

Physical function in community-dwelling older adults – a focus on health inequality and ageing in place

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*A thesis submitted for the degree of Doctor of Philosophy at the University of
Dublin, Trinity College Dublin, Ireland*

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May 2023

Declaration

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Lauren Swan

Acknowledgements

Firstly, I would like to thank my supervisor, Professor Maria O'Sullivan, for agreeing to supervise my MSc. thesis in 2018 and encouraging me to continue my studies. You have dedicated so much time and effort into my personal and professional development over the last 4 years. I feel incredibly lucky to have you as a supervisor. To Dr Austin Warters, thank you for being such a kind and generous mentor. When I sent that email over 7 years ago with an idea for a volunteering project, who would have thought it would lead to the body of work that we have completed to date. Without your encouragement, I would have never considered pursuing a PhD - thank you for recognising my potential. Thank you to my sponsor organisation, North Dublin Home Care, and Debbie Rooney, CEO. I feel fortunate to have worked alongside you all, specifically throughout the pandemic, and continue to be inspired by the work you do every day. It has been an immense privilege to conduct research alongside home support workers and older people in receipt of this service – who were always happy to support me.

To my parents, it is difficult to put into words how grateful I am to you both. Dad, all of your effort and selflessness, including weekends spent at chess competitions and frantic drop-offs to maths grinds in between deliveries, have led to this. You have always championed the value of education and made sure that we viewed every opportunity for further study as a privilege not afforded to many. To Mam, thank you for providing the unwavering self-belief and confidence that I often lack. The reason I can throw myself into things is because I know I have your unconditional support to fall back on. To my brothers, Darren and Adam, I understand that anything I put in writing may be used against me at a later date – thank you, and to your better halves, Linda and Rose, thank you for being my constant hype squad. To my best friend, Shannen, although 8,000 miles away, I feel like you have been by my side every step of the way. To Aoife and Lauren, thank you for always checking in on me and supporting me throughout this journey. To my wonderful niece and nephew, Addison and Riley, I look forward to reading your PhD theses one day!

Lastly, to Luke, the weekends spent at conferences, cancelled plans, constant pep-talks and presentations made while on holidays – you have never complained. Thank you for being the support I lean on all too often.

Summary

This thesis investigated associations between socioeconomic position (SEP) and physical function in community-dwelling older adult populations, with implications for ageing in place. The work addressed a number of markers of physical function, largely focusing on sarcopenia. Sarcopenia in ageing, is essentially a loss of muscle strength, that adversely affects physical function, commonly leading to impairment in activities of daily living (ADLs). Social gradients in physical function in older adult populations have been reported, but limited research has specifically focused on socioeconomic disadvantage and sarcopenia. While evidence of ‘accelerated ageing’ in populations with socioeconomic disadvantage is emerging, there is a need to explore health inequalities across markers of physical function in populations of older age (80+ years), with physical dependency or disadvantaged SEP. The identification of groups at high risk of functional decline, including sarcopenia, may inform strategies to better support ageing in place.

The first part of this thesis, Chapters 3 and 4, aimed to describe the prevalence of probable sarcopenia, a marker of impaired physical function, in community-dwelling older adults, with a specific focus on socioeconomic determinants. This was achieved through cross-sectional analysis of two large population studies. Firstly, we conducted an analysis of Wave 1 of The Irish Longitudinal Study on Ageing (TILDA), a large nationally representative study of ageing in Ireland (n= 3,342). The prevalence of probable sarcopenia was 23%, significantly higher in older adults with the most compared with least disadvantaged SEP, when defined by educational attainment (29% vs 18%, $p<0.001$) and wealth (29% vs 17%, $p<0.001$). Multivariable analyses identified disadvantaged SEP, defined by educational attainment, in addition to older age, low physical activity, number of chronic conditions, osteoarthritis and receipt of home care as predictors of probable sarcopenia (Chapter 3).

In Chapter 4, to corroborate and extend the previous findings, a similar cross-sectional study of community-dwelling older adults in England was conducted through analysis of Wave 6 of the English Longitudinal Study of Ageing (ELSA) (n= 6,052). This study included more comprehensive measures of SEP, including educational attainment and subjective social status, applicable to community-based settings, and two measures of probable sarcopenia: hand grip strength and chair rise test performance. Probable sarcopenia was detected in 34% of participants, highest among people with disadvantaged SEP, when classified as completing no formal educational qualifications (47%) or disadvantaged subjective social status (53%). The findings show irrespective of how SEP was defined, or which marker of probable sarcopenia was applied, older

adults with disadvantaged SEP had an increased likelihood of probable sarcopenia. Collectively, both population studies represent important new findings, showing associations between disadvantaged SEP and probable sarcopenia in Irish and English older adults, with mean age 69 and 71 years, respectively, with further work exploring populations of older age with increased physical dependency.

Given that some groups are underrepresented in national ageing studies, routine health administrative data were analysed to investigate whether associations between SEP and physical function may persist in populations of older age and increased functional dependency (Chapter 5A). A cross-sectional study of a large population of older adults (mean age 84 years, 70% aged 80 years and older), all with ADL dependency and supported in the community by formal home support in Ireland (n= 1,591), was conducted. The study showed that older adults living in socioeconomically disadvantaged areas experienced greater polypharmacy, high physical dependency, acute hospitalisation, and suggested a 6.5-year earlier need for state home support than in affluent settings (Chapter 5A). The findings suggest that the association between disadvantaged SEP and markers of poor physical function persist in populations of older age with physical dependency. To further explore physical function in this population, a prospective home-based study was conducted with a small cohort of older adults in receipt of formal home care. Chapter 5B described sarcopenia, along with frailty, malnutrition risk and physical inactivity, in addition to markers of SEP, with ADL-dependant community-dwelling older adults. A majority of this cohort met the criteria for probable sarcopenia, frailty, and physical inactivity with over a quarter identified as at risk of malnutrition and warrant a larger scale study. The findings suggest a need for interventions and customised strategies to maintain physical function in this population, for example physical activity and dietary approaches.

This was explored in Chapter 6, which examined the feasibility of delivering a physical activity programme for older people within formal home care services; specifically focussed on barriers and enabler identified through semi-structured qualitative interviews with 22 health care assistants. Overall, the findings suggest that embedding physical activity initiatives within home support services could be feasible, however several barriers were identified including limited time and the task-orientated environment of home support. While this study may provide a useful starting point in the delivery and design of interventions for community-dwelling older adults, the thesis findings indicate that broader issues may also need to be considered including socioeconomic disadvantage and psychosocial factors. Importantly, the findings suggest a need to move

beyond unifactorial interventions, to more personalised proactive approaches, which may maintain physical function and support ageing in place.

This thesis consistently shows associations between disadvantaged SEP and probable sarcopenia, in two large ageing studies. Further work, derived from administrative data, showed that disparities in physical function persist in populations of more advanced age and physical dependency, for example older adults in receipt of formal home support. Notably, the latter represents a population group often underserved in traditional health research. Overall, the body of work highlights that prioritising resources and primary care interventions in socioeconomically disadvantaged areas seems valuable, as suggested by SláinteCare. We explored one potential approach, embedding physical activity within formal home support services in the community, however, this needs tailoring and future work should explore interventions that are acceptable to older adults with older age, disadvantaged SEP, and physical dependency, including people supported in the community with formal home support services.

Impact of the Covid-19 pandemic on the work presented in this thesis:

The research outlined in the present thesis crossed the timeline of the Covid-19 pandemic, and for much of this time, in-person fieldwork was not possible. This necessitated restructuring of the scope and direction of the studies presented in the final thesis. The focus was to explore SEP and physical function in relatively healthy 'younger-old' adults (<80 years), in addition to people with older age and physical dependency, including older adults supported in the community by formal home support. The thesis availed of opportunities to analyse two large population datasets in ageing. Alongside this, we studied SEP and markers of physical function in community-dwelling older adults with ADL-dependency and supported by home care. Furthermore, I engaged in an existing intervention study exploring physical activity in home care and led a qualitative component utilising telephone interviews. The original thesis plan placed a greater focus on the prospective in-home study to recruit a larger cross-sectional sample of older adults, which would allow for in-depth qualitative and quantitative analyses. This study planned to commence in early 2020 and was scaled back in response to Covid-19-related public health measures. Ultimately, this fieldwork could not begin until 2022 and was limited to a single-site. Despite the small sample of older adults recruited, the initial findings provide real-world insight into an underserved population. Throughout the thesis, adaptations related to the ongoing Covid-19 pandemic were regularly discussed and agreed with research supervisors and collaborators, highlighted in annual progress and continuation reports and reviewed regularly.

Dissemination

Scientific Articles Accepted

As a result of thesis work:

Swan L., Horgan, N F., Martin, N., Warters, A., and O'Sullivan, M. Assessing Sarcopenia, Frailty and Malnutrition in Community-dwelling Dependant Older Adults – An Exploratory Home-based Study of an Underserved Group in Research (2022). International Journal of Environmental Research and Public Health. <https://doi.org/10.3390/ijerph192316133> (**Chapter 5B**)

Swan L., Horgan, N F., Fan, C W., Warters, A., and O'Sullivan, M. Residential area socioeconomic deprivation is associated with physical dependency and polypharmacy in community-dwelling older adults: an analysis of health administrative data in Ireland (2022). Journal of Multidisciplinary Healthcare <https://doi.org/10.2147/JMDH.S380456> (**Chapter 5A**)

Swan L., Warters, A., and O'Sullivan, M. Socioeconomic Disadvantage is Associated with Probable Sarcopenia in Community-dwelling Older Adults: Findings from the English Longitudinal Study of Ageing (2022). Journal of Frailty and Ageing. <https://doi.org/10.14283/jfa.2022.32> (**Chapter 4**)

Swan, L., Horgan, F., Cummins, V., Doyle, F., O'Sullivan, M., Galvin, R., Burton, E., Sorensen, J., Skelton, D., Townley, B., Rooney, D., Jackson, G., Warters, A and O'Sullivan, M. Embedding Physical Activity within Community Home Support Services for Older Adults in Ireland – A Qualitative Study of Barriers and Enablers (2022) Clinical Interventions in Aging, 17, 223-234. <https://doi.org/10.2147/CIA.S351431> (**Chapter 6**)

Swan, L., O'Sullivan, M., Warters, A. "Socioeconomic Inequality and Risk of Sarcopenia in Community-dwelling Older Adults (2021). Clinical Interventions in Aging, 16, 1119-1129. <https://doi.org/10.2147/CIA.S310774> (**Chapter 3**)

Related to thesis work:

Horgan, F., Cummins, V., Doyle, F., O'Sullivan, M., Galvin, R., Burton, E., Sorensen, J., Jabakhanji, S., Skelton, D., Townley, B., Rooney, D., Jackson, G., Murphy, L., **Swan, L.**, O'Neill, M., Warters, A. Enhancing Existing Formal Home Care to Improve and Maintain Functional Status in Older Adults: Results of a Feasibility Study on the Implementation of Care to Move (CTM) in an Irish Healthcare Setting (2022). International Journal of Environmental Research and Public Health. <https://doi.org/10.3390/ijerph191811148>

Burton, E., Horgan, F., Cummins, V., Doyle, F., O'Sullivan, M., Galvin, R., **Swan, L.**, Sorensen, J., Skelton, D., Townley, B., Rooney, D., Warters, A. A Qualitative Study of Older Adults' Experiences of Embedding Physical Activity Within Their Home Care Services in Ireland (2022). Journal of Multidisciplinary Healthcare <https://doi.org/10.2147/JMDH.S351714>

Horgan, F., Cummins, V., Doyle, F., O'Sullivan, M., Galvin, R., Burton, E., Sorensen, J., Skelton, D., Townley, B., Rooney, D., Jackson, G., **Swan, L.**, Warters, A. "Enhancing existing formal home care to improve and maintain functional status in older adults: Protocol for a feasibility study on the implementation of the Care to Move (CTM) programme in an Irish healthcare setting (2020). Journal of Frailty, Sarcopenia and Falls. <https://doi.org/10.22540/JFSF-05-0101>

Conference Oral Presentations

L Swan, F Horgan, V Cummins, F Doyle, R Galvin, E Burton, J Sorensen, SB Jabakhanji, D Skelton, B Townley, D Rooney, G Jackson, L Murphy, A Warters, M O'Sullivan. Embedding Physical Activity within Home Care Services for Older Adults in Ireland – A Qualitative Study of Barriers and Facilitators (2021). Age & Ageing. <https://doi.org/10.1093/ageing/afab216.199> Irish Gerontological Society (IGS) Annual Conference 2021.

Swan, L., Warters, A., O'Sullivan, M. Socioeconomic Position and risk of Sarcopenia in community-dwelling Older Adults: Findings from the English Longitudinal Study of Ageing. International Conference on Frailty and Sarcopenia Research 2021. <https://doi.org/10.14283/jfa.2021.34>

Swan, L., Warters, A., O'Sullivan, M. Socioeconomic Inequality and Risk of Sarcopenia in Community-Dwelling Older Adults. Trinity's Health and Education International Research Conference 2021

Conference Poster Presentations

Swan, L., Martin, N., Warters, A., O'Sullivan, M. Assessing Sarcopenia, Frailty and Malnutrition in Community-dwelling Dependant Older Adults – A Home-based Study of an Underserved Group in Research (2022). Age & Ageing. <https://doi.org/10.1093/ageing/afac218.016>

Swan, L., Warters, A., O'Sullivan, M. Health and Socioeconomic Determinants of Probable Sarcopenia: An Analysis of the English Longitudinal Study of Ageing (2021) International Sarcopenia Translational Research Conference 2021.

Swan, L., Warters, A., O'Sullivan, M. Characteristics of community-dwelling dependant older adults in receipt of home support in areas of high socioeconomic deprivation (2020). SPHeRE 8th Annual Conference.

Swan, L., Warters, A., O'Sullivan, M. Socioeconomic inequality is a determinant of probable sarcopenia in community-dwelling older adults (2020). Clinical Nutrition ESPEN. <https://doi.org/10.1016/j.clnesp.2020.09.844> 2020 ESPEN Virtual Conference 2020

Research Awards

Recipient of the Irish Gerontological Society's President Award for Best Healthy Ageing Research at the 2021 IGS Annual Conference

Recipient of the Dove Press Publisher's Best Medical Abstract Video Award 2022

List of Abbreviations

ADLs	Activities of Daily Living
ALM	Appendicular Lean Mass
ANOVA	Analysis of Variance
ASM	Appendicular Skeletal Muscle Mass
AWGS	Asian Working Group on Sarcopenia
BIA	Bioimpedance Analysis
BMI	Body Mass Index
CFS	Clinical Frailty Scale
CI	Confidence Interval
CR	Chair Rise
CRP	C-reactive Protein
CSAR	Common Summary Assessment Report
CT	Computed Tomography
CTM	Care To Move
DXA	Dual-energy X-ray Absorptiometry
ELSA	English Longitudinal Study of Ageing
EWGSOP	European Working Group on Sarcopenia in Older People
EWGSOP2	European Working Group on Sarcopenia in Older People 2
FCI	Functional Comorbidity Index
FNIH	Foundation for the National Institute of Health
GCE	General Certificate of Education
HCA	Health Care Assistant
HGS	Hand Grip Strength
HSE	Health Service Executive
IADLS	Instrumental Activities of Daily Living
ICFSR	International Clinical Practice Guidelines for Sarcopenia
IL-6	Interleukin-6
INGS	International Working Group on Sarcopenia
IPAQ	International Physical Activity Questionnaire
IQR	Interquartile Range
Kg	Kilogram
LBM	Lean Body Mass
MNA-SF	Mini Nutritional Assessment – Short Form
MRI	Magnetic Resonance Imaging

N	Sample size
NFQ	National Framework Qualifications
NHS	National Health Service
NVQ	National Vocational Qualification
OR	Odds Ratio
OT	Occupational Therapist
PI	Principal Investigator
PIL	Participant Information Leaflet
PS	Probable Sarcopenia
Q	Quartile
RCT	Randomised Controlled Trial
SAT	Single Assessment Tool
SD	Standard Deviation
SDG	Sustainable Development Goal
SDOC	Sarcopenia Definitions and Outcomes Consortium
SEP	Socioeconomic Position
SHARE	Survey of Health, Ageing and Retirement in Europe
SHSS	Statutory Home Support Scheme
SPPB	Short Physical Performance Battery
SSS	Subjective Social Status
TILDA	The Irish Longitudinal Study on Ageing
TNF α	Tumour Necrosis Factor α
TUG	Timed-up and Go
UK	United Kingdom
UKHLS	United Kingdom Household Longitudinal Survey
VIFs	Variance Inflation Factors
WHO	World Health Organization
χ^2	Chi-square test for independence

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Chapter 1 - Introduction

1.1 Healthy Ageing: An Unequal Experience

In Ireland, the number of adults aged 80 years and older is projected to rise to 549,000 by 2051, representing a 371% increase on 2016 Census figures ¹. Ireland's ageing population underlines a growing need to ensure older adults are supported to remain living at home for as long as they wish, coined 'ageing in place'. This is reflected in Sláintecare's 2021-2023 Implementation Strategy & Action Plan ², which outlined a commitment to "support people to live independently in their own community for as long as possible". This strategy describes additional complexity in supporting people with socioeconomic disadvantage to age successfully, acknowledging the need for inclusive policies and personalised interventions ²;

"There are many groups of people who require tailored health and social care interventions, in order to address the health inequalities they face."

Research examining the accumulation of socioeconomic disadvantage over the life course reports social gradients in health from childhood that become steeper with age, until later life, when limited evidence suggests narrowing health disparities ^{3,4}. Irrespective of how socioeconomic position (SEP) is defined, whether by individual-level factors such as education, wealth or occupational class, or using area-level deprivation indices, individuals with disadvantaged SEP can expect to live shorter lives, with a greater proportion of their life spent in ill-health ^{5,6}. In the United Kingdom (UK), adults living in areas with high socioeconomic deprivation observe a healthy life expectancy of 52.3 years compared to 70.7 years among those living in the least deprived areas ⁷. Similarly, a five-year differential in life-expectancy has been reported between adults residing in the most vs. least deprived areas in Ireland ⁸. Whether health disparities persist in populations of advanced age (80+ years) or start to abate in later life is less clear, with most evidence derived from younger cohorts.

