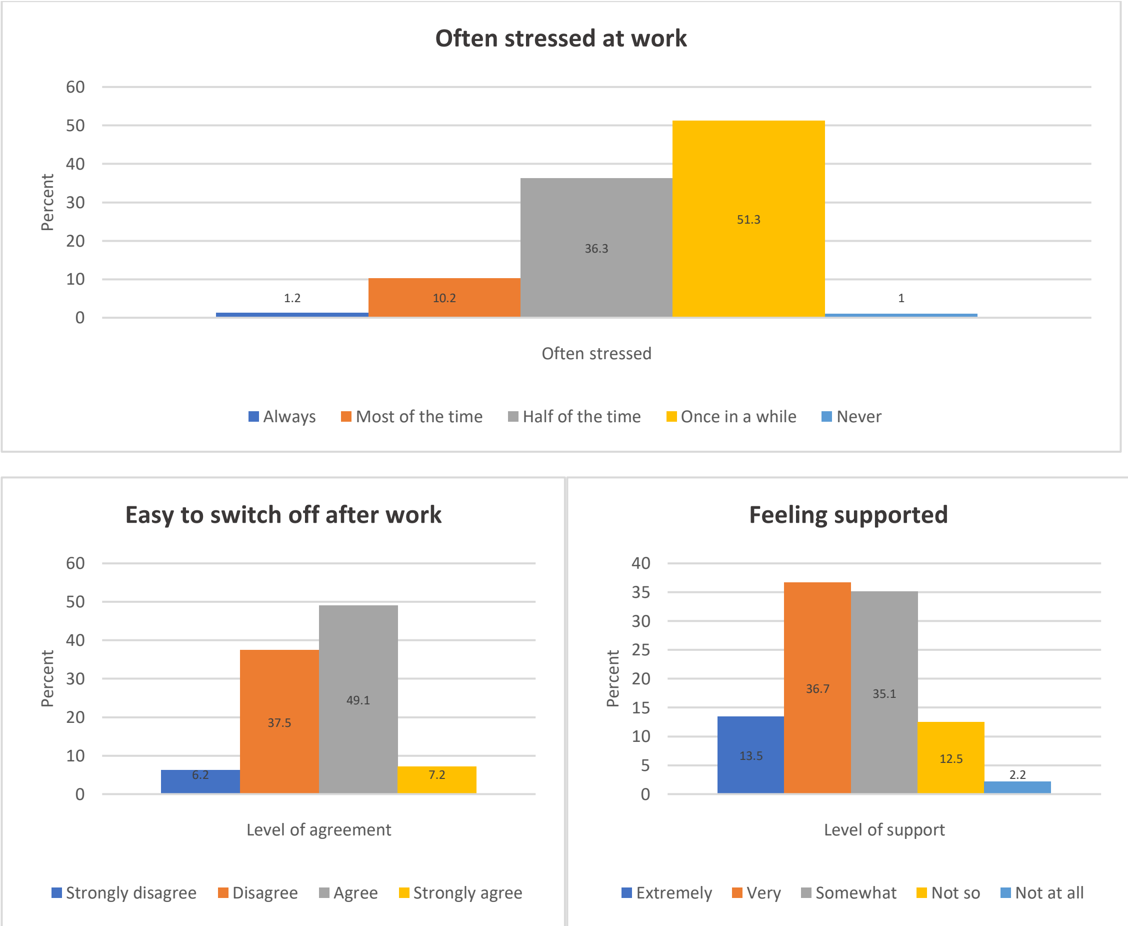


Figure 8.10. Stress factors in physiotherapists

8.3.4.5.6. Physical Activity and Exercise

Over half reported engaging in light activity (56%) five times or more a week. Nearly a third reported engaging in moderate activity (32.3%) five times or more a week. Over a third (36.3%) reported engaging in strenuous activity three times or more a week. Nearly two-thirds (64.2%) report not getting enough exercise. A majority (97.5%) reported exercise is at least somewhat important to them. A summary of findings are seen in *Figure 8.11*.

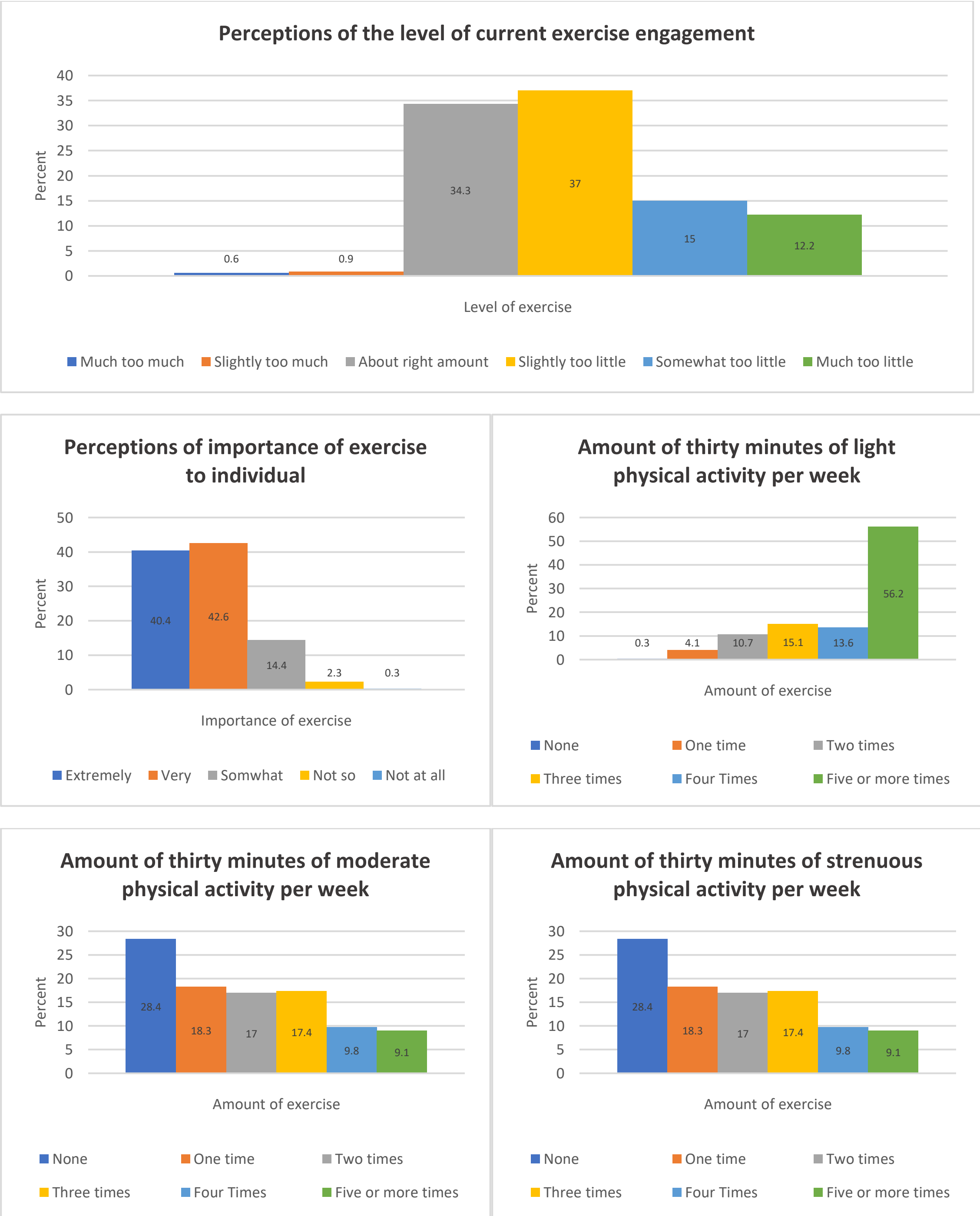


Figure 8.11. Physical activity and exercise factors in physiotherapists

8.3.4.5.7. Diet

A majority (80.6%) reported eating breakfast (80.6%), lunch (87.1%), and dinner (94%) daily. Nearly a fifth (18.2%) reported not eating fast food. A majority (92.8%) reported not eating microwavable or ready-made deals daily. Two-fifths (40.9%) reported not drinking sugar-carbonated beverages. A small percentage (1.6%) reported not eating sweet things such as sweets, chocolates or crisps. Over three-quarters (77.3%) reported eating two or more fruits a day. A majority (85.8%) reported eating two or more vegetables a day.

8.3.4.5.8. Health Check-Ups

Over two-thirds (69.6%) reported getting a medical check-up on a yearly basis. Two-thirds (66.1%) reported getting a dental check up on a yearly basis, as seen in *Figure 8.12.*

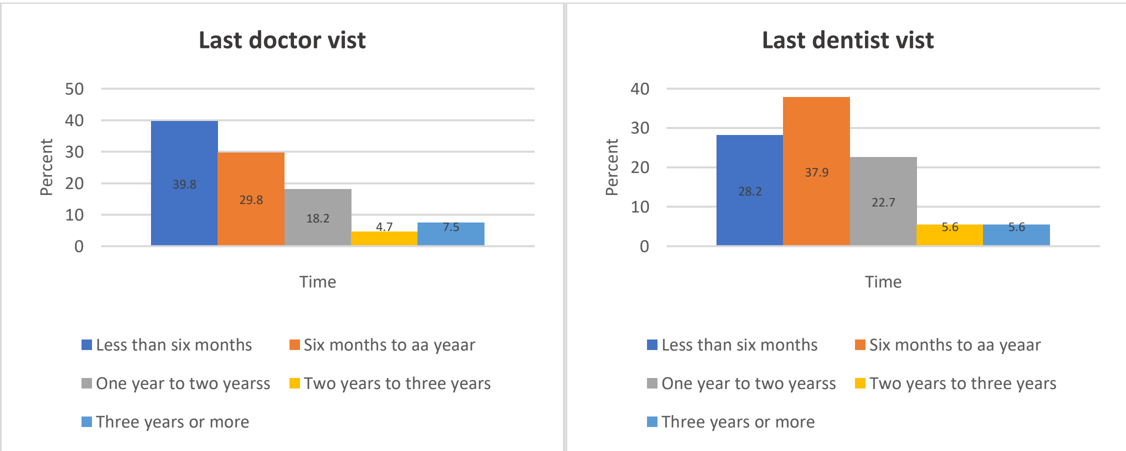


Figure 8.12. Health check-ups factors in physiotherapists

8.3.4.6. Work Factors

8.3.4.6.1. Culture

Over two-fifths (42.2%) agree staff are treated fairly when they make mistakes. Over three-quarters (77.4%) agree to being honest in telling patients how much sleep they had. Less than two-fifths (38.4%) agree to error disclosure being promoted and implemented effectively in physiotherapy, as seen in *Figure 8.13.*

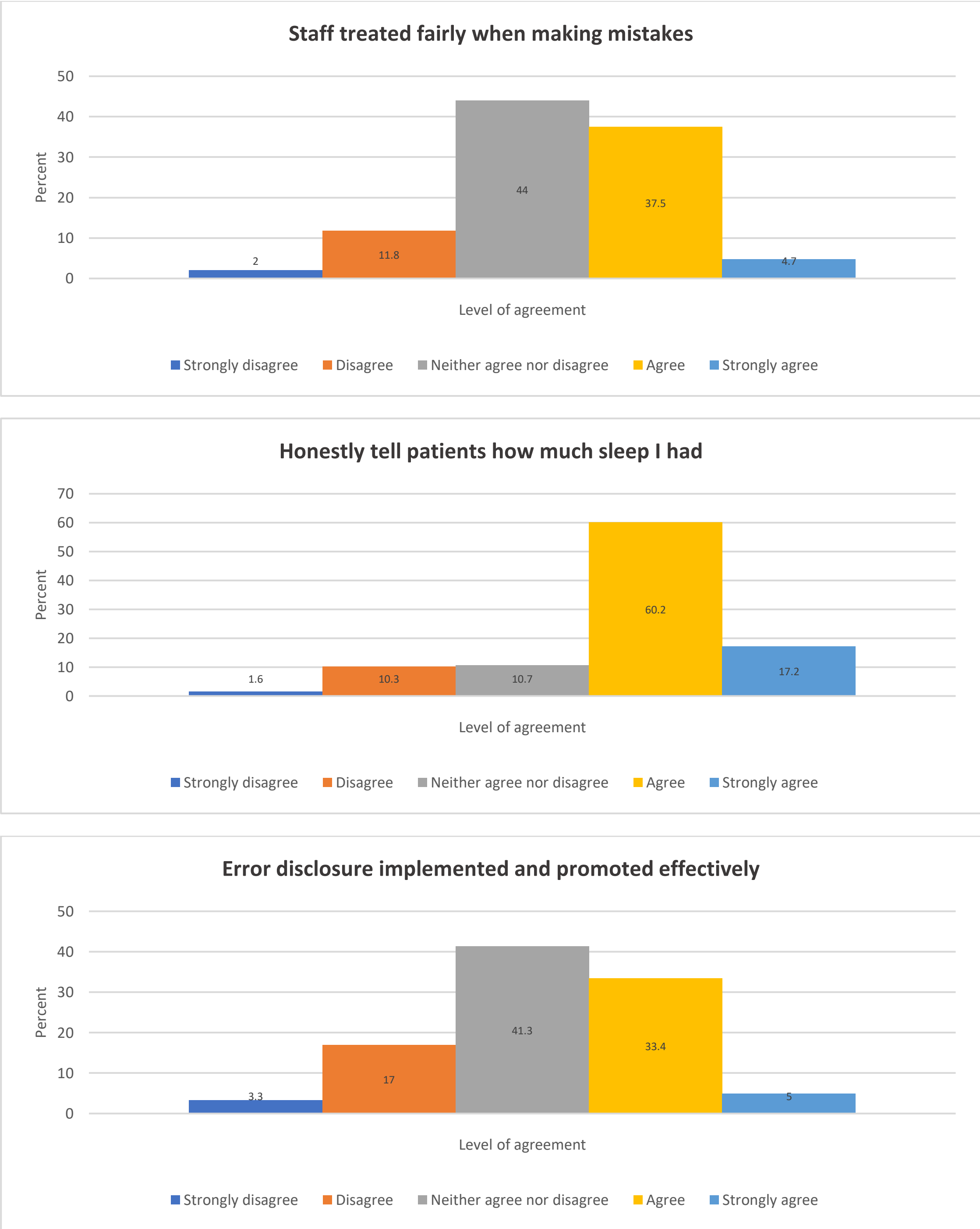


Figure 8.13. Work culture factors in physiotherapists

8.3.4.6.2. Resources

A third (33.6%) agree to having enough staff to handle the workload, as seen in *Figure 8.14.*

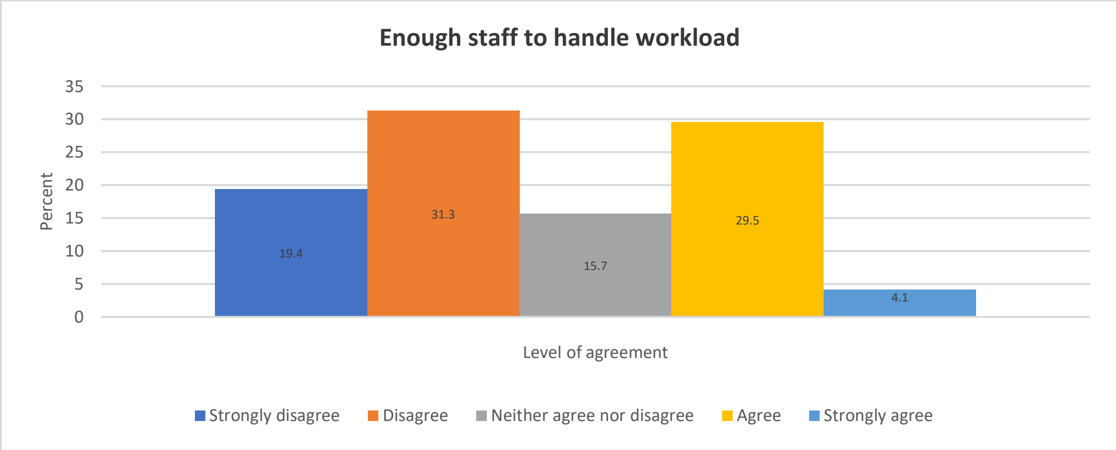


Figure 8.14. Resource factor in physiotherapists

8.3.4.6.3. Commuting

Approximately two-thirds reported commuting less than 30 minutes to work (66.8%) and from work (62.4%).

8.3.4.6.4. On-call work

A majority (81.2%) reported not completing on-call work. Nearly three-quarters (73.1%) reported sleeping six hours or more on average when on-call. A majority (81%) reported sleeping six hours or more on average after on-call, as seen in *Figure 8.15.*

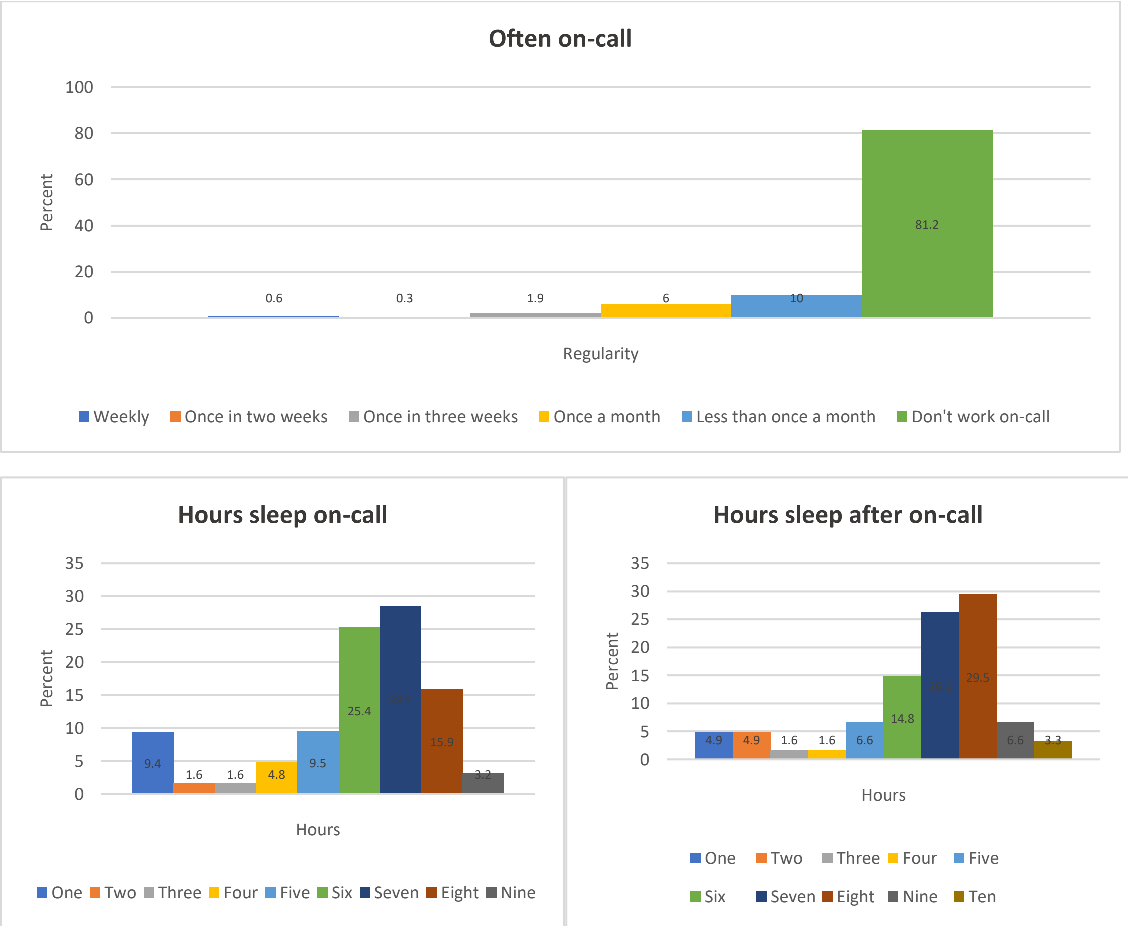


Figure 8.15. On-call factors in physiotherapists

8.3.4.7. Performance Outcomes

The minority reported their physical health or emotional problems at least somewhat disrupted their social activities (29.1%) or professional activities (19.5%). The majority reported their work performance at least good when not on-call (99.7%), and when on-call (84.6%). A minority reported that at least half of the time fatigue negatively impacted their ability to perform tasks (27.7%) optimally. A minority agree to having made minor (34.6%), or major (1.6%) work-errors as a result of fatigue. A summary of findings are seen in *Figures 8.16* and *8.17.*