A growing body of evidence highlights the impact of socioeconomic disadvantage in healthy ageing trajectories ⁹, however, socioeconomic determinants are sometimes overlooked compared to other modifiable risk factors of disease. A meta-analysis of 1.7 million participants in 48 independent prospective cohort studies identified socioeconomic disadvantage, defined by occupation class, as a leading cause of premature mortality globally ¹⁰. When compared to other modifiable risk factors, SEP was associated with a 2.1 year reduction in life expectancy, similar to the effect of physical inactivity (-2.4 years) but significantly higher than high alcohol intake (-0.5 years), obesity (-0.7 years) and hypertension (-1.6 years) ¹⁰. Governmental policy,

enacted through the Healthy Ireland initiative, has established formal public health taskforces targeting physical inactivity (*National Physical Activity Plan*¹¹), obesity (*Obesity Policy and Action Plan*¹²), high alcohol consumption (*Healthy Ireland Alcohol Policy*¹³) and smoking (*Tobacco Free Ireland Programme*¹⁴). Yet, a similar approach has not been adopted for the socioeconomic determinants of health. The Sláintecare Strategic Action Plan outlines a strong commitment to alleviating health inequalities². Research exploring the role of socioeconomic disadvantage in ageing, should allow for the identification of groups at high risk of adverse health outcomes. Timely intervention, including the development of inclusive policies that consider socioeconomic disadvantage, is required to reduce health inequalities and support healthy ageing.

1.2 Physical Function in Ageing

1.2.1 Physical Function in Ageing

In 2015, the World Health Organization (WHO), introduced a new definition of healthy ageing, moving beyond unrealistic concepts centred on disease-free states, to an emphasis on “maintaining the functional ability that enables well-being in older age”¹⁵. Physical function, a domain of healthy ageing, is the ability to safely complete the tasks necessary to maintain quality of life and age in place, determined by a combination of mobility status, upper and lower extremity strength, postural stability, balance and endurance¹⁶. While the proportion of older adults with functional limitations increases with age¹⁷, this trajectory is not inevitable. Evidence suggests, that some population groups, including those with socioeconomic disadvantage, will experience steeper trajectories of physical decline, including premature onset of functional limitations¹⁸.

Life course model of modifiable risk and protective factors of impaired physical function		
Optimise and reduce modifiable risk factors over the life course		
	Protective Factors	Risk Factors
Birth	Parental education - Physical stimulation -	- Low birth weight - Malnutrition
Childhood	Parental education and occupation - Physical activity - Adequate diet - Access to open recreational space -	- Childhood trauma or stress - Low educational attainment
Adulthood	Educational attainment - Occupation - Income - Physical activity - Adequate diet -	- Obese BMI - Unsafe working conditions - Smoking - High alcohol consumption - Residential Area Deprivation
Late Life	Educational attainment - Income - Wealth - Physical activity -	- Cognitive impairment - Social Isolation - Polypharmacy - Malnutrition - Underweight BMI
↑ Accumulated Risk of Physical Functional Limitations		

Figure 1.1 A life course approach to physical health: modifiable risk and protective factors of physical functional limitations in later life. Education and wealth inequalities in healthy ageing. The Lancet Public Health ¹⁹. Progression of functional limitations in relation to physical activity: a life course approach. European Review 2011 ²⁰.

As highlighted in Figure 1.1, the onset and progression of functional limitations in ageing is a multifactorial and complex process, with accumulating evidence identifying socioeconomic disadvantage as an important risk factor of physical decline ^{9,21,22}. While some physical decline can be attributed to the biological process of ageing, research suggests the rate of decline may be greater in individuals with socioeconomic disadvantage, minority group ethnicity, physical inactivity, multiple chronic conditions, obese BMI, cognitive impairment and depression ^{9,23–25}. Recent research describes individuals with socioeconomic disadvantage as experiencing ‘accelerated ageing’ in several domains of physical function, including gait speed and grip strength ⁹. The LIFEPAATH Consortium, in analyses of walking speed in adults aged 45-90 years old (n= 109,107), reported that men at age 60 years with socioeconomic disadvantage had a

walking speed equivalent to that of a man aged 67 years with high SEP ²¹. Similarly, women in the most disadvantaged SEP group observed 4.6 years of lost function when compared to those with high SEP ²¹. Identifying groups that may experience different rates of physical decline is important, as evidence from intervention studies shows physical function can be regained and restored ²⁶.

Most evidence, however, is derived from populations aged under 80 years, with the exception of the Newcastle 85+ study. Kingston et al reported the loss of physical function in ageing follows a hierarchical scale, with difficulty in completing personal care tasks initially observed, escalating to dependency in feeding ²⁷. Among the Newcastle 85+ study cohort, socioeconomic factors, including lower educational attainment, were identified as influencing the number of accumulated functional limitations, suggesting an enduring effect of socioeconomic disadvantage in later life ²⁸. Others, in research with younger study populations, suggest socioeconomic-differentials in physical decline attenuate in the oldest-old (80+ years) ^{19,22}. Whether socioeconomic disadvantage influences physical function, including objective measures of physical decline and sarcopenia, in populations of older age is less clear.

1.2.2 Assessing physical function in community-dwelling older adults

The assessment of physical function in community-dwelling older adult populations forms a critical component of ageing research and clinical practice. The domain of physical function encompasses a broad range of subjective and objective measurements, approaches and instruments. Traditionally, the assessment of physical function has focussed on the capacity of an individual to independently complete specific tasks, such as activities of daily living (ADLs) ^{29,30}. More recently, research has placed a greater emphasis on the use of objective measurements including physical performance or muscle strength tests such as hand grip strength, chair rise test performance, gait speed and the timed-up-and-go test (TUG) ^{31,32}, forming components of the Short Physical Performance Battery (SPPB) ¹⁶. While objective measurements have demonstrated a predictive validity for incident adverse health outcomes ³³, there is a need to explore measures of physical function that are meaningful to older adults, such as subjective measures of independence in ADLs, showing correlations with quality of life ³⁴.

While this thesis explores both subjective and objective markers of physical function, it largely focuses on hand grip strength and chair rise test performance, markers of the muscle condition, sarcopenia. Hand grip strength is frequently examined in research,

included in many large ageing studies, due in part, to its role as an indicator of overall health status and as a primary outcome measure in intervention studies ^{35,36}. A recent systematic review and meta-analysis of the prognostic value of hand grip strength in community-dwelling older adult populations, identified a predictive validity for decline in cognitive and physical function and mortality ³³. The measurement of hand grip strength is applicable to community-based settings due to the cost, availability and ease of data collection using a hand-held dynamometer ³⁷, providing an accessible tool in the evaluation of physical function and sarcopenia. The measurement of chair rise test performance however, is more complex, with the likelihood of test non-completion increasing with age and physical dependency ^{38,39}.

In community-based settings, the assessment of hand grip strength, chair rise test performance and validated ADL-questionnaires, applicable to community-based settings, represent simple, practical, and inexpensive tools at a population-level. This deficit-based approach to the conceptualization of physical function, however, may overlook individual-level factors, such as the role of fatigue ⁴⁰, in addition to environmental and behavioural factors. The identification of groups at high risk of functional impairments is integral to the design and delivery of primary care initiatives that may support ageing in place ⁴¹.

1.2.3 Sarcopenia in ageing in community-dwelling older adults

Sarcopenia, a condition characterised by the accelerated loss of muscle strength, mass and function ³⁷, is associated with falls, disability, hospitalisation and mortality ^{42,43} and closely linked to impaired physical function ⁴⁴. A recent systematic review and meta-analysis identified associations between sarcopenia criterion, low muscle strength, and future ADL dependency in older adults ⁴⁵. As detailed in Figure 1.2, sarcopenia and impaired physical function display overlapping characteristics, including the diagnostic markers of low hand grip strength and poor chair rise test performance ³⁷, and common socioeconomic, demographic, health and behavioural risk factors ⁴⁶. Importantly, the onset of sarcopenia and impaired physical function, identified as potentially reversible processes ^{26,47}, share a primary prescription treatment of physical activity ³⁷.

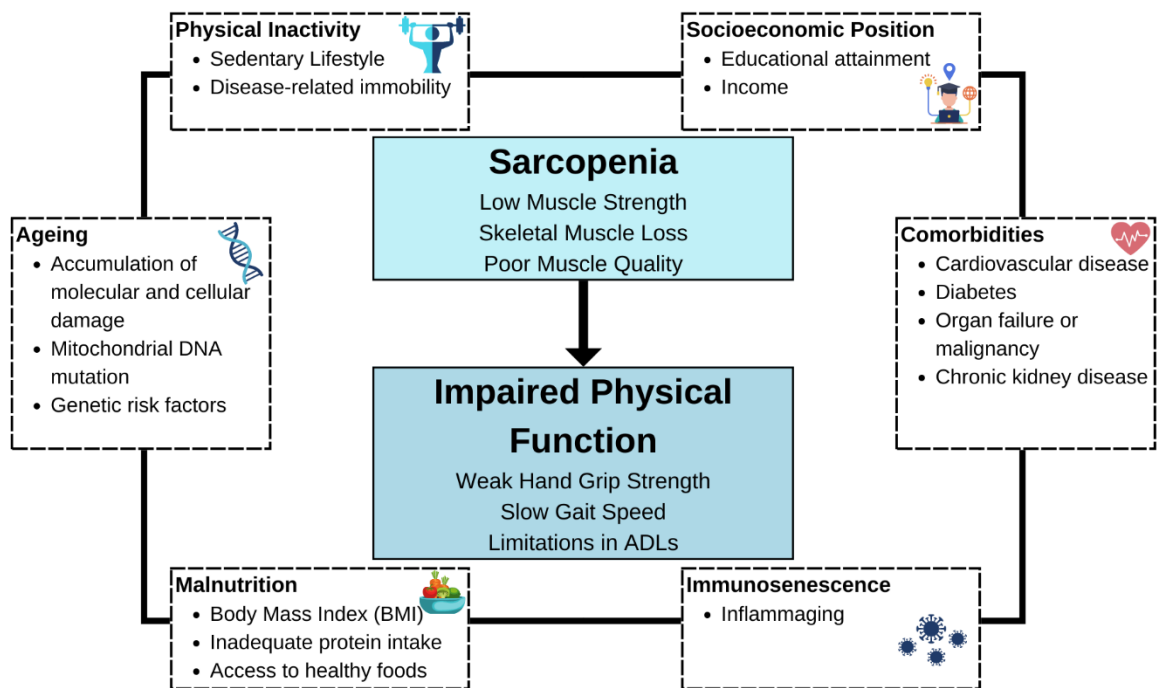


Figure 1.2: Association between sarcopenia and impaired physical function including shared characteristics and risk factors

There are several biological mechanisms attributed to the development of primary (age-related) and secondary (evidence of other causal factors) sarcopenia, and both types may co-exist ³⁷. These proposed biological mechanisms include impaired muscle protein synthesis, mitochondrial dysfunction, changes in cell apoptosis, impaired neuromuscular integrity, greater intramuscular muscle fat content, increased muscle protein breakdown and anabolic resistance ⁴⁸. Additionally, there is good evidence to support the role of inflammation in the development of sarcopenia, with higher level of circulatory inflammatory markers showing inverse associations with muscle mass, strength and function ⁴⁹. This is important as emerging evidence suggests individuals with socioeconomic disadvantage experience a greater burden of sarcopenia ^{50–52}, with links between disadvantaged SEP and increased inflammatory markers also detected ⁵³. Sarcopenia likely involves complex interplay between multiple biological pathways, thus increasing the difficulty of detecting sarcopenia onset and designing targeted pharmacological treatments. While socioeconomic disadvantage and sarcopenia are linked to increased levels of inflammatory markers, SEP has broader effects including access to health-enhancing resources and behaviours, as detailed later in Section 1.4.2.

1.2.3.1 Defining Sarcopenia in Ageing

Sarcopenia is major public health concern, with an estimated global prevalence between 10-27% in people aged 60 years and older ⁵⁴ and associated with limitations in ADLs, falls, disability, hospitalisation and mortality ^{55–57}. The European Working Group on Sarcopenia in Older People 2 (EWGSOP2) define sarcopenia as ‘a muscle disease rooted in adverse muscle changes that accrue across a lifetime’ ³⁷. These current guidelines represent an update on the EWGSOP 2010 definition ⁵⁸, and provide a practical European definition, focusing on skeletal muscle strength more readily applied to older populations. Prior to this, sarcopenia definitions largely focussed on muscle mass, confining identifications to research and acute settings, with the updated 2019 guidelines highlighting the importance of community-based settings in the assessment and treatment of sarcopenia ³⁷. Currently, four definitions are most commonly applied in epidemiological research, of which three have recently been updated (**Table 1.1**) ^{37,59–61}.

Table 1.1: Current definitions of sarcopenia operationalised in health research

Probable/Pre-Sarcopenia	Sarcopenia	Severe Sarcopenia
European Working Group on Sarcopenia in Older People 2 (EWGSOP2) ³⁷		
HGS: <16 kg in women <27 kg in men	ASM: <15 kg in women <20 kg in men	Gait speed: ≤ 0.8 m/s
<i>OR</i>	<i>OR</i>	TUG: ≥ 20 s
CR: 5 chair rises >15 seconds	ASM/height²: <5.5 kg/m ² in women <7.0 kg/m ² in men	SPPB: ≤ 8 point score
		400m walking test: Non-completion or ≥ 6 minutes
Foundation for the National Institute of Health (FNIH) ⁵⁹		
N/A	HGS: <16 kg in women <26 kg in men	N/A
	AND	
	ALM: <0.512 m ² in women <0.789 m ² in men	
Asian Working Group for Sarcopenia (AWGS) ⁶⁰		
HGS: <18 kg in women <28 kg in men	ASM/height²: <5.4 kg/m ² in women <7.0 kg/m ² in men	6-metre walk: <1.0 m/s
<i>OR</i>		SPPB: ≤ 9 point score
CR: 5 chair rises ≥ 12 s		
International Working Group on Sarcopenia (INGS) ⁶¹		
N/A	Gait speed: <1 m/s	N/A
	AND	
	ASM/height²: ≤5.67 kg/m ² in women ≤7.23 kg/m ² in men	

Abbreviations: ALM, Appendicular Lean Mass; ASM, Appendicular Skeletal Muscle Mass; CR, Chair Rise; HGS, Hand Grip Strength; SPPB, Short Physical Performance Battery TUG, Timed-up-and-Go test.

1.2.3.2 Current Guidelines in Europe - EWGSOP2 Definition of Sarcopenia

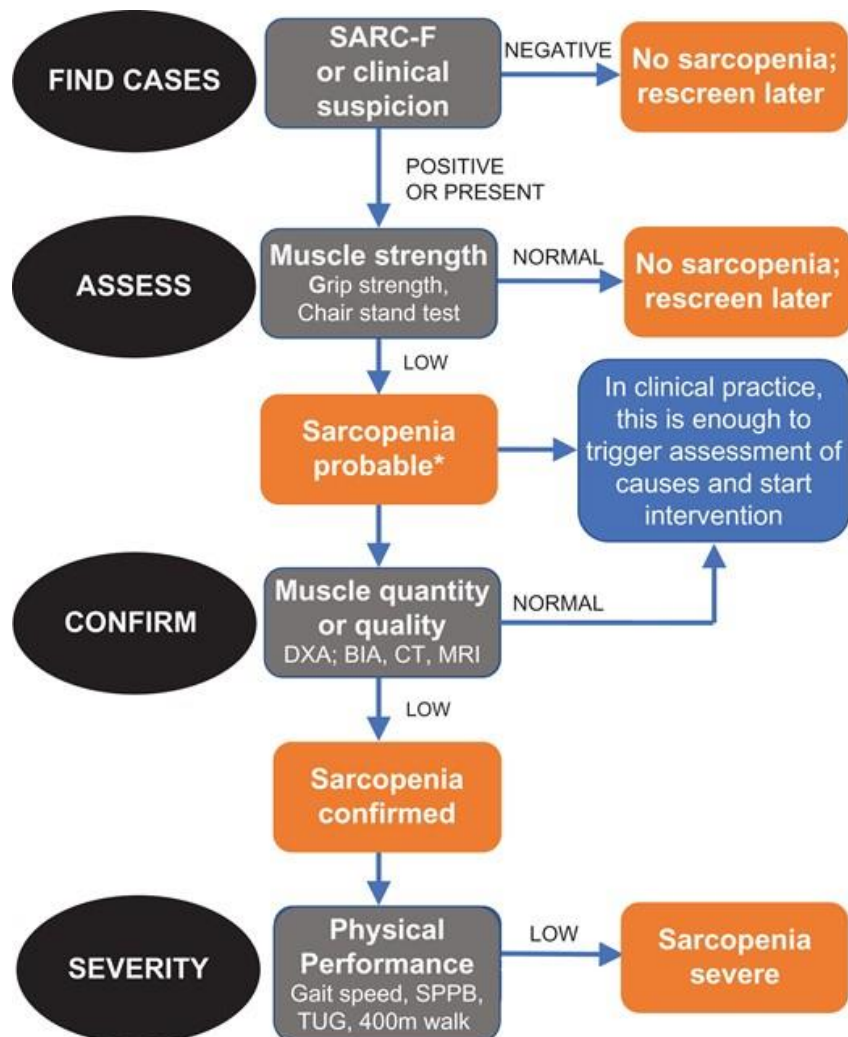


Figure 1.3: EWGSOP2 algorithm for case-finding, diagnosing and assessing severity of sarcopenia ³⁷

In 2018, EWGSOP convened to update their original definition of sarcopenia based on the most up to date evidence ³⁷. The updated EWGSOP2 guidelines recognise muscle strength rather than mass, as a primary determinant of sarcopenia. This transition aimed to acknowledge the role of muscle strength rather than mass in predicting adverse health outcomes ^{62,63}. Additionally, the designation of muscle strength as a primary parameter of sarcopenia aimed to overcome challenges in assessing muscle mass and quality in routine clinical settings ³⁷. The EWGSOP2 guidelines set out a case-finding algorithm for sarcopenia (**Figure 1.3**), recommending the use of the SARC-F tool, with a positive score (≥ 4 or more) indicating the presence of sarcopenia ³⁷. EWGSOP2 recommend the assessment of muscle strength by hand grip strength or chair rise test performance, if low muscle strength is detected, sarcopenia is deemed probable. Importantly, the

identification of probable sarcopenia is considered an appropriate timepoint to commence further muscle assessment and initiate targeted interventions ³⁷. A sarcopenia diagnosis is confirmed based on the assessment of muscle quantity or quality, which requires assessment by Magnetic Resonance Imaging (MRI) or Computed Tomography (CT), and therefore, becomes less practical in community settings ³⁷. Severity of sarcopenia is assessed using physical performance measures including gait speed, SPPB, timed-up and go and the 400m walking test. Sarcopenia is defined as severe if low muscle strength, mass and impaired function are all detected. This updated definition of sarcopenia, shares overlapping characteristics with the Fried frailty phenotype ⁶⁴, including low grip strength and gait speed, however, they represent two distinct entities. While sarcopenia is a muscle condition, frailty represents a much broader state of vulnerability involving multiple physiological systems ⁶⁵. Importantly, sarcopenia and frailty share common risk factors, including fatigue and weight loss ^{37,66}, and a common primary treatment, physical activity ^{67,68}.

1.2.3.3 The role of muscle strength and mass in sarcopenia criteria

While the EWGSOP2 guidelines, applied in the present thesis, prioritise low muscle strength in the defining criteria of sarcopenia, not all guidelines agree, with others emphasising muscle mass. As detailed in **Table 1.1**, each consensus definition takes several criteria into account, with considerable misalignment on whether muscle strength, rather than mass, is a primary determinant of sarcopenia. This discernment, can be attributed in part, to challenges in assessing muscle mass in routine clinical practice ³⁷. MRI and CT are considered the gold standard tools for muscle mass and quality assessment however, they are not often available in routine clinical practice and community-based settings ³⁷. Similarly, issues around portability and the effect of hydration status on output measurements are noted for dual-energy X-ray absorptiometry (DXA) ⁶⁹. Although increased portability and affordability of bioimpedance analysis (BIA) is noted, its accuracy has been shown to vary ³⁷. While recent evidence supports the D3-creatine dilution method as a potential diagnostic tool for the identification of sarcopenia ⁷⁰, issues surrounding the availability of equipment in routine clinical practice and community-based settings persist.

The use of sarcopenia as a catch-all term for impaired muscle strength, mass and function has contributed to some discernment amongst scholars and is reflected in the variability of definitions currently in use. The updated EWGSOP2 and AWGS definitions reflect recent evidence highlighting muscle strength as a principal determinant of

sarcopenia. In previous definitions, such as the 2010 EWGSOP guidelines, Cruz-Jentoft et al describe the presence of both low muscle mass and impaired muscle function as definitive parameters of sarcopenia onset ⁵⁸. Recent findings however, indicate that changes in muscle strength are only partially explained by the loss of muscle mass. Analysis of data from the Health, Ageing and Body Composition Study (n= 1,880, mean age 73.5 ± 2.8 years), report that annualised rates of knee extensor strength loss were over three times greater than the rate of lean leg mass loss ⁷¹. Similarly, Hughes et al, in a study of 120 older adults at 9-year follow-up (mean age 70.1 ± 7.7 years), found that while loss of muscle mass was highly correlated with strength changes, it only accounted for 5% of this loss ⁷².

EWGSOP2, highlighted the importance of mapping the diagnostic criteria of sarcopenia to clinically relevant outcomes, acknowledging an inconsistent body of evidence examining associations between muscle mass and adverse health outcomes. Though this remains a debated issue in the field, a dearth of literature shows, when adjusted for muscle mass, low muscle strength independently predicts mortality and disability ^{62,63}. Analyses of data from 13,421 community-dwelling men and 4,828 women aged 65 years and older, performed by the Sarcopenia Definitions and Outcomes Consortium (SDOC), found low hand grip strength independently predicted incident falls, hip fracture, mobility impairment and mortality ⁷³. In this cohort, appendicular lean body mass (ALM) examined using DXA, however, was not consistently and independently associated with adverse health outcomes ⁷³. EWGSOP2 guidelines recognising the importance of outcome based measures, emphasise the importance of muscle strength and functional performance in maintaining independence ³⁷.

1.2.3.4 The emergence of 'Probable' Sarcopenia as a Practical Assessment

In 2019, EWGSOP2 guidelines introduced the concept of 'probable sarcopenia' ³⁷, indicated by the presence of low muscle strength. This can be assessed by practical measures, for example by hand grip strength or poor chair rise test performance. Low hand grip strength is defined as less than 16 kg in females and less than 27 kg in males ³⁷. Poor chair rise test performance is deemed present if the time taken to complete five chair rises is greater than 15 seconds ³⁷. The gender-specific cut off values for low hand grip strength were derived from analyses of normative hand grip strength data in 49,964 healthy adults aged 4-90 years old ⁷⁴. The selected cut-off values of 16 kg in women and 27 kg in men, represented hand grip strength measures 2.5 standard deviations from the mean gender-specific peak values ⁷⁴. Other criteria were considered, including setting

the threshold at 2 standard deviations from mean peak grip strength, equating to 19 kg in women and 32 kg in men, however, the discriminatory power was deemed low in adults aged 80 years and older ⁷⁴. It is important that the cut-off values selected to identify low hand grip strength are not arbitrary and are mapped to clinically relevant outcomes. Previous research has identified hand grip strength cut-off values of 19 kg in females and 30 kg in males as robust indicators of slow walking speed and self-reported difficulty in walking ⁷⁵. Similarly, hand grip strength values of 21 kg in women and 37 kg in men have been shown to predict mobility limitations in adults aged 55 years and older (n= 1562) ⁷⁶. The threshold for poor chair rise test performance was set to 15 seconds, as this time has been shown to correspond to a gait speed lower than 1 m/sec ⁷⁷.

Reported prevalence of probable sarcopenia in published studies vary widely, with considerable methodological differences including the mode of assessment (hand grip strength and/or chair rise test performance), population demographics, recruitment site, gender-specific cohorts, and selected SEP measures. As detailed in Table 1.2, probable sarcopenia is common in community-dwelling older adults aged 60 years and older, with an estimated prevalence between 19-73% ⁷⁸⁻⁸⁶. Generally, higher prevalence was observed in cohorts of older age ⁸³. Given the concept of probable sarcopenia was introduced by EWGSOP2 in 2019, evidence of socioeconomic risk factors is in its early stages. Available literature on SEP and probable sarcopenia remains limited, with few studies including socioeconomic indicators ^{79,80,82}. Dodds et al in a cross-sectional analysis of participants of the 1946 British Birth Cohort (n= 1686, all aged 69 years old), found no association between occupation class at age 53 years and probable sarcopenia, although most study participants had high occupation class (88%) ⁸⁰. Pérez-Sousa et al, in an ethnically diverse population in Colombia (n= 5237, mean age 70.4 ± 7.8 years), reported a probable sarcopenia prevalence of 47% in older adults with disadvantaged social class compared to 31% among the high SEP group, however the authors did not examine whether associations persist in multivariable analyses ⁸². No prevalence estimates of probable sarcopenia were available for community-dwelling older adults in Ireland and no cross-sectional study aimed to examine socioeconomic determinants of probable sarcopenia.

Longitudinal analyses provide some evidence of links between SEP and sarcopenia. Evidence from the Tasmanian Older Adult Cohort Study (n= 1090, mean age 63.0 ± 7.5 years), report associations between lower educational attainment and manual occupation class with probable sarcopenia at 6 six year follow-up ⁸⁷. Similarly, Chen et al, in analyses of participants of the China Health and Retirement Longitudinal Study

found associations between educational attainment and probable sarcopenia, defined by AWGS criteria, in cross-sectional analyses however, this association did not persist at 4-year follow-up⁸⁸. It remains unclear whether socioeconomically disadvantaged older populations experience a greater burden of sarcopenia, critical to early detection and timely intervention of a potentially reversible condition^{37,47}. Given that a social gradient has been observed in other chronic conditions such as cardiovascular disease^{21,89}, in addition to frailty⁹⁰, a state of increased vulnerability to external stressors⁹¹, future work should explore sarcopenia. This could be explored in community-dwelling older adults through detection of EWGSOP2-defined probable sarcopenia, with a specific focus on socioeconomic determinants, in large representative populations of older adults.

Table 1.2: Prevalence of EWGOSP2-defined probable sarcopenia overall, and according to socioeconomic position (SEP) in community-dwelling older adults aged 60 years and older in published cross-sectional studies

Measure of PS	Lead Author	Year	Location	Cohort	N	%PS	SEP Measure	%PS based on SEP Disadvantaged SEP	High SEP
HGS	Tsekoura ⁸⁵	2021	Greece	Participants recruited through an acute hospital, mean age 71.5 ± 7.6 years and 73% female	402	25.4%	Past occupation	Not reported	
HGS	Bertschi ⁷⁸	2021	Switzerland	Participants recruited through acute hospital, mean age 84.0 ± 10.0 years and 66% female	305	24.6%	None		
HGS	Pérez-Sousa ⁸²	2020	Colombia	Colombian Health and Wellbeing and Ageing Survey cohort, mean age 70.4 ± 7.8 years and 57% female	5237	46.5%	Social Class	46.5%	31.1%
HGS	Wearing ⁸⁶	2020	Switzerland	Community-dwelling older adults, mean age 84.1 ± 5.7 years and 62.6% female	219	26.3%	None		
HGS	Sousa-Santos ⁸⁴	2019	Portugal	Nutrition UP 65 study cohort, median age 74 years (range 65-100) and 58% female	1500	36%	None		

Measure of PS	Lead Author	Year	Location	Cohort	N	%PS	SEP Measure	%PS based on SEP Disadvantaged SEP	High SEP
CR	De Souza ⁷⁹	2021	Brazil	Participants recruited through primary care facility, mean age 69.9 ± 7.1 years and 58% female	306	50.0%	Education (years) and income	Not reported	
HGS/CR	Dodds ⁸⁰	2020	UK	1946 British Birth Cohort, aged 69 years old, 51% were women	1686	19%	Occupation class at age 53 years	Not reported	
HGS/CR	Sobestiansky ⁸³	2019	Sweden	Uppsala study, all men aged 85-89 years old	287	73%	None		
HGS/CR	Kim ⁸¹	2019	Korea	Korean Frailty and Ageing Cohort Study, mean age 75.9 ± 4.0 years, 50% were women	2099	23.5%	None		

1.3 Health Inequalities in Ageing

1.3.1 Measuring the Socioeconomic Position of Older Adults

Research on socioeconomic inequalities in sarcopenia burden remains limited. This gap in the literature has been attributed in part, to the complexity of measuring the socioeconomic position (SEP) of older adults and assumptions around homogeneity in ageing ⁹². SEP, often used interchangeably with the term socioeconomic status despite their theoretical differences, refers to the social and economic factors that influence one's position within the hierarchical structure of society and is applied in the present thesis ⁹³. Reflecting the complexity of the construct, SEP has been operationalised in a number of ways, most commonly as individual-level factors such as educational attainment, wealth, income, occupation class, social class, subjective social status or as area-based deprivation indices ⁹².

While there are multiple markers of SEP which are often used in combination and may exhibit overlapping properties, they are not interchangeable ⁹³. Research exploring patterns in health inequalities, attribute the magnitude of observed inequalities to the choice of SEP indicator ⁹⁴. Often, how researchers define SEP follows a pragmatic approach based on the availability of social and economic data and whether it can be easily and reliably collected ⁹². Other times, the SEP indicator is selected based on its appropriateness to the study population and the hypothesised underlying mechanisms between the socioeconomic factor and the outcome of interest ⁹³. Questions remain, around how the choice of SEP indicator influences the observed health inequalities in older adult populations.

Ideally, the SEP indicator of choice should be theoretically guided ⁹². Three mechanisms are proposed as mediating the relationship between SEP and health in later life ⁹², and focus on the role of material, behavioural and psychosocial factors ⁹⁵. The materialist pathway describes how greater financial resources enables access to health enhancing commodities such as housing, adequate diet, safe environments and access to healthcare ⁹². The behavioural pathway captures lifestyle risk factors including adequate dietary intake, alcohol consumption, physical activity and smoking ⁹². Additionally, this pathway encompasses knowledge of good health behaviours, ability to navigate complex health systems and health literacy ⁹². The final pathway aims to describe the psychosocial environment including our ability to alleviate the indirect and direct effects of stress, disempowerment and social disintegration ⁹².

The most frequently applied measures of individual-level SEP in epidemiological research include education, income, and occupational class, with each representing a preference for a specific theoretical pathway ⁹². While some SEP indicators aim to capture one's position in the social hierarchy (subjective social status and social class), others act as a proxy measure of the resources and human capital available to each individual (wealth, income and educational attainment). There are strengths and limitations associated with each indicator, and their measurement in older adult participants adds further complexity ⁹².

1.3.1.1 Education

A growing body of evidence shows that adults with higher educational attainment live longer and healthier lives when compared to those with lower educational attainment ⁹⁶. Education can be measured as years of formal education completed, age when exited formal education or highest qualification completed (educational attainment), and is considered a robust indicator of SEP in older adult populations ⁹². Education-based SEP indicators typically capture childhood and early adulthood socioeconomic conditions which may constrain or generate opportunities across the life course ⁹⁷. Considering childhood and adolescent social and economic conditions is important, as evidence suggests this represents a critical period in life which may be more sensitive to exposures of socioeconomic disadvantage ⁹⁸. In contrast to income or occupation based SEP indicators, the application of childhood and early adulthood socioeconomic indicators limits the probability of reverse causation when examining associations with adverse health outcomes commonly observed in later life ⁹⁹.

A majority of research focussing on education-based disparities in health is grounded in fundamental cause theory ¹⁰⁰, described later in Section 1.3.2. This theory conceptualises education as a fundamental cause of health inequalities enacted through the unequal distribution of material and non-material resources between groups. It is hypothesised that educational attainment influences health through several mechanisms: increased human capital, psychosocial resources, living conditions and health literacy, including the ability to navigate complex healthcare systems (**Figure 1.4**) ⁹⁶. Greater educational attainment is associated with stable employment and higher income ¹⁰¹. Furthermore, education is proposed as influencing knowledge of good health behaviours, with higher educational attainment associated with lower cigarette and alcohol consumption and more frequent physical activity ¹⁰². In contrast to income or occupational class measures, which may be influenced by employment transitions such

as retirement, education-based SEP indicators remain relatively static in later life ⁹². While income or occupation at older age may not accurately reflect lifetime socioeconomic conditions, educational attainment represents a ‘peak measure’, or an endpoint, recognising the highest formal qualifications obtained.

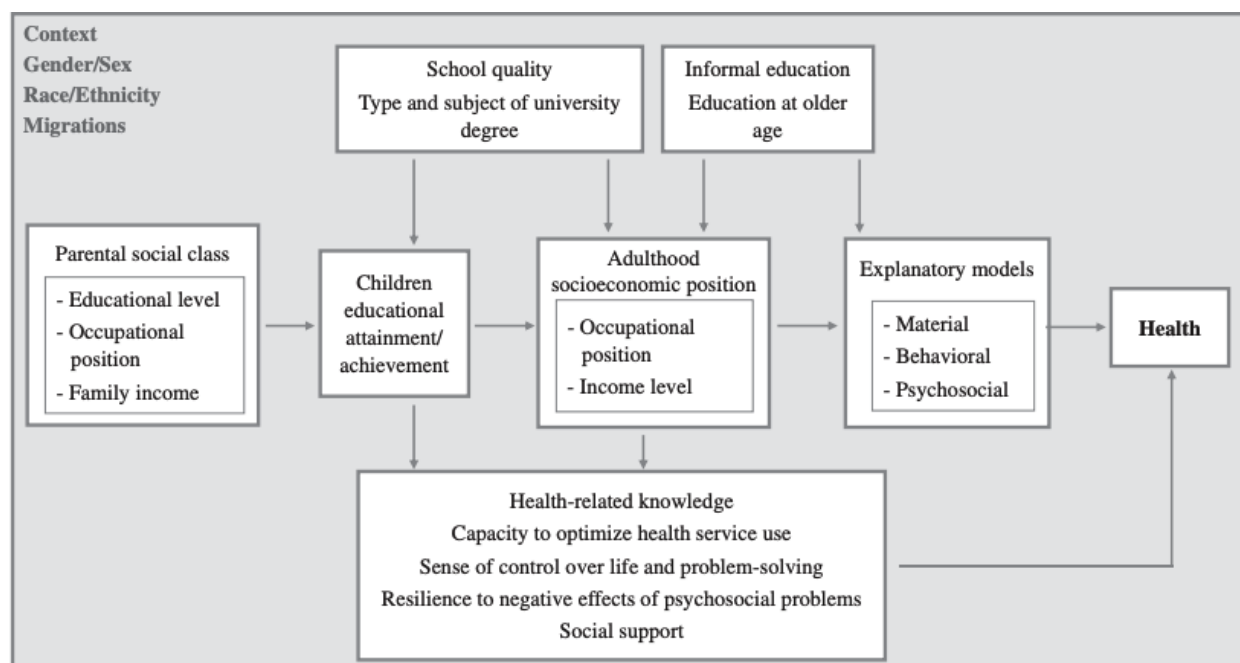


Figure 1.4: Proposed pathways between education and health (Measuring education in the context of health inequalities. Journal of Epidemiology 2022)⁹⁷.

While education-based measures of SEP are increasingly operationalised in epidemiological research, there is a paucity of literature examining quality of education and individual experience of the schooling environment ⁹⁷. The quantification of educational attainment may overlook differences in the quality of education received and intergenerational changes in education policy such as compulsory education reforms with the potential to influence health. In Ireland, perhaps the most significant education reform occurred in 1926 with the enactment of the School Attendance Act, making formal education compulsory up to 14 years old ¹⁰³. Within this context, a substantial proportion of the population exited formal education at the minimum age which may impede education differentiation within the population ¹⁰⁴. The School Attendance Act was followed by the introduction of free secondary level education in 1967 ¹⁰⁵. Findings from natural experiments examining the impact of national education reform in Ireland report significant improvements in self-rated health, physical activity and risk of cardiovascular disease in later life, providing evidence of a causal relationship between education and health ¹⁰⁶.