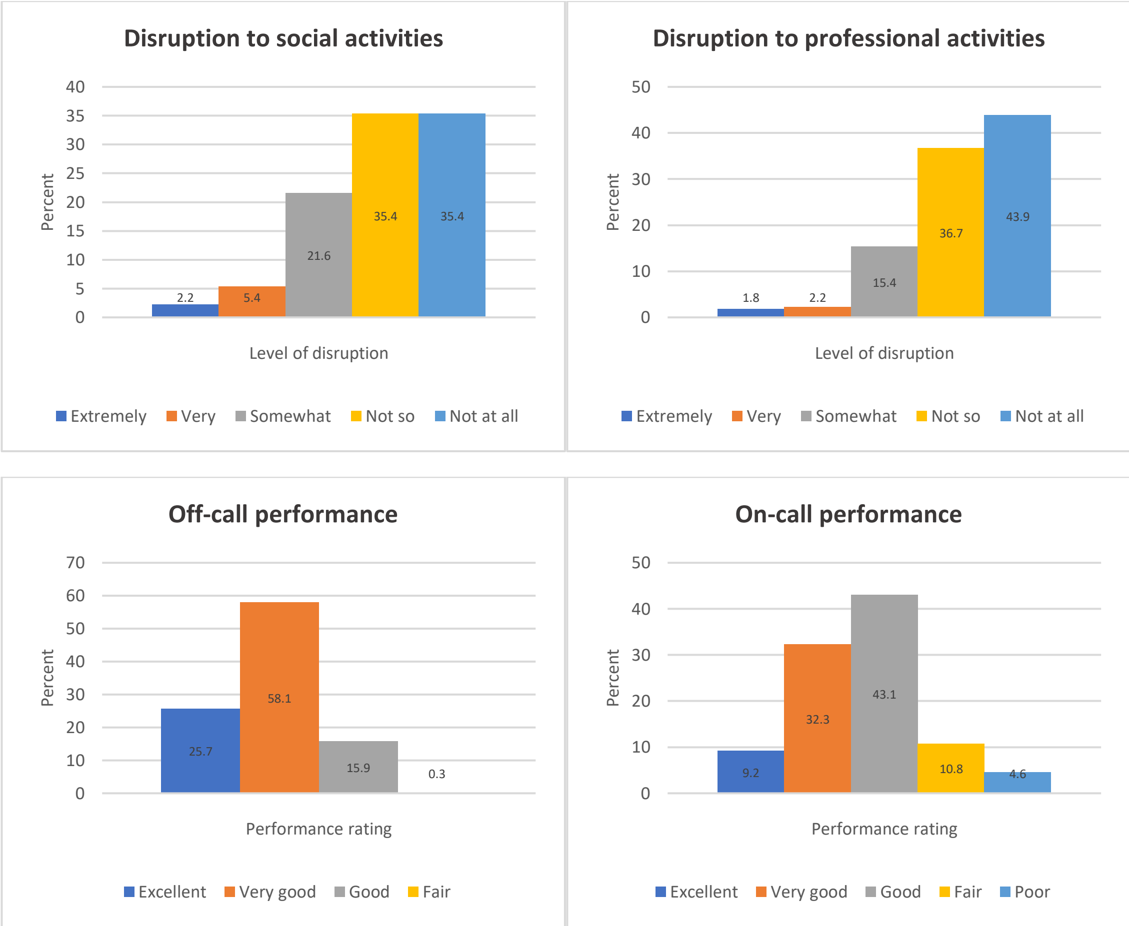


Figure 8.16. Performance outcomes in physiotherapy

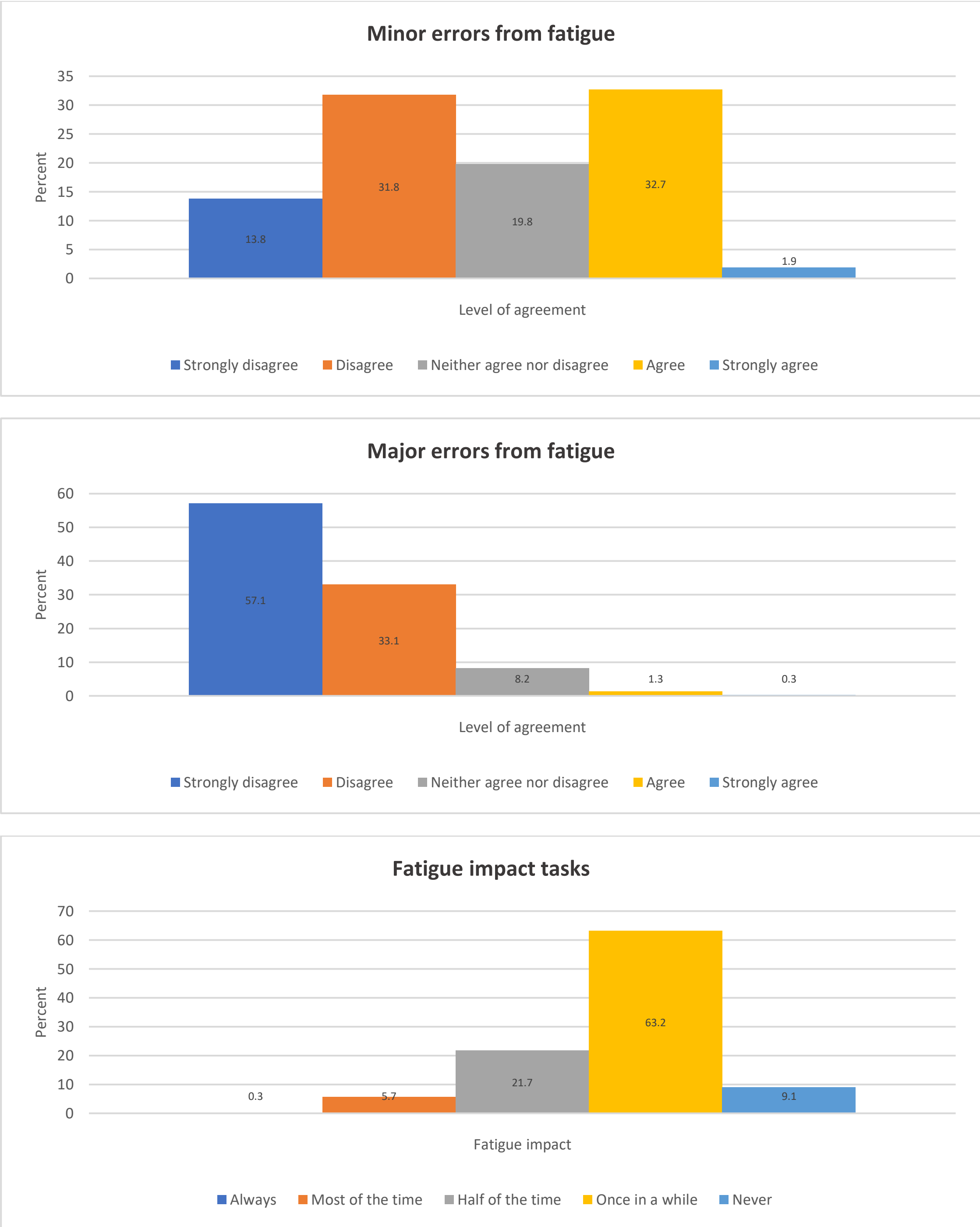


Figure 8.17. Fatigue-related performance outcomes in physiotherapy

8.3.4.8. Differences between primary cohort of surgeons and physiotherapists

8.3.4.8.1. Differences in health, wellbeing and lifestyle

There was statistically significant differences between the primary cohorts of surgeons and physiotherapists in health and wellbeing (*Figure 8.18*), and lifestyle factors (*Table 8.8*).

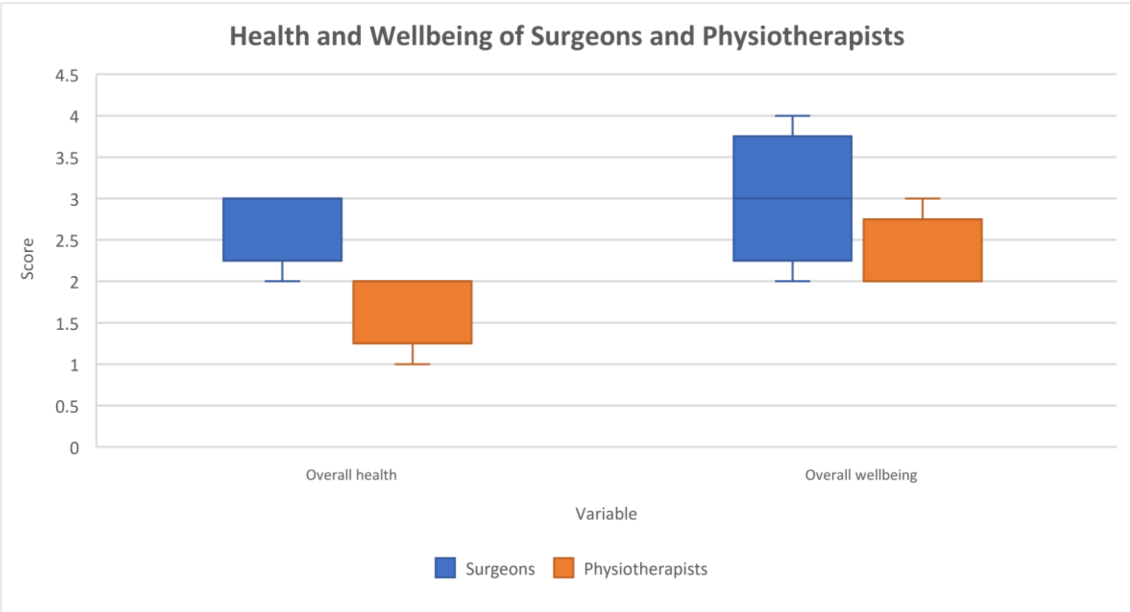


Figure 8.18. Physiotherapy reporting statistically significantly better overall health (p=.025) and overall wellbeing (p=.001) when compared to surgeons

Table 8.8. Differences in lifestyle factors primary cohort of surgeons and physiotherapists with median, interquartiles and interpretation

Variable	Surgeons	Physiotherapists	P value	Interpretation
Caffeine				
Caffeine intake	4(3-5)	2(2-3)	.021	Surgeons reporting greater caffeine intake
Sleep and Fatigue				
Consistent sleep pattern	2(1-2)	1(1-2)	.025	Physiotherapy reporting more consistent sleep pattern
Manage fatigue effectively	3(2.5-4)	4(3-4)	.025	Physiotherapy reporting managing fatigue more effectively
Stress				
Easy to switch off	3(2-4)	3.5(3-4)	.040	Physiotherapy reporting finding it easier to switch off
Physical Activity and Exercise				
Light activity	4(3-5)	5.5(4.25-6)	<.001	Physiotherapy reporting greater engagement in light activity
Moderate activity	3(2-4)	4(3.25-5)	.006	Physiotherapy reporting greater engagement in light activity
Strenuous activity	2(1-3.5)	4(2-4)	.011	Physiotherapy reporting greater engagement in light activity
Amount of exercise	6(5-6.5)	4(4-5)	.032	Physiotherapy reporting more appropriate amount of exercise
Health Check-ups				
Last doctors visit	2(1-5)	1.5(1-2)	.010	Physiotherapy reporting visiting doctor more recently

8.3.4.8.2. Differences in performance outcomes and work factors

There was significant differences between the primary cohorts of surgeons and physiotherapists in work factors (*Table 8.9*), and performance outcomes (*Figure 8.19*).

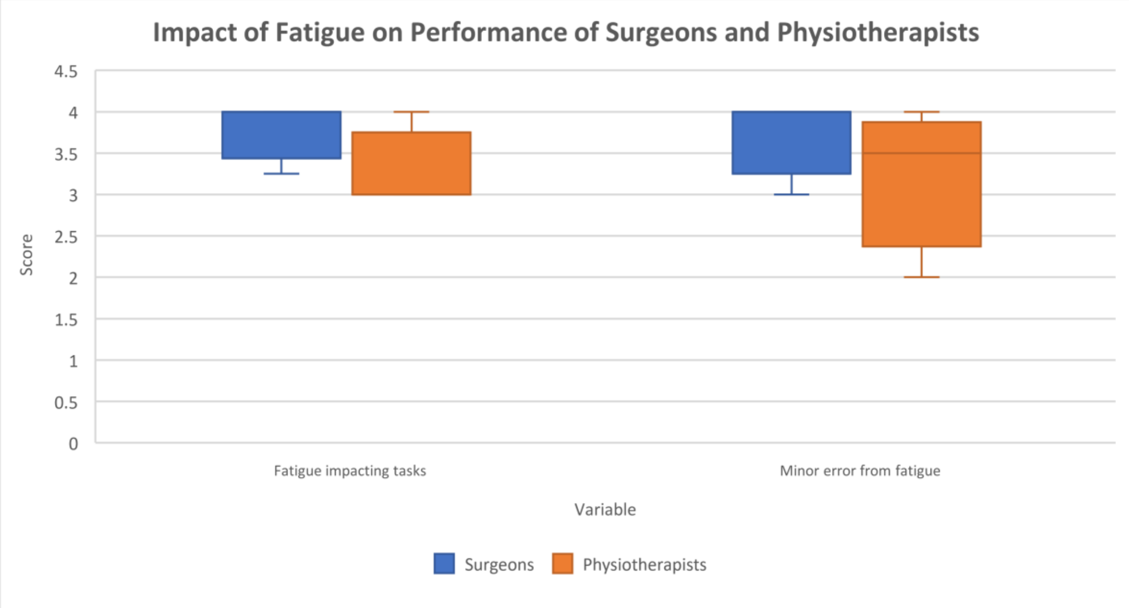


Figure 8.19. Physiotherapy reporting statistically significantly higher impact of fatigue on tasks (p=.042) but less minor errors from fatigue (p=.048) when compared to surgeons

Table 8.9. Differences in work factors primary cohort of surgeons and physiotherapists with median, interquartiles and interpretation

Variable	Surgeons	Physiotherapists	P value	Interpretation
Culture				
Honesty with patients	3(2-4)	4(4-4)	.032	Physiotherapy reporting greater honesty with patients
Error disclosure promoted	3(3-4)	4(3-4)	.040	Physiotherapy reporting greater promotion of error disclosure
Resources				
Enough staff	3(2-4)	4(4-4)	.032	Physiotherapy reporting greater staff to manage workload
On-call Work				
Often on-call	1(1-1)	3(2-3)	<.001	Physiotherapy on-call less often
On-call sleep hours	6(5.5-7)	7(6.5-8)	<.001	Physiotherapy sleeping more on-call
After-call sleep hours	4(3-5)	7(6-7)	.048	Physiotherapy sleeping more after-call

8.3.5. Discussion

While physiotherapy and surgery reported similar levels of fatigue, physiotherapists reported significantly higher levels of positive wellbeing and health. Physiotherapists reported a statistically significantly higher difference in reported ability to monitor fatigue effectively, alongside reporting overall higher levels of compliance with optimal lifestyle recommendations.

In addition, work factors such as better resourcing, less on-call work, and more open-disclosure cultures were reported in physiotherapy. The translation across to performance outcomes found that physiotherapists were more likely to report fatigue impacting performance, but surgeons reporting they have made an error due to fatigue.

There was statistically insignificant differences between fatigue levels, similarly to that reported in previously chapters, which suggests that fatigue is an issue within both professions. When looking at sleep specifically, nearly two thirds of surgeons were reaching recommended guidelines of 7-9 hours of sleep (Hirschkowitz et al., 2015), and while this is higher in physiotherapists (84.3%), what differentiates physiotherapists from surgeons in sleep habits is consistency. Over three-quarters of physiotherapists reported having a consistent sleep pattern, compared to less than half of surgeons. This is an interesting insight, and provides further insights from the findings of the first study in this chapter. This survey found high levels of compliance with indicators of both quantity and quality of sleep suggesting that other sleep factors could have determined the higher PSQI score above such as sleep latency, sleep efficiency, and sleep disturbances which were not formally captured. Higher levels of compliance with sleep indicators amongst physiotherapists, as well as stress management, may have contributed to the statistically significantly higher levels of reported self-management of fatigue. While similar reported levels of stress were found between both professions, physiotherapists were more likely to report being able to detach from work, thus promoting work-life boundaries. Similar to the findings in surgery, difficulty in switching off, and being bothered by feelings of anxiety and/or depression, were higher in female physiotherapists suggesting again the need to explore gender-specific issues within healthcare. This was similar in younger physiotherapists, with paralleled lower sleep, increased caffeine, greater fatigue, and ineffective coping mechanisms. This further verifies the need to explore self-management strategies in younger cohorts of healthcare.

There are several comparisons in lifestyles between both professions worth considering. Physiotherapists demonstrated higher levels of self-reported compliance with healthy behaviours in most domains, but there were some areas worth improvement. Similar to the surgical cohort, there was lower levels of hydration with only 11% of participants reaching the recommended guidelines. What is perhaps most surprising, given the emphasis the profession places on preventive healthcare, and particularly physical activity, is the low level of compliance with recommended guidelines. While higher than surgeons, only around one in three physiotherapists were engaging in health-enhancing exercise. This is despite nearly all participants reporting exercise as important to them. With a majority of both professions reporting that they likely aren't getting enough exercise, the question of why has to be asked. Similar research on Canadian physiotherapists found participants overwhelmingly reported reaching the guidelines, but on objective assessment just under three-fifths were actually compliant (Neil-Sztramko et al., 2017). This has larger implications for healthcare professionals as a whole. If the profession, which beacons positive health approaches at its philosophical core, is facing significant barriers in reaching high levels compliance with physical activity guidelines, then it is likely that parallel professions, with poorer awareness of the principles of preventive healthcare, may report even lower levels of compliance. Research exploring barriers to physical activity participation in healthcare workers found that weather (84.9%) and family responsibilities (84.4%) were significant barriers (Al-Mohannadi et al., 2020), the latter of which disproportionally affects females. This is supported by the findings of this study where females were less likely than their male counterparts to engage in moderate levels of physical activity.

While there was some differences between both professions regarding work factors, such as cultural norms, reported resourcing, and regularity of on-call work, there was also commonalities between them. This may indicate potential global work-related factors influencing performance outcomes in healthcare. Half of physiotherapists still reported that there have insufficient staff to handle current workloads. For those physiotherapists completing on-call work, they reported sleeping double the amount of hours to surgeons (6 hours as opposed 3 hours), but still had associated fatigue. This further vindicates the necessity to safeguard against fatigue in on-call associated work in the healthcare sector through a multi-faceted approach. Just under three-fifths of physiotherapists felt they were treated unfairly when making mistakes, which, while lower than surgery, reflects a broader negative culture towards error-making in healthcare industries. Less than two-fifths believed error-disclosure is effectively managed within the profession, suggesting it could also be a profession-based issue. This may have negative implications for disclosure of fatigue and establishing effective reporting of errors resulting from fatigued states. They also have particular relevance to job-related theories. A low level of perceived social support, due in part from a non-disclosure closure, is one of three components which contributes to 'job strain' in the DCS model (Karasek, 1979). This state is associated with lower physical and mental health which would support the findings of this study.

Translation to performance outcomes offers interesting insights. While physiotherapists were more likely to report fatigue impacting their non-professional performance, surgeons were more likely to report fatigue resulting in minor work-related error. This suggests that a potential cognitive dissonance exists, between perceived performance decrement and that of error-making in both professions, suggesting a gap in performance science knowledge. Performance outcomes strongly linked with positive overall health and wellbeing. Those with better overall health reported lower fatigue, a lower level of disruption in their social and professional activities, better performance both off-call, and lower levels of performance decrements resulting from fatigue. Better overall wellbeing showed, in addition, lower levels of major and minor fatigue-related errors. Such findings further validate the importance of mitigating fatigue as a potential determining factor to both health, wellbeing, and performance outcomes, irrespective of the profession.

8.3.6. Limitations

As this was an opt-in survey, there may be heterogeneity of the data. The sample size from the physiotherapy population was predominantly reporting from non-hospital based settings which makes it more difficult to make sweeping recommendations for hospital settings to implement organisational interventions. Instead, it argues for the need to view healthcare professions as fatigue-prone, and argues for the necessity to identify individual-based interventions to improve health factors; and to compliment such interventions with environmental supports. Larger sample sizes are desired for broader generalisations to the profession as a whole. Finally, like all self-reported study designs, there is the risk of bias in reporting, and thus findings reflect insights into self-awareness and self-efficacy of healthcare professions in the areas of fatigue, performance and lifestyle management, as opposed to objective truths about these studied factors.

8.3.7. Conclusion

This study demonstrated commonalities between two healthcare professions in variables which influence health, wellbeing, fatigue and performance. It showed that while physiotherapists reported higher levels of compliance with known lifestyle factors, that similarities in reported fatigue exist between professions. This study supports the hypothesis that fatigue is a subjective experience, with multiple causes. The areas of overlap between both professions in levels of reported fatigue also suggests the role of common structural and professional barriers, vindicating that healthcare may be a fatigue-prone sector. This supporting evidence suggests the need to look at the ‘surviving’ to ‘thriving’ paradigm shift, at a theoretical level, to establish commonalities for organisationally-led initiatives in healthcare.

8.4. EXPLORATORY FORMATION OF A THEORETICAL FRAMEWORK TO UNDERSTAND TRANSITION TO THRIVING IN HEALTHCARE

8.4.1. Research Question

What is the relationship between variables that impact on performance, and how do they influence individuals transition to a state of thriving?

8.4.2. Objectives

1. To explore relationship between previously identified variables which impact on performance from *Chapter 7* to form an exploratory theoretical framework

8.4.3. Methods

8.4.3.1. Study Design

The data collected from two healthcare professions, surgeons and physiotherapists, at baseline in *Chapter 7,* is used in this exploratory theoretical analysis. Their data forms a preliminary investigation into understanding influencers on performance variables in healthcare professions. Association between variables is a form of construct validity, and explores the degree to which performance behaves in association with a variety of other modifiable factors (Cronbach and Meehl, 1955). A hypothesised relationship which directed the analysis, informed by the literature, and the previous findings of this research, is seen in *Figure 8.20*. It explores the relationship between psychological and clinical performance constructs for theory development, and the influencing variables required to transition from a state of 'surviving' i.e. fatigue and non-thriving, to 'thriving'.

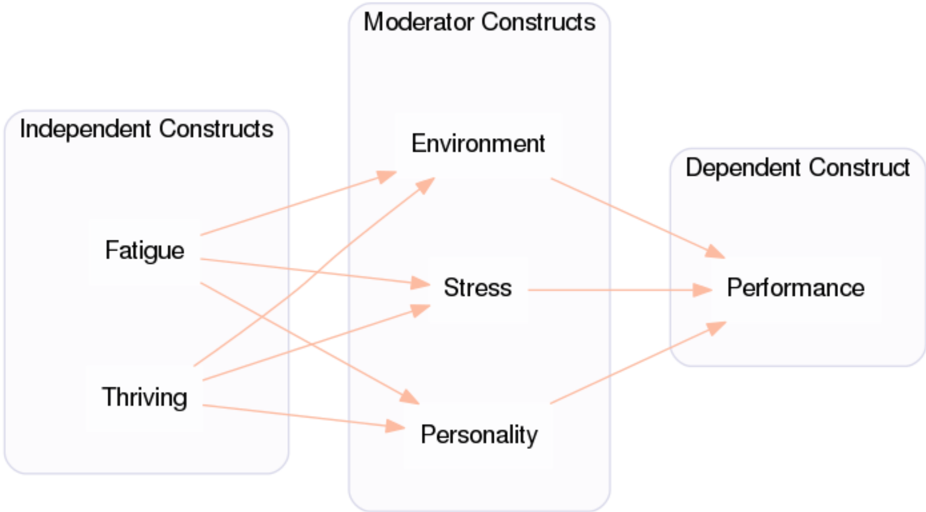


Figure 8.20. Hypothesised dependent relationship between performance with other constructs

8.4.3.2. Statistical Analysis

Spearman correlational analysis was used to explore relationships between variables. Relationship levels were categorised as seen in *Table 8.10*, differentiated in accordance with Hill's criteria of association on effect size (Hill, 1965). An additional research team member Prof. Andrew Baillie (Sydney, Australia), assisted in developing theoretical analytical capacity through methodology meetings. Smaller constructs were included if there was significant associations. For larger constructs, a minimum of three relationship associations was agreed as a baseline requirement between constructs relationships, for it to be deemed included in the final framework. Larger constructs were defined as assessments which contained greater than four components (i.e. 'fatigue', 'vitality', 'learning', 'positive affect', 'negative affect', 'self-efficacy', 'hope', 'optimism', and 'resilience').

Table 8.10. Strength of association between variables categorised and associated colour code

Relationship definition	Spearman correlation (r_s)
Low-moderate	0.5-.059
Moderate	0.6-0.69
High-moderate	0.7-0.79
Strong	0.8-0.89
Very strong	0.9-0.99

8.4.4. Results

A full theoretical framework is attached in *Appendix AR*. Followed hereafter are a list of the relationships and their associated effect size.

8.4.4.1. Fatigue and Recovery Relationship

Table 8.11. Relationship between 'fatigue' and 'exhaustion' with 'recovery' and 'BPN' states

Variable	Variable	Relationship	r_s
Fatigue	Recovery	High-moderate	-.729 (.007)
	BPN	Strong	-.833 (.001)
Exhaustion	Recovery	Low-moderate	-.599 (.040)
	BPN	High-moderate	-.724 (.008)
Recovery	BPN	High-moderate	.716 (.009)

8.4.4.2. Fatigue and Thriving Relationship

Table 8.12. Relationship between 'fatigue' and 'thriving'

Variable	Variable	Relationship	r_s
Vitality	Fatigue	High-moderate	-.731 (.007)
	Exhaustion	Moderate	-.657 (.020)
	Recovery	Strong	.807 (.002)
	BPN	High-moderate	.777 (.003)
	Sleep	High-moderate	.741 (.006)
Learning	Fatigue	Moderate	-.616 (.033)
	Recovery	Strong	.825 (.001)
	BPN	High-moderate	.766 (.004)
Positive affect	Fatigue	Low-moderate	-.590 (.044)
	Exhaustion	Moderate	-.660 (.020)
	Recovery	High-moderate	.777 (.003)
	Sleep	Moderate	.617 (.033)
Negative affect	Fatigue	High-moderate	.756 (.004)
	Exhaustion	Moderate	.603 (.038)
	Recovery	Low-moderate	-.590 (.044)
	BPN	High-moderate	-.778 (.003)

8.4.4.3. *Fatigue, Thriving, and Performance Relationship*

Table 8.13. Relationship between 'clinical performance' rating and 'psychological performance' rating

Variable	Variable	Relationship	r_s
Self-talk	Management	Moderate	.688 (.013)
Emotional control	Communication	Moderate	.616 (.033)
Goal setting	Communication	Moderate	.692 (.013)
	Management	High-moderate	.788 (.049)
	Professionalism	Moderate	.657 (.020)
Negative thinking	Communication	Moderate	-.680 (.015)
	Professionalism	Low-moderate	-.588 (.,044)
Imagery	Management	Moderate	.648 (.023)
	Clinical skill	Moderate	.633 (.027)
	Patient safety	High-moderate	.764 (.004)
Activation	Scholarship	Moderate	.625 (.030)

Table 8.14. Relationship between 'performance' and 'thriving'

Variable	Variable	Relationship	r_s
Vitality	Communication	Moderate	.671 (.017)
	Professionalism	High-moderate	.709 (.010)
	Management	High-moderate	.755 (.004)
	Self-talk	Strong	.830 (.001)
	Negative thinking	Strong	-.810 (.001)
	Automaticity	High-moderate	.778 (.003)
	Activation	Strong	.837 (.001)
Learning	Patient safety	Moderate	.651 (.022)
	Professionalism	Moderate	.635 (.027)
	Management	Moderate	.628 (.029)
	Scholarship	Low-moderate	.589 (.044)
	Self-talk	Very strong	.911 (<.001)
	Automaticity	High-moderate	.758 (.031)
	Negative thinking	High-moderate	-.783 (.003)
	Activation	Strong	.824 (.001)
Positive affect	Communication	Moderate	.649 (.023)
	Professionalism	Moderate	.653 (.021)
	Patient safety	Moderate	.681 (.015)
Negative affect	Communication	Moderate	-.657 (.020)
	Professionalism	Moderate	-.624 (.030)
	Relating to patient	Strong	-.845 (.001)
	Management	Strong	-.860 (<.001)
	Clinical skill	High-moderate	-.798 (.002)

Table 8.15. Relationship between 'performance' and 'fatigue'

Variable	Variable	Relationship	r_s
Fatigue	Communication	Moderate	-.671 (.017)
	Professionalism	Moderate	-.617 (.033)
	Relating to patients	High-moderate	-.742 (.,006)
	Self-talk	Low-moderate	-.597 (.041)
	Emotional control	Moderate	-.638 (,.026)
Recovery	Professionalism	Low-moderate	.577 (.050)
	Management	High-moderate	.703 (.011)
	Patient safety	Low-moderate	.588 (.045)
	Self-talk	Strong	.828 (.001)
	Imagery	Moderate	.649 (.022)
	Negative thinking	High-moderate	-.739 (.006)
	Automaticity	Moderate	.607 (.036)
	Activation	Strong	.822 (.001)
BPN	Patient safety	Moderate	.667 (.018)
	Self-talk	High-moderate	.716 (.009)
	Automaticity	Low-moderate	.592 (.042)
Exhaustion	Self-talk	Moderate	-.691 (.013)
	Negative thinking	Moderate	.667 (.018)
Sleep	Activation	Moderate	.687 (.014)
	Relaxation	Low-moderate	.594 (.042)
	Attentional control	Low-moderate	.593 (.042)

8.4.4.4. Fatigue, Thriving, Influencing Factors, and Performance Relationship

Table 8.16. Stress influencing the relationship between 'performance', 'fatigue' and 'thriving'

Variable	Variable	Relationship	r_s	Variable	Relationship	r_s
	Thriving and Fatigue			Performance		
Stress				Relating to patient	Moderate	-.611 (.035)
				Clinical skill	Strong	-.849 (<.001)
				Patient safety	Moderate	-.670 (.017)
Coping	Thriving Learning	Low-moderate	.586 (.035)	Relating to patient	High-moderate	.720 (.008)
				Clinical skill	High-moderate	.717 (.009)
				Professionalism	Moderate	.687 (.014)
				Management	Moderate	.637 (.026)
				Patient safety	Moderate	.647 (.023)

Positive appraisal	Thriving vitality	High-moderate	.757 (.004)	Relating to patient	Moderate	.620 (.031)
	Thriving learning	High-moderate	.760 (.017)	Professionalism	Moderate	.621 (.031)
				Communication	High-moderate	.788 (.002)
Negative appraisal	Thriving learning	Moderate	-.605 (.037)			
	Fatigue	Low-moderate	.587 (.045)			
	Recovery	High-moderate	-.750 (.005)			
Self-efficacy	Thriving vitality	Moderate	.692 (.013)	Communication	High-moderate	.768 (.004)
	Thriving learning	Moderate	.673 (.017)	Scholarship	High-moderate	.768 (.004)
	Exhaustion	Moderate	.664 (.019)			
	Recovery	Moderate	.605 (.037)			
Hope	Thriving vitality	Very strong	.920 (<.001)	Professionalism	High-moderate	.740 (.006)
	Thriving learning	Very strong	.910 (<.001)	Communication	Strong	.831 (.001)
	Fatigue	Low-moderate	-.583 (.047)	Management	Moderate	.667 (.018)
	Exhaustion	Moderate	-.600 (.039)	Scholarship	Moderate	.640 (.025)
	Recovery	Strong	.816 (.001)	Patient safety	Moderate	.693 (.012)
	BPN	Moderate	.648 (.023)			
Resilience	Thriving vitality	Strong	.891 (<.001)	Relating to patient	High-moderate	.710 (.010)
	Thriving learning	Strong	.818 (<.001)	Communication	Low-moderate	.579 (.049)
	Fatigue	Moderate	-.697 (.012)			
	Exhaustion	High-moderate	-.744 (.006)			
	Recovery	Moderate	.629 (.028)			
	BPN	Strong	.819 (.001)			
	Sleep	Low-moderate	.597 (.041)			
Optimism	Thriving vitality	Strong	.838 (<.001)	Relating to patient	Strong	.860 (<.001)
	Thriving learning	Very strong	.901 (<.001)	Clinical skill	Strong	.803 (.002)
	Fatigue	Strong	-.866 (<.001)	Professionalism	Moderate	.624 (.030)
	BPN	Strong	.802 (.002)	Communication	High-moderate	.709 (.010)
	Sleep	Moderate	.652 (.022)	Patient safety	Strong	.838 (.001)

Table 8.17. Personality influencing the relationship between 'performance', 'fatigue' and 'thriving'

Variable	Variable	Relationship	r_s	Variable	Relationship	r_s
	Thriving and Fatigue			Performance		
Extraversion	Thriving vitality	Strong	.840 (.001)	Clinical skill	Low-moderate	.583 (.047)
	Thriving learning	Strong	.856 (.001)	Negative thinking	Moderate	-.668 (.018)
	Recovery	Moderate	.698 (.012)	Self-talk	Low-moderate	.589 (.044)
	BPN	Low moderate	.591 (.043)			
Agreeableness	Thriving vitality	High-moderate	.746 (.005)			
	Thriving learning	Moderate	.684 (.014)			
Neuroticism				Relating to patient	Moderate	-.698 (.012)
				Emotional control	High-moderate	-.723 (.008)
Openness	Fatigue	High-moderate	-.794 (.002)	Relaxation	Low moderate	.576 (.050)
	Exhaustion	Low-moderate	-.585 (.046)			

Table 8.18. Environment influencing the relationship between 'performance', 'fatigue' and 'thriving'

Variable	Variable	Relationship	r_s	Variable	Relationship	r_s
	Thriving and Fatigue			Performance		
Autonomy	Thriving vitality	Moderate	.603 (.038)	Communication	High-moderate	.766 (.004)
	Thriving learning	Strong	.827 (<.001)	Professionalism	Moderate	.611 (.035)
	Positive affect	Strong	.855 (<.001)	Scholarship	High-moderate	.743 (.006)
	Negative affect	Moderate	-.653 (.021)			
	Fatigue	High-moderate	-.714 (.009)			
	Exhaustion	High-moderate	-.708 (.010)			
	Recovery	Moderate	.641 (.025)			
Supportive-receptive	Thriving vitality	Moderate	.615 (.033)	Scholarship	Moderate	.677 (.016)
	Negative affect	Moderate	-.644 (.024)	Patient safety	High-moderate	.703 (.011)
	BPN	Strong	.863 (<.001)	Emotional control	Low-moderate	.594 (.042)
				Imagery	Low-moderate	.594 (.042)
Workload	Thriving learning	High-moderate	.724 (.008)	Communication	Strong	.860 (.015)
	Negative affect	High-moderate	.749 (.005)	Scholarship	Moderate	.656 (.021)
	BPN	Moderate	-.656 (.020)	Emotional control	High-moderate	.790 (.002)

8.4.5. Discussion

The above findings indicate an intricate relationship between reported performance, the individual, and their environment. The largest associations will be discussed in the sections below as they provide the most interesting insights worthy of further investigation.

There was a visible relationship between fatigue and recovery, with higher opportunities for recovery reducing levels of fatigue and exhaustion. In particular, the fulfilment of the BPN (Deci and Ryan, 2004), appears to be particularly useful as a means to assist in recovering from fatigue. Feeling a sense of competency in non-work activities could be promoted by engaging in a hobby, while fulfilling feelings of relatedness can be fulfilled by doing such hobbies with others. Autonomy in non-work activities is more difficult, as it suggests the environmental constraints in which an individual finds themselves in. This could include parenthood, but further investigation into the perceived non-autonomous recovery opportunities in healthcare workers is warranted.

Inverse levels between fatigue and thriving states appear to simultaneously occur. A negative high-moderate relationship between fatigue and vitality scores suggests that one state may strongly influence the other. In the previous chapter, it was discovered that high levels of thriving and fatigue can co-exist, but may be mediated by additional variables such as opportunity for recovery. This is supported here with strong correlations in both thriving domains with recovery opportunities, fulfilment of BPN, and sleep quantity and quality scores.

A harmonious relationship between clinical and psychological performance markers exists. Goal setting and imagery could lead to increased motivations and appears to improve management and patient safety in the workplace. It also has relationships with communication, professionalism, and less so with more traditional skills, such as technical skill and scholarship.
There is a significant efficacious influence of both thriving and fatigue on performance outcomes. Higher levels of vitality may play a role in improving non-technical performance, while also increasing other psychological skills such as self-talk, activation, and reducing negative thinking. A very strong relationship between learning opportunities and performance skills, in particular activation, was found suggesting thriving states could play an influential role in accessing flow states of performance. Affect levels played a lesser role in influencing performance variables, with the exception of higher negative affect reducing empathy and management in the workplace. On the other hand, higher recovery opportunities predicted

better scoring in psychological performance markers, in particular self-talk and activation, suggesting the importance of recovery as part of the repertoire of actions to optimise performance.

There was an overall weaker relationship between fatigue states on performance when compared to thriving states, which further vindicates the necessity to explore performance-based interventions from a positive psychological intervention approach, as it may elicit greater benefit to performance markers.

Having identified the relationship between performance and psychological states of being, exploring the potential role of influential variables was warranted. Three variables were identified from the previous chapter; stress responses and psychological capital, personality, and environmental influencers.

Stress responses appear to play somewhat of an influential role in performance outcomes. A higher level of positive appraisal increased levels of reported vitality and learning, while also being associated more associated with better communication skills. In addition, lower levels of negative appraisal was associated with better recovery from work. The development of coping responses correlated higher with empathy for patients. This could reduce associated compassion fatigue and burnout. While stress levels weren't found to influence thriving or fatigue, they were negatively associated with clinical skill, suggesting the need to explore additional psychosocial variables which influence more traditional procedural skills in surgery. Positive coping responses improved perceptions of better clinical skill, at the level of high-moderate correlation, but additional variance between the scores suggest additional variables not controlled for in this study design are present.

The psychological capital of the individual appears to be a significant influencer. Higher levels of hope strongly associated with higher levels of vitality, and were closely linked with higher levels of recovery. Similar to hope, higher optimism was associated with higher thriving, while also appearing to play a more significant role in reducing levels of fatigue. Both hope and optimism were associated with better clinical performance markers from both traditional and non-traditional domains. While a swathe amount of literature has focused on resilience in surgery (e.g. Zwack and Schweitzer, 2013), the psychological resource played a lesser role in mediating performance outcomes. It did promote levels of thriving, while also playing a stronger role in reducing associated levels of fatigue, but predicted less performance outcomes. Both levels of optimism and resilience appear to be promoted more so by fulfilling of BPN. Finally, self-efficacy was the least influential, but did have moderate and high-moderate correlations, with both psychological states and performance outcomes, suggesting it may influence some of the variance in the relationship.

Previous findings suggested that the personality of a surgeon could play an influential role in performance outcomes, though this hypothesis could not be fully substantiated within this analysis. Strong relationships were found between greater levels of extraversion and thriving states, as well as recovery, but this didn't translate across to performance differences to any great extent. Similarly, a greater level of openness to experience may reduce associated fatigue, and promote relaxation skills, but further research is required. Most interestingly was the role of neuroticism. Higher scores didn't influence fatigue or thriving levels, but did influence performance outcomes, such as lower emotional control in the workplace. Further research into the potential identification of personality factors is warranted, as previous research has identified high levels of neuroticism to be associated with ineffective stress appraisal (Lahey, 2009).

A similar finding of this thesis was the confounding role of the institution and profession in influencing both fatigue and performance outcomes. The data analysis of this chapter would support those hypotheses to an extent. Greater levels of autonomy in the workplace were strongly associated with higher levels of learning opportunities, as well as positive affect. Autonomy-supportive reporting appeared to mitigate fatigue and exhaustion, while also influencing affective skills such as communication, and cognitive skills such as scholarship.

Having a supportive network was also strongly associated with fulfilment of the BPN of an individual, likely being closely related to 'relatedness' as a psychological need (Deci and Ryan, 2004). While support was less predictive of thriving or fatigue, higher levels did improve reported perceptions of providing optimal patient safety, suggesting that practitioners see the importance of teamwork to promote patients best interests. These findings support previous research on surgeons, which found the positive effect of supportive working environments on surgeons work abilities and patient satisfaction (Mache et al., 2014).

Finally, and most interestingly, was the finding that higher workloads were actually associated with higher levels of learning opportunities, as associated with the construct of thriving. This was also associated with practitioners reporting better communication skills and scholarship in their work. Higher workload also positively correlated with better emotional control, even though it increased negative affect, and reduced BPN fulfilment. This would suggest that perceived optimum workload can be a strong influencer of optimal performance, but may be prone to after-effects, such as having negative impact on affect and psychological needs, which need to be addressed, in order to sustain that performance. It is hypothesised that the incongruence between addressing these after affects and expecting sustained performance could lead to more chronic states such as burnout in a profession like surgery. This is supported by organisational psychology theories, such as the DCS model (Karasek, 1979), which suggests that excessive workload leads to negative physical and mental health outcomes.

8.4.6. Limitations

This was a preliminary exploration to develop a hypothesised theory between fatigue and thriving in healthcare. The small sample size does limit the generalisability of the findings, but the development of a network between the relevant psychological and performance constructs allows a greater understanding of how best to optimise performance, and establish foundation for exploration of these constructs further in rigorous larger scale studies. Similarly, recruitment of a broader range of healthcare professions will allow exploration of whether this exploratory theoretical framework has generalisability to a larger cohort of healthcare professions.

Given the non-parametric nature of the data as well as the small sample size the correlational values were based off Hills criteria of association (Hill, 1965) to show the relationships between variables, and to establish if a reasonable theory exists between variables of interest. It could not establish the direction of the influence in relationship between variables of interest e.g. if higher psychological skill could predict higher vitality or vice versa. In larger-scale and repeated studies, regression would allow for percentage claims about the amount of variance explained by one variable on another, and the strength of influence. Similarly, multilevel modelling could be utilised if the model was generalised linear, thus allowing inferences to be drawn on the role of hierarchical structures and their influence on different levels of organisational behaviour. This would be useful when considering the effectiveness of interventions at the individual or professional level, allowing quantification of implicit group behaviours (e.g. culture) which may be promoting or impeding a particular intervention.

Finally, one of the limitations of using a control group of physiotherapists as opposed to a control group of surgeons is the potential role of item bias, or differential item functioning. In this instance, the clinical performance markers may be particularly vulnerable to different interpretations between disciplines. In larger parametrically distributed studies, differential functioning of items statistical testing could be used to control for item bias (Raju and Ellis, 2002).

8.4.7. Conclusion

It has been established, within this sample of surgeons and physiotherapists, that thriving and fatigue states could coexist. The transition towards states of thriving may be influenced by recovery states, higher levels of psychological capital, use of psychological skills, and environmental support. Focus on improving thriving states could predict performance optimisation to a greater extent than reducing fatigue levels. This finding has larger implications for design of work-place interventions, necessitating the need for focus on promoting 'thriving' opportunities in work, in conjunction with efforts to mitigate 'fatigue' levels, as a means to optimise performance in healthcare.

The studies in this chapter established a comparative understanding between surgery and physiotherapy. Using both professions as a sample for exploring theoretical assumptions underlying fatigue and associated factors on performance is novel. There are parallels to be drawn between both professions, including sleep-related issues, as well as unique differences, such as lifestyle, psychosocial, and work factors, which allowed further exploration of how to optimise performance within individuals at the personal, professional, and system level of intervention.

9. Chapter 9 – Discussion

Surgery is a high-performance industry, utilising maladaptive strategies to optimise performance. The initial exploration of this thesis identified fatigue as a significant influencer of performance decrement, but as the research journey progressed, the relationship between fatigue and thriving in performance became more nuanced. The discussion summarises that journey by discussing findings of the research, and by highlighting the new understandings, as well as areas for future improvement. It highlights the contributions though the six main areas seen in *Figure 9.1.*

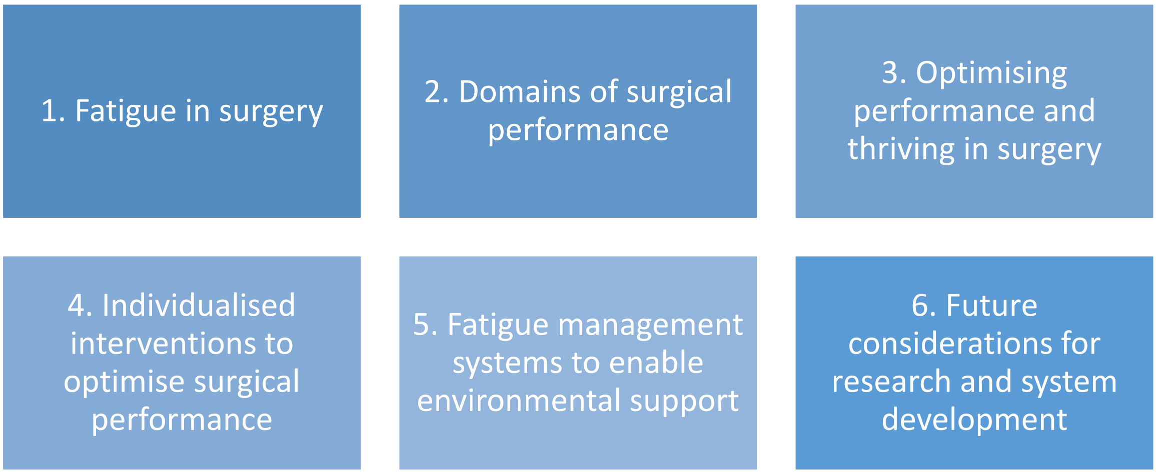


Figure 9.1. Six components of discussion

9.1. FATIGUE IN SURGERY

A new understanding

This body of work provides a significant reconstruction of understanding the phenomena of fatigue in surgery. While previous research on fatigue in surgery has focused on sleep deprivation, this overemphasis has deprived opportunities to view the state through a psychological approach. It was identified, in the qualitative studies in *Chapter 5,* that a multitude of factors influence perceived fatigue levels in surgeons, supporting the idea that causes of fatigue are heterogenous. Fatigue can be now redefined in surgery, to additionally consider the interplay between an individual's motivations and their environment. The revised theory of the role of fatigue within surgery is that it serves as an adaptive function to assist in the management of individuals motivations. In doing so, it is an emotional signal, prompting surgeons to conduct a cost-benefit analysis of changing current tasks and goals, to balance an increasingly taxed effort-regulation system. This reframing of the purpose of fatigue thus encourages the development of increased self-awareness in individuals to better regulate their performance.

Sleep deprivation was one area of overlap identified consistently throughout the chapters as a problem within surgery. This is primarily caused from on-call work, as identified from *Chapter 3,* but also from cultural milieu within the profession, resulting in internalised behaviours of normalising sleep restriction. There were significant areas of overlap between sleep deprivation and fatigue identified by participants in *Chapter 5,* suggesting the complexity of differentiating both states in the profession. This is due to the historical blurring of both constructs (Lavidor et al., 2003). This poor differentiation could be contributing to the inertia towards impactful interventions to optimise performance through fatigue mitigation.

Does fatigue impact on performance?

It was established throughout this research that fatigue can lead to decrements in the three domains of surgical performance - technical, cognitive, and affective skill - adding to the dearth of higher-quality research which has previously explored this topic (Sturm et al., 2011).

From a technical perspective, performance decrements in simulated tasks from sleep-associated fatigue have been identified (*Chapter 2* and *Chapter 3*). Systematic findings of the literature suggest decrements in performance could be up to 32%. This decrement was more prevalent in technical tasks which incorporated cognitive components, and supported subsequent findings of impacts on vigilance attention and clinical decision-making (*Chapter 3* and *Chapter 4*) . This body of work provided a novel way of assessing a clinically meaningful cognitive performance marker through validating and assessing clinical decision-making in a simulated manner. This is particularly important as attempts are made to explore applicability of laboratory performance markers to real-life clinical practice. Preliminary insights of this research suggested higher cognitive loads were associated with greater risk-taking in a surgical procedure, due in part to an over-reliance on biased cues informing the clinical decision-making process. The overreliance on intuitive processes in these circumstances, and the default activation of the executive override function associated with the dual process theory (Croskerry, 2009), suggests that fatigue could lead to poor decision-making. Larger scale efforts should further explore these findings in higher-fidelity and fatigue-induced settings. From an affective perspective, initial insights into the perceived impact of fatigue on emotional regulation were identified by participants in *Chapter 5,* and trends between higher fatigue and lower wellbeing were identified in *Chapter 6* and *Chapter 8.*

Perceptions varied between participants subjective reporting in *Chapter 5,* but it was largely agreed that fatigue affected cognitive and affective domains more than technical performance. When exploring this incongruence, in the context of theoretical assumptions, it provides some interesting insights. Fatigue results from increased sustained effort responses, often when competing motivational interests are at play, while performance decrement only occurs in absence of sustained-effort responses (Hockey, 2013, p.76). Fatigue and performance decrement only occur in tandem when in situations where subjective effort cannot meet the tasks requirements (Hockey, 2013, p.108). Unfortunately in the context of surgery, regular exposure to high work demands, low resources, and sleep deprived associated states leaves the profession prone to chronic fatigue states. This may lower the margins and lead to early onset performance decrement. Persistent levels of fatigue reduce the tolerance for effort (Chaudhuri and Behan, 2004), which leads to gradual levels of decline in capacity to deal with complex and increasing demands in the profession. Some tasks are more likely to be impacted than others, and largely support the findings of this research. Technical performance may be protected for two reasons. In experienced surgeons, tasks perceived to be familiar and automated will utilise embedded learned skills, thereby not impacting upper executive functioning. Second, technical skill is the aspect of work which surgeons find most engaging, and thus demands for motivational control are less likely. On the other hand, cognitive and affective performance may be more impacted, given the non-standardised fashion in which they are learned, and the lesser priority placed on their importance as part of the repertoire of surgical performance skills in the profession. The presence of environmental stressors at this point will no longer be able to be regulated by lower executive control mechanisms, thus causing impairment of upper executive functioning and performance decrement. An example of particular tasks which may be prone to decrement in this regard could include clinics and ward rounds. For the reasons above, as well as the rapid succession of several task demands with similar overlapping mental executive function requirements, these tasks may be more prone to latent degradation of the safe working margins of an individual's performance, which could have wider ramifications for patient safety.