Some research model education as continuous years of schooling or age when exited formal education, assuming a degree of uniformity in the impact of each additional year of school. In reality, the difference between 16 years of formal education, equating to the completion of third-level degree, or 15 years, reflecting the discontinuation of third-level education without a formal qualification, may be more pronounced than other timepoints on the education spectrum ⁹⁶. This is supported by literature which found decreasing risk of mortality with each additional year of formal education however, the completion of upper-secondary level qualifications or a third level degree were associated with greater gains in health ¹⁰⁷. The findings suggest that it is formal qualifications rather than years of schooling that observe the greatest influence on health.

It is important to note, no single measure of SEP could fully capture the complex social and economic factors that impact health across the life course. The effect of disadvantaged educational attainment in health may be more pronounced in different social groups, with stronger social gradients in health observed in women compared to men and among adults of minority group vs white ethnicity ⁹⁶. This may reflect variations in education quality, institution type and labour market prospects compounded by co-existing inequalities such as gender and racial discrimination. Despite these differences based on demographic stratification, educational disparities in health are observed for all ⁹⁶.

It would be over-simplistic to suggest that one measure of SEP could fully encompass the underlying mechanisms and domains of socially patterned disparities in health. Indeed, there are advantages and limitations associated with each measure of SEP and their selection often reflects a preference for a specific theoretical pathway (**Table 1.3**) ⁹². Moreover, SEP does not remain static throughout the life course and the impact of socioeconomic factors may vary over time. This is relevant in studies of older adult populations, with 'age as a leveller' theories proposed as reducing inequalities in older age due to better access to healthcare and income equity ¹⁰⁸. While there are several caveats, and no one measure can fully encompass an individual's SEP, socioeconomic disparities in health are pervasive, irrespective of how SEP is defined. Educational attainment has been identified as a robust measure of socioeconomic position in older adult populations with disparities in health expectancy and mortality previously reported ^{92,109}. The proposed theoretical mechanisms relating to knowledge of good health behaviours, economic opportunities and access to health care are critical in the design and implementation of effective strategies that support healthy ageing. Given the ease of collecting education-based measures of SEP in routine clinical and community

settings, such markers carry structural and pragmatic benefits in the screening and assessment of older adult populations.

Table 1.3: Strengths and limitations of SEP measures in older adult populations

SEP Indicator	Operationalisation	Strengths	Limitations
<i>Education</i>	• Years of formal education • Age when exited formal education • Highest formal qualification completed (educational attainment) • Literacy measures	• Pragmatic: data is easy to collect in routine clinical and community settings • Often available in cohort studies • May be comparable between countries • Considered a robust indicator of SEP in older adult populations • May capture components of psychosocial, behavioural and materialist pathways to health inequalities • Less prone to non-response error than other SEP measures such as income/wealth • Education may influence future occupational class and lifetime earnings • Reverse causation is relatively limited as educational attainment often precedes disease onset in adult-life	• Gender bias: historic pattern of lower educational attainment among women • Requires consideration of childhood illness and early-life health gradients in education • May not accurately reflect diversity in educational experience and quality of education received • Continuous measures assume uniformity and equal value of each additional year of formal education • Evidence of inconsistency in reporting education history • Should consider birth cohort effects in education • Greater difficulty distinguishing the most disadvantaged, as older adults are overrepresented in lower educational attainment groups • Attainment categories designed in high income countries may not be directly applicable to low and middle income countries

SEP Indicator	Operationalisation	Strengths	Limitations
<i>Income</i>	- Household-level or individual-level gross income - Household-level or individual-level disposable income - Percentage above/below official poverty threshold	- Captures materialist pathway to health inequalities - Often dictates access to health and social care services - Fosters consumption of health enhancing commodities	- Complex in older adult populations due to transitions in employment status such as retirement - Older adults who are no longer in paid employment may have low-income but have accumulated greater financial resources - May not reflect 'peak' income - Requires the collection of data from multiple income streams - Gender bias: lower value pensions observed among women - Reverse causation: evidence suggests individuals with poor health observe a loss in income - Income is more susceptible to short-term changes - Comparability requires income to be standardised based on number of persons dependent on this income
<i>Wealth</i>	Total household assets – includes income and accumulated financial resources	- Captures older adults accumulated financial resources - Computations that consider outgoing expenditure may provide an accurate	Should take number of household members and shared-ownership into account

SEP Indicator	Operationalisation	Strengths	Limitations
		economic profile of older adults	Similar complexity in data collection as noted for income
<i>Occupational class</i>	- Occupation classified into hierarchal or non-hierarchal class schema e.g. UK National Statistics Socioeconomic Classification (NS-SEC) - Dichotomised variable: employer vs employee	- Easy to obtain in routine clinical and community settings - Often available in cohort studies - Shares overlapping properties with income as it is associated with income security and stability - May capture exposure to environmental hazards or certain working conditions - May reflect social standing	- Older adults are often no longer in employment - Current employment status may not reflect 'peak' occupational class - Recent changes in occupational structure such as an observed decrease in manual workers and increase in low-paid service industry workers may affect the discriminatory power of occupational class schema - Gender bias: often excludes historic pattern of women working in the home - Classification varies based on each country's socioeconomic index - Often measured at different timepoints (e.g. occupation at aged 53 years⁸⁰) which impedes comparability
<i>Subjective Social Status (SSS)</i>	MacArthur's Scale	- Reflects current self-perceived subjective status - Ease of collection in clinical and community-based settings	- Unclear how accurately SSS reflects actual socioeconomic position - Reverse causation: may be influenced by poor health

SEP Indicator	Operationalisation	Strengths	Limitations
		• Captures theoretical pathway of control and power to health inequalities • Reflects evidence suggesting it is not the absolute value of the social and economic factors that influences health, but how people perceive their position relative to society.	
<i>Residential area deprivation</i>	• Geographical area deprivation scores that characterise small areas on a continuum from disadvantaged to affluent • Townsend Deprivation Index • Index of Multiple Deprivation	• Easy to obtain and widely available in cohort studies • Beneficial when examining how social environment may influence health outcomes • May reflect characteristics that affect health such as environmental resources and the availability of public services • Allows for the evaluation of the geographical distribution of health inequalities • May provide important insights relevant to future health and social care service planning • Often used as a proxy measure of SEP where individual-level data is not available e.g. administrative data and e-health records	• Variation in how many households per geographical area • May not accurately reflect everyone living in a residential area i.e. individuals of disadvantaged SEP renting in areas classified as affluent • When used as a proxy for individual-level SEP it is likely to underestimate SEP

SEP Indicator	Operationalisation	Strengths	Limitations
<i>Material deprivation</i>	Often includes household amenities and car ownership	Captures materialist pathway to health inequalities	
<i>Composite measures</i>	Individual or area-level measures usually computed as a score of socioeconomic disadvantage indicators	- Captures a range of pathways to health inequalities - May include data from different timepoints along the life course - Composite measures may avoid problems that arise through use of individual measures of SEP such as correlation or interactive effects with other risk factors	- More time consuming and greater difficulty collecting and computing multiple SEP measures - May obscure the underlying mechanisms between SEP and adverse health outcomes - Greater complexity providing 'real-world' recommendations based on findings

1.3.2 Health Inequalities: The Fundamental Causes; Theories and Concepts

Several indicators of socioeconomic position are applied in ageing research to determine health inequalities, defined as systemic and unjust differences in health, between and within populations ⁹⁴. A body of research highlights social gradients in disease when populations are ranked by SEP ¹¹⁰, although this remains unclear for the muscle condition sarcopenia. The first serious discussion on the social determinants of health began with the publication of the Black Report in 1980 ¹¹¹. This report described how since the inception of the National Health Service (NHS), health disparities in the UK had widened. The authors argued that these inequalities were driven by socioeconomic factors external to the health system: income, education, occupation and conditions of employment ¹¹².

Following the publication of the Black Report, Link and Phelan described how epidemiological research placed a disproportionate emphasis on identifying individual-level risk factors of disease, without examining ‘what puts people at risk of risks’ ¹⁰⁰. According to the authors, this approach presents a belief that many risk factors are potentially controllable at individual level. In contrast, Link and Phelan posit social factors including socioeconomic position and social support as the ‘fundamental causes’ of disease ¹⁰⁰. Widely known as ‘Fundamental Cause Theory’, this is frequently cited in literature as a means to understand why and how health inequalities occur (**Figure 1.5**) ¹¹³. The authors offer an explanatory theory of how fundamental causes of disease are those which influence multiple disease outcomes and their risk factors, impeding access to resources that may prevent or delay the onset and progression of ill health ¹⁰⁰. This is reflected in Link and Phelan’s explanation that “socioeconomic status operates as a ‘fundamental cause’ of disease by allowing people with high socioeconomic status to use broadly serviceable resources such as knowledge, money, and power, to avoid risks and to minimize the consequences of disease once it occurs” ¹⁰⁰.

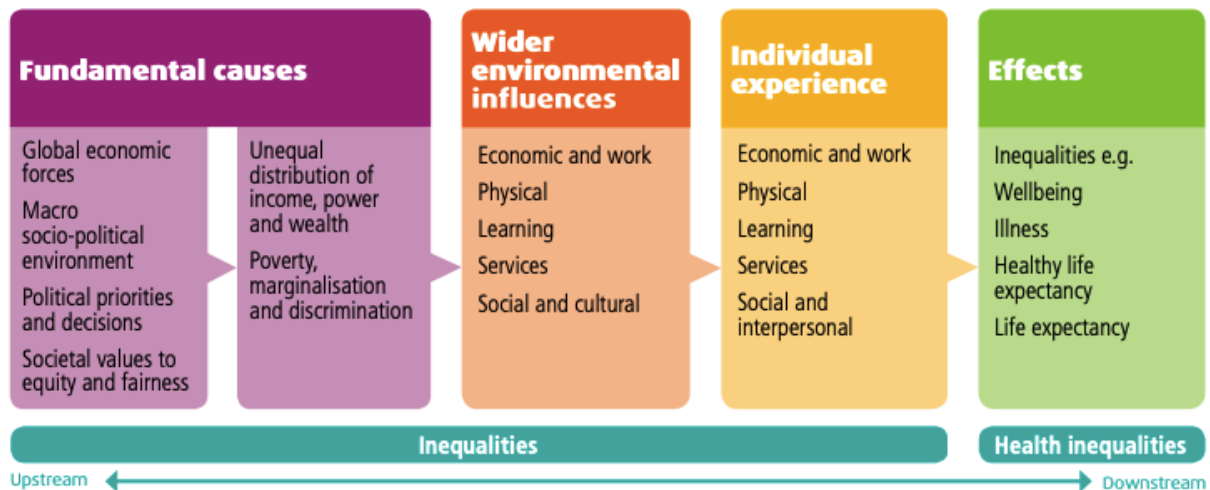


Figure 1.5: Theory of Causation (Source: NHS Scotland 2014)¹¹⁴

Freese and Lutfey have further explored the theory of fundamental causality to understand the mechanisms through which socioeconomic position affects health ¹¹⁵. Referencing work by Sankar et al ¹¹⁶, the authors ask why, despite considerable medical advancement in the United States over the last 50 years, have inequalities in health outcomes increased? Examining this trend through the lens of fundamental causality, it is proposed that disparities have widened through the unequal distribution of health gains between social groups ¹¹⁵. Freese and Lutfey argue that the basic premise of individuals possessing differential means that can be used to improve health outcomes, assuming some level of health agency exists, will ultimately result in disparities ¹¹⁵. This proposed heterogeneity in means, and thus access to resources, provides some theoretical reasoning as to why different indicators of SEP show robust associations with health outcomes in a varying range of settings and contexts ¹¹⁵.

Others, interpret pervasive social gradients in health as reflecting a bi-directional relationship between disadvantaged SEP and poor health, with some arguing that poor health causes downward social mobility ¹¹⁷. This is important as if in fact, ill health causes disadvantaged SEP, then SEP cannot be a fundamental cause of poor health ¹¹⁵. While chronic ill health may result in declines in income, wealth or impede educational attainment, research has shown this accounts for a small proportion of the association between SEP and health ¹¹⁸. Indeed, evidence from longitudinal studies offers robust evidence of associations between disadvantaged SEP and poor health outcomes at follow-up, when controlled for competing risk factors ⁹. It is for this reason, that education is commonly utilised in studies examining health inequalities in ageing, as it is usually

obtained in childhood and early adulthood, issues with reverse causation remain relatively limited ⁹⁹.

It is unlikely that one mechanism offers a complete explanation of the fundamental social determinants of health. In addition to arguments on social selection, 'control over destiny' and stress paradigms have been proposed ¹¹⁹. The hypothesised link between a lack of control over one's life and socially patterned health outcomes is described by Marmot: "For people above a threshold of material wellbeing, another kind of wellbeing is central. Autonomy – how much control you have over your life – and the opportunities you have for full social engagement and participation – are crucial for health, wellbeing and longevity. It is inequality in these that plays a big part in producing a social gradient" ¹¹⁹. Marmot argues that it's one's position in the social hierarchy and what they can do in a given society (autonomy and social participation), rather than measures of material deprivation, that have the greatest influence on health ¹²⁰. This is supported by evidence from the Whitehall studies, a longitudinal study of civil servants in the UK, that reports an inverse gradient between employment grade and subjective social status with mortality at 10-year follow-up ¹²¹.

The theoretical underpinnings suggested by Link and Phelan and Marmot are not mutually exclusive and likely reflect the complex mechanisms through which socioeconomic disadvantage 'gets under the skin' ¹²². Others, draw from cumulative disadvantage and life course theories to explain socially patterned disparities in health. The latter, places ageing in the context of everyone obtaining a peak functional capacity in their life course, influenced by factors as early as conception (genetic predisposition) and followed by a decline, the rate of which is dependent on prior peak capacity and other later life environmental, health and social factors ¹²³. Dannefer proposes that the unequal distribution of social and economic resources within and between populations leads to cumulative levels of advantage or disadvantage among groups ¹²⁴. While there is some discernment among scholars around the ambiguity of 'resources', this cumulative (dis)advantage has been shown to translate into unjust differences in health ¹¹⁵. Cumulative disadvantage theory is often applied in life course studies of health inequalities reflecting the life-long process of ageing and potential opportunities to intervene. In research with older adults, Ferraro et al note "disadvantage accumulates over the life course, thereby differentiating a cohort over time" ¹²². Despite extensive discussion on why and how health inequalities occur, avoidable and unfair differences in health outcomes persist.

1.4 Sarcopenia and Socioeconomic Position

1.4.1 Epidemiological evidence; SEP and musculoskeletal health in ageing

While research on sarcopenia and socioeconomic position remains limited, a growing body of evidence highlights inequalities in components of sarcopenia, namely muscle strength, mass and function^{87,88}. Findings show sarcopenia onset occurs as early as the fifth decade of life¹²⁵, with contributory factors, including socioeconomic conditions, rooted in the life course (**Figure 1.6**)³⁷. Applying a life course approach to sarcopenia, research identifies associations between birth weight and grip strength in later life¹²⁶, attributed to the quantity and type of muscle fibres established at birth¹²³. Importantly, findings show socioeconomic factors, parental education and occupation class, are associated with lower birth weight in the UK (n= 65,909)¹²⁷. This evidence suggests that SEP may play a role in musculoskeletal health and development from an early age.

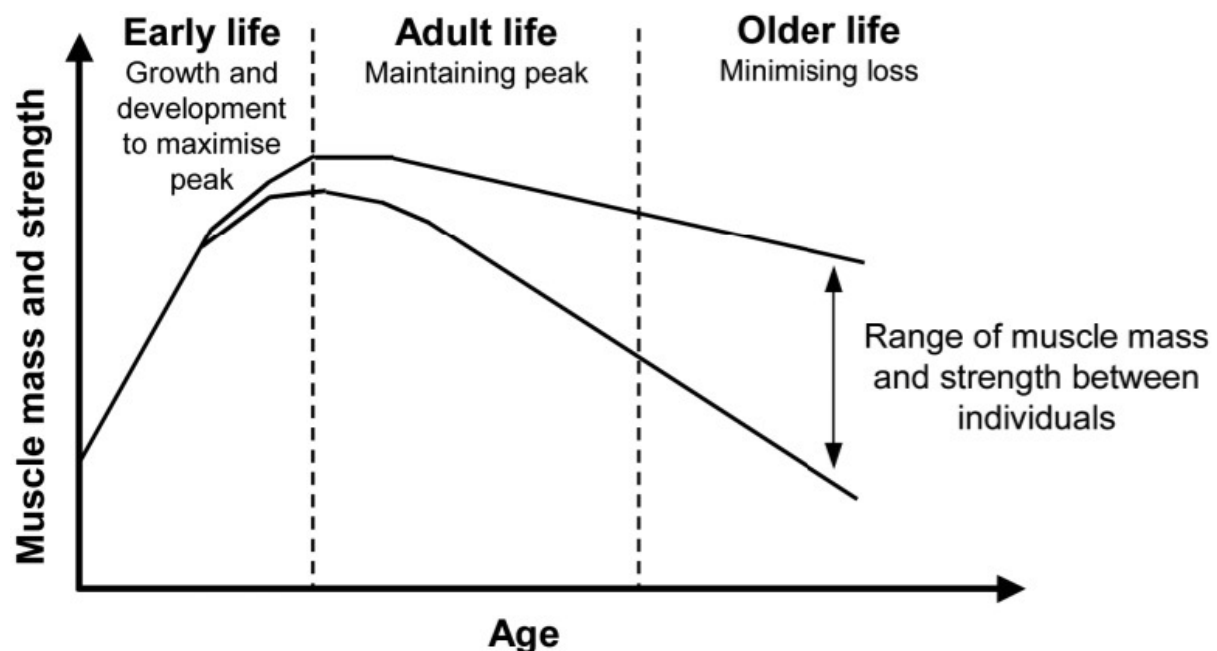


Figure 1.6: Overview of a life course approach to muscle mass and strength
(Source: Sayer et al)¹²⁸

Similar evidence is reported for the effect of childhood SEP on musculoskeletal health in later life. Analysis of 469 healthy children aged 6-13 years in Poland, found disadvantaged SEP, defined by parental education and material deprivation, was associated with lower muscle mass in childhood¹²⁹. A similar trend is observed for low muscle strength, influenced by early life circumstances, including parental occupation, material deprivation and housing quality, in a longitudinal analysis of 24,179 community dwelling adults aged 50-96 years old¹³⁰. Additionally, analyses of hand grip strength data from 7,617 participants of the 1970 British Cohort Study, report associations between childhood and

early adulthood indicators of SEP, parental educational attainment and own educational attainment, with weaker grip strength at age 46 years ¹³¹. The findings suggest socioeconomic differentials in muscle strength can be detected as early as mid-life.