Longer-term fatigue

This research shows an understanding of the longer-term manifestation of fatigue in the profession. Regular levels of fatigue were identified by participants (*Chapter 6*). The ramifications of sustained effort in situations of competing interests, which is often common in surgery, leads to the increased risk of experiencing fatigue after-effects. While this fatigue might not be felt in the current task, it can begin to gradually increase upon task cessation, and can spill over into the management of other tasks in the workplace, such as administrative duties or patient management, as well as personal life management skills. Poor regulation of fatigue responses, such as managing fatigue after-effects, places surgeons at an increased risk of developing more chronic states, such as burnout. Burnout, for the purposes of this research, is understood as a form of emotional fatigue or a dysfunction of affective performance. It is thought to represent the transition from the 'resistance strain state' to the 'disengagement state' (Hockey, 2013, p.129), implicating fatigue responses and management in the process of its development. It is caused by an overload of the stress system from work-related issues (Shirom et al., 2006), and characterised by emotional exhaustion, depersonalisation, and reduced professional efficacy (Maslach and Jackson, 1981). Burnout may also have stronger elements of negative emotion, such as depression, though the debate on this is ongoing (Maslach and Leiter, 2016). The current conceptual understanding of causes and effects of chronic work-related fatigue, and the state of burnout remain poorly understood (Hockey, 2013, p. 214), and are beyond the scope of this research. Both states, however, represents personal indicators in understanding individual's interaction with work environments, and for this purpose are discussed in tandem with regards to performance outcomes and management.

The median of participants identified experiencing burnout (*Chapter 7*). These findings are similar to other burnout research conducted on surgeons, with evidence suggesting that the prevalence of the condition is on the rise. In 2009, 40% of American surgeons met the criteria for burnout (Shanafelt et al., 2009), but this has steadily increased to 53% (Shanafelt et al., 2015), and 69% (Lebares et al., 2018) respectively. In the context of this research, which examined surgeons from who were members of a surgical professional society, primarily from Ireland and the United Kingdom, there was less of a consensus. Findings from survey exploration in *Chapter 6* identified regular fatigue in 62% of participants, high levels of regular anxiety and/or depression (64.2%), but a much smaller levels of poorer wellbeing (26%) relative to what was expected, suggesting the necessity to explore these phenomena further.

Not engaging in effective rest when experiencing fatigue, and a myriad of work variables, leads to a state of prolonged stress and the development of burnout. In the intervention study, those reporting burnout engaged in significantly lower recovery opportunities (*Chapter 7*). A greater number of nights on call and hours worked per week have previously predicted burnout

(Shanafelt et al., 2009), and were discussed by participants in *Chapter 5* as causes of fatigue. Common stressors include inefficient work processes and lack of autonomy, as well as not engaging in desired tasks, and experiencing higher emotional burdens (Shanafelt et al., 2009). The largest predictor of burnout in surgeons, as determined by a systematic review of the research, is difficulty with work-life balance (Dimou et al., 2016), which closely relates to detachment from work and reduced rest opportunities. Previous research has determined that only 36% of surgeons reported feeling that they have an appropriate work-life balance (Shanafelt et al., 2009). The findings of this research would suggest that there is a combination of personal and environmental causes which are contributing to the fatigue-to-burnout transition in the profession. Higher levels of physical and psychological demands could lead to greater exhaustion, while lack of resources could be more associated with depersonalisation and cynicism from work. In this instance, it is possible that surgeons may experience high levels of burnout indictors in one domain, but not in others, and thus different individualised interventions may be warranted for different aspects of burnout management (van Dierendonck et al., 1998).

An incidental finding of this body of work was that particular cohorts within the profession may be more prone to developing burnout. Female surgeons and younger surgeons perceived additional stress loads in their work, which places them at a disproportionate risk of fatigue. Similarly, it was identified how physiotherapy, as a female-dominated profession, experienced high levels of reported burnout (*Chapter 8*). Another variable, identified as being a potential confounder, was that particular specialisations are more prone to developing burnout. In *Chapter 5*, participants identified how general surgeons, in particular, are more fatigued because of the significant amount of on-call work and associated demands. Similar research on surgeons identified that trauma, urologic, otolaryngology, vascular, and general surgeons are all predisposed to higher levels of fatigue and burnout (Shanafelt et al., 2009).

Prolonged fatigued states have been previously mentioned as lowering the safe working parameter within performance, and this may be through reduced cognitive functioning (Oosterholt et al., 2012). Translation of the phenomena to performance outcomes include the provision of suboptimal patient care practices (Williams et al., 2007), increased medical error risks (Shanafelt et al., 2010), and lower teamwork cohesion (Welp et al., 2016). At a personal level, increased substance abuse has been identified (Oreskovich et al., 2012), and more than a doubled risk of suicide ideation amongst personnel who are reporting burnout (van der Heijden et al., 2008).

Recognising the above, this research provides insight into the required interventions to prevent or mitigate its manifestation. Recovery from more chronic fatigued states requires a slow recovery process, and if participants perceive there to be an emotional element to the fatigue, distinct emotional-based interventions may be more impactful. The development of these skills can reduce levels of perceived effort and increase motivation within tasks (Hockey, 2013). These were identified by participants in *Chapter 7* as aspects of the individualised behaviour change intervention completed, which will be discussed later in this chapter. Participants also identified the influential role of work factors in influencing personal outcomes (*Chapter 5* and *Chapter 6*). This supports findings on gold-standard interventions in the field of burnout prevention (Maslach, 2001). Bridging the gap between the organisation and the individual in the areas of their work-life, which they define as six areas (workload, control, reward, community, fairness and values), is the starting point in exploring burnout prevention on a larger scale (Leiter and Maslach, 1999).

Strategies to improve fatigue management

Regular tracking of fatigue levels and associated easing and aggravating factors may elicit improved self-regulation. This was trialled in *Chapter 7,* and generating reports on the serviceability of these findings, for individual surgeons, warrants further investigation. The first recommendation is therefore to increase introspection and self-awareness of performance both individually, and within the profession. Systematically collecting this data can also serve the purpose of identifying environmental changes that organisations can implement. Similarly, creating a culture where fatigue is used as a feedback marker may elicit desired behaviour changes to mitigate fatigue before performance and wellbeing is impacted. This is not without its challenges. While surgeons reported moderate levels of reflective practice, they were less reflective on non-cognitive domains (*Chapter 4*). Prior research has shown that surgeons have poor self-awareness in assessing their level of wellbeing relative to colleagues and national norms (Shanafelt et al., 2014). In particular, establishing levels of the fatigue after-effect may be the first index marker for surgeons (Broadbent, 1979) to identify what aspects of their work may be inducing fatigue states, even if those fatigue states don't arise immediately. Once they become cognisant of these stressors, they can increase self-awareness of fatigue levels within those contexts and mitigate it before it develops into more chronic states.

The second recommendation is a focus on developing motivational capacity for surgeons to engage in tasks they typically find fatiguing. The findings of *Chapter 3* versus *Chapter 4* supports this hypothesis, as participants were less susceptible to the effects of fatigue due to their interests in learning the surgical skills in *Chapter 3*, while being less engaged in the complex decision-making performance in *Chapter 4*. The self-reporting by surgeons, in *Chapter 5,* even suggests that surgeons experience an *"adrenaline rush"* when experiencing tasks they enjoy, irrespective of the sleep-deprived state they may be in. Increasing intrinsic motivation to pursue completion of task goals may assist in alleviating motivationally-driven levels of fatigue (Hockey, 2013). This involves development of attentional-selectivity capacity (Kahneman, 1970), by shifting the perspective towards tasks which may be typically less interesting for surgeons e.g. non-theatre based tasks.

The third recommendation is an allocation of resources to alleviate the environmental constraints faced by surgeons. Surgery is particularly unique within the context of healthcare as it requires the high performance skills, which parallels other high-stake industries, but is frequently constrained by the limitations of insufficient resources. In other industries, performance regulation is supported by increased deployment of physical and financial resources to ensure optimal workload. This is not the case in surgery, and results in systemic sub-optimal performance level in all domains of practice. This was most evident through the incidental finding of baseline levels of early onset sleepiness in surgeons before going on-call (*Chapter 3*). This level of sleepiness was further perpetuated by on-call work, with regularity of the model of work likely contributing to ongoing issues of sleep quantity and quality in the profession. As previously mentioned, fatigue and performance decrement only occur in tandem when in situations where task requirements exceed subjective capacity (Hockey, 2013, p.108). Efforts to mitigate fatigue within individuals therefore are futile if task requirements are beyond physiologically possible subjective efforts of the surgeon. Increasing autonomous practice may be one such area for intervention, as lower autonomy was associated with higher fatigue levels (*Chapter 8*). Closely associated with resources is the necessity for rest opportunities after task completion to mitigate after-effects. There was a fundamental relationship between fatigue and recovery identified in *Chapter 8.* In particular, the fulfilment of the BPN (Deci and Ryan, 2004), appears to be a particularly useful framework to model recovery opportunities, and activities to promote these psychological needs in non-work activities have been previously discussed.

One of the most significant challenges to healthcare systems and surgical practice arose during this research. The unprecedented COVID-19 pandemic placed significant demands on surgeons, and the World Health Organisation (WHO) has previously identified healthcare workers as a cohort who are particularly vulnerable and susceptible to the effects of pandemics (Koh et al., 2003). Preliminary research suggests that surgeons, alongside other healthcare workers, were exposed to higher levels of stress, disturbed sleep and emotional demands leading to increasing rates of clinical depression and anxiety during the peaks of the pandemic (Teng et al., 2020). Alongside this, surgeons were at a higher risk of contracting COVID-19 (Nguyen et al., 2020) and living with the longer term consequences, also known as 'Long-COVID'. Chronic levels of fatigue are associated with this condition (Halpin et al., 2020; Townsend et al., 2020). Given the poor recovery opportunities typically in surgery, this is an area of concern. Knowing the perceived lack of awareness of their own limitations (Woodrow et al., 2008), it is recommended that the risks associated with developing Long-COVID are reverberated to surgeons, as well as the necessity for intervention to reduce 'Long-COVID' development in surgeons as research emerges.

9.2. DOMAINS OF SURGICAL PERFORMANCE

There are three areas of performance which were discussed throughout this body of work. This research identified a disparity between technical and non-technical skill engagement, which became most evident in the first wave of the COVID-19 pandemic. The implications of fatigue and associated factors on surgical performance, as well as opportunities for improving performance is next discussed.

Technical performance

The procedural skill involved in surgery is unique and differentiates the profession from other aspects of medicine. Surgeons described being energised when completing surgery, which speaks to a self-perception of optimal performance. Positively, these perceptions may protects surgeons from experiencing the negative consequences associated with fatigue. This suggests the necessity to reconsider workload packages of surgeons, to increase access to theatre exposure, so as to enable greater access to optimal performance states. However, the disproportionate weighting against the importance of non-technical performance cannot be ignored, and has been previously described as impeding modern approaches to delivering patient-centred care (Orri et al., 2014). Enabling greater access to technical training opportunities was identified by participants as important. Given the multiple demands of surgical training, the most profound way to improve technical performance may be through applying deliberate pedagogical approaches which assist in achieving performance expertise in time-constraint environments. Deliberate practice (Ericsson and Pool, 2016) is necessitated in surgical settings for developing competency in complex tasks. This should be facilitated through structured learning opportunities in real-life and simulated settings.

Cognitive performance

The relationship between cognitive performance with fatigue and associated factors is better understood in light of the findings of this research. The findings of *Chapter 3* identified decrements in aspects of performance with increased fatigue states. This decrement was more evident in tasks which demands cognitive input, as evidently seen by the maintenance of performance in technical tasks, but the decrement in tasks which involves additional cognitive components such as vigilance and decision-making. Part of this variability may be explained by the participants interests in the tasks, indicating individual factors such as motivations, could be influencing performance outcomes. Fatigued surgeons are particularly vulnerable to cognitive decline in sleep deprived states. Irrespective of personal cognitive safeguards, studies have suggested that sleep deprivation negatively impacts even planned activities (Harrison and Horne, 2000).

Clinical decision-making performance (*Chapter 4*) was likely influenced by individual factors, such as preconceptions, knowledge, experience and training, as well as task and environmental factors, such as clinical case complexity and time pressure as stressors. The intrinsic relationship between self-reported performance decrement due to personal, task and environmental factors was identified throughout (*Chapter 5, Chapter 6, and Chapter 7*). All of these variables can be described as their 'situational awareness'. Defined as an individual's accurate perception of their environment (Endsley, 1995), situational awareness has large implications for surgical performance. Situational awareness reduces in stressful and fatiguing situations, resulting in tunnel-visioning. This has potential implications for clinical decision-making processes, and could result in surgeons utilising heuristic approaches in decision-making when they should be considering use of analytical thinking.

While related to cognitive load, situational awareness also provides insight into the motivational theories of fatigue (Hockey, 2013), with both theories believing that goals play a pivotal role in directing attention, and thus performance success. The formation of these goals-orientated attentions is significantly influenced by the environment in which the surgeon practices. Motivations play an important role in shaping an individual's decision-making, and in particular defensive motivations (Chaiken et al., 1996). Working in this mode of thinking activates 'threat' responses associated with negative stress appraisal which can be impacting surgeons fatigue levels, as well as leading to non-patient centred care. In considering the variables which influenced decision-making behaviours, patient factors played a lesser role than practitioner or disease factors in forming planned clinical management (*Chapter 4*). An initial exploration into how inappropriate use of particular intuitive mechanisms may lead to incorrect judgement and error concluded the chapter. The mechanisms influencing this direction of decision-making include several variables, one of which, explored in this research, was cognitive load. Biased decision-making was executed at a greater level in instances where perceived higher cognitive load exists. This would support previous social psychological research on greater stereotyping amongst situations of higher load (Wigboldus et al., 2004).

Traditional models of decision-making have focused on the use of intuitive and explicit learning to inform decision-making. Given this research identified a disparity between weighting of variables which influence decision-making processes, further research is warranted to explore the potential implicit psychosocial learnings, which inform professional behaviours of surgeons, lead to stereotype formation, and which can be harmful for patient care (Woo et al., 2004). Consideration of unconscious bias from an emotional, cognitive and sociocultural perspective should be incorporated into future surgical training. This is best facilitated by exploring how to place greater parity of patient factors and disease factors in decision-making processes.

Another meaningful way to optimise clinical decision-making, alongside other domains of cognitive performance, is through successful management of stress responses to reduce the likelihood of misguided intuition. Developing higher-order thinking skills, also referred to as metacognition, could contribute to expertise by reducing associated cognitive load from tasks. It was identified, using the RPQ, that surgeons already score higher in some domains of this field of practice, relative to the general public (*Chapter 4*). Emerging research has supported this finding. One randomised controlled trial found clinical decision-making efficiency improved by 21% in a cohort of surgeons who received training in stress management and coping, resulting in lower cognitive loads when compared to a control group (Goldberg et al., 2018).

In addition to stress management, the development of accurate mental models can enable successful situational awareness, irrespective of personal or environmental confounders (Mogford, 1997). This could mean greater automation of decision-making processes through protocol or technology. It could also mean systematic planning of workload to reduce distracting aspects of work. Fatigue from regular decision-making has been established (Persson et al., 2019), and thus efforts to automate decision-making processes will likely elicit improvements in performance.

Affective Performance

This research provides novel insight into the importance of considering the affective, or emotional aspects of non-technical skill in surgery. There exists an interweaving relationship between technical and cognitive tasks with affective performance, as individuals behaviours are driven by responses to emotional signals. Motivation has been defined as the prerequisite requirement for sustained engagement in deliberate practice (Ericsson and Pool, 2016), as well as previously mentioned roles in employing additional resources to tasks, and reducing risks of performance decrement from fatigue. In this instance, a high level of intrinsic motivation may be the primary marker determining expertise in surgery. In addition, the regulation of emotional states during interpersonal tasks in the workplace is also facilitated by having optimal performance in this domain, thus supporting many of the domains of good professional practice (Medical Act, 2007).

High levels of stress were identified in surgeons (*Chapter 5 and Chapter 6*). This is associated with impacts on performance and fatigue measurements, as evidently seen in the theoretical understanding of the phenomena in *Chapter 8.* A balanced amount of stress is required to achieve optimal performance, in what is described as the Yerkes-Dodson law (Yerkes and Dodson, 1908). On the other hand, excessive stress could negatively impacting working memory capacity (Arnsten, 2009), with one systematic review finding that both non-technical and technical performance are negatively impacted by higher stress states (Arora et al., 2010). A follow up study by the same authors measured stress, using salivary cortisol and heart rate monitoring in simulated technical performance settings, and found moderate correlations between stress markers and decremented simulated performance (Arora et al., 2010). It is the ability to identify when stress responses are negatively impacting performance that is poorly understood in surgery. This research provides an answer to that, by recommending that the emotional signal of subjective fatigue is the primary marker which should be taken as a performance decrement indicator for surgeons.

As a parallel impact, prolonged stress responses have personal consequences, and *Chapter 6* identified a negative relationship between stress on health and wellbeing. Prolonged stress responses can manifest physical disease, with established links to health conditions such as cardiovascular disease (Dimsdale, 2008).

Surgeons are primarily using non-sustainable methods of coping, as evidenced by the self-management strategies identified in *Chapter 5*. The ability to handle stress is divided into active and avoidance coping strategies. It can also be viewed through the lens of reaction, such as having a problem-focused or emotional-focused coping reaction. It aims to reduce the cumulative effect of work-stress (McEwen, 1998). The coping strategies utilised by surgeons could be as a result of internalised cognitions from professional norms, but also could be influenced by significant environmental constraints. For example, the considerable expectations of workload placed on surgeons could result in greater utilisation of avoidance strategies in situations of lower control. A series of common trends emerged in relationships between reported stress, health, wellbeing, and performance (*Chapter 6*). These variables were associated with changes primarily in lifestyle factors such as sleep, exercise and stress, and work factors such as resourcing and cultural norms. While this body of work didn't substantiate a relationship between personality and wellbeing markers, as it was largely out of scope of the research, character dispositions may also play a confounding role, with higher scores in neuroticism having greater associations with poorer wellbeing (Lahey, 2009).

This research provides an alternative view of the required interventions to influence stress responses. First, in regulating levels of stress, a primary marker of optimal affective performance is through positive stress appraisal. The transactional model of coping is the process used to reappraise stress within situations and adjust coping strategies appropriately (Lazarus and Folkman, 1984). Individuals engage in a process of stress appraisal whereby they initially evaluate their level of threat associated with the task, followed by the demands of a situations on an individual's resources (Lazarus and Folkman, 1984). The second aspect of this appraisal process involves the development of coping strategies.

Based on the holistic understanding of the surgical profession, the incorporation of emotional intelligence as part of surgical training may be an important curricular development. Lower levels of burnout have been reported in surgeons with higher emotional intelligence, emotional control, and emotional expression (Gleason et al., 2020; Benson et al., 2007). Higher levels of emotional intelligence have also been found to be strong predictors of wellbeing reporting in surgical residents (Lin et al., 2016), as well as better performance on the United States Medical Licencing Examination (USMLE) (Hollis et al., 2017). One study did report an improvement of emotional intelligence in a residency programme after the introduction of a wellbeing and resilience programme (Riall et al., 2018). Consideration of individuals environmental conditions should also be factored into interventions. Emotionally intelligent competencies enables an individual to perceive, understand, and control emotional reactions (Salovey and Mayer, 1990). Developing traits in self-awareness, self-management, self-motivation, empathy, and managing relationships are important for this process. These are facilitated through introspection, which allows conscious awareness of emotional experiences, and appropriate identification of the associated causes and effects of emotions. It may assist in reducing fatigue levels in the profession also, through improving an individual's conscious awareness of motivational drives, and thus appropriate reallocation of motivational resources to a task that is of less interest, or cessation of the task completely before fatigue after-effects occur.

A focus on work factors is important as interplay between the three performance domains (i.e. technical, cognitive and affective) occurs at this level. The cultural norms of the profession are important to consider, given the burdensome emotional experiences in surgery. In instances where error or complications arise, surgeons may face emotional impacts of anxiety and guilt in what is called 'second victim syndrome' (Ozeke et al., 2019). In two studies, involving 27 surgeons each, a majority reported being personally impacted by surgical complications, and the emotional impact of their work on patients and families (Pinto et al., 2013; Orri et al., 2015). Such complications often impacted subsequent perceived practice, and was influenced by procedural variables, such as preventability of the error, personal variables such as personality, patient variables such as outcomes and reactions, and professional or institutional variables such as culture. Many described the presence of a 'blame' culture and suggested the need for psychological safety in the workplace to reduce the personal burdens. An inability to identify the emotion, and attribute its true cause creates a state of its 'affective realism' (Wormwood et al., 2019), whereby surgeons could end up treating the experience as resulting from the environment alone, and not their perception of the environment. This is particularly the case with the findings identified throughout this research, in particular within *Chapter 5*. An overreliance on environmental factors to determine fatigued experiences was identified. In these instances, surgeons may end up apportioning misjudgements to variables beyond their control, when in fact it is the personal emotional processes in which they do have control over, that are dictating decision-making outcomes (Croskerry et al., 2010).

There is a need to develop greater levels of social cohesion within the workplace. This may be facilitated through attitudinal shifts to performance regulation within the profession, as well as the necessity to teach surgeons skills on reframing of life stressors. Qualitative research has been conducted on coping strategies in response to intraoperative stress (Wetzel et al., 2006), which speaks of the importance of controlling self and controlling the environment. A randomised control group study involving sixteen surgeons found improved teamwork alongside increasing coping, and reduced stress in cohorts who received a training programme on coping strategies, mental rehearsal, and relaxation (Wetzel et al. 2011). Similarly, a randomised design on 20 novice surgeons found that those who engaged in 30 minutes of mental practice before completing a simulated laparoscopic cholecystectomy task reported lower levels of subjective stress and objective stress markers (Arora et al., 2010). Aspects of performance improved through improving coping using the training of self-awareness, focus, relaxation, positive self-talk, improved efficiency in decision-making (21% faster), and greater technical skill proficiency (Goldberg et al., 2018). Some of these resources were identified in this research as being potentially useful in optimising affective performance and will be discussed later in this chapter.

9.3. OPTIMISING PERFORMANCE AND THRIVING IN SURGERY

A fundamental shift is required when considering what it means to perform for a surgeon. The first half of this body of work focused primarily on the impact of factors which negatively impact on surgical performance, but the latter half provided insights regarding how to better optimise performance within current constraints. The first and most obvious shift in the narrative needed is consideration of the intrinsic relationship that surgical work plays on the personal lives of surgeons. As previously mentioned, aspects of perceived optimal wellbeing and performance were identified in irregular but consistent settings, such as the operating theatre. If surgeons can't engage in non-work activities, which enable a broader appreciation of activities which can promote wellbeing, they may become dependent on the precarious conditions of work which allows them to access momentary achievement, but not experience sustainable and longer-term self-actualisation and vitality. With the broadening of responsibilities of surgeons involving non-technical aspects of perioperative care, motivation may be challenged in these tasks, which can lead to fatigued states. This may be opposing access to states of thriving.

A high amount of work hours, alongside regular on-call duties, makes it difficult to detach from work. Diametrically, the work, in and of itself, remains a strong part of the identity of individual surgeons, who enjoy working longer hours, suggesting that interventions to improve surgical performance must go beyond consideration of environmental changes alone. In a systematic review on quality of life predictors in surgery, a greater number of hours worked per week was found to be a significant predictor of poorer quality of life (Pulcrano et al., 2016). Quality of life is defined as “an individual’s perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns” (WHO, 1993). On the other hand, the wellbeing measures of surgeons in this body of work identified that the relationship between work hours and wellbeing is not as straight forward (*Chapter 6*). Subjective wellbeing refers to how people think and feel about their lives (Diener et al., 1999). In understanding wellbeing, evaluation is typically through a combination of affective and cognitive processes. Life satisfaction is one of the primary indicators, and higher scoring has been found to be influenced by self-esteem levels (Diener et al., 1999) and agency (Bailey et al., 2007). It could be that aspects of the work of surgeons positively buffer against the negative effects of environmental constraints. This would suggest that there are components of surgical life which may predispose the profession to having optimal performance and wellbeing. The next step is identifying those components and embedding them further. While restrictions exist on the malleability of wellbeing levels within individuals due to heritability (Bartels, 2015), the principle argued within this body of work is that changing internal processes could lead to lasting improvements in wellbeing (Lyuborimsky, 2001). A commonly used model to promote positive wellbeing is that of the PERMA model, an acronym for positive emotion, engagement, relationships, meaning and purpose, and accomplishment (Seligman, 2018). When exploring these five components, in conjunction with this research’s findings, it could be hypothesised that surgeons experience high levels of meaning and purpose, as is common in vocational practice. On the other hand, they experience lower levels of other aspects, such as accomplishment due to insufficient technical skill exposure.

This research was the first to explore the positive wellbeing enablers and inhibitors in the context of surgery. The phenomena of ‘thriving’ was selected for investigation as it combined both perceptions of wellbeing and performance. States of thriving arise from responses to high learning and vitality. Surgeons are exposed to high learning environments on a daily basis, albeit lower technical learning opportunities during COVID-19 did impact this access (*Chapter 5*). Thriving levels are low in the profession, primarily in the vitality domain, as reported through a myriad of subjective and objective markers throughout the research. While surgeons identified that fatigue and sleep deprivation are the main barriers to thriving, objective synthesis of findings in *Chapter 8* identified that higher levels of fatigue and thriving can co-exist. This body of work hypothesises that coincidence is facilitated by three known personal variables - psychological capital, engagement in psychological performance markers, and recovery opportunities.

Psychological capital

The first variable which appears to play an influential role in accessing thriving states is higher positive psychological resources, also known as psychological capital. Significantly higher levels of hope were identified in participants who identified they were thriving in their work. In addition, two other personal resources, optimism and resilience, were predictive of 'thriving at work' outcome measurements.

Hope

High levels of hope were highly influential towards levels of vitality, and were strongly linked with recovery states. Hope was also strongly associated with better clinical performance markers from both traditional and non-traditional domains. These strong relationships suggest that hope may be the most significant personal resource to moderate the trajectory towards optimising performance.

Hope can be defined as a quality set which comprises of belief in an ability to initiate and sustain action through generating plans and using available resources (Snyder et al., 1996). Alongside optimism, which is discussed next, the states share parallels with the trait of grit, which involves a combination of passion and persistence for goals (Duckworth et al., 2007). One study on orthopaedic surgeons found that surgeons demonstrated higher level of grit compared to the general population (65th percentile) (Kurian et al., 2019). Surgeons who exhibit higher levels of grit can maintain their motivation over longer periods, irrespective of adversity. Individuals who exhibit high levels of grit are more likely to maintain goals in absence of positive feedback (Duckworth et al., 2007). The state is motivated by having a higher personal long-term goal (e.g. becoming a consultant), which provides meaning and direction to all other goals. Developing 'grit' in surgery may be an important psychological skill, given the difficulty in changing environments with the regular rotation of surgeons in their training. Performance wise, higher grit has been explored as a potential screening for successful progression in surgery (Burkhart et al., 2014), and higher levels of grit predicted better learning amongst medical students (Miller-Matero et al., 2018). In addition, higher levels of grit were found to reduce levels of burnout (Walker et al., 2016) and improve wellbeing (Salles et al., 2014), which has particular implications for performance regulation in surgeons. In orthopaedic surgeons, grit was found to be higher in particular demographics, such as increased age, those who play sport and females (Camp et al., 2019), suggesting that developing psychological capital is something which can be identified, modelled, and effectively rolled-out to larger cohorts or surgeons.

Optimism

Similar to hope, higher optimism levels correlated with higher thriving at work, while also appearing to play a significant role in reducing levels of fatigue, and improving both traditional and non-traditional performance domains.

Optimism is defined as a quality set which comprises of beliefs in generalised outcomes (Scheier and Carver, 1985). It correlates more closely with positive appraisal as a coping mechanism, while hope is associated with higher levels of self-efficacy. Self-efficacy in work refers to perceived abilities to carry out work tasks that are both within the remit, and that extend beyond, typical requirements (Parker, 1998). Higher self-efficacy moderately correlated to thriving states, but to a lesser extent than hope (*Chapter 8*). Hope can be thought therefore to be related to positive appraisal of attaining specific goals, while optimism refers to a more generalised expectation of broader general outcomes (Bryant and Cvengros, 2004). Optimism has been found to utilise more effective coping strategies in life situations (Scheier and Carver, 1992), and surgeons who reported positive outlooks in their work previously reported lower levels of burnout (Shanafelt et al., 2012). Given this, it can be suggested that personalised interventions can help foster higher levels of hope and change challenge appraisal processes. A dearth of research exists on promoting optimism in the workplace, though approaches, such as learned optimism (Seligman, 2006), could be potentially useful. Similarly, optimism appeared to be promoted more so by fulfilling of BPN of relatedness, competency and autonomy (*Chapter 8*), suggesting the interplay between recovery opportunities on influencing levels of optimism also.

Resilience

Resilience levels played a lesser role in influencing performance outcomes when compared to the previously mentioned resource. Nonetheless, high resilience promoted levels of thriving, reducing associated levels of fatigue. It predicted less performance outcomes.

Resilience can be defined as a quality set which comprises of abilities to moderate negative stress through adaption, and the ability to successfully cope with change (Wagnild and Young, 1993). It is commonly described as the ability to bounce back from a crisis in order to maintain baseline performance. Resilience has been suggested to be a precursor state to states of thriving. Thriving is an adaptive response, whereby challenge, in and of itself, can be a stimulant for personal and professional growth (O'Leary and Icovics, 1995). While resilience results in return to pre-event levels of function, thriving states provide added value and improve performance and wellbeing. Resilience is strongly coupled with recovery states (Carver, 1998), indicating the importance of rest states for maintaining performance in times of high adversity. This supports the hypothesis that thriving is determined not by fatigued states, but by recovery process engagement as well. This is discussed later in this chapter. Similar to optimism, resilience appear to be promoted more so by fulfilling of BPN (*Chapter 8*). Previous resilience strategies in surgery have been identified (Zwack and Schweitzer, 2013), with the most commonly used practices and routines including leisure time activity (69%), cultivation of contact with colleagues and family (60%), and personal reflection with goal setting (47%). Useful attitudes have been found to support resilience in surgeons, including self-awareness (49%), acceptance and realism (44%), and creating inner distance by taking an observer perspective (40%).

Psychological performance

Possessing and utilising a myriad of psychological skills was the second variable which was associated with thriving states. A systematic review of 28 articles which explored the effect of mental skills training in reducing stress and improving performance concluded psychological interventions in surgery were effective (Anton et al., 2017). The role of self-talk, imagery, and activation as psychological performance skills, differentiated those who reported they were thriving from those who weren't. In addition, it also predicted better clinical performance in both traditional skills, such as scholarship, and non-traditional skills, such as management.

Imagery

Imagery levels were significantly higher in those who were thriving, and was associated with several clinical performance markers, including patient safety. It has been hypothesised that use of imagery may be effective given the overlapped use of neural networks involved in planning and execution of performance, referred to as a functional equivalence (Johnson, 1982). Mental imagery was the most prominent psychological skill intervention in surgery according to a recent systematic review (Anton et al., 2017), and has been viewed as an important mental factor for surgical excellence amongst highly qualified surgeons (McDonald and Letts, 1995). Imagery can be visual or kinaesthetic, and viewed through first-person or third person lens (Cumming and Williams, 2012). It may also assist in expediting the learning trajectory of skills. A randomised controlled simulated laparoscopic cholecystectomy trial of 18 novice surgeons found that the cohort who practiced 30 minutes of mental practice before each procedure had significantly improved performance, compared to the control group, who watched an educational video at each attempt (Arora et al., 2011). In that instance, formal incorporation of mental skills training, as part of the learning process in attaining technical skill, may assist in dealing with issues around trainee exposure to the learning environment, following the restrictions imposed by working time limits.

Self-Talk

In accordance with SDT, self-talk may influence levels of motivation through the manner in which self-talk conveyed. In self-deprecating talk, motivation is decreased, while self-supporting talk will sustain motivations (Deci and Ryan, 2004). A very strong relationship between learning opportunities and self-talk was identified in *Chapter 8.* Given the vast amount of continuous professional development required in surgery, having positive self-talk throughout the career trajectory may assist in sustaining perceived learning opportunities in the environment. This could enable greater resourcefulness and development of growth mindsets towards learning in challenging environments. Higher recovery opportunities also predicted better scoring in psychological performance markers in self-talk, suggesting that those who utilise the skill also engage in effective performance regulation. Nonetheless, these are hypotheses which warrant further investigation, and self-talk remains a largely under researched area in high performance professions such as surgery. In a parallel industry, one systematic review in sport (Tod et al., 2011) created a theoretical underpinning of the role of self-talk in performance. They found that there were benefits to the use of positive, instructional and motivational self-talk, which could be the foundational theoretical underpinnings for study of its use in surgical performance.

Activation

Activation may provide the most interesting insights into psychological skills for optimal performance, and warrants further rigorous investigation. It had influential roles in fatigue recovery, thriving, and performance domains. Activation can be determined as the ability to 'switch on' to optimal performance when required, and resonates with components of the flow state. Flow is described as a state of full engagement, control, concentration, and action awareness. It is typically described as peak performance, and characterised components listed in *Table 9.1* (Nakamura and Csikszentmihalyi, 2002; Abuhamdeh and Csikszentmihalyi, 2012).

Table 9.1. The ten components of flow states characterisation

Components of Flow States
Clear goals
Concentration
Loss of self-consciousness
Distorted perception of time
Direct feedback to actions
Balance between capability and challenge
Control over the situation
Intrinsically rewarding
Attentional-involvement
Creative problem solving skills

Three components in particular have been identified as important for activation of flow states, and all are easily implemented within surgical practice. These are clear goals, immediate feedback, and the appropriate challenge/skill ratio. Working slightly beyond our skillset capabilities is the ideal challenge-skill ratio, and has been found to be effective in many settings in promoting flow (Fong et al., 2015).

Interestingly, flow states are not predicted by stable job characteristics (Nielsen and Cleal, 2010), which challenges arguments against inabilities to work optimally within constraint environments. Instead, flow states are elicited in individuals who have a perceived internal locus of control (Keller and Blomann, 2008). It for this reason that higher introceptive capacity is important for surgeons, to enable them differentiate if an increase in effort is the prerequisite to entering the flow state, versus if fatigue is culminating a result of competing motivational demands (Hockey, 2013) or physiological process such as sleep deprivation. The former will encourage perseverance in order to achieve a flow state. The later will lead to increased fatigue if pursuing the same task. Developing personal beliefs about internal locus of control to either rest, if required, or persevere, is important to increase access to flow states. Increasing the access to achievement of goals is important for flow experience. This can be facilitated in two ways – by establishing personal goals, which are independent of environmental constraints, as facilitated by the coaching intervention in *Chapter 7,* and by establishing regular performance appraisal and goal setting and evaluation opportunities within training.

Those reported experiencing flow had parallel differentiating characteristics as those experiencing thriving (*Chapter 7*). Thriving, which is described as the combination of experienced development and success (Brown and Arnold. 2017), allows upper broadening of the parameters for optimal performance. In opportunities of high stress, surgeons could experience states of thriving by entering a flow states which enhances performance to a new higher baseline level. Greater quantities of flow experiences may be experienced by those who report they are thriving, and this warrants further investigation in surgery.

Recovery

Certainly the most interesting finding of exploring the theoretical underpinnings between fatigue and thriving is that, while participants identified fatigue and sleep deprivation to negatively impact thriving states, objective synthesis of the findings suggests that both can co-exist as long individuals engage in effective recovery processes. This finding was supported by increased engagement in recovery states between those reporting they were thriving and those who were not.

By promoting rest, there is opportunity for reappraisal of current tasks, for alternative tasks to be planned for, or to fulfil basic physiological or psychological needs, which may reduce fatigue levels. Insights suggest that a relationship between non-fulfilment of the BPN in non-work states with performance and wellbeing measures (*Chapter 8*). It suggests an onus on the individual themselves to promote active recovery in non-work settings, but also the confounding role that an individual's personal life may have on fatigue levels. Perceived non-relatedness, such as loneliness or low self-efficacy, and non-autonomy should be considered. The fulfilment of BPN in non-work settings can influence levels of perceived self-determination (Deci and Ryan, 2004), and thus have spill over negative consequences on work performance. Establishing the cognitive skills to be able to rest effectively in surgery is important if mandated efforts for rest are to be implemented in systems. It was established that surgeons find it difficult to take time off, and to use time off effectively (*Chapter 5*). In a grounded study design, Taylor and colleagues found that surgical residents were likely to abide by the cultural norms within the profession in deciding whether to continue to work in post-call states or to go home (Taylor et al., 2013). In a subsequent study, when finishing work, residents identified facing a dilemma in off-duty time, particularly in post-call states, as to either recover from sleep deprivation or attempt to engage in non-work activities (Taylor et al., 2016). The inability to do both, despite working hour regulations, highlights a particular limitation of the current working models of surgeons. In work settings, while switching tasks can be effective in mitigating fatigue, taking more rest breaks is likely to be more effective. While more complex tasks may be preserved from performance decrement, there remains the issue of fatigue after-effects due to the increased compensatory efforts to guide attention (Hockey, 2013, p.66). If surgeons are not providing themselves with sufficient time to recover from complex task demands they may enter into a cycle of longer-term fatigue and burnout.

Since the industrial revolution, rest has not been prioritised within modern work settings. While mandated work-hour limitations exist, there remains variable levels of compliance. In addition, individuals are finding it increasingly difficult to know how to 'rest'. The tired but wired phenomena is reflective of the over-stimulated 21st century individual as a whole. If efforts to prioritise rest are sought, then current objectives, which overemphasise time-on-task efforts for performance assessment, will require revision. While productivity will remain a key indicator of effectiveness in an organisations functioning, additional outcome measurements, such as wellbeing, will also determine strategic directions for organisations efforts to promote thriving.

9.4. INDIVIDUALISED INTERVENTIONS TO OPTIMISE SURGICAL PERFORMANCE

This research was novel in using an evidence-based and theory driven approach to understand the most optimal way to improve surgical performance. In particular, the intervention targeted personal domains, identified from the collective synthesis of modifiable categories throughout this research, which could be individually tailored to each surgeon. The intervention proved to be feasible, while the pilot findings suggest it may lead to improvements in performance through improved thriving and reduced fatigue. A systematic review of all coaching interventions studies of surgeons found that positive satisfaction was always above 80% in participants (Valanci et al., 2020) and therefore, it is argued that individualised approaches, which emphasise a self-deterministic approach, be considered the default primary intervention for optimising surgical performance.

Self-determination

The main theory used for analysis of the findings of this intervention was SDT (Deci and Ryan, 2004). This framework provides a theoretical understanding of how motivation is facilitated by fulfilment of the basic psychological needs of competence, autonomy, and relatedness. Fulfilling of the BPN allows an increase in personal resources which helps surgeons in their capacity to optimise functioning (Vansteenkiste and Ryan, 2013), which could assist with coping effectively with fatigue and thriving in work. It was identified how lower levels of BPN fulfilment reduced ability to recover from work, leading to higher reporting of fatigue (*Chapter 8*). Similarly, higher BPN had high moderate correlations with thriving states, as well as increasing psychological capital. It was further enabled by the environmental variables of lower workloads and more supportive-receptive experiences in the workplace which will be discussed later in this chapter. Higher BPN fulfilment improved reported feelings of providing optimal patient safety which is the mission of healthcare provision.

In accordance with SDT, fulfilling the BPN not only improves wellbeing, but also results in heightened levels of intrinsic motivation (Deci and Ryan, 2004). This will sustain efforts to optimise performance at higher levels of baseline, and allow successful pursuit of goals which will improve learning and vitality, creating a positive feedback loop. Peak performance is the ability to achieve optimal outcomes within tasks consistently (Louie et al., 2020), reflecting a balance between physical and mental capabilities. The behaviour-change intervention in *Chapter 7* focused on developing these capabilities through automatic and reflective motivation, as well as psychological capability capacity building.

Goal setting

The intervention to optimise surgical performance utilises goal setting as a mechanism of behaviour change. This mechanism has been supported by a recent review which suggests goal setting as a strategy which may assist in developing peak performance in surgery (Louie et al., 2020). Goal setting has been shown to be a promising empirically based intervention for increasing motivation and making successful behaviour change (Epton et al., 2017). In addition, theoretical relationships identified correlations between goal setting and better self-reported performance in communication, management and professionalism (*Chapter 8*), thus suggesting it may also assist in making targeted improvements in parts of clinical performance.

One of the most commonly used parameters to set goals is the SMART criteria (specific, measurable, attainable, relevant, time based) (Doran, 1981). It is posited that ambitious goals should be ideally set to find a balance between challenge and current skills (Abuhameh and Csikszentmyhalyi, 2012). In the design of the intervention in *Chapter 7,* it was discussed how increasing awareness of the scientific principles of performance management was facilitated through phase 1 of the intervention. Root cause analysis, as a prerequisite to goal identification and planning, can help identify the barriers to achieving performance optimisation. This was facilitated as part of phase 2 of the intervention. Using goal setting theory developments

(Latham and Locke, 2007), attempts to shift the higher levels of fatigue to higher levels of thriving occurred through four processes – choice, effort, persistence and strategy. In choice, attention is focused on goal-attainment, and therefore distracting motivational demands can be diminished. Goal setting can be influenced through the framing effect (Locke and Latham, 2006), and thus efforts to shift stress appraisal of goal attainment from a threat situation to that of a challenge or opportunity situation may elicit improved performance outcomes. Secondly, effort is increased in goal setting activities due to the desire for end-results. Goal setting effectiveness is influenced by temporal discounting, and it is therefore important that participants can see progressive behaviour change in order to sustain likelihood of engagement. This was facilitated through the intrinsic reward component of phase 2 of the intervention. Thirdly, persistence is increased in goal setting activities which can reduce the impact of the strain state on performance outcomes. This is best facilitated through building self-efficacy in behaviour change capabilities. In particular, goal setting as a motivation for behaviour change is the key aspect of coaching interventions. Lastly, strategy for behaviour change, is facilitated through a planned mechanism for behaviour change, which occurred as part of the coaching process.

Coaching Focus

Education and coaching interventions were identified as the most appropriate means of facilitating behaviour change, given their ability to increase psychological capability while also promoting reflective motivational activities. Coaching used evidence-based approaches to improve performance and wellbeing in individuals. A systematic review on the effect of coaching on surgical performance found that it improved perceptions, attitudes, technical skill, non-technical skill, and other performance measures (Min et al., 2015). It was discussed previously that three areas of focus could help in accessing states of thriving – development of psychological capital, followed by psychological skill, and recovery states. These three areas were identified by some participants in their evaluation of the intervention as being areas of focus for optimising surgical performance.

Building Individuals Psychological Capital

The conclusion assessment identified improvements in psychological capital alongside improved trends in thriving, positive affect, and performance outcomes. It is likely that the process of engaging in a behaviour change, whether it be a lifestyle modification or cognitive reappraisal, improved individuals personal resource capacity. Given that work-related stresses are often an issue in surgery, one of the means to facilitate this change in personal resource capability is through the development of meaning in work. Exploring meaning in work has been shown to increase engagement and access to the 'flow state' (Csikszentmihalyi, 1990). Other research identified those who placed greater emphasis on developing meaning in work and life as having lower levels of burnout (West et al., 2014; Shanafelt et al., 2012). For many, this means re-establishing their original calling or vocation to the profession. The focus on stress appraisal, as a predominant area of focus for many of the participants in the intervention study, resonates with these findings. Surgery is a profession which involves helping many, and recognising those activities could enable greater access to reward and pleasure system activation of the brain. Similarly, developing stoic-based philosophies, so as to life to overcome work-based challenges, has also been found to be a predictor of reducing fatigue in medicine (Taylor et al., 2019), suggesting the important role of philosophy in training of surgeons. This has shown promising results in one study of 74 physicians, whereby biweekly discussions, which incorporated meaning-building, alongside other cognitive activities such as mindfulness, resulted in sustained reductions in burnout levels, up to at least 12 months after the study was completed (West et al., 2014). The utilisation of the coaching space, as a preliminary opportunity to develop these higher-order positive thought processes, may have facilitated changes in psychological capital.

Increasing Capacity and Use of Psychological Skill

Developing a repertoire of psychological skills was identified as being important for a myriad of reasons mentioned previously in this chapter. Incremental shifts towards greater use of psychological skill was noted in the post-intervention assessment, particularly in the lower and upper percentile ranges. It is believed that in order to develop the intrinsically motivated self-regulatory skills required to maintain optimal performance, basic psychological skills, which are incorporated within the domains of the TOPS-2-SF, must be first developed. Development of these basic psychological skills to a level of proficiency has been found to reflect higher levels of expertise and predict success in performance (Kudlackova et al., 2013; Tod et al., 2011). In particular, the development of these skills may be the starting point in developing perceived internal locus of control, thus leading to greater levels of self-determination of performance and wellbeing irrespective of environmental constraints.

Promoting and Optimising Recovery States

There exists a relationship between recovery and fatigue (*Chapter 8*), and this was identified by many participants as their area of focus in the intervention. There was improvements in the conclusion assessment including greater sleep quantity, self-reported reductions in fatigue by 40% of participants, downwards trends in reported fatigue reporting, as well as trends towards improved recovery states. These findings are generalisable to the published research, with surgeons who reported a better work-life balance reporting lower levels of burnout (Shanafelt et al., 2012). This facilitation of a work-life balance also was the most highly ranked area for desired intervention in surgeons (Shanafelt et al., 2014). A shift in median reporting from 'yes to 'no' in experiencing burnout between the pre and post-coaching intervention further validates the potential role of coaching in developing these buffers.

Barriers

There were a series of barriers which were identified as playing an influential role in optimising surgical performance. In particular, aspects of the individual surgeons themselves, including levels of self-efficacy, hope, optimism, vitality, and positive affect, were found to influence self-reported predictors for behaviour change likelihood (*Chapter 7*). This would suggest that successful completion of desired behaviour change goals is individualised, and influenced by personal variables, such as cognitions i.e. the importance of the goal for the individual, as well as self-efficacy i.e. their belief in attaining the goal. It is for this reason that self-determination was the theoretical philosophy, and a non-prescriptive approach for identified personal behaviour change was utilised. In addition to the above influencers, higher levels of emotional control, goal setting, lower negative thinking, and having an appropriate workload may also predict readiness to make behaviour changes.