Evidence from younger cohorts suggests disadvantaged SEP impacts the peak muscle capacity obtained in adulthood, which in turn may influence muscle strength in older age ¹³¹. Furthermore, recent research suggests disadvantaged SEP influences the trajectory of decline in muscle strength in older adult populations ^{9,130}. Longitudinal analysis of participants of the English Longitudinal Study of Ageing (n= 5018, mean age 64.4 ± 8.5 years), reported disadvantaged SEP, defined by wealth, was associated with greater decline in grip strength and physical function at 8-year follow-up ⁹. Additionally, recent research identified social patterns in grip strength among participants of the UK Household Longitudinal Study (UKHLS) aged 16-99 years old (n= 19,292) when examined by educational attainment and income ¹³². In line with previous findings, the authors identified lower peak grip strength among adults with disadvantaged SEP. Despite accumulating epidemiological evidence identifying links between socioeconomic factors and musculoskeletal health throughout the life course, few studies have examined social gradients in sarcopenia in later life.

1.4.2 Socioeconomic position and impaired muscle strength, mass and function – potential mechanisms behind the link

It is hypothesised that socioeconomic disadvantage exerts its effects via biological and behavioural pathways. While exact mechanisms remain unclear, evidence suggests that chronic low-grade inflammation plays a role ¹³³. Potential mediators of the association between disadvantaged SEP and poorer musculoskeletal health include inflammatory biomarkers such as C-reactive protein (CRP), Interleukin-6 (IL-6) and Tumour necrosis factor α (TNF α) ¹³³. Others, highlight risk factors of sarcopenia that observe social gradients, including physical inactivity, inadequate nutrition, smoking and alcohol consumption ^{134,135}.

1.4.2.1 Biological pathway

Generally, older age is associated with low grade inflammation, a chronic state of increased levels of pro-inflammatory biomarkers including C-reactive protein (CRP), Interleukin-6 (IL-6) and Tumour necrosis factor α (TNF α) ¹³³. Evidence suggests that sarcopenia is associated with higher serum inflammatory parameters, with significantly elevated concentrations of IL-6 and TNF α detected in older adults with sarcopenia ¹³⁶.

Similarly, in participants of the Longitudinal Aging Study Amsterdam (n= 986, mean age 74.6 ± 6.2 years), higher levels of IL-6 and CRP were associated with greater decline in muscle strength at 3-year follow-up ¹³⁷. Additionally, research shows increased levels of TNF α stimulate muscle atrophy and may have the potential to decrease muscle fibres, increasing the risk of sarcopenia onset ⁴⁸.

To date, a majority of cross-sectional studies support an association between disadvantaged SEP and increased inflammation. A recent systematic review and meta-analysis of 43 studies (n= 111,156), found disadvantaged SEP was associated with higher levels of CRP and IL-6 ⁵³. Similarly, a pooled-analysis of 1,650 adults aged 11-60 years, found elevated levels of inflammatory biomarkers including CRP and IL-6 in individuals with disadvantaged SEP ¹³⁸. Interestingly, this pattern widened with age leading to larger disparities in low-grade inflammation in adults aged 50 years and older ¹³⁸. Despite evidence identifying associations between SEP and inflammation in ageing, the mechanisms behind the link remain unclear. Seminal work by Baum et al, posits a stress pathway wherein individuals with disadvantaged SEP experience chronic stress through increased exposure to detrimental environmental and psychosocial conditions ¹³⁹, which may influence low-grade inflammation in later life ¹⁴⁰. This upregulation of the inflammatory process observed in individuals with sarcopenia and socioeconomic disadvantage, denotes one potential mechanism behind a greater burden of sarcopenia in some social groups.

1.4.2.2 Health behaviour pathway

Physical activity, a known risk factor of sarcopenia ³⁷, observes a social gradient, with socioeconomically disadvantaged older adults more likely to be physical inactive ¹³⁴. While research shows a majority of older adults do not meeting current physical activity guidelines of 150 minutes of moderate intensity activity per week ¹⁴¹, individuals residing in areas of high socioeconomic deprivation are twice as likely to be physically inactive ¹⁴². Analysis of data from over one million adults in England identified a link between physical inactivity and several markers of socioeconomic disadvantage including, educational attainment, household income and residential area deprivation ¹⁴³. Interestingly, the social gradient in physical inactivity appeared to become steeper with age ¹⁴³.

Research examining links between disadvantaged SEP and sarcopenia identify physical inactivity as a potential mediator. Lee et al, in a study of Korean older adults (n= 6081) reported associations between low household income and educational attainment with impaired muscle strength, mediated in part, by physical inactivity ¹⁴⁴. This study controlled

for a limited number of chronic conditions and therefore, issues related to reverse causation must be noted ¹⁴⁴. Furthermore, analysis of the Tasmanian Older Adult Cohort Study (n= 1099, mean age 63.0 ± 7.5 years) reported that the association between educational attainment and neighbourhood deprivation with sarcopenic obesity was mediated in part, by lower daily step count ⁵¹. Similar to physical activity, other health behaviours, namely, inadequate protein intake ¹⁴⁵, malnutrition ^{145,146}, obesity ¹⁴⁷, smoking ¹⁴⁸ and high alcohol consumption ¹⁴⁹, known risk factors of sarcopenia ³⁷, observe social gradients, although most evidence is derived from younger cohorts.

1.4.2.3 Access to healthcare services

Some research suggests disparities in more proximal factors, including access to healthcare, plays a role in healthy ageing ¹⁵⁰, and may influence the development of conditions such as sarcopenia. A recent review of access to healthcare and health-related outcomes in older adults, identifies associations between disadvantaged SEP and access to screening and clinical preventative services ¹⁵⁰. Findings from the Survey of Health, Ageing and Retirement in Europe (SHARE) study, utilising claims data from nine European countries, identified an association between educational attainment and waiting times for specialist consultation and non-emergency surgery ¹⁵¹. In Ireland, geographic inequalities in access to non-acute services, including aged-care services, were previously reported ¹⁵².

There is a paucity of literature examining the underlying mechanisms between disadvantaged SEP and greater burden of sarcopenia, however, the proposed mechanisms are not mutually exclusive and likely includes a combination of interacting factors. There is a need for empirical evidence identifying associations between SEP and sarcopenia to support further research focussed on the underlying mechanisms.

1.4.3 Potential treatments for sarcopenia

In 2018, the International Clinical Practice Guidelines for Sarcopenia (ICFSR), made a strong recommendation based on moderate certainty of evidence that the prescription of resistance exercise can be effective in the management of sarcopenia ⁶⁷. This designation as a primary-treatment of sarcopenia reflects recent findings identifying resistance exercise as an effective intervention to improve muscle strength, mass and physical function in healthy older adults ¹⁵³. A recent systematic review and meta-analysis of resistance exercise RCTs in older adult populations (aged 75 years and older) reported a significant effect on muscle strength and whole-muscle hypertrophy ¹⁵⁴. The findings

persisted in sub-analyses of the oldest-old (80 years and older), suggesting resistance exercise is an effective treatment to improve muscle strength in groups currently underserved in sarcopenia research.

Positive effects of physical activity on physical frailty and sarcopenia have been shown in the SPRINTT trial ¹⁵⁵. Bernabei et al investigated the effect of a multicomponent physical activity intervention in community-dwelling older adults aged 70 years and older with physical frailty and sarcopenia (n= 1519, mean age 78.9 ± 5.8 years) and noted significant improvements in incident mobility disability ¹⁵⁶. In contrast, the DO-HEALTH RCT of strength-training and nutritional supplementation in healthy older adults aged 70 years and older (n= 2157, mean age 74.9 ± 4.4 years), found no significant improvement in physical performance, nonvertebral fractures or cognition ¹⁵⁷. Of note, 83% of Do-Health study participants self-reported moderate to high physical activity levels prior to study enrolment, had a mean number of 12.3 years of formal education, indicating high SEP, and few were aged 85 years and older (4%) ¹⁵⁷. To date, most physical activity trials have predominately focussed on healthy older adult populations under the age of 80 years old, although some research has explored populations in long-term residential care or acute settings ^{158,159}. Few studies have examined the delivery of physical activity within routine care services ¹⁶⁰, with populations of advanced age, increased physical dependency or socioeconomic disadvantage, where universal prescription may prove beneficial.

Resistance exercise, coupled with nutritional support interventions, specifically protein supplementation, are recommended in the treatment of sarcopenia ¹⁶¹. Evidence suggesting muscle-centric benefits of protein supplementation in older adult populations however, appears context-specific. A recent systematic review and meta-analysis of protein supplementation studies found greater protein intake may increase lean body mass (LBM), but only when coupled with resistance exercise ¹⁶². Of note, this review excluded participants with frailty, decreased mobility, or multimorbidity which may limit the generalisability of the findings ¹⁶². In a RCT of protein supplementation in pre-fail and frail older adults, participants given 1.5 g protein/kg/day for 12 weeks observed significant increases in appendicular skeletal muscle mass and skeletal muscle mass index ¹⁶³. Additionally, improvements in gait speed were observed in older adults with 1.5 g protein/kg/day supplementation compared to the 0.8 g protein/kg/day group ¹⁶³. Similarly, in a study of protein-energy supplementation in Korean frail older adults with disadvantaged socioeconomic position, improved physical function was reported for the intervention group ¹⁶⁴. While studies suggest a potential role for protein supplementation

in the prevention of sarcopenia in older adults, small studies with varying study design and extensive exclusion criteria contribute to a body of low quality evidence ¹⁶⁵.

While evidence suggests positive effects of resistance exercise on muscle strength, mass and function, results from both physical activity and nutritional intervention trials remain inconsistent ⁶⁷. Methodological differences including heterogeneity in the dose and progression of physical activity interventions, and an over-representation of healthy older adults with high SEP, indicated by education and income, in intervention studies may contribute to the variability of findings ^{157,166,167}. There is a need for further research focussing on the identification and treatment of sarcopenia in populations currently underserved in traditional health research, including older adults aged 80 years and older, with physical dependency and socioeconomic disadvantage ¹⁶⁷.

1.5 Summary of Evidence

Social gradients in physical function in older adult populations have been reported, but limited research has specifically focused on socioeconomic disadvantage and sarcopenia. The latter, captured by probable sarcopenia, appears to be a suitable and practical measure to investigate in community-dwelling settings, and yet has not been examined based on SEP. While evidence of ‘accelerated ageing’ in populations with socioeconomic disadvantage is emerging, there is a need to explore health inequalities across markers of physical function in populations of older age (80+ years), with physical dependency or disadvantaged SEP. It is not clear whether the influence of SEP persists in older age, or whether the biological process of ageing outweighs the effect of socioeconomic factors. The identification of groups at high risk of functional decline, including people with sarcopenia, may inform strategies to better support ageing in place. There is a need to explore suitable approaches with the potential to maintain physical function and quality of life, such as physical activity initiatives, in community-based settings.

1.6 Thesis Aims

The overall aim of this thesis was to explore physical function in community-dwelling older adults with a focus on socioeconomic position (SEP). While several markers of physical function are explored in this thesis, initial studies largely focussed on probable sarcopenia, a precursor of the muscle condition sarcopenia and a predictor of impaired physical function. The research includes community-dwelling older adults from national ageing studies, in addition to administrative health data and prospective studies that included older adults with older age (80+ years) and physical dependency, supported in the community with formal home support.

The specific objectives of this thesis were to:

1. To describe the prevalence of probable sarcopenia, an indicator of impaired physical function, and its association with socioeconomic position in a large population of community-dwelling older adults in Ireland (**Chapter 3**; based on TILDA)
2. To build on initial findings, using two measures of probable sarcopenia and socioeconomic position, applicable to community-based settings, in a large population of community-dwelling older adults in England (**Chapter 4**; based on ELSA)
3. To examine if associations between SEP and poor physical function persist in populations of older age (80+ years) and increased ADL-dependency (**Chapter 5A**; based on Irish health administrative data)
4. To explore, in a small sample of the population described in objective 3, the frequency and practicality of assessing sarcopenia, along with frailty, and malnutrition risk, in a prospective in-home study of community-dwelling older people with physical dependency (**Chapter 5B**; based on a prospective exploratory in-home study)
5. To consider potential interventions, specifically physical activity approaches, aimed at maintaining physical function in community-dwelling older adults with ADL dependency (**Chapter 6**; based on analysis of barriers and enablers to the delivery of an in-home physical activity programme with this group)

Chapter 2 - Methods

This chapter outlines the methods used in the studies described in this thesis. This includes a comparison of cross-sectional socioeconomic determinants of probable sarcopenia in community-dwelling older adults using two large nationally representative studies of ageing: The Irish Longitudinal Study on Ageing (TILDA) (**Chapter 3**, n= 3342) and the English Longitudinal Study of Ageing (ELSA) (**Chapter 4**, n= 6052). Following this, pre-defined health characteristics, including markers of impaired physical function, cognition and mental health, were examined, using an area-level SEP indicator, in routine health administrative data of ADL-dependant community-dwelling older adults (**Chapter 5A**, n= 1591). Building on the findings, in a small sample of the population described in Chapter 5A, we explored the practicality of assessing sarcopenia, frailty, and malnutrition risk, in addition to markers of SEP, through in-home research (**Chapter 5B**, n= 31). Research fieldnotes and post-study feedback surveys were utilised to describe assessment completion rates, challenges in conducting the in-home research assessments and participants' willingness to engage in future research. Finally, enablers and barriers to the delivery of a home-based physical activity programme for older adults supported by home care was explored through semi-structured qualitative interviews with trained Health Care Assistants (HCAs) involved in a community-based feasibility study (**Chapter 6**, n= 22). This chapter begins by outlining the methods applied in Chapter 5B, representing the fieldwork study included in this thesis.

2.1 Study Populations

The study populations, included in this thesis, comprised community-dwelling older adults aged 60 years and older in Ireland and England. Chapters 3 and 4, draw from nationally representative population studies: The Irish Longitudinal Study on Ageing (TILDA) and the English Longitudinal Study of Ageing (ELSA). Chapter 5A, describes a population of community-dwelling older adults in receipt of formal home support, with 70% aged 80 years and older. A small sample of this cohort are the focus of Chapter 5B, which included an in-home study design. Chapter 6 explores potential strategies to maintain physical function, through qualitative interviews with HCAs involved in the delivery of an in-home physical activity initiative.

2.2 Exploratory Fieldwork Study: In-home assessment of sarcopenia, frailty and malnutrition in community-dwelling older adults with ADL-dependency (Chapter 5B)

2.2.1 Ethical approval

Ethical approval for this study was granted by Trinity College Dublin's Faculty of Health Science Research Ethics committee and written informed consent was obtained from all participants (FREC/210909) (Appendix 1).

2.2.2 Study sponsorship

This study was funded in-part by North Dublin Home Care, a non-profit home care organisation in Ireland (Registered Charity Number: 20076245). North Dublin Home Care covered the study associated costs including the purchase of a hand-held dynamometer, printing material and postage fees. Additionally, North Dublin Home Care provided on-site training in manual handling and patient safety, with certificates included in Appendix 2.

2.2.3 Study design & participant recruitment

This study examined the practicality of conducting in-home assessments of probable sarcopenia, frailty and malnutrition with ADL-dependant community-dwelling older adults. Participants are described as ADL-dependant as all were in receipt of state-funded home care services at the time of assessment. Convenience sampling was employed to recruit participants from a single home care organisation in Ireland, who acted as the study gatekeeper. To ensure diversity of participants, a home care provider operating in areas of both high and low residential area socioeconomic deprivation was selected. Assessments were conducted between December 2021-March 2022, wherein participants were visited by a Health Researcher and a Clinical Nurse Manager 2 (CNM2), experienced in the provision of formal home support services in Ireland. Post-study feedback surveys were completed with participants to examine their motivations and preferences for research participation. The study gatekeeper conducted the post-study feedback surveys by telephone to maintain objectivity and reduce the risk of bias. All interviews were conducted in March 2022 and recorded digitally.

2.2.4 Inclusion and exclusion criteria

The study gatekeeper in conjunction with experienced home care service managers screened service users based on the following inclusion criteria: aged 65 years and older, living in the community and in receipt of state-funded home care. Inability to provide informed consent or follow simple instructions due to cognitive impairment and those in

receipt of palliative care or deemed medically unstable were excluded from the eligible recruitment pool.

2.2.5 Study protocols

Assessments, including the measurement of hand grip strength and chair rise test performance, were conducted in accordance with standardised study protocols (Appendix 3) and were approved by the Faculty of Health Science Research Ethics committee.

2.2.6 Participants information leaflets and consent forms

The study recruitment flyers, participant information leaflets (PIL) and consent forms were approved by the Faculty of Health Science Research Ethics committee. Study recruitment flyers (**Appendix 4**) were sent by post to service users meeting the previously described inclusion and exclusion criteria by the study gatekeeper. Participation was self-selecting, with the research team notified of an expression of interest by the study gatekeeper. Following this, the study was explained in detail over the phone and participant information leaflets were posted (**Appendix 5**). Assessments were scheduled following a 7-day informed consent period, with consent forms completed prior to study commencement (**Appendix 6**). Participants were provided with an information sheet that included the contact details of the research team. Study contact steps and the required documentation are outlined in Table 2.1.

Table 2.1: Contact steps and required documentation

Stage	Reason	Description	Document
1	Pre-screen and distribution of recruitment material	Study gatekeeper screens service user recruitment pool and excludes those not meeting the study inclusion criteria. Gatekeeper sends study information flyer.	Study information flyer
2	Provide study details	Following an expression of interest, research team member LS calls prospective participant and explains study details. PIL is posted.	PIL
3	Arrange research visit	Following a 7-day informed decision period, prospective participants are called to arrange the research visit.	
4	Research assessment	Answer any questions and obtain informed consent. Complete physical assessments. Complete assessments and questionnaires. Document any fieldnotes.	Consent form and assessment pack
5	Collect feedback from participants	Post-assessment, the study gatekeeper conducts feedback surveys with participants on their experience of the research study.	Survey questions

2.3 Study Measures applied throughout the Thesis

This section describes the demographic, socioeconomic and health variables collected and utilised throughout the thesis' Chapters 3-6. This included the assessment criteria for probable sarcopenia: hand grip strength test, chair rise test performance and the SARC-F case-finding tool. Other variables of interest included anthropometric measurements, behavioural factors and information on health status. The pre-defined variables included in each chapter are outlined in **Figure 2.1**.

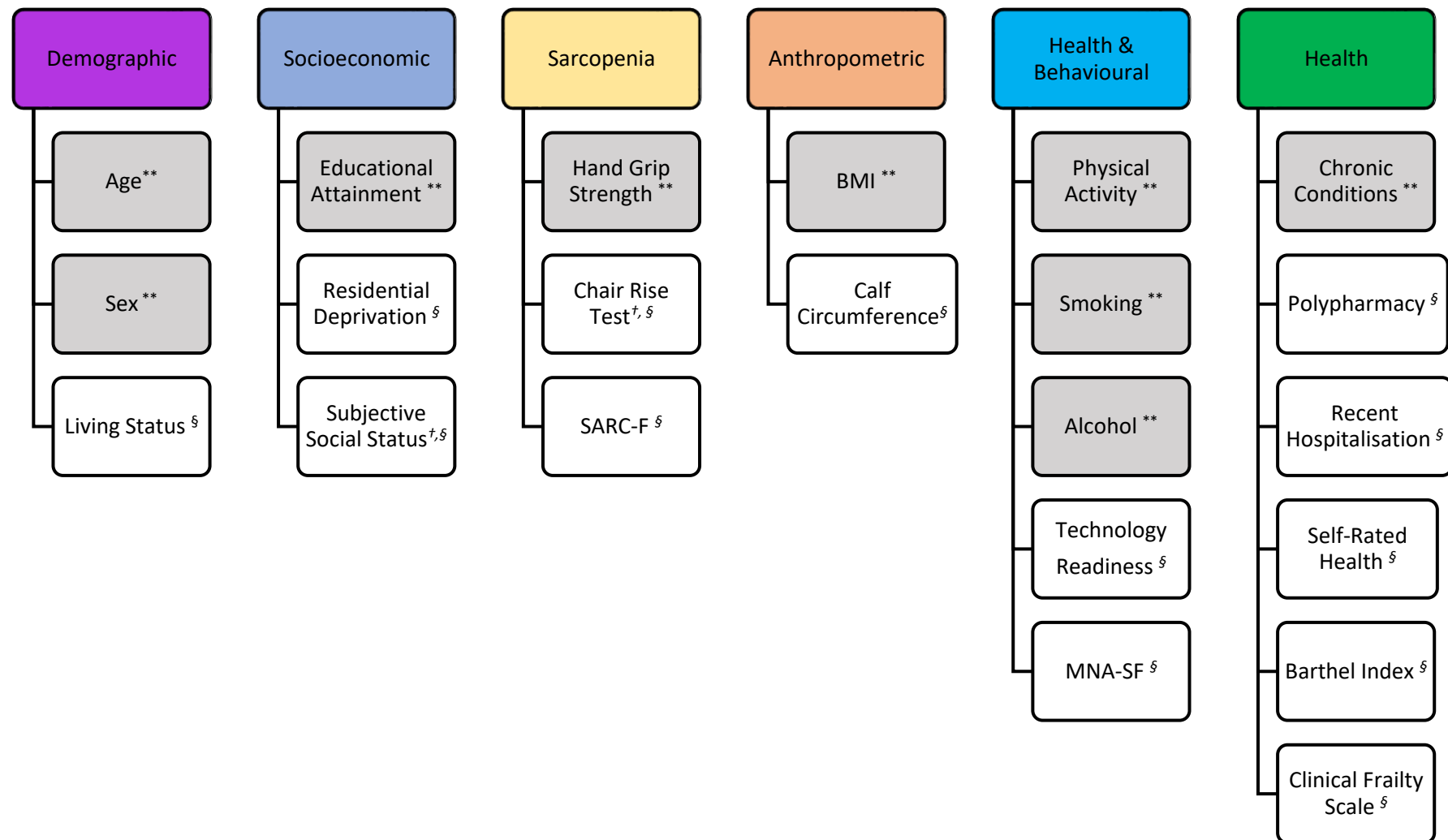


Figure 2.1: Overview of demographic and health variables of interest. Symbols denote the availability of measures in Chapter 3 (TILDA*), Chapter 4 (ELSA †), Chapter 5B (Fieldwork §) or in Chapters 3, 4 and 5B (). Abbreviation: BMI: Body Mass Index; IPAQ: International Physical Activity Questionnaire; MNA-SF, Mini Nutritional Assessment – Short Form**

2.3.1 Demographics

In all research studies, demographic information was recorded, including data on age and sex. Additional information on living status was available in health administrative data and fieldwork (Chapter 5) and recorded as living alone (yes/no).

2.3.2 Socioeconomic Position

Socioeconomic Position (SEP) was most commonly operationalised using three indicators of socioeconomic conditions: including educational attainment, residential area socioeconomic deprivation, and Subjective Social Status (SSS).

Educational attainment, a robust measure of SEP in older adult populations ⁹², was defined by highest educational qualification completed at the time of interview. For participants, qualifications were classified into four groups according to Ireland's National Framework Qualifications (NFQ) ^{168,169}, as *Group 1*) if no formal qualifications completed or primary school education only. *Group 2*) Secondary school lower: completion of the Intermediate Certificate or equivalent. *Group 3*) Secondary school upper: completion of Leaving Certificate or a professional qualification below degree level. *Group 4*) Completion of a third-level degree (**Table 2.2**).

Among participants of ELSA, highest educational qualification was classified according to England's National Vocational Qualification (NVQ) framework ¹⁷⁰, as *Group 1*) no formal educational qualifications or completion of a Level 1 National Vocational Qualification (NVQ). *Group 2*) secondary school lower: completed O-Levels or equivalent, a Level 2 NVQ or a non-coded internationally obtained qualification. *Group 3*) secondary school upper: completion of General Certificate of Education (GCE) A-Levels or equivalent, NVQ Level 3, or a professional qualification below degree level. *Group 4*) completion of a third-level degree or NVQ levels 4–5 (**Table 2.2**).

Table 2.2: Classification guide for highest educational qualification reported

Ireland (NFQ Framework)	SEP Group	England (NVQ Framework)
No formal education or primary school education only	1	No formal educational qualifications or completion of a Level 1 NVQ
Completion of the Intermediate Certificate or equivalent	2	Completion of O-Levels or equivalent, a Level 2 NVQ or a non-coded internationally obtained qualification
Completion of Leaving Certificate or a professional qualification below degree level.	3	Secondary school upper: completion of GCE A-Levels or equivalent, NVQ Level 3, or a professional qualification below degree level.
Completion of a third-level degree	4	Completion of a third-level degree or NVQ levels 4–5

Abbreviations: NFQ, National Framework Qualifications; NVQ, National Vocational Qualification; GCE, General Certificate of Education

Residential area socioeconomic deprivation, an aggregate-level socioeconomic indicator, was available for the administrative health dataset, and used in this context due to the absence of individual-level SEP markers such as educational attainment. Residential area socioeconomic deprivation was assessed using the HP Pobal Deprivation Index developed using 2016 Census data in Ireland ¹⁷¹. The HP Pobal Deprivation Index divides Ireland into 18,488 ‘small areas’, with a mean number of 100 households per area and measures the relative affluence or disadvantage of an address based on the geographical small area to which it is confined within. This is advantageous, as historically, residential deprivation indices were constructed at higher levels of spatial aggregation such as at Electoral Division (ED) level. The HP Pobal Deprivation Index was developed based on three domains of residential area socioeconomic disadvantage: demographic profile, social class composition and labour market status. Each domain is informed by pre-defined social and economic indicators, that will increase or decrease the absolute deprivation score for each small area (**Table 2.3**). Based on these

indicators, each small area was categorised as one of the following: affluent, marginally above average, marginally below average or disadvantaged.

Table 2.3: HP Pobal Deprivation Index scoring mechanism including domains and contributing indicators

Domain	Indicator	ΔDeprivation Score
<i>Demographic Profile</i>	The change (%) in population in the previous 5 years (2011-2016)	+
	The mean number of persons per room per household	+
	The percentage of population with a third level education	+
	The percentage of households headed by a single parent with children aged under 15 years old	-
	The proportion of the population aged under 15 or over 64 years of age (age-dependency ratio)	-
	The percentage of population with a primary school education only	-
<i>Social Class Composition</i>	The percentage of population with a third level education	+
	The percentage of households headed by professional/ managerial/ technical employees, including farmers with 100+ acres of land	+
	The percentage of population with a primary school education only	-
	The percentage of households headed by semi-skilled or unskilled manual workers, including with less than 30 acres of land	-
	The mean number of persons per room per household	-
<i>Labour Market</i>	The male unemployment rate	-
	The percentage of households headed by a single parent with children aged under 15 years old	-
	The female unemployment rate	-

(+) denotes a positive effect and (-) denotes a negative effect on deprivation score

Area-based measures of socioeconomic disadvantage, while increasingly used in government reports, have inherent limitations. Firstly, while the HP Pobal Deprivation

index combines several socioeconomic measures to produce a composite index for individual small areas, it is not an individual-level measure of SEP. Furthermore, the HP Pobal Deprivation Index does not include health or income-related variables, commonly included in area-based deprivation indices applied elsewhere ¹⁷². The constructors of the HP Pobal Deprivation Index note the bi-directional relationship between socioeconomic disadvantage and health and attribute the absence of income data to concerns around data protection ¹⁷¹. Despite the described limitations, small-area-based socioeconomic indicators appear to be robust, showing strong correlations with morbidity, mortality, and a range of health outcome measures ^{173–175}.

Subjective Social Status (SSS), was defined using the MacArthur scale of perceived position in the social hierarchy, applied in large ageing studies such as ELSA and the Brazilian Longitudinal Study of Ageing ^{176,177}. This tool includes a graphic of a ladder comprised of 10 rungs. Participants were instructed to consider the ladder rungs as representative of society, where the highest rung represented those “who have the most money, most education and best jobs” and the bottom rung included the most disadvantaged or ‘the worst off’ ¹⁷⁶. Participants marked a cross on the rung which they perceived to best represent their position relative to society. The ladder scores ranged from 5-100 with lower scores indicating greater socioeconomic disadvantage. Information on SSS was collected among participants of ELSA and in fieldwork. The MacArthur scale of SSS has been used in large epidemiological studies with significant associations observed between disadvantaged SSS and adverse health outcomes, independent of objective measures of SEP ^{178,179}.

2.3.3 Assessing Probable Sarcopenia

Assessing probable sarcopenia as a marker of physical function was a core aim of chapters 3, 4 and 5B. Sarcopenia, a condition characterised by the progressive loss of muscle strength, mass and function ³⁷, is an important marker of current and future impaired physical function in older adults ³⁷. This thesis focussed on probable sarcopenia, a precursor of sarcopenia onset, with the identification of probable sarcopenia deemed an appropriate timepoint to initiative intervention ³⁷. Probable sarcopenia was defined in line with EWGSOP2 guidelines for low muscle strength and deemed present if low hand grip strength or poor chair rise test performance was detected (**Figure 2.2**) ³⁷. In line with EWGSOP2 guidelines, gender-specific cut off values for low hand grip strength were applied: <16 kg for females and <27 kg for males ³⁷. Poor chair rise test performance was defined by a time taken to complete 5 chair rises greater than 15 seconds ³⁷.

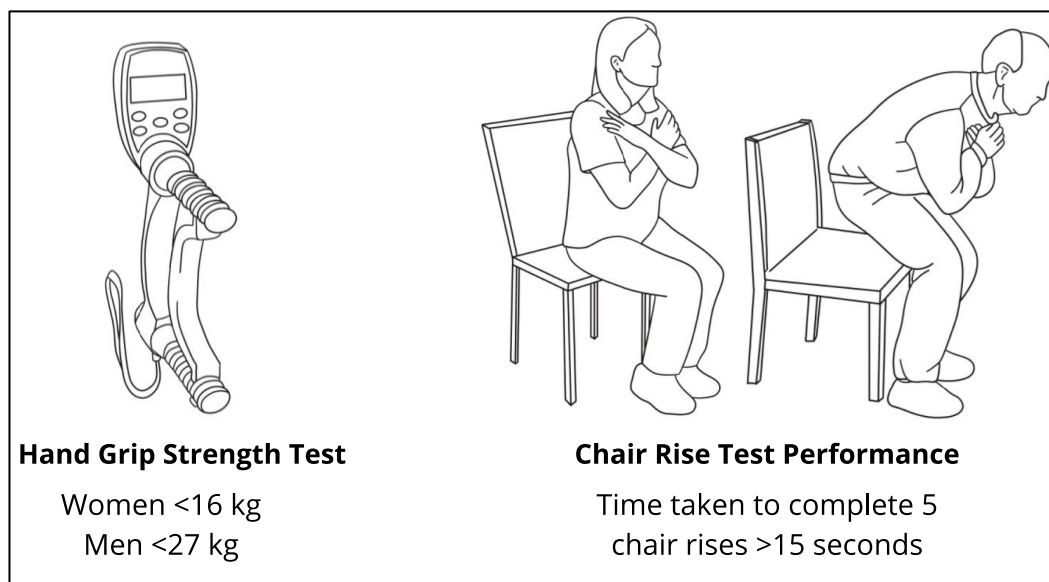


Figure 2.2: EWGSOP2 criteria for low hand grip strength and poor chair rise test performance

The availability of markers of low muscle strength in the chapters included in this thesis are outlined in Table 2.4. Probable sarcopenia was assessed by hand grip strength alone in participants of TILDA (Chapter 3) due to the absence of data on chair rise test performance (**Table 2.4**). Data on chair rise test performance was available for participants of ELSA (Chapter 4) and collected, where possible, as part of fieldwork (Chapter 5B). Additionally, the SARC-F tool was employed to aid sarcopenia case finding in Chapter 5B, in line with EWGSOP2 guidelines ³⁷.

Table 2.4: Availability of EWGSOP2 criteria for sarcopenia in the health assessment components of TILDA (Chapter 3), ELSA (Chapter 4) and Fieldwork (Chapter 5B)

EWGSOP2 Criteria				TILDA	ELSA	Fieldwork
<i>Case-finding</i>						
SARC-F				x	x	√
<i>Probable Sarcopenia</i>						
Hand Grip Strength				√	√	√
Chair	Rise	Test		x	√	√
Performance						

Abbreviations: TILDA, The Irish Longitudinal Study on Ageing; ELSA, the English Longitudinal Study of Ageing

Hand grip strength is considered a powerful biomarker of ageing given its well-documented associations with multimorbidity and premature all-cause mortality ³⁶. While considered a reliable marker, several protocols have been developed to standardise the measurement of hand grip strength ¹⁸⁰. As detailed in the fieldwork study protocol (**Appendix 3**), hand grip strength was measured using a Jamar Plus+ Digital Hand Dynamometer (IL, USA) and standardised using the procedure described by Roberts et al ¹⁸¹. Briefly, participants were seated upright in a chair with their forearms supported by armrests and instructed to sit with their hips and knees at a 90-degree angle. The dynamometer was placed in the testing forearm and with the base supported by the assessor to control for gravitational effects. Three measurements were taken from each hand with participants encouraged to squeeze the dynamometer using maximum effort for approximately 3 seconds. Six measurements were taken in total (three per forearm), with 30 seconds of rest between trials. Readings were displayed on the digital analogue in kilograms and the maximum dominant hand grip strength value was used in analyses.

In contrast, TILDA used a Baseline Hydraulic Hand dynamometer (White Plains, NY, USA), while ELSA used a Smedley dynamometer (Stoelting Co, IL, USA) to measure hand grip strength in nurse-led health assessments ^{74,182}. Acceptable inter-instrument reliability and concurrent validity has been shown between Jamar and Baseline Dynamometers ¹⁸³. Use of the Smedley dynamometer in ELSA has known limitations, with research suggesting the Smedley dynamometer may overestimate muscle weakness in comparison to Jamar hydraulic dynamometers, despite high correlation observed between both ¹⁸⁴. Most participants in ELSA completed the hand grip strength test while in a standing position (80%) ⁷⁴, with three measurements taken from both

hands. Similarly, participants of TILDA completed the hand grip strength test while standing, unless this position could not be maintained, in which participants completed the test while in a seated position. Two measurements were taken per hand for participants of TILDA. In analyses of hand grip strength data collected in TILDA (Chapter 3), ELSA (Chapter 4) and fieldwork (Chapter 5B), the maximum hand grip strength value was used in analyses. As per the protocol for each study, participants with swelling, pain or recent injury or surgery in hands or arms were excluded from the hand grip strength test.

Chair rise test, sometimes referred to as the chair stand test or the 5-times sit to stand test (5XSST), and a proxy measure of lower extremity strength¹⁸⁵, involved participants rising from a sitting to standing position five times as quickly as possible while being timed. The chair rise test aims to monitor lower extremity strength, speed and power, with each considered an important contributory factor to the ability to complete ADLs such as rising from a chair, climbing stairs and walking¹⁸⁵. The chair rise test has been applied in a range of community and acute-based settings, with poor performance associated with subsequent falls, disability and mortality in older adult populations^{77,186}.

In fieldwork (Chapter 5B), chair rise test performance was measured as the time taken to complete 5 chair rises using the Newcastle protocol proposed by Dodds et al for home-based assessments with older adults³⁹. As described in the study protocol (Appendix 3), participants were asked to sit upright in a firm straight-backed chair, with feet placed flat on the floor and arms crossed diagonally on their chest. Participants were asked if they felt safe to stand up from the chair without the use of arms. Following agreement, a single chair rise was completed. Participants were then instructed to return to the starting test position and asked if they felt safe to complete the same procedure five times as quickly as possible while being timed. The time taken to complete five chair rises was measured by the assessor until the participant was standing straight for the fifth time. If the participant was unable to complete a single or multiple chair rise test, the reason was recorded.