While a series of efforts were made to overcome barriers to engagement in the project, participants still identified that cultural issues within the profession, in particular the negative appraisal of coaching as a performance management strategy, existed. The internalised cognitions from cultural norms has been previously discussed as the most significant barrier to engagement in coaching, and supports findings on barriers to thriving identified previously found (*Chapter 7*). However, recent research suggests that surgeons internalised cognitions are malleable when using coaching interventions (Byrnes et al., 2021). This exploratory qualitative study of 34 surgeons found that while surgeons initially agreed that coaching created a cognitive dissonance between their perceived level of competency and actual competency, they identified opportunities for improvement in the process. In particular, those who received lower outcome scores were more likely to make meaningful engagement in the process. The fact that coaching created a psychologically safe environment, void of the cultural pressures of the profession, was identified by the surgeons as important, as it encouraged practice of vulnerability which is important for professional reflection (Byrnes et al., 2021). This supports the feedback from surgeons at the end of this body of work (*Chapter 7*). This is particularly important as the majority of participants involved in the intervention were consultants (50%) who can model acceptable behaviours and re-establish new cultural norms more effectively than trainees.

One of the largest institutional barriers identified by most participants was the ability to find time to engage in these interventions. The issues of logistics as a barrier to coaching has been previously identified (Valanci et al., 2020), which does argue the case for environmental adaptions to offer space for engagement in these behaviour change processes, placing parity of them alongside other aspects of surgical training. Logistics also had particular ramifications given the timing of this intervention. The online format of the intervention did provide greater flexibility, but surgeons faced significant pressures in work during the 3rd wave of the pandemic at the start of this intervention. Despite 80% of participants reporting COVID-19 didn't likely impact the intervention feasibility, the longer term impact of the 3rd wave of the pandemic has placed significant pressures on healthcare workers, likely placing performance optimisation, as opposed to performance management, as a low priority for surgeons. Future research should explore how COVID-19 particularly impacted the capacity for engagement of surgeons, and natural propensity to engage might be different when pandemic-associated workload reduces.

Sustainability

Sustainable behaviour change is best facilitated by reducing cognitive load associated with a particular behaviour through repetition. This allows automaticity of the behaviour, commonly referred to as habits. The mechanisms on which to sustain behaviour change remain debated, and it is likely that variability between different behaviours, and amongst different people is likely. At a minimum, 66 days is required for behaviour change interventions (Lally et al., 2010), and this was fulfilled in this intervention as coaching sessions were interspersed and tailored to the individual surgeon.

The intervention showed downward trajectories in fatigue levels, as well as self-reported moderate changes in likelihood to create and sustain required behavioural changes (*Chapter 7*). Some participants also reported increased self-value on the skills they learned as part of their new repertoire of skills for performance management. It has been found that deliberate practice of a desired behaviour change, particularly in the early stage of behaviour change, is an important factor for habit persistence (Lally et al., 2010), and future study designs in this regard should evaluate how much practice of the skills surgeons learned as part of their coaching intervention occurred. In a similar intervention, 88 physicians in the United States partook in six individualised coaching sessions, facilitated by a professional coaching service. The coaching intervention spanned across six months with significant decreases in emotional exhaustion reported, when compared to a control group. Absolute levels of high burnout overall was also reduced by 17.1%, while it increased by 4.9% in a control group. Lastly, significant improvements in levels of resilience and quality of life were found in the intervention group (Dyrbye et al., 2019). These longer terms changes resonate with the three areas of coaching focus, identified earlier in this chapter, for accessing thriving states – psychological capital, recovery states and increased use of psychological skills. This further supports the need for surgical performance to incorporate a myriad of non-technical skills.

One of the primary reasons coaching was identified for use in the intervention was to increase sustainability by challenging preconceived cognitions. Self-regulation of behaviour is an energy consuming activity which can result in glucose depletion (Baumeister et al., 2007; Gailliot et al., 2007), in what is referred to as reduced willpower or 'ego-depletion'. One of the difficulties in creating or changing old habits is the role of the 'central executive' of working memory processes (Baddeley and Hitch, 2001), which will determine relevant and irrelevant information based on its preconceived cognitive framing. Particularly in times of fatigue, when working memory is impacted, an increased emphasis on automatic behaviours is more likely. It is important therefore, to reframe cognitive processes to prioritise performance management as a key component of work if this behaviour is to become habitual and automatic in a surgeons practice. Similarly, it is equally important that developing strong motivating factors to sustain efforts in times of reduced willpower must be considered. Coaching provides guided identification of self-motivational factors, as well as cognitive strategies to build self-regulation (e.g. cognitive reframing or recognising behavioural cues).

9.5. FATIGUE MANAGEMENT SYSTEMS FRAMEWORK TO ENABLE ENVIRONMENTAL SUPPORT

While it is argued in this research that performance optimisation is largely a self-determined and personal endeavour, there are clear environmental constraints to consider which either enable sustainability or block access to self-determination. The theoretical foundation findings identified that greater likelihood of behaviour change was facilitated through increased autonomy and workload. In addition, having a supportive network was also strongly predictive of fulfilment of the BPN of an individual, and thus recovery states. Given this, further exploration of the cultures, expectations, and organisational factors which influence individuals performance warrants further investigation.

Organisational variables

Autonomy

Participants discussed how increased autonomy and perceived control over their work reduced levels of fatigue and increased their level of thriving (*Chapter 5* and *Chapter 7*). These reports were verified with theoretical correlational analysis (*Chapter 8*). Low levels of autonomy in the workplace may be causing fatigued surgeons, even in cases where active coping strategies to stress responses are employed. The DCS model (Karasek, 1979) posits that low levels of autonomy and control in work, coupled with perceived high workload, can lead to a state of 'job strain', which has negative implications for physical and mental health. This 'job strain' draws parallels to that discussed in the motivational theory of fatigue (Hockey, 2013), but is further exacerbated by environmental constraints. The questions remain as to where the issues of autonomy lie. Do surgeons feel a sense of control from senior staff within their profession, or is it within the organisation itself? It is likely that a combination of both is at play and contributing to issues whereby current interventions to either improve wellbeing or performance in surgery is falling short in its objectives. Increasing autonomy-supportive environments in the workplace may buffer some of the impact of the high workload, and thus may be the starting point for improving performance in surgeons without making significant shifts in workload allocation.

Supportive network

The role of surgical supportive network was identified as contributing to both levels of fatigue and thriving (*Chapter 5* and *Chapter 7*). This was somewhat supported by the objective synthesis of findings in *Chapter 8,* in that it predicted thriving but not fatigue. In addition, supportive networkers were correlated with reported feelings of providing patient safety, suggesting that practitioners see the importance of teamwork to promote patients best interests. These findings support previous research on surgeons, which found the positive effect of supportive working environments on surgeons work abilities and engagement in their work (Mache et al., 2014). A survey study on German surgeons reported a significant association between levels of work engagement, as measured by the Utrecht Work Engagement Scale, with reported abilities in work and work-related resources. This supports the hypothesis of a supportive work environment to foster work engagement and work ability.

It was previously mentioned how grit was identified as important for performance optimisation in surgery, but it is possible that it could have unintended consequences on cultural norms. Could grit be causing tunnel-visioning of individual surgeons, expecting individuals to persevere in both conditions which are below optimal standards, and to perform in a highly individualistic manner? In doing so, higher levels of grit could be contributing to the closed cultural norms within the profession. Role theory (Biddle, 1986) posits that individuals behaviours steep from the 'roles' that they play in their own lives, which are influenced by the physical and social environment. This has contributed to normalisations of the 'sleepy surgeon' or 'tired healthcare worker' as acceptable behaviours. Given this, surgeons may feel that the interpersonal relationships in their workplace will view them negatively if they seek support in these states. This also resonates to a broader issue around how healthcare staff are viewed within society, particularly during the COVID-19 pandemic. This is a prime opportunity to embellish the support of the nation for appropriate strategic investment, and planning for prospective healthcare provision.

The hypothesis, identified by participants, that surgical personality could influence the relationship between fatigue and thriving to optimise performance (*Chapter 5*) was not fully substantiated in this body of work. Strong relationships were found between greater levels of extraversion and thriving states, as well as recovery, but this didn't translate across to performance differences to any great extent. Most interestingly was the role of neuroticism. Higher scores didn't influence fatigue or thriving levels, but did influence performance outcomes, such as lower emotional control in the workplace. In another study of 274 surgical residents, higher scores in conscientiousness, emotional stability and extraversion were found in surgeons compared to non-surgeons (Hoffman et al., 2010). They scored lower on openness to experience which may reflect the difficulty in introducing behaviour change (Hoffman et al., 2010). A similar study comparing surgical personality on 599 surgeons, with non-surgical colleagues, found there was higher levels of conscientiousness, agreeableness, openness and neuroticism in surgeons (Whitaker, 2017). This is in contrast to the previously mentioned study. One interesting insight that this study found was that neuroticism scores increased as surgeons got older, when compared to population norms (Whitaker, 2017). While this research couldn't verify the role of personality, other research has found personality type to significantly influence on decisions on whether to operate or not operate (Teunis et al., 2015). This has particular ramifications for decision-making processes, suggesting it warrants further rigorous investigation.

While personality may not play a large role, internalised cognition from cultural norms may. In an exploratory study of fatigue in residents in Canada, Taylor and colleagues found that despite fatigue being viewed as a collective hazard in other high-stake industries, it is viewed as a personal endeavour to be overcome in the medical profession (Taylor et al., 2016). Considering the above, internal-based changes, as facilitated by the individualised coaching intervention in *Chapter 7,* may be better supported by cultural environmental changes. This could include strong leadership in the domain of performance management from consultants and senior surgeons. Similarly, alignment of agreement of common goals within organisational systems to personal goals could encourage sustainable behaviour change through fostering supportive and collective networks.

Workload

A higher workload which goes beyond a surgeon's capacity was identified as an organisational variable, which contributed to increasing levels of fatigue and reducing thriving access (*Chapter 5* and *Chapter 7*). However, on theoretical analysis, a higher workload actually predicted higher levels of thriving in learning opportunities (*Chapter 8*). This translated to higher reported confidence and satisfaction in communication skills and scholarship. This incidental finding suggests under stimulation in work can also lead to fatigued states, perhaps through the presence of boredom (Hockey, 2013, p.16).

Interestingly, higher workload also positively correlated with emotional control, even though it increased negative affect, and reduced BPN fulfilment. This would suggest that perceived optimum workload can be a strong influencer of optimal performance, but may also be prone to after-effects, such as impact on affect and BPN, which need to be addressed to sustain that performance. It is hypothesised that the incongruence between not addressing these after-effects, and still expecting sustained performance, can lead to more chronic states such as burnout. Particularly to surgery, on-call associated work appeared to be a significant part of the work-life which impacted on perceived abilities to thrive, as well as fatigue levels, and this could be due to the insufficient recovery opportunities. One study used a novel approach to identify at risk-fatigue periods amongst surgical residents by tracking their sleep and awake periods while using the sleep, activity, fatigue, and task effectiveness (SAFTE) model (McCormick et al., 2012). Amongst 27 surgeons, residents were found to be fatigued 48% of the time and impaired 27% of the time. Using these models, prediction of medical error was increased by 22% in fatigued states, with night-float residents in a particularly vulnerable state. This suggests that optimal and sustainable performance interventions can't be considered without reconsideration of current workload models. Similarly, the combination of low autonomy and excessive workload beyond an individual's capacities can also lead to negative physical and mental outcomes. A study exploring 44 surgeons' health and job demands found that a majority of surgeons reported difficulties in coping with job demands (86%) due to their physical health at least once a month. The authors concluded that the high level of physical demands in surgery, which places strain on musculoskeletal systems and energy levels, reduces a surgeons functioning in their work (Ruitenburg et al., 2012).

Based off the considerations of the above organisational factors, it can be concluded that environmental interventions will support or impede individuals in making behavioural change to optimise performance. This was also a recommendation from the BCW macro-level intervention when designing the behaviour-change intervention (*Chapter 7*). The level of stakeholder engagement should include both professional and organisational management. Scaled up and larger scale efforts with decision-maker input and promotion are important for two reasons – they remove institutional barriers, which focuses on fatigue mitigation, and they change cultural barriers which allows for greater internalised processing of expected behaviours within individuals themselves, and possibilities to thrive in their work.

Specific Considerations

Particular demographics were more prone to facing performance management issues. While individuals may be able to optimally perform in their work, significant institutional, cultural, and environmental barriers must be overcome first. In light of that, any organisational intervention should seek not to perpetuate further inequity within systems, and consider the specific additional considerations of these demographics when implementing large-scale interventions.

Gender

Surgery has been, and remains at present, a male-dominated profession. Inequities between genders in the workforce has been identified. Initial observational data suggested sleep deprivation and fatigue were issues in the parallel healthcare profession of physiotherapy. Physiotherapy, like most healthcare professions, is female dominated and with that, brings particular gender-specific issues which can result in increased fatigue and burnout. These issues were further exacerbated in the last year, with females reporting a disproportionally higher negative impact from the pandemic (Ausín et al., 2021). With the changing dynamics in the surgical profession, it is important that considerations of the role of gender on surgical performance and fatigue are considered. While these demographic changes are facilitating changes in negative culture in the profession, a significant portion of female surgeons are experiencing a disparity in workload and recovery opportunities in comparison to their male colleagues. Female surgeons discussed how they are expected to be more resilient in the workplace, and that they faced increasing life-demands at home, including childcare responsibilities (*Chapter 5*). In *Chapter 6*, it was seen how female surgeons reported higher levels of stress in the workplace. Female surgeons also identified how internalised cognitive processes from surgical cultures have placed significantly greater demands on female surgeons to 'strive' to be better than their male colleagues. Similarly, females reported lower scoring on thriving measures on baseline assessment of the intervention (*Chapter 7*), albeit this disparity was bridged on post-intervention assessment.

Though overt structural changes, such as protected leave, are likely to facilitate gender equity, recent research has suggested that sexism in the profession through the medium of microaggressions may be the driving force behind the present disparity. A recent study identified a large gender bias against female surgeons, which they categorised by four themes – exclusion, adaption, resilience to workplace slights, and increased effort (Barnes et al., 2020). In a survey of 1412 surgeons in the United Kingdom and Republic of Ireland, sexism (42%) was identified as the most common form of bullying and undermining behaviour (Clements et al., 2020). Given this, interventions should consider gender as a variable of importance. Establishing greater gender work-life balance and culture change will be important to ensure equity of fatigue mitigating opportunities for healthcare workers as a whole cohort. This may include a gradual return to work responsibilities in the workforce from parental leave, greater flexibility in working hours, provision of childcare facilities on site, and most importantly cultural change towards recognising the current perpetuating barriers which remain unchallenged.

Youth and Experience

It has been identified throughout that younger practitioners may be particularly prone to performance management issues. Younger trainees reported lower hours of sleep (*Chapter 3* and *Chapter 6*). The COVID-19 pandemic also reduced training exposure, as seen in *Chapter 5,* which could have led to reduced opportunities to thrive. It has been hypothesised that level of experience may mitigate the effects of performance decrement, due to learned adaptions to non-optimal conditions, though this claim was not substantiated within the research findings. Instead, more experienced surgeons are more likely to maintain performance due to a combination of personal and environmental factors associated with their professional title. They reported higher levels of autonomy, reduced fatigue, and increased sleep opportunities. In the on-call study exploration in *Chapter 3*, more experienced surgeons reported better EEG scores, due to sleeping more (*Chapter 6*). Subjectively they reported better performance, but also highlighted additional stressors as you progress in your career (*Chapter 5*).

Younger staff are also particularly likely to conform to cultural norms. A qualitative study, exploring the foundations of fatigue in the medical profession, found that from at least third year in medical school, medical students begin to perceive the need to be able to withstand sleep deprivation, believing that in doing so, they are protecting patient safety. The medical students identified three perceived threats of fatigue within healthcare – threat to their personal health, to patient safety, and to professional reputation. They believed that personal health could be managed through perseverance, that patient safety was protected by faith in the system, and that professional reputation is upheld by the principles of stoicism (Taylor et al., 2019). With this in mind, it is evident that cultural shifts to changing how fatigue is viewed in healthcare should begin as early as medical school, where the hidden curriculum is embedding professional identities in students from clinical rotations. Developing leadership skills, and a focus on evidence-based self-management approaches is important in this regard.

Specialties

It was identified in *Chapter 6* that general and vascular surgeons engaged in the highest amount of on-call work, and in *Chapter 5* surgeons identified how a combination of patient requirements, workload variation, and cultural norms within the specific disciplines contributed to states of fatigue. Current research suggests disparities with regards to specialties, with one systematic review finding paediatric and endocrine surgeons reporting highest career satisfaction, and vascular surgery reporting the lowest (Pulcrano et al., 2016). It has been discussed elsewhere in this chapter that trauma, urologic, otolaryngology, vascular and general surgeons are all predisposed to higher levels of fatigue and burnout (Shanafelt et al. 2009), and thus further investigation of the specialties and their performance management experiences are warranted.

Race

Previous research has identified that racist attitudes are perpetuated within the surgical profession, as experienced by 21% of respondents in a large-scale survey study on bullying in the workplace (Clements et al., 2020). A dearth of research exists on the role of racism in healthcare systems, but a recent British Medical Journal special edition on racism in Medicine, have identified that ethnic minority doctors working in the United Kingdom are twice as likely to be referred to their regulator for disciplinary proceedings (Majid, 2020). Other published work identified greater failure rates in ethnic minority medics in training (Linton, 2020). The special edition highlights the existence of objective disparities between similarly trained professionals. Further exploration of the potential role of racial issues in surgery are warranted, with particular emphasis on how diversity of cultural norms and racial norms are changing performance expectations in the profession.

Environmental constraints such as on-call work, cultural norms within professions, as well as inequitable policies, which favour particular cohorts over others to succeed in work, remain. It is evident therefore that efforts to optimise performance as a whole are futile without considerations of the impact of interventions on specific demographics within the profession who are not starting off on a level playing field.

Areas of future focus

There are two areas for future focus – the first is the development of comprehensive fatigue management systems, and the second is the necessity to focus organisational interventions for optimising performance.

Fatigue management systems

The development of a comprehensive fatigue management system within healthcare may be the most significant environmental change which could permeate into desired individual behaviour change. In a large qualitative study design exploring causes of surgical error, fatigue or excessive workload was found to have been the root cause of 33% of all errors (Gawande et al., 2003), suggesting it plays a significant role in patient safety.

Fatigue risk management systems (FRMS) take into consideration a myriad of organisational variables, which contribute to manifestation of the state in the sector. In developing FRMS, consideration of the field of human factors is warranted. Human factors relates to the study of relationships between workers and the work-systems in which they operate. It has particular applicability for patient safety as an outcome measurement for assessing overall effectiveness of interventions to mitigate fatigue. The central tenet of the discipline is the recognition of the limitations of humans' performance, and thus appropriate adaption of the environment in such a way that such performance variability doesn't result in egregious error. Surgeons were aware of error-making in some instances, but felt they never made any large errors as a result of fatigue (*Chapter 5*). In addition, errors according to systems, were not viewed as errors by surgeons –

such as writing a wrong prescription. This likely correlates to the perception of making minor errors from fatigue as previously discussed (*Chapter 6*) . Both chapters support the idea that non-disclosure is due to poor cultural norms around error-making. Fundamental changes to the perceptions of error-making are required to bring about changes in this manner. Within surgery, efforts to explore the factors associated with origin of error in the environment (Elbardissi et al., 2017), and to standardise performance standards across surgeons (Lyman et al., 2020), have been recent initiatives, inspired by human factors, to optimise surgical performance. While systemic and overarching efforts are warranted for environmental intervention, cognisance should be given to the recognition that differences exist between individuals cognitive and affective processes, and thus efforts to standardise thinking and emotional responses in situations cannot be fully controlled for. To overcome this variability, developing individuals self-awareness of error-making is a pivotal point of transition in organisational thinking, which encourages self-responsibility and self-mitigation. To guide this united thinking, consideration of the expertise of parallel industries in developing overarching systems may shine the most light.

Framework for Fatigue Management

The International Civil Aviation Organisation Fatigue Risk Management Taskforce argues the need for all stakeholders to be cognisant of four scientific principles of fatigue management (ICAO, 2016): the need for sleep; the influence of workload; the impact of sleep loss and recovery; and the role of circadian rhythm on sleep and performance. Within these principles, the interplay between the individual surgeon, the workflow and workload modelling, and the organisational norms can be explored. Using these principles, organisational interventions (Caldwell et al., 2009) which could be applied to healthcare include regulations and policies at a national and organisational level for fatigue management, as well as in-house fatigue countermeasures. Similarly, supporting personnel’s individual fatigue strategies, and the use of technologies for tracking fatigue levels to inform evidence-based localised fatigue mitigation interventions may be useful. While the organisational efforts are important, fatigue management involves joint responsibilities from all stakeholders in reducing systemic levels of fatigue within systems. A framework for hierarchical intervention adapted to healthcare, in the context of COVID-19 (Whelehan et al., 2021), is seen in *Figure 9.2.* This framework discusses how individuals can be leaders of cultural change, assisting in the development of recovery cultures within organisations. This in turn is supported by systemic organisational efforts included structural and educational endeavours.

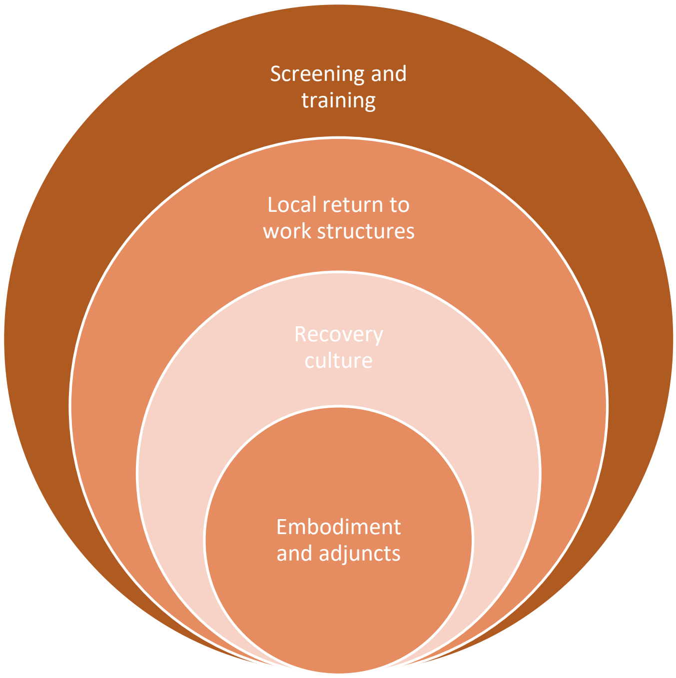


Figure 9.2. Preventive and proactive leadership responsibilities to tackle fatigue

In supporting the development of FRMS, there are particular aspects of the work-environment which require further exploration.

Culture

The complex relationship between performance and patient safety was previously discussed (*Chapter 5* and *Chapter 6*). It appears from these findings that a dissonance exists in recognising the reality that fatigue exists in surgery, that science supports the fact it impacts performance, but that patient safety is somehow maintained. A part of this misalignment could be influenced by the Hippocratic principle of 'first, do no harm' so embedded within the surgeons psyche. While surgeons may become aware of this in instances where egregious error occurs, they are less aware of cause-effect relationships in instances of minor error-making. Surgeons also spoke of increasing vigilance as a mechanism to reduce error-making (*Chapter 5*), which reflects norms of ignorance to the limitations of an individual's physiological and psychological processes. It also could reflect resolution of a cognitive dissonance with reality, in which surgeons could be reframing their concept of what error-making is as they progress through their training. The lack of control mechanisms in place to transparently identify the impact of minor, yet cumulative, error-making enables these behaviours. It also echoes previous research that non-technical skill is unequally emphasised in training (Arora et al., 2009).