A similar protocol was applied in the health assessment component of ELSA, with participants asked to stand from a firm straight-backed chair without the use of arms¹⁸⁷. First attempting a single chair rise, followed by the multiple chair rise test, with the reason for non-completion in both instances noted. Those unable to complete the chair rise test due to the use of a walking aid, requiring use of arms to stand or unable to hold a standing position were classified as having poor chair rise test performance, in line with previous

studies ¹⁸⁸. As per EWGSOP2 guidelines, a time taken to complete 5 chair rises greater than 15 seconds was classified as poor chair rise test performance ³⁷.

The SARC-F tool, recommended for use in sarcopenia case-finding by EWGSOP2 ³⁷, is a five-item questionnaire covering the domains of Strength, Assistance with walking, Rise from a chair, Climb stairs - Falls (SARC-F) ¹⁸⁹. The SARC-F tool is a validated screening tool for predicting adverse outcomes in people with sarcopenia showing associations with functional limitations, impaired muscle strength, gait speed and recent hospitalisation ¹⁸⁹. It is proposed the SARC-F tool will aid sarcopenia case-finding by identifying those already experiencing symptoms of musculoskeletal decline. This includes muscle weakness, slowness, transferring from a chair, inability to climb stairs and recurrent falls ³⁷.

The **SARC-F questionnaire** asks the following questions:

1. How much difficulty do you have in lifting and carrying 10 pounds?
2. How much difficulty do you have walking across a room?
3. How much difficulty do you have transferring from a chair or bed?
4. How much difficulty do you have when climbing a flight of 10 stairs?
5. How many times have you fallen in the past year?

Each question carries a maximum of 2 points and is scored according to increasing difficulty, with a positive of score of ≥ 4 points indicating sarcopenia onset ³⁷. This cut-off score has been shown to have low to moderate sensitivity and high specificity to predict impaired muscle strength ¹⁹⁰. Referencing this evidence, EWGSOP2 note that the SARC-F tool will likely detect those with severe sarcopenia ³⁷. The SARC-F tool represents a relatively simple and inexpensive screening tool in the identification and management of sarcopenia ³⁷.

2.3.4 Anthropometric Measures

The inclusion of anthropometric measurements is important when assessing musculoskeletal health, given that the ageing process is associated with higher levels of visceral fat and adiposity that may co-exist with sarcopenia ¹⁹¹.

Body Mass Index

In fieldwork (Chapter 5B), participants' height was measured using a Seca 213 portable height measure (Hamburg, Germany). Footwear was removed, and participants were

measured in a standing position, facing outward, with feet placed flat on the floor and knees straight with readings recorded to the nearest 0.1 cm. Weight (kg) was measured using a calibrated Seca Aura 807 Electronic Scales (Hamburg, Germany) on hard floor surfaces. Participants were asked to remove heavy items of clothing, including outerwear and footwear.

A similar approach to the measurement of height and weight was adopted in TILDA and ELSA. In the health assessment component of TILDA, participants' height was measured using a Seca 240 wall mounted measuring rod (Hamburg, Germany). In TILDA, weight was measured using a SECA electronic floor scales. Height and weight were measured in cm and kg to one decimal place, respectively. Similarly, in ELSA, weight was measured to the nearest 0.1 kg using a portable electronic scales and height to the nearest 0.1 cm using a portable stadiometer. BMI was calculated from weight in kg to one decimal place and height (m²) and classified according to World Health Organisation (WHO) criteria: underweight (≥ 15 – 18.5 kg/m²), healthy weight (≥ 18.5 – 25 kg/m²), overweight (≥ 25 – 30 kg/m²) and obesity (≥ 30 kg/m²)¹⁹².

Calf Circumference

Calf circumference is has been used in the assessment of sarcopenia as a proxy measure of skeletal muscle mass estimation¹⁹¹ for example , in settings where more accurate diagnostic methods (e.g. BIA, DXA) are unavailable⁴⁷. Research suggests calf circumference is associated with nutritional risk, incident mobility disability and mortality in older adults^{193–195}. Measurement of calf circumference forms a component of the Mini Nutritional Assessment – Short Form (MNA-SF), utilised when data on BMI is unavailable, and applying a cut-off value of <31 cm¹⁹⁶. In fieldwork (Chapter 5B), participants were asked to sit upright, in a relaxed position, with hips and knees as close to 90 degrees as possible and feet placed on the floor. Calf circumference (cm) was measured at the widest point of the lower leg, at a plane perpendicular to the long axis of the calf, using a flexible tape measure. Measurements were taken from both legs with the highest value reported in analyses.

2.3.5 Health and Behavioural Risk Factors

Information on known health and behavioural risk factors, associated with impaired physical function, were collected, including physical activity levels, nutrition, alcohol consumption, and smoking. Given recent interest in the potential of e-health in older adult populations, specifically telemedicine¹⁹⁷, information on technology readiness was collected.

Physical Activity

Physical activity was considered an important factor given the well-established links with musculoskeletal health and role as a primary treatment of sarcopenia ³⁷. In fieldwork, physical activity levels were examined using the standardised International Physical Activity Questionnaire – Short Form (IPAQ-SF), also used in TILDA, and other large population studies. The IPAQ-SF assesses the time spent sitting or engaged in vigorous, moderate, and light activity and by MET minutes per week, a multiple of estimated resting energy expenditure, in the previous 7 days ¹⁹⁸. Among participants of ELSA, respondents were asked how often they engaged in vigorous intensity, moderate intensity, and low intensity physical activity with illustrative examples of each activity level shown on prompt cards. Respondents were classified as having high, moderate, or low physical activity levels. The absence of a validated or standardised physical activity tool in ELSA should be noted, however the thresholds applied for each activity level have shown associations with mortality in ELSA participants ¹⁹⁹.

Measures of Malnutrition

Malnutrition (undernutrition) is associated with sarcopenia and other adverse health outcomes ^{37,200}. In the in-home study, malnutrition was assessed by the Mini Nutritional Assessment Short Form (MNA-SF), a validated 6-item tool used in the screening of malnutrition ¹⁹⁶, and classified as normal nutritional status (12-14 points), at risk of malnutrition (8-11 points) or malnourished (0-7 points). In ELSA and TILDA, low BMI category was noted as a marker of undernutrition, as nutrition screening tools were not available.

Technology Readiness

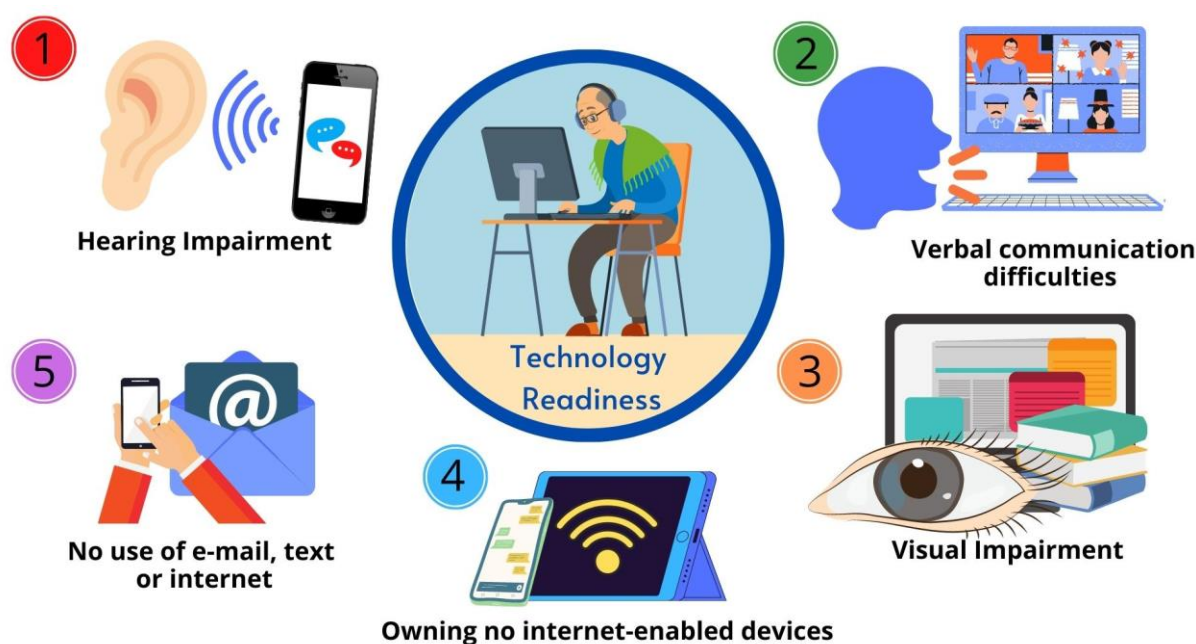


Figure 2.3: Direct and indirect factors influencing technology readiness in older adult populations

The term “technology readiness” refers to the necessary skills and resources required for the use of internet or internet-enabled devices ²⁰¹. No standard, validated questionnaires are routinely used to assess technology readiness in older adult populations. Most evidence to date is derived from survey data from large observational studies ^{197,202}. In fieldwork (Chapter 5B), technology unreadiness was defined as meeting one of the previously defined criteria ¹⁹⁷: 1) inability to use a telephone due to a hearing impairment, 2) verbal communication difficulties 3) difficulty reading or watching television due to visual impairment, 4) owning no internet-enabled devices and 5) no use of email, texting or internet in the previous month (**Figure 2.3**). Attention was given to functional domains that may influence the ability to engage in telemedicine such as visual and hearing impairments or verbal communication difficulties ¹⁹⁷.

Other Health and Behavioural Factors

The uptake of lifestyle risk factors such as smoking and alcohol consumption have been shown to vary based on individual-level SEP and show associations with adverse health outcomes ²⁰³. Alcohol consumption and smoking status were collected based on self-report. Smoking status was classified as current, past or never smoker. Alcohol intake was recorded as a dichotomous variable based on self-reported consumption in the previous 12 months (yes/no).

2.3.6 Indicators of Health Status

Self-rated Health

Self-rated health, a subjective judgement of current health status, is a strong predictor of mortality ³¹. While the measurement of self-rated health is widely used in large international surveys and clinical trials ³¹, there is some discernment among scholars and clinicians around the accuracy of the seemingly non-specific one-item measure ^{204,205}. Research examining the usefulness of the measure in older adults, found similar performance between self-rated health and objective health status in predicting short-term mortality risk ²⁰⁵. In the present study, participants were asked ‘in general, how would you rate your health?’ with potential responses following a five-point scale: excellent, very good, good, fair or poor.

Functional Comorbidity Index

The Functional Comorbidity Index (FCI) is a tool developed to adjust for the effect of comorbid disease in studies with physical function as a primary outcome ²⁰⁶. Limitations of this tool include the absence of data on disease severity, applicable to longitudinal population studies of ageing which do not routinely collect symptom-based data ²⁰⁶. The FCI included a total of 18 prevalent diagnoses, with conditions selected based on associations with physical function ²⁰⁶. Osteoarthritis and obese BMI, documented risk factors of sarcopenia ³⁷, were excluded from the FCI and included as independent variables. Long-term conditions assessed using the FCI produced a continuous count in fieldwork analyses (range: 0-17) and in participants of TILDA and ELSA based on the availability of data on chronic conditions (range 0-15) (*Supplementary Table 2.1*) ²⁰⁶.

Polypharmacy

Polypharmacy, commonly defined as the regular use of 5 or more medications ²⁰⁷, is associated with greater risk of hospitalisation and mortality in older adult populations ²⁰⁸. Polypharmacy was considered important as it may be considered a proxy measure of number of chronic conditions ²⁰⁸. Number of prescribed medications was self-reported, confirmed with products and prescriptions within the home and excluded nutritional supplements and over the counter medications. In administrative data (Chapter 5A), number of prescribed medications was documented in Common Summary Assessment Reports (CSARs), completed by allied healthcare professionals as part of the review and referral process for formal home care packages. Excessive polypharmacy was defined by reporting 10 or more prescribed medications ²⁰⁷.

Frailty

Frailty, the cumulative decline of in-built reserves in multi-body systems ⁹¹, represents a state of increased vulnerability to external stressors in older adults. Frailty is associated with adverse health outcomes including premature disability, hospitalisation and mortality ²⁰⁹. In fieldwork (Chapter 5B), frailty was assessed using the judgement-based Clinical Frailty Scale (CFS), initially developed for the Canadian Study of Health and Ageing ²¹⁰. The CFS quantifies the degree of disability from frailty in multiple domains including independence in ADLs, multimorbidity, mobility, physical activity and cognition ²¹⁰. The CFS can be easily administered in community based settings, with community-dwelling Irish older adults identified as frail (CFS) identified as at significantly higher risk of premature mortality at 8-year follow-up ²¹¹.

Physical Dependency (Barthel Index)

In routine health administrative data (Chapter 5A), physical dependency was indicated by the Barthel Index, a 10-item scoring tool assessing the degree of independence in ADL performance including continence, personal care, toileting, feeding and mobility ²⁰⁰. In the context of this research thesis, the Barthel Index was used as maker of physical function and ADL-dependency primarily for Chapter 5 as it is routinely completed for older adult populations receiving home care, whereas sarcopenia and frailty are not routinely recorded. Indeed the Barthel Index is the instrument applied in the 'assessment of need' for support as part of referral process for formal home care and subsequent reviews ²¹². The Barthel Index, recommended for routine use in the assessment of older adults ²¹³, produces an output score ranging from 0-20 with higher scores indicating greater independence. Barthel scores were classified by maximum dependency (score 0-4), high dependency (score 5-8), moderate dependency (score 9-11), mild dependency (score 12-19) and independence (score 20), as per previous studies ²⁰⁰.

Health and Social Care Utilisation

In TILDA, home care utilisation was recorded based on self-reported receipt of state-funded home help or assistance from a Personal Care Attendant in the previous 12 months, at time of interview. In Chapter 5, the number of formal home support hours received per week was obtained from CSARs. In fieldwork (Chapter 5B), participants were asked if they had been admitted to hospital in the previous 12 months, and the answer recorded as a dichotomous variable (yes/no). In routine administrative data (Chapter 5A), acute hospitalisation was recorded, where this was documented as the reason and source of the referral to home support for ADL assistance. In fieldwork, information on day centre attendance was based on self-report.

2.4 Embedding physical activity within community home support services for older adults in Ireland – A qualitative study of barriers and enablers (Chapter 6)

2.4.1 Ethical approval

Ethical approval for this study was granted by the Royal College of Surgeons in Ireland Research Ethics Committee (REC – 2018:1489) and written informed consent was obtained from all subjects involved in the study (**Appendix 7**). Clinical Trial Number: ISRCTN72605421.

2.4.2 Study sponsorship

This research was funded by a Health Research Board, Applied Partnership Award grant number APA-2017-013.

2.4.3 Overview of the 'Care to Move' programme feasibility study

Chapter 6 sought to explore potential solutions that may address sarcopenia and poor physical function and promote independence for community dwelling older people. This study was conducted as part of a multidisciplinary collaborative feasibility study, aiming to examine the implementation of a physical activity program, Care to Move (CTM), within formal home care services for community-dwelling older adults with ADL-dependency in Ireland ²¹⁴. The programme comprised of physical activity training delivered to formal Health Care Assistants (HCAs), who became trained 'movement motivators', encouraging older adults in receipt of formal care services to do more 'movement' associated with self-care activities. 'HCA' is used in Irish healthcare, though, several other terms are in use nationally and internationally in practice and research to describe the staff who participated in this study (including home care worker, home care assistant, home help, caregiver, home support worker, domiciliary care worker). The Care to Move programme was not a structured exercise programme, rather HCAs supported older adults to integrate strength and balance activities within their daily routine. The published study protocol and results are detailed elsewhere ^{214,215}.

In brief, HCAs completed a 2-day CTM training course delivered by a Senior Physiotherapist and qualified CTM trainer. The CTM training included communicating the importance of movement, deploying specific movement prompts within usual care activities, and motivating older adults to engage with previously prescribed home exercise plans designed by formal therapy services. HCAs completed the CTM training

course between March 2019 – February 2020. In total, 47 HCAs were trained in CTM and delivered the programme to participants for around 6 months.

Prospective older adult participants were recruited from a non-profit home care organisation in Ireland and screened based on pre-defined inclusion and exclusion criteria. Inclusion criteria: aged 65 years and older, scored 6 or less on the CFS, reported at least one fall in the previous 12 months, and were independently mobile (with or without a walking aid). Exclusion criteria were as follows: moderate to severe cognitive impairment, unstable clinical conditions, receiving palliative care, or unable to follow instructions about physical activity. Recruitment took place between May 2019 – November 2020, crossing the timeline of the Covid-19 pandemic.

2.4.4 Qualitative interviews with Health Care Assistants (HCAs)

In a feasibility study, the CTM programme was delivered through existing home support services ²¹⁴. In this descriptive qualitative study ²¹⁶, HCAs who were trained in CTM and subsequently encouraged and supported movement in daily life tasks with older adults in receipt of formal home support services, participated in semi-structured telephone interviews (n= 22). Although a total of 47 HCAs were trained in the CTM programme between March 2019-February 2020, HCA workforce retention was severely impacted by the Covid-19 pandemic ²¹⁴. A total of 22 HCAs remained employed with the home support provider and were actively providing home support services between August-September 2020 and all agreed to participate in semi-structured interviews. The semi-structured interviews explored the HCAs' experiences and views of promoting physical activity, barriers, and enablers to the delivery of the programme and suggestions for future implementation (**Appendix 8**). The latter included views on the potential role of technology. All interviews were conducted by telephone between August and September 2020, audio-recorded, and transcribed verbatim. The average length of interview was 16 minutes (range from 11 to 24 minutes). Written informed consent was obtained from all participants which included publication of anonymised responses. Accordingly, HCAs are described using coded identification numbers (e.g. HCA001).