Changing these internalised cognitions is important for FRMS development. Phase 1 of the intervention in *Chapter 7* attempted this through a multi-external stakeholder engagement to educate surgeons on the importance of human limitations. The desired outcome would be to develop open disclosure cultures of error-making in healthcare. This process involves recognition that error is inevitable, but mitigable through learning from systematic error-reporting systems. Removing the social shirks associated with error making means also changing attitudes to error-making in the surgical profession itself. A just culture is one in which individuals are made responsible for their own errors in a psychologically safe environment, with the focus on recognising the potential impact of their performance, and the ways to learn from mistakes to better optimise their performance. It also recognises that patient safety cannot be assured in surgery without supportive cultures (Gogalniceanu et al., 2021), which have been successfully implemented in aviation. Within surgery, developing a 'just culture' of transparency and fairness allows 'psychological safety' (Carmeli and Gittell, 2009) within systems to disclose fatigue and learn from error. Surgeons in particular are hesitant to report errors (Han et al., 2017), and particularly ones which don't result in immediate error (*Chapter 5*). This has implications for their ability to understand the relationship between fatigue and error-making, suggesting the need to initially educate on what defines error and the impact of several minor errors. Alongside disclosure of error, greater disclosure of fatigue within individuals is warranted. In doing so, establishing casual patterns between error-making and fatigue allows opportunity for more targeted interventions. Interventions to tackle fatigue and error-making are about marginal gains. In complex human-based systems it is difficult to establish cause-and-effect relationships, and thus rigorous testing of interventions across settings and different time frames with quantitative and qualitative feedback are warranted.

Developing a positive high-performance culture is likely to elicit beneficial outcomes. In the context of thriving in high-performance industries, two enablers discussed in elite sport which did not appear in surgery are that of the importance 'previous success' and 'goal setting' (Brown et al., 2018). Within teams, constructs from elite sport (Brown and Arnold, 2019) can be used as examples of good practice in helping establish a thriving culture, such as 'forming collective goals' (i.e. patient safety values), 'maintaining equality in the playing squad' (i.e. parity amongst trainees), and 'ensuring effective teammate communication' (i.e. teamwork in the context of professional duties). This is first done through development of competencies which promote self-awareness, self-regulation, and self-determination. When looking at frameworks for 'thriving at work' (Kleine et al., 2019), surgeons fulfilled aspects of this framework including perceptions of optimal performance and commitment to work attitudes, but other variables, such as psychological capital and relational resources were absent. These can be developed through individualised interventions such as the aforementioned coaching initiatives. In doing so, the paradigms of thriving enables shifts focus from that of performance outcomes which promote hedonic states only, to development of eudemonic states.

Education and Training

Education and training is the primary means of challenging cultural norms, and in changing behaviours of healthcare workers towards rest. An example of a training curriculum, adapted from the ICAO for healthcare, is provided in *Figure 9.3* (Whelehan et al., 2021; ICAO, 2016). The use of crew resource management (CRM) training for surgery should be considered in implementing some of the aforementioned required changes (Gerstle, 2018). CRM aims to improve non-technical skills such as situational awareness, communication, and enhance decision-making through a process of respectful questioning of peers. These efforts have shown promising results with one study of 857 healthcare workers, exploring the impact of CRM training on patient safety behaviours, finding that there were significant improvements. Increased reporting of error was also noted, as well as perceived self-empowerment in the workplace (Sax et al., 2009). Nonetheless, making these changes will be slow, so progress should be assessed on a regular basis to measure effects.

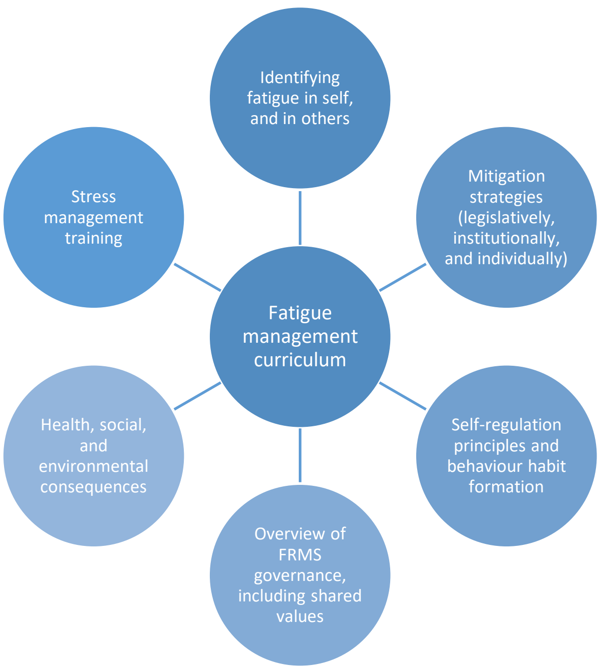


Figure 9.3. Example of a training curriculum on fatigue risk management for healthcare workers

There are two areas worth further consideration. First, cultural change towards implementation of safer practice must be cognisant of the interplay of power dynamics between professions in healthcare. In particular, participants reported feeling less comfortable confronting incompetence in a medical personnel compared to a nurse (Sax et al., 2009). Interventions to improve patient safety in this regard will mean shared training with a united purpose of fatigue mitigation and error-reduction. Second, while education is important for improving self-awareness, previous research has found training on sleep hygiene alone is not effective (Arora et al., 2007) in changing behaviours in healthcare workers towards rest. It was identified, in *Chapter 4,* that higher cognitive loads may leads to more risk-taking in intuitive operative clinical decisions. One area worth further consideration is the use of a risk calculator to judge levels of operative risk and feeding this information back to individuals. This approach has shown a significant decrease in variation of decision-making processes in the operating theatre, as well as educating surgeons on greater accuracy of risk (Sacks et al., 2016).

Developing high fidelity training multi-disciplinary settings, such as in simulated environments where evident links between fatigue and performance can be established, may elicit unavoidable cognitive dissonance in a psychologically safe manner. Such an intervention, particularly in times when surgeons are fatigued and their clinical decision-making processes are most vulnerable, may translate to reduced error in decision-making.

Systems

At a system level, surgeons are often operating in state of incapacitation, defined as “any situation where the level of available resources is lower than the required level of resources need to maintain the optimum performance” (Mawhin et al., 2012, p.201). Modelling of fatigue mitigation systems from similar high-stakes industries is likely to positively impact thriving opportunities. Such systems typically recognise the necessity for change at all levels of decision-making within an organisation, and the development of systems and processes which mandate workers to limit their time-on-task demand and incorporate effective rest opportunities. Performance management frameworks should be developed by institutions in conjunction with input from surgeons in this process.

Development of robust systems which can screen and identify fatigue, as well as alert responsible persons of ‘at-risk’ contexts, are warranted. One study used a novel approach to identify at risk-fatigue periods amongst surgical residents by tracking their sleep and awake periods while using the SAFTE model (McCormick et al., 2012). This innovative study design, using validated software, could offer future opportunities to systemically address issues of fatigue in healthcare. The preliminary aspects of this method of tracking were trialled in this intervention of this body of work (*Chapter 7*), though more robust tracking systems are warranted for larger-scale efforts. The implications for comprehensive data collection could lead to systemic intervention to optimise working conditions. Fatigue risk calculators have been previously explored in the context of rota design in medical professionals (Cumber and Greig, 2019), with findings suggesting that nearly half of shifts included demonstrated a risk of fatigue-related error due to increased probability of sleepiness. This finding differentiates the cause of fatigue as being solely the responsibility of human resource management and not the individual surgeon themselves. Part of the issue lies in the overreliance of systems utilising 'effectiveness' as the only performance metric. Broadening the performance metrics to explore productivity, efficiency, and utility (Jex and Britt, 2008, p.97), may assist in increasing stakeholder buy-in to the importance of systemic fatigue mitigation efforts to improve organisational functioning.

Workload

The efforts-reward imbalance model states that perceived job demands are high when a surgeon is exerting a high level of effort, in conjunction with receiving little extrinsic or intrinsic reward for their work (Siegrist, 1996). This suggests the need to increase rewards to offset the unavoidable high demands on the profession. In the theoretical exploration in *Chapter 8*, it was identified that issues arise when higher workload exists in conjunction with lower recovery and autonomy.

Antipodally, higher workload in itself was actually associated with increased learning and thriving opportunities. This suggests that workload and workflow remodelling could bring seismic shifts to performance and wellbeing outcomes, while not compromising on the necessity for a significant increase in staffing. The role of the type of work the surgeon is doing may also play an important role with regards to level of motivation in work, and thus fatigue mitigation. Participants identified technical performance is the particular aspect of work in which they thrive (*Chapter 7*). It is likely that surgical procedures increases level of meaning in work, responsibility for behaviours, and sense of achievement for surgeons. Establishing an acceptable challenge-skill ratio may increase access to optimal flow performance states (Fong et al., 2015), which could be facilitated through a higher workload when done in conjunction with increased autonomy to buffer the effects, and allow individuals the ability to regulate their own performance. This is a promising approach to minimise impact of higher workload, by engaging the surgeons motivational processes in modelling of the workday. One study attempted to use upstream efforts reduce stress in a surgeon's work by establishing goal-orientated work to improve efficiency in surgical services. A tracking of workload and subsequent reorganisation of workload resulted in reduced stress and improved work satisfaction (Chung et al., 2007).

Working Hours

The current working hours of a surgeon was identified as a significant barrier to fatigue mitigation (*Chapter 5*), and this was particularly true for on-call associated work. Despite efforts such as the EWTD, compliance issues remain prevalent in surgery. Irrespective of cultural expectations to work long hours, there remains insufficient human resources within Irish healthcare to sustain on-call services without compromising individuals work-life balance. Further exploration of initiatives such as iCOMPARE (Desai et al., 2018) and FIRST trial (Bilimoria et al., 2016), which provide greater flexibility in working hours, may mitigate some of these on-call associated issues in the context of Irish healthcare, but it is evident that the healthcare system is in need of larger cohorts of surgical personnel to reduce the regularity of on-call work, as well as to end 24-hour on-call associated work. COVID-19 presented a fresh perspective on workflow models, yet fatigue persisted for many (*Chapter 5*). The development of organisational-level efforts will be insufficient to reduce fatigue levels in healthcare if the collective effort by individual surgeons to embed these interventions is not fulfilled.

Work Variety

Variety in work is identified as being important to managing work-place fatigue, and the balance should be sought to ensure surgeons can detach from particular tasks to assist in cognitive load recovery. In particular, the task-specific variables seen in *Table 9.2*, adapted from the ICAO to healthcare (Whelehan et al., 2021; ICAO, 2016), should be considered when deciding whether to pursue a task further or to take a break.

Table 9.2. Workload considerations in healthcare setting in management of fatigue

Considerations of work variables which increase work-related cognitive load
Emergency tasks
Higher level of difficulty of task
Poor knowledge of patient condition
Poor collegial support
Postprandial dip / Night-shift work
Poor communication with patients
High level of patient caseload

One example of a systemic effort to reduce fatigue-related decrement is the use of micro-breaks within work-schedules. This was previously identified as a strategy for fatigue mitigation by participants (*Chapter 5*). There remains inconsistent evidence on whether such an intervention is effective, as one study found no difference between surgeons who took micro-breaks (Kromberg et al., 2020), while a similar study found surgeons perceived improved perceived physical performance and focus when taking micro-breaks, which were combined with stretching component (Park et al., 2017). Breaks are not a safe-proof mechanism for error-prevention. In a retrospective analysis of 427 reports of wrong-site surgeries, it was found that errors occurred in 31 instances despite protocols of time-outs (Clarke et al., 2007). This further supports the necessity for multifaceted approaches to reduce systemic error within healthcare systems.

Resourcing

All changes required must be cognisant of the interplay between human capacities, and the necessity for additional resources in appropriate contexts. Resourcefulness within systems only occurs in contexts where sufficient resources are available for staff to utilise. This was highlighted by participants in *Chapter 5* as a significant barrier to fatigue mitigation, and nearly 70% of participants reported insufficient human resources in *Chapter 6*. Current reported disparities between the national health service, and the union representing workers, on staffing compliance with EWTD regulations (Fagan, 2020) is unsatisfactory. Higher levels of burnout have been reported by surgical residents who reported lower perceptions of job resources (Gleason et al., 2020). If insufficient resources are given to the development of positive organisational cultures, evidence-based policies and procedures, and training of staff, then performance and well-being impacts are inevitable.

Organisational interventions to optimise performance

Establishing a fatigue risk management system can help establish a performance standard which is better than current provision, yet resolution of fatigue factors alone may not be sufficient to access states of thriving. The findings of barriers and facilitators to fatigue and thriving states, discussed in *Chapter 5* and *Chapter 7,* shared comparisons, but in accordance with the Herzberg's motivation-hygiene theory (Herzberg et al., 1957), resolving dissatisfiers doesn't ensure work satisfaction. This research was the first in surgery to rigorously explore the positive psychological aspects of a surgeons performance and wellbeing, thus providing an alternative narrative. It provides an opportunity to intervene with evidence-based interventions to promote optimal performance and wellbeing. For example, overcoming issues of on-call associated sleep deprivation are more likely to resolve hygiene factors, but not necessarily promote motivation to optimise performance.

In order to reduce job dissatisfaction and increase job satisfaction a combination of both styles of intervention is likely to elicit the most positive effects. Consideration should be given to the barriers that are inhibiting surgeons from performing optimally in the workplace. In *Chapter 7*, the inhibitors to thriving were both personal and environmentally caused. Environmentally, the inhibitors to optimal performance were categorised as regulations, professional demands, insufficient training, and culture. In addition, the theoretical synthesis of the findings suggested low autonomy and supportive-receptive networks also predicted lower levels of optimal performance, while higher workload predicted higher levels of optimal performance (*Chapter 8*). In seeking the transition from fatigue to thriving states, it may be worth considering the different modes of work management seen in *Table 9.3* (Hockey, 2013, p.128). This table provides insight into the relationship between personal factors (such as coping strategies) and environmental factors (such as control and autonomy) on levels of performance. Leveraging changes at these levels are likely to elicit changes in effort, performance, and subjective states, transitioning surgeons from states of strain to disengaged, towards states of strain to engaged optimal performance.

Table 9.3. Modes of work management

Mode	Coping	Control	Effort	Level of performance
Strain	Reactive	Low	High	High
Disengaged	Reactive	Low	Low	Low
Engaged	Proactive	High	Moderate	Optimal

One of the significant debates which arise in discussions amongst healthcare workers when discussing optimal performance, and which was identified in the qualitative findings of *Chapter 5,* was the perceived role of resilience. It was discussed earlier in this chapter how resilience is an important aspect of psychological capital which could influence the relationship between fatigue and thriving states. On the other hand, current perceptions of resilience places overemphasised responsibility on individual capacities instead of developing resilient environments in which the individual is situated. It is for this reason that a consensus is required amongst stakeholders on where resilience within systems and the workforce lies. It is likely that such discussions will result in the recommendation of a combination of individual behavioural adaptions in conjunction with economical changes to healthcare service provision. A recent systematic review and meta-analysis of controlled intervention to reduce burnout in medical professionals found that while small effects were noted in physician-focused interventions, there was much higher impacts on interventions which were organisationally-directed (Panagioti et al., 2018). This further highlights the importance of a two-prolonged approach in tackling growing issues of fatigue and burnout from before, during, and after the pandemic.

Efforts to promote health in occupational settings may be a future area of work for optimising performance, which is supported by the findings of this research (*Chapter 5*, *Chapter 6,* and *Chapter 7*). Health promotion interventions involve a combinations of education initiatives, alongside supports, to enable groups of individuals to improve their health (Green and Kreuter, 1993). This encompasses a myriad of organisationally-led but personally-driven initiatives. Schwartz Centre Rounds® (Maben et al., 2018) may offer one such means of improving resilience in the profession. These provide psychologically safe environments to promote reflection and open-discussion on the emotional and social impacts of work. Similarly, interventions focused on fostering positive wellbeing could be effective. One study on surgeons used a ten-week trial of self-directed micro-tasks of reflections on known predictors of professional satisfaction and wellbeing. These included developing meaning in work, fostering social support, establishing work-life balance, building on strengths, and promoting positive emotions (Dyrbye et al., 2016). The authors found that while there was no statistically significant difference between the intervention and control group after the 10-week trial on a myriad of wellbeing measures, they did find statistically significant improvements in quality of life measurement, burnout, and fatigue levels between pre and post-intervention measures. Further research to explore the potential role of such forms of multi-faceted interventions are warranted.

One of the barriers to sustainable implementation or organisational efforts is intangible feedback on initiatives. Similarly, 'ownership' of the responsibility of fatigue management can be shirked by many stakeholders, alongside problem blindness at higher levels of governance. These issues are likely to have been exacerbated during the COVID-19 pandemic, where leadership styles became increasingly reactive and tunnel-visioned, not being afforded the opportunity to think at a systems level. Healthcare remains an industry which is largely compliancy driven, evidently seen in that while error-reporting exists within healthcare, it is typically used for inspection, as opposed to informing learning and strategic decisions. Incorporating performance metrics, relating the cause-effect relationship of fatigue may lead to embedding of such practice and meaningful intervention thereafter.

9.6. FUTURE CONSIDERATIONS FOR RESEARCH AND SYSTEM DEVELOPMENT

Based off the findings of this body of work and the discussion above, there are a series of considerations and recommendations for prospective system development and research.

System development

There are four areas for system development, identified in *Figure 9.4.*

Figure 9.4. Areas for future system development

Organisational interventions

There is a necessity for changes in current work structures and designs to facilitate optimal performance for surgeons. To this point, efforts to tackle fatigue in surgery to this point have focused solely on optimising sleep opportunities for individuals through work rotas (Desai et al., 2018; Bilimoria et al., 2016), which are welcomed and should be explored in the Irish context. Biomathematical modelling can capture biological influences, allowing prediction of alertness (Kostreva et al., 2002) and calculation of risks (Folkard et al., 2006). In addition, consideration of the circadian rhythm and the genotypical circadian patterns of an individual may explain variability within the findings of the research in this domain. This research established that using a small sample size, the hypothesis of surgeons being predominantly morning larks was refuted (*Chapter 4*). Establishing circadian rhythm norms for individuals, and matching this with their work demands and their levels of sleep, is likely to provide a better overall picture of the relationship between fatigue and work. Using genotypical patterns of alertness and tailored work around these patterns may improve performance in surgery. This may mean if surgeons lean towards morning alertness then highly-demanding tasks such as surgery should be prioritised for the early hours of work. Restructuring the work environment to facilitate greater worker-autonomy, such as allowing individuals to work night-shifts if they so desire, may elicit better performance outcomes. Going beyond rota design, providing opportunities to respond to life requirements may be a means to facilitate better work life-balance. Increasing autonomy in the workplace will facilitate transitions of strain states to engaged states. This will reduce anxiety, fatigue, sustain efforts, and keep performance at an optimal level. Instructional design within the workplace can also assist in reducing the 'extraneous' load placed on cognition of surgeons (Sweller and Chandler, 1991).

In order to establish robust embedding of fatigue mitigation within healthcare, establishing a screening programme, through subjective reporting of simulated performance, to assess fitness for duty may be the seismic shift needed to tackle fatigue. Surgeons often work in poorly optimised circumstances, meaning it is increasingly difficult to attribute error making to individual performance decrement. It is imperative that this process is a non-judgemental and supportive intervention, with the view to identifying areas of improvement both within individuals and systems. A similar process should ensue with regards to error-disclosure and reporting. Disclosing error and establishing links with fatigue is important for system-led initiatives, but it is important to recognise early on that reports of error are likely to increase within the context of the hospital setting, and that this is to be encouraged. There may be initial hesitancy towards this from organisational management, due to the perceived view of society towards that institution, so an appropriate public relations strategy to explain the purpose of the cultural change should be made. The aviation research has been champions of identifying the practical importance of performance decrements to real-life practice. Similar methodologies warrant investigation in healthcare to explore the impact of fatigue on system efficiency and patient care. In healthcare, the standard point for considerations of bridging the gap could be the meta-analytical finding that sleep loss of less than 30 hours can reduce clinical performance by more than 1.5 standard deviations (Philibert, 2005). A systematic review of the causes, consequences and risks associated with fatigue in aviation found that risk increased substantially when the workday was longer than 16 hours, and when the pre-duty sleep levels were less than 6 hours (Bendak and Rashid, 2020). While the performance domains differ between surgery and aviation, generalisations to the risk of cognitive decrement can be made. Given that surgeons reported a median of 6.6 hours of sleep in *Chapter 3*, 6 hours of sleep on-call in *Chapter 6,* and 5.5-6 hours of sleep in *Chapter 7,* this would suggest surgeons are consistently in or around an 'at risk' level of fatigue-influenced performance decrement. In addition, many surgeons report working beyond 16 and up to 24 hour work days, particularly when on-call. The question must be posed, as to what point does performance have to be so detrimental that governmental and/or organisational intervention will intervene to rectify? Serious consideration is required with regards to organisational expectations of surgeons to perform in sleep deprived states. This is particularly worrying given that many studies have found that humans do not adapt to chronic levels of sleep restriction, but rather perform sub-optimally (Pilcher and Huffcutt, 1996) at the detriment to physical and mental health. A combination of procedures facilitated by cultural change, as successfully done in the aviation sector, for patient safety is needed. In aviation, management systems including regular rest opportunities, work scheduling for circadian alignment, and mitigation of emotional stressors is considered in a pilots fitness-for-duty. Such efforts, despite regulatory changes such as the EWTD, have not been considered in surgery.

Simulation offers huge potential in exploring the impact of fatigue and also mitigating it. Such settings should be high in fidelity, incorporating many of the interpersonal and environmental stressors of work. Emerging areas of research have begun to explore the potential impact of reducing extrinsic and germane load by having individuals perform deliberate practice and warm-up in tasks which may be particularly prone to fatigue. By creating schemas, to chunk large pieces of information, cognitive load can be reduced (Sweller and Chandler, 1991). Evidence is similarly emerging on the potential role of training to optimise working memory functioning to ensure control of attention and emotional regulation (Xiu et al., 2018). Using simulation as the medium to carry out such training, surgeons could be trained to perform all tasks, irrespective of whether they are technical or non-technical in goal-orientated manners, reducing the motivational demands associated with the fatigued state (Hockey, 2013). In aviation, the continuous evaluation of performance through simulation ensures a rigorous professional development protocol, which is absent in surgery. Recognising how expertise can diminish, consideration of simulation as both a formative and summative assessment measure for non-trainees should also be considered.

As society advances, automation of work tasks which were previously human-driven is becoming the norm. There are advantages to this as automation can reduce the cognitive load associated with repetitive task-making, which allows greater opportunities for advancing practice and utilisation of skills unique to humans, such as interpersonal and creative skills for decision-making and practice. In doing so, it can reduce decision-making associated fatigue. On the other hand, technology also offers the opportunity to safeguard against some of the fallacies of the human mind, as well as protect against physiological and psychological states of fatigue.

Short-term adjuncts

There will exist circumstances where organisational interventions will be futile and thus short-term adjuncts to mitigate acute fatigue should be considered. The first of these worth consideration is caffeine. Strategic caffeine intake should be taken at times of lull in performance to increase alertness, but intake should be reduced many hours before sleep to ensure a majority of the stimulant's effects are absent. Caffeine intake in the profession however is high (*Chapter 6*). It is used as the primary substance to assist with increasing vigilance, as identified by participants in *Chapter 5,* and thus the unintended consequences of high caffeine intake must be also be considered. High caffeine intake is associated with reduced sleep quality (Clark and Landolt, 2013), increased blood pressure, cortisol and norepinephrine responses in rest states (Lane et al., 1990). The overreliance of caffeine stimulant in the profession should serve as a warning sign for maladaptive performance functions in the profession. Similarly, while caffeine intake has been shown to improve reaction time, it has not been shown to reduce error-making (Crochet et al., 2009; Aggarwal et al., 2011), which has large applicability to surgical practice.

Previous research has explored the potential use of performance enhancement drugs, such as modafinil, in improving surgical performance. In a randomised controlled trial on doctors, modafinil has been shown to improve higher order cognitive functioning (including working memory, reduced impulse in decision-making, and increased attentional flexibility), but not clinical psychomotor performance (Sugden et al., 2012). The risk lies in overreliance on medication to effectively treat what is an environmental and behavioural issue. Issues regarding development of addictive behaviours to these medications, in what may lead to longer term mental and physical health issues, raises ethical concerns regarding their use as a means of tackling fatigue in surgery. The necessity for use of these stimulants in the first instance should be considered when making changes which wish to reduce sleep deprivation and fatigue in the profession.

One promising prophylactic for fatigue mitigation, particularly in on-call and post-call work, is strategic napping. Napping of less than twenty minutes may lead to improvements in acute alertness and may improve learning of technical skill (Spruit et al., 2017). In considering the development of napping protocol, considerations should be given to environmental, procedural and ergonomic variables to ensure effective rest opportunities are facilitated.

Coaching

The most significant intervention worth considering for improving surgical performance is the development of a robust coaching programme within surgery. This research provided an insight into feasibility and pilot outcomes of a coaching intervention within a single surgical cohort. In keeping with classic test theory hypothesis (Crocker and Algina, 1986), that retesting to establish greater reliability sets the boundaries for validity of the findings i.e. 'you can't be accurate if you can't be precise', further scaled-up efforts to incorporate larger sample sizes are warranted to make broader generalisability to the surgical profession as a whole.

One of the most promising systems being developed to sustain larger scale coaching efforts is the Wisconsin Surgical Training programme. This cross-institutional effort has established a peer-nominated coaching programme whereby surgeons were trained as coaches. This method of coaching appears to additionally overcome a lot of the logistical and cultural issues around performance management in surgery (Greenberg et al., 2018). In particular, senior members of staff within departments are the change-agents of cultural norms, and thus future efforts to recruit larger cohorts may better be facilitated by leadership of the project by senior surgical members with expertise in coaching (Greenberg et al., 2018). Strong mentorship and positive modelling was identified as a mitigator to fatigue (*Chapter 5*) and an enabler to accessing states of thriving in surgery (*Chapter 7*). Changing norms is best facilitated by in-group efforts, and the interjection of a surgical role-model to facilitate behaviour change should be considered. There was the limitation of out-group bias in this body of work (Turner et al., 1979), and this may have limited engagement. It is also likely that the high level of self-stigma in the profession (Hayes et al., 2017) was a significant barrier.

Given that trainees are subject to the influence of a power-differential within their work, through the median of consultants assessment of their performance, leadership is best fostered at the consultant level to bring about changes in culture. This was a strongly recommended intervention function in *Chapter 7,* which was not included in the final intervention design. Training senior surgeons to become coaches to younger surgeons may elicit the best results. When exploring the utility of coaching interventions on senior surgeons, this barrier was identified by Mutabdzbic and colleagues (Mutabdzbic et al., 2015). In their grounded theory study, they found that senior surgeons saw little value in changing behaviours as they got older due to both an overconfidence effect and a lack of interest in life-long learning. The extent to which surgeons are overconfident in their performance and influenced by in-group cultural norms appears to be significant barriers in making achieving buy-in for meaningful sustainable behaviour change. This may mean efforts by out-group disciplines to address fatigue are futile unless senior management are cognitively forced to recognise and challenge their biases, acknowledge the limitations of fatigued performance, learn from their errors, recognise the huge power they exert over their professions culture, and lead by example in promoting a fatigue mitigation culture. Given the significant environmental constraints of the healthcare system, transformational leadership is required to improve adaptability of individual members of the surgical team (Conchie, 2013). Having such leadership in surgery leads to new behavioural norms, divergent thinking, increased motivation, and engagement (Conchie, 2013).

While professional cultural norm can facilitate behaviour change, organisational habits and norms should also be considered. Organisational behaviours could be shifted in times of change or when spotlight is externally placed on an organisation. COVID-19 negatively impacted healthcare staff in many ways, but also fostered a level of greater cohesiveness between professions. By developing strong social support and ties new habits can form, where healthcare workers, as a whole, can perceive a new sense of professional identity and duty. Breaking down closed cultures, promoting disclosure of the emotional toll of work through efforts, such as Schwartz Centre Rounds®, and ensuring that fatigue mitigation and burnout prevention, is part of that professional duty is now more possible than ever.

Individual lifestyles

Greater efforts should also made by individuals to maintain their own wellbeing. Recognising the intrinsic relationship between body and mind, this research identified the development of three processes i.e. recovery state optimisation, psychological skill use, and capacity-building of psychological capital as areas which could improve access to states of thriving. Two high-level interventions for surgery are recommended in this regard – mindfulness and active recovery strategies.

One of the most promising emerging areas of preventive medicine is the use of meditative practice. In particular, a meta-analysis on types of meditation found that transcendental meditation showed the strongest effect on promoting relaxing states (Eppley et al., 1989). It may offer potential benefits to surgeons, as it can promote greater relaxation responses, while also improving metacognition and introspection. Mindfulness is the state of non-judgemental awareness of subjective feelings and thoughts. It may assist in developing capacity to access states of ‘flow’, as it allows focused attention without distraction by developing decentred perspectives on the governing role of thoughts and emotions on ones behaviour. A pilot randomised study on early career surgical residents in the United States found that those who received the intervention of an 8-week course on mindfulness-based stress reduction (MBSR) reported lower stress and depressive symptoms compared to their baseline (Sancar, 2019). In addition, improvements were noted in motor performance and aspects of executive function. A parallel study involving 21 surgeons, who completed weekly 2-hour MBSR classes and 20 minutes of daily home practice, found that there were also potential benefits to wellbeing and executive function (Lebares et al., 2019). A recent systematic review stated that mindfulness can have positive impacts on performance and wellbeing (Scheepers et al., 2019). Interestingly, this study didn't find an impact of mindfulness interventions on reducing burnout rates, refuting the evidence that mindfulness alone can tackle complex issues such as burnout. While it may impact on particular aspects of burnout, such as depersonalisation or emotional exhaustion, more complex and evidence-based interventions are warranted to reduce burnout rates overall.

A second area worth exploring is active recovery strategies. This area of practice reflects the relationship that bodily movement can influence cognition and affect, and thus establishes the importance of considering physical interventions for mental enhancement. In *Chapter 5,* surgeons identified the potential influential role of both diet and physical activity on mitigating fatigue, and in *Chapter 6,* it was seen that surgeons engaged in poor dietary and physical activity habits. Interestingly, surgeons identify exercise as being very important for them. Formal physical activity programmes, alongside psychological input, has proved beneficial in a randomised controlled trial of healthcare staff previously (Christensen et al., 2011). Such efforts should be tailored to the individual, promoting a goal setting approach, thus helping surgeons in detaching from work, breaking down cultural norms, mitigating fatigue, and promoting greater levels of eudemonic wellbeing in the process.

Future research

There is a multitude of future research opportunities in the field of optimising surgical performance but for the purpose of this discussion it will be focused on three aspects, seen in *Figure 9.5*.

Figure 9.5. Areas for future research

Surgical performance exploration

Future research is required to explore the multi-component aspects of performance in surgery, and to place equal parity of such competencies to provide optimal patient care. Part of that redefinition is the understanding that optimal patient safety cannot coexist without optimal staff wellbeing. One of the difficulties in establishing the impact of variables on performance in surgery is the heterogenous approaches to categorising performance domains, which reflect the entirety of the professional role. Similarly, linking these performance outcomes to clinical outcomes is difficult given the current limitations on real-life assessment. Better non-technical skill has been found to be an important indicator of enhanced overall surgical skill performance (Mishra et al., 2007), as well as developing surgical innovation, and promoting positive wellbeing (Orri et al., 2014). A systematic review also identified that better cognitive and affective performance, through appropriate stress appraisal intraoperatively, improved technical performance, and that teamwork functioning and technical skill were found to have a strong relationship with one another (Hull et al., 2012). Non-technical skill research has increased in surgery, driven in part by the non-technical skills for surgeons project (NOTSS) (Yule et al., 2008). Future research to establish the link, and build further evidence to support the necessity for rigorous assessment of non-technical skill in both cognitive and affective domains is warranted. One innovative way to explore the role of the non-technical influence in technical settings is through the redefinition of competencies in accordance with particular tasks, such as operative competency (Grober and Jewett, 2006). This competency identifies how technical skill proficiency is only part of the equation for operative performance. A field of assessment which accounts for the combined trajectory of technical and non-technical skill is more likely to reflect real-life performance and correlate with better patient outcomes.

One of the significant challenges which exists within performance assessment is subjectivity from both the individual themselves and other assessors. Research findings in surgery suggest self-rating of performance doesn't correlate well relate to objective markers (Varban et al., 2020; Maschuw et al., 2008; Pena et al., 2015), but that surgeons may be better at predicting technical skill performance (Moorthy et al., 2006). Objective metrics to establish performance markers at a physiological level are warranted. Recent research has attempted to use audio-video data, to inform epistemic network analysis, on the integration of error management skills (which incorporates non-technical skill), and found differences between high-performing and lower-performing trainees (Ruis et al., 2018). Based on a recent systematic review, 27 studies have explored surgeons through use of fMRI (Modi et al., 2017), with a significant focus on technical skill acquisition. In particular, surgical expertise could be predicted by activation of the mirror-neuron system when watching a surgical task (Kok et al., 2018). Use of electrodermal activity is also a promising objective marker for measuring clinical competency, with one study finding reduced phasic activity with increasing clinical competence (Quick et al., 2017). Fewer studies have explored non-technical performance, such as decision-making, and this warrants further research. One study found greater levels of brain activity in regions associated with executive function and self-awareness in surgeons who completed regular meditation when completing an emotional regulation task (Sancar, 2019). Correlating such objective markers to subjective assessment metrics, particularly in non-technical domains, may provide further construct validity in assessment methods.

Effectiveness in performance is the precision of goal completion, and is the primary means of assessing surgical performance. When discussing surgical performance in the modern era, and depending on the context in which the healthcare setting is, shifts may be required to re-evaluate surgical performance through an efficiency paradigm. Efficiency refers to the costs of achieving such goals. In some instances efficiency may be emphasised due to the perceived need for surgeons to complete as many operations as possible, as is commonplace in resource-scarce environments. In others the emphasis is placed on effectiveness as the model may be driven by privatised healthcare. When discussing what is meant by 'surgical performance' in future studies, these should be considered.

Fatigue exploration

Objective measurement tools, such as fMRI, have been able to identify increased activities associated with exhaustion, such as increased activity in the right posterior cingulate cortex and right middle frontal gyrus (Durning et al., 2013). Despite this, efforts to define fatigue as a fully objective process, independently of the measurements humans have created as its metrics are futile. This is known as Muscio's paradox (Muscio, 1921). A systematic review, which sought to establish a reliable and valid survey instrument for fatigue measurement in emergency medical personal, found limited evidence for any instrument (Patterson et al., 2018). Ultimately, establishing a consortium of fatigue definition across healthcare is important if empirical efforts to mitigate it are to be implemented. Two barriers to creating standardised measurements for fatigue have been identified (Hockey, 2013). The first is the historical association of viewing fatigue as resulting from exhaustion of energy, fuelled by industrial revolution based metaphors. One of the greatest enigmas in performance decrement is whether it is resulting from depletion of resources, or a deletion of willpower (Hockey, 2013, p.33). Small energy differences are noticed in mentally demanding tasks (Raichle and Mintun, 2006), but these are not sufficient to provide a full explanation of the phenomena of fatigue. The second is the overemphasis of fatigue, inevitability resulting from work, as a negative state. It doesn't account for the emerging literature that work-demands differ between individuals, in that autonomy is greater in some levels of the profession than others, and that individuals engage in some tasks which lead to states of 'engagement', while others lead to 'resistance'. From a practical perspective, viewing fatigue as an emotional state which triggers an increase in self-awareness of cognitive and/or physical demands is an innovative strategy for performance optimisation in surgery. Future research should explore these phenomena, being cognisant of their historical biases and the emerging lens through which fatigue is being explored i.e. a motivational perspective.

One of the primary areas of future research, in surgery particularly is the distinguishing between fatigue and sleepiness. Emerging differences between the states of fatigue and sleepiness, through better understanding of the processes underlying both processes, will allow researchers to explore how they differ from one another, and influence one another. At a neurobiological level, there are differences in how both states impact glucose levels, with sleep deprivation depleting glucose metabolism at a much higher rate (Thomas et al., 2003) through the increase in adenosine production in the astrocytes nerve cells.

Unavoidable circumstances can lead to fatigue in surgery which cannot be immediately resolved. For that reason, one potential avenue for fatigue-performance relationships is through the use of biofeedback. Establishing if a surgeon is performing below their typical competency may be the primary signalling marker that the fatigued state is becoming problematic for performance standards. This can be assessed through objective measures using physiological changes. Feedback, linking these stressor indicators to performance outcomes, may increase self-awareness in surgeons to modify their performance. Similarly, observation of cortisol and other biological markers, as objective measurements of self-regulation of stress, may allow opportunities to explore adaptive responses to stressors and develop evidence-based positive coping strategies in surgery. This has wider implications for reducing chronic states of fatigue in surgery also. By changing mindset and stress appraisal, surgeons can decrease cortisol levels, in what is known as the growth index of stress (Hockey, 2013). The use of biomarkers, such as salivary cortisol and heart rate monitoring, to evaluate stress levels in surgeons and evaluate whether stress is negatively impacting on performance may offer meaningful objective feedback to surgeons on the potential limitations of their performance. In *Chapter 5*, it was discussed how surgeons perceived performance to be preserved in situations of high-stress, but systematic reviews and simulated study designs (Arora et al., 2010; Arora et al., 2010) have found that, in some instances, such stress responses may negatively correlate to optimal technical skill. One recent study identified, that in post-call states, residents showed increased inflammatory markers. Alongside this, reduced morning cortisol levels was identified suggesting reducing functioning of the central stress response system (Choshen-Hillel et al., 2021). The implications of low-grade systemic inflammation may have impacts of physical and mental health outcomes longer-term. For these reasons, the use of objective metrics of fatigue, and the associated variables, may assist in bridging the gap between acceptable fatigue and fatigue which impacts performance and/or health. Such interventions have been trialled and proved effective in surgery (Kratzke et al., 2021), though it must consider additional variables, such as the capability of the surgeon to use the information they are being provided with to reduce stress.

Behavioural neuroscience offers future opportunities to explore objective markers of the impact of fatigue on bodily systems. In particular, disfunctions around the basal ganglia appear to play a role with regards to fatigue (Chaudhuri and Behan, 2004). The pre-frontal cortex and parietal areas have been implicated in working memory functioning (Honey et al., 2002), but automaticity of processing may also play a role, as training of working memory has shown increased volumes in the basal ganglia region (Brooks et al., 2016). One study did find that neurocognitive tasks may be more taxing than technical tasks, which are well learned in surgery. The authors also suggest that attentional strategies, to activate enhanced prefrontal cortex activity, may be warranted in sleep deprived states (Leff et al., 2010). Consideration for additional objective measurements of cognitive load, such as task-invoked pupillary response, which has been found to be sensitive to cognitive load, may also be useful (Granholm et al., 1996)

Flow and thriving exploration

Given the dearth of research in surgery exploring positive psychological performance, exploration of thriving and flow is warranted. Establishing metrics for assessing thriving in work may be the primary means to argue the necessity for future positive psychological interventions in healthcare. This could be facilitated through qualitative, followed by empirical quantitative approaches. Constructs could be established by using objective markers, such as EEG. Depressive moods are associated with shortened REM latency and increased REM duration (Palagini et al., 2013). Interventions targeting depressive states may consider using EEG as an objective metrics to measure differences in wellbeing. In establishing markers, effectiveness of interventions targeted at improving wellbeing can be assessed. One area of promise in this regard is meditation. Some studies have shown that meditative practice can lead to both transient positive state creation, and longer-term trait formation. Meditation in some instances has shown differences in brain regions. Higher wellbeing has been found to correlate to larger amounts of grey matter in the right praecuneus (Sato et al., 2015), a part of the brain associated with promoting the sense of 'self'. Mindfulness-based interventions have been shown to play a positive effect on these regions (Kurth et al., 2014).

This research explored positive psychological constructs, and identified a myriad of additional factors to consider in optimising performance in surgery. Given this, the domains of flow and thriving in surgery, and their relationship to performance and wellbeing warrant further robust investigation. It was identified that, typically, surgical procedures are the flow environment. Similarly, surgery is a team-based profession, and emerging evidence on the concept of 'group flow' (Walker, 2010) should be explored in surgery, particularly with regards to this potential buffering effect on fatigue. Experience sampling, trialled in this research for fatigue assessment, has been suggested as a research methodology to better identify when and how flow states occur in surgery. In addition, flow questionnaires can be used to assess individuals experiences of flows and relate them to specific tasks and context. Finally, flow experiences can be objectively assessed using neuroscientific techniques. Flow states are characterised by transient hypo-frontality (Dietrich, 2004), whereby the prefrontal cortex activation is reduced, thus reducing complex decision-making and anxious states. Use of EEG can show access to effective learning and flow states in surgery. Gamma waves are highest in states of 'binding', which allows the 'eureka' moment of peak performance, to occur in surgery (Santarnecchi et al., 2019). Emerging discussions from the Flow Research Collective™, a research and training organisation partnering with several academic institutions, has begun to identify neurohormonal differences associated with the flow states including increases in norepinephrine and dopamine in the system. Further research into the biological markers associated with the flow state, using surgery as a case example, are warranted, as well as establishing relationships between peak performance experiences and longer-term eudemonic wellbeing and thriving states.

10. Chapter 10 – Conclusion

Aristotle once said *"We are what we repeatedly do".* Centuries old cultures, which have propagated ill-found philosophies of over-working, over-exerting, and under-resting have placed surgeons in a fatigue endemic. This had been fuelled by additional environmental stressors, including industrial revolution structures, and a complex healthcare system which constantly grapples with either lack of, or inappropriate allocation of resources. A fundamental shift in understanding the causes and effects of fatigue in surgery has been provided, with triangulating evidence. Evident also is the likely impact of fatigue on all three domains of surgical performance.

This body of work established the need for the review of fatigue in surgery to be explored through a multi-method data collection approach. This included going beyond typical positivist approaches, and merging qualitative and quantitative findings to inform an evidence-based and theoretically informed behaviour-based intervention. Local, national, and international surgical cohorts were explored, with comparisons drawn with local and national physiotherapy cohorts. Fundamentally, changing how fatigue is viewed within healthcare systems offers new opportunity to learn its impact on performance, system efficiency, and ultimately on patient care. Innovative solutions to complex issues were explored through collaboration and informed designs and interpretations, with input from the disciplines of sleep medicine, psychology, and human factors parallel high-performance industries, such as aviation and elite sport.

Fatigue management is a joint responsibility of stakeholders within institutions, and developing supporting organisation systems which enable collective responsibilities of self-management performance optimisation are important. Healthcare systems which were traditionally inflexible, with an overemphasised structural hierarchical management, need to proactively inform organisational changes which are tackling longer known risk-phenomena, such as fatigue in surgeons. This change in practice requires a cultural shift in how staff wellbeing is prioritised in surgery, and its relationship to patient outcomes. Modelling this shift from resource to individualised approaches requires good management and leadership in a context where there are ever increasing demands and limited resources. The COVID-19 pandemic, as seismic and devastating as it was for many, including healthcare workers, provided an opportunity for change. Often times the required change needed is one which comes when change is unavoidable. In particular, the pandemic highlighted the potential role of personal behaviour-based interventions in performance management. The primary mechanism for change, so as to enable performance optimisation, lies with the individual themselves. Emphasis on educating staff on the link between self-regulation and performance optimisation, to increase self-awareness, is pivotal to necessitate the required behaviour changes needed to reduce fatigue in the surgical profession. However, environmental restructuring to facilitate performance optimisation, particularly through biomathematical modelling of work-life will likely sustain behavioural efforts. Additionally, the cultural issues, which are prevalent in surgery, may be best addressed through engaging change-agents in any efforts. The findings of this thesis are likely to have aspects of generalisability to other healthcare professions, as the physiotherapy population, used throughout the body of work, shed insight into shared levels of fatigue. In that, interventions should be cognisant not to perpetuate further inequity between demographics. One example identified throughout was the role of gender. Healthcare is a predominantly female-dominated industry, and the additional domestic responsibilities typically, though not always, are borne by females. It is important therefore that the traditional distinction between work-life balance must be cognisant of additional non-work stressors when considering means to optimise work performance.

There is oftentimes a focus on negative performance domains, and the impact of current environmental and cultural restrictions on surgical performance. This thesis provides legitimate and warranted need for further exploration of the positive aspects of performance, and how the roles of three personal variables – recovery processes, psychological capital and psychological skills utilisation may mediate the levels of thriving while also being subject to fatigue in healthcare. With the ongoing COVID-19 pandemic, fundamental shifts in the lens through which healthcare is viewed through, and the metrics on which healthcare sustainability is considered, are warranted. Recognising the increasing 'blurred lines' between personal and professional lives, particularly in a profession like surgery, means that any intervention must have the surgeon, as a whole person, at its centre. This has wider implications for the professional body and healthcare system in its entirety. In particular, it provides insight into the necessity for self-regulation and management as the bedrock of performance management, and the required lifestyle and work factors necessitated to change the prevailing narrative of 'surviving' in surgery to the proposed opportunities for 'thriving' in surgery.

On May 13th 1989, Libby Zion's father, Mr Sidney Zion, wrote an earnest editorial in *The New York Times.* He outlined how his late daughter was admitted to a New York hospital with minor ailments, and unexpectedly died soon after. Mr Zion spoke about how those practitioners who rationalise that "It's good for doctors to work so hard" are part of the problem. This mindset, he determined, was a “guaranteed disaster for untold patients”. While Mr Zion and his family took solace in recent initiatives to reduce fatigue in residents, such as working time limitations, he lamented at the discourse surrounding their implementation; “not that they’re against the reforms, God forbid. It’s just not the propitious time, too many other things on the table, we’ve got to take care of the patients”.

Mr. Zion saw a vision for a future healthcare system, one which saw parity placed on optimising performance in staff to ensure optimal patient safety – “Once upon a time in America, the finest hospitals were run by the least experienced and most overworked apprentice doctors. Until one Sunday night in New York, a red-headed girl named Libby Zion..” changed it all. Despite advances in healthcare provision and performance management since then, there remains a significant amount of work to be done to prevent such egregious and tragic errors from happening again. This body of work has shown how issues of fatigue continue to perpetuate healthcare systems, and the individuals within them. These issues are complex and require a multifaceted intervention. This research provided a narrative shift on how to optimise performance, considering the vision of a thriving surgeon as the gold standard of achievement on which all prospective efforts should be aiming for. The establishment of behaviour-change interventions, supported by professional and structural supports will enable the optimisation of performance in surgery. Over three decades later, this change has the potential to fulfil Mr. Zion’s vision.