2.4.5 Qualitative Data Analysis

All transcripts were analysed using a reflexive approach to thematic analysis which followed the 6 phase guide provided by Braun and Clarke to identify themes within the data ^{217,218}. Interviews were read in their entirety. Following this, inductive coding

commenced, wherein segments of data were systematically highlighted including words and phrases relevant to each code ²¹⁹. Codes with similar meaning were grouped and collapsed to form themes pertinent to enablers and barriers to implementation of the program. These themes were then reviewed, and the research team conferred to discuss overarching themes. Following refinement of the identified themes, other authors were consulted for feedback and consensus based on the interview data, ensuring that overarching themes and sub-themes accurately reflected the supporting data. Finally, all authors provided feedback on the written manuscript. Authors who conducted the qualitative analyses did not partake in the CTM training delivered to the HCAs, to maintain objectivity and reduce bias.

2.4.6 Individual Contribution

As part of the larger feasibility study ²¹⁴, I led and designed a sub-study examining the barriers and enablers of embedding physical activity within formal home care services in Ireland. I engaged in each stage of the study design, including the conceptualisation of study aims, conducting the qualitative interviews with HCAs, data analysis and manuscript formation.

2.5 Statistical Data Analysis

In this thesis, descriptive statistics are namely reported as proportions (n), mean averages, standard deviation (SD), median and interquartile range (IQR). Normality was assessed visually using histogram plots, in addition to normal probability plots and Shapiro–Wilks test. Comparison of baseline characteristics was conducted using ANOVA analysis or Kruskal–Wallis tests for continuous variables, as appropriate. Chi-square test for independence (χ^2) was used to examine categorical variables. Mantel–Haenszel test for trend was used to examine trends between categorical variables and residential deprivation (Chapter 5A). Multicollinearity was assessed using correlation matrices and Variance Inflation Factors (VIFs). Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) are reported for multivariable logistic regression analyses. All analyses were performed using IBM SPSS Statistics V27 software

Supplementary Table 2.1: Classification of self-reported physician-diagnosed chronic conditions in TILDA, ELSA and Fieldwork

FCI Item	Fieldwork Variable	Score	TILDA Variable	Score	ELSA Variable	Score
Arthritis (rheumatoid and osteoarthritis)	<i>Has rheumatoid arthritis ^a</i>	1	<i>Has rheumatoid arthritis ^a</i>	1	<i>Has rheumatoid arthritis ^a</i>	1
Osteoporosis	<i>Has osteoporosis</i>	1	<i>Has osteoporosis</i>	1	<i>Has osteoporosis</i>	1
Asthma	<i>Has asthma</i>	1	<i>Has asthma</i>	1	<i>Has asthma</i>	1
COPD, ARDS or emphysema	<i>Has COPD, ARDS, chronic bronchitis or emphysema</i>	1	<i>Has chronic lung disease such as chronic bronchitis or emphysema</i>	1	<i>Has chronic lung disease such as chronic bronchitis or emphysema</i>	1
Angina	<i>Has angina</i>	1	<i>Has angina</i>	1	<i>Has angina</i>	1
Congestive heart failure (or heart disease)	<i>Has congestive heart failure or heart disease</i>	1	<i>Has congestive heart failure</i>	1	<i>Has congestive heart failure</i>	1
Heart attack (myocardial infarct)	<i>Had heart attack</i>	1	<i>Had a heart attack including myocardial infarction or coronary thrombosis</i>	1	<i>Had a heart attack including myocardial infarction or coronary thrombosis</i>	1
Neurological disease (e.g. multiple sclerosis or Parkinson's)	<i>Has neurological disease</i>	1	<i>Has Parkinson's</i>	1	<i>Has Parkinson's</i>	1
Stroke or transient ischemic attack	<i>Had stroke or TIA</i>	1	<i>Had stroke</i> <i>Had a mini stroke or TIA</i>	1	<i>Had stroke</i> <i>Had TIA</i>	1
Peripheral vascular disease	<i>Has peripheral vascular disease</i>	1		Excluded ^b		Excluded ^b
Diabetes mellitus types I and II	<i>Has diabetes mellitus types I and II</i>	1	<i>Has diabetes or high blood sugar</i>	1	<i>Has diabetes</i>	1
Upper gastrointestinal disease (e.g. ulcer, hernia or reflux)	<i>Has upper gastrointestinal disease</i>	1	<i>Has stomach ulcers</i>	1	<i>Has stomach ulcers</i>	1
Depression	<i>Has depression</i>	1	<i>Has depression</i>	1	<i>Has depression</i>	1
Anxiety or panic disorders	<i>Has anxiety or panic disorders</i>	1	<i>Has anxiety</i>	1	<i>Has anxiety condition</i>	1
Visual impairment (e.g. cataracts, glaucoma, macular degeneration)	<i>Has cataracts</i> <i>Has glaucoma</i> <i>Has macular degeneration</i>	1	<i>Has cataracts</i> <i>Has glaucoma</i> <i>Has age-related macular degeneration</i>	1	<i>Has cataracts</i> <i>Has glaucoma</i> <i>Has macular degeneration</i>	1

Hearing impairment (<i>very hard of hearing even with hearing aids</i>)	<i>Has hearing impairment</i>	1	<i>Self-rated hearing (with or without hearing aid) as fair/poor</i>	1	<i>Self-rated hearing (with or without hearing aids) as fair/poor</i>	1
Degenerative disc disease	<i>Has degenerative disc disease</i>	1		Excluded^b		Excluded^b
Obesity (<i>BMI >30 kg/m²</i>)	<i>Body Mass Index >30 kg/m²</i>	Excluded^b	<i>Body Mass Index >30 kg/m²</i>	Excluded^b	<i>Body Mass Index >30 kg/m²</i>	Excluded^b
MAXIMUM TOTAL SCORE		17		15		15

^a Osteoarthritis and Obese BMI were considered as independent variables. ^b Data not captured in the Irish Longitudinal Study on Ageing (TILDA) and the English Longitudinal Study of Ageing (ELSA). Abbreviations: COPD, Chronic Obstructive Pulmonary Disease; ARDS, Acute Respiratory Distress Syndrome; TIA, Transient Ischemic Attack; BMI, Body Mass Index.

Chapter 3 - An investigation of probable sarcopenia in community-dwelling older adults in Ireland based on socioeconomic position

3.1 Introduction

In Chapter 1, we described a growing body of evidence highlighting associations between disadvantaged socioeconomic position (SEP) and impaired physical function, specifically, muscle function in older adults ^{130,132,220}. SEP refers to the social and economic factors that influence one's position within the hierarchical structure of society ⁹³. In research, SEP has been operationalised in a number of ways, most commonly as individual-level factors such as educational attainment, wealth, income and occupation class ⁹². While SEP has been linked with several chronic diseases in ageing ¹⁰, associations between SEP and probable sarcopenia, a precursor of the muscle condition sarcopenia ³⁷, has not been extensively studied.

In 2019, the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) updated their definition of sarcopenia, introducing the concept of probable sarcopenia ³⁷. As per EWGSOP2 guidelines ³⁷, probable sarcopenia is present if low hand grip strength (<16kg for women and <27 kg for men) or poor chair rise test performance is detected (5 chair rise >15 seconds). The reported prevalence of EWGSOP2-defined probable sarcopenia in community-dwelling older adult populations vary significantly, with estimates between 19-73% ^{80,83}. This variance is attributable in part to differences in the demographic profile of study populations, with higher prevalence commonly observed in cohorts of older age or study populations recruited in primary care settings ⁸³. There are methodological differences across studies, with some defining probable sarcopenia by hand grip strength alone ^{82,84,86,221}, where information on chair rise test performance is unavailable, in line with EWGSOP2 guidelines ³⁷.

Emerging evidence from longitudinal studies suggests probable sarcopenia is associated with adverse health outcomes including increased length of stay in hospital and greater mortality risk in older adult populations ^{83,222,223}. Research suggests that probable sarcopenia is multifactorial, influenced by older age, physical inactivity, BMI and comorbidity ^{80,82,86}. Recent findings from cross-sectional studies suggest associations between socioeconomic disadvantage and sarcopenia, however, there is a paucity of research in this area. Dodds et al, found no association between manual occupation class at age 53 years and probable sarcopenia in participants of the 1946 British Birth Cohort (n= 1686, all aged 69 years old) ⁸⁰. Recently, a study from Colombia reported a significantly higher prevalence of probable sarcopenia in participants with disadvantaged social class (46.5%) vs high SEP subjects (31.1%) (n= 5237, mean age 70.4 ± 7.8 years) ⁸². Similarly, Brennan-Olsen et al, in a 6-year longitudinal analysis of older adults in Australia, reported lower hand grip strength and lower extremity strength

in disadvantaged SEP groups, classified by educational attainment and occupation class⁸⁷, however the study population were aged under 80 years old and EWGSOP2 criteria for low muscle strength was not applied. Findings on SEP and probable sarcopenia remain limited and inconsistent, with few studies including socioeconomic variables in multivariable analyses adjusting for demographic and behavioural factors⁸⁰.

In the present chapter, we investigated if disadvantaged SEP, defined by educational attainment and wealth, was a determinant of probable sarcopenia in a large population of community-dwelling older adults aged 60 years and older, based on data from The Irish Longitudinal Study on Ageing (TILDA). We hypothesised that probable sarcopenia would be more prevalent in older adults with the most vs least disadvantaged SEP, when defined by educational attainment and wealth. It was anticipated that the findings may assist in the development of strategies for early detection and treatment of sarcopenia and support the diverse needs of older adults in the community.

The aims of the present chapter:

- To describe the prevalence of probable sarcopenia (EWGSOP2 guidelines), in community-dwelling older adults, overall and according to SEP, defined by education and wealth
- To explore associations between SEP and probable sarcopenia when controlled for demographic, health and behavioural factors

3.2 Methods

3.2.1 Study Design and Population

This study was based on a publicly available dataset of Wave 1 of the Irish Longitudinal Study on Ageing (TILDA). TILDA is a nationally representative, ongoing longitudinal study which includes adults aged 50 years and older in Ireland ²²⁴. Wave 1 took place in 2009-2011 and included a total of 8,504 community-dwelling older adults. Participants were invited to take part in a health centre or home-based health assessment of which 6,152 adults enrolled (72.3%). Of those who completed the health assessment component, a majority completed this in a health centre (86%) and 14% completed a home-based health assessment. The TILDA study was conducted according to the guidelines set out in the Declaration of Helsinki, and ethical approval was granted by the Trinity College Dublin Research Ethics Committee ²²⁵. Written informed consent was obtained from all participants.

For the present study, the inclusion criteria were as follows: community-dwelling adults, aged 60 years and older, participated in the health assessment and completed the hand grip strength assessment. Of those who participated in a health assessment, 3,469 individuals were aged 60 years and older and only those with two complete measurements for dominant hand grip strength were included in the study (n= 3,342) **(Figure 3.1)**

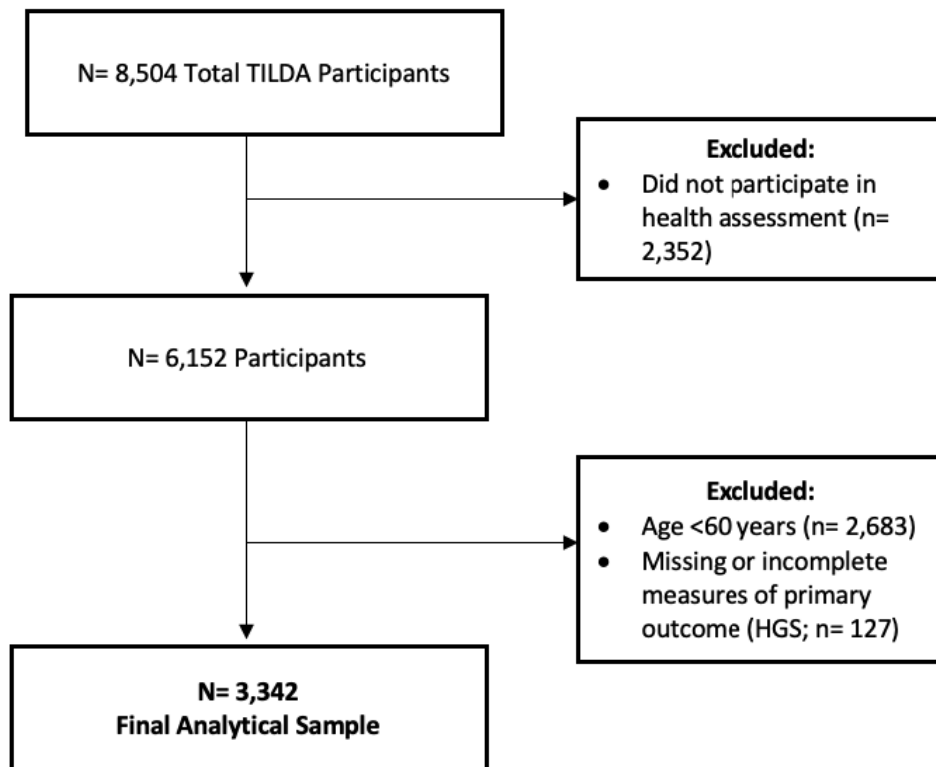


Figure 3.1: Study Inclusion and Exclusion Criteria

3.2.2 Identifying Probable Sarcopenia

Probable sarcopenia was defined as per the EWGSOP2 cut-off criteria for hand grip strength of less than 27kg in men and 16kg in women ³⁷. Grip strength was assessed using a Baseline Hydraulic Hand Dynamometer with two measures taken per hand and the maximum value for the dominant hand used in analyses, in line with previous studies ^{80,83}. Acceptable inter-instrument reliability and concurrent validity has been shown between Jamar and Baseline Dynamometers ¹⁸³.

3.2.3 Determining Socioeconomic Position

Socioeconomic position was defined by the highest self-reported level of formal education completed and total asset wealth. Completion of none, part or all of primary education was classified as disadvantaged SEP. Participants who exited formal education following the completion of Junior/Intermediate Certificate or Leaving Certificate examinations were classified as the intermediate SEP group. Completion of a third-level qualification was classified as high SEP. Highest educational qualification was previously identified as a suitable indicator of SEP amongst older adult populations ⁹². Total asset wealth, a measure of economic resources and computed as a derived variable in TILDA, was defined by several indicators including self-reported value of

primary residence in addition to second homes, savings, debts and value of private pensions. Total asset wealth was classified as four groups according to 25th, 50th, 75th and 100 percentiles, with Q1 representing the highest wealth quartile, and Q4 indicating the lowest wealth quartile.

3.2.4 *Covariates*

A full specification of covariates included in analyses from Wave 1 is outlined in Chapter 2. Demographic factors included gender and age, with the latter top-coded at age 80 years old, frequently applied to preserve anonymity in public release data. Potential risk factors for probable sarcopenia were selected based on current evidence ³⁷. Briefly, this included physical activity levels (IPAQ), classified as high, moderate, or low physical activity levels. Body Mass Index (BMI) was calculated based on weight (kg) and height (m²) and classified as underweight range (≥ 15 -18.5 kg/m²), healthy (≥ 18.5 -25 kg/m²), overweight (≥ 25 -30 kg/m²) and obese range (≥ 30 kg/m²) ¹⁹². Comorbidities were classified according to the Functional Comorbidity Index (FCI), modified as per previous studies ²²⁶, based on the available participant data. Osteoarthritis was recorded as present based on self-reported diagnosis by a physician. Home care utilisation, an indicator of limitations in activities of daily living (ADLs) ²²⁷, was recorded based on self-report and included state-funded home-help or personal care attendants. Smoking status was classified as never smoked, past smoker or current smoker. Alcohol consumption status was recorded as a dichotomous variable: current alcohol consumer or non-consumer.

3.2.5 *Statistical Analysis*

Descriptive statistics are reported as proportions (*n*), means $\pm$ SD or percentages. Normality was assessed visually using histogram plots, in addition to normal probability plots and Shapiro–Wilks test. Chi-square test for independence was applied to compare sociodemographic and independent variables of interest for the probable sarcopenic vs reference group. Independent Student t-tests were used for comparing continuous variable characteristics of the sarcopenic group with the reference group. Mantel-Haenszel test for trend was used to examine trends between probable sarcopenia and SEP categorical variables. Following univariate analysis, factors showing significant associations ($p < 0.05$) with probable sarcopenia were included in multivariable logistic regression analysis. Multicollinearity was assessed using correlation matrices and Variance Inflation Factors (VIFs). Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) are reported for multivariable logistic regression analyses. Statistical

weightings for health assessment participation were not available in the publicly available version of Wave 1 TILDA data, used in this study, therefore, multivariable regression analyses present unweighted ORs and CIs. All analyses were performed using IBM SPSS Statistics V24 software.

3.3 Results

3.3.1 Study Population

The study population (**Table 3.1**) was of mean age 68.9 ± 6.3 years, with 42.4% aged 70 years and older and 53.1% female. Based on educational attainment as a marker of SEP, 34.9% of participants exited formal education at primary level ($n = 1,166$), 36.1% after completion of Junior or Leaving Certificate (high school) examinations ($n = 1,207$) and 29.0% completed third-level education ($n = 969$). Overweight and obesity were common (78.4%), and just under one third (32.7%) of participants reported low levels of physical activity. A majority of the population reported being current or past smokers (55.3%) and consumed alcohol (70.4%). Most of the study population had two or more documented chronic conditions (54.2%). Overall, 4.9% of participants were in receipt of state-funded home care services.

Table 3.1: Characteristics of the population group overall, and based on the presence of probable sarcopenia as defined by the EWGSOP2 criteria for low hand grip strength ($n = 3,342$)

	Overall ($n = 3,342$)	Reference ¹ No Probable Sarcopenia ($n = 2,559$)	Probable Sarcopenia ($n = 783$)	p-Value
Age, mean $\pm$ SD (years)	68.9 ± 6.3	67.9 ± 5.9	72.3 ± 6.7	$<0.001^*$
Gender, n (%)				
Female	1775 (53.1)	1369 (53.5)	406 (51.9)	0.419
Male	1567 (46.9)	1190 (46.5)	377 (48.1)	0.419
Age Categories, n (%)				
60-64	1039 (31.1)	907 (35.4)	132 (16.9)	$<0.001^*$
65-69	885 (26.5)	735 (28.7)	150 (19.2)	$<0.001^*$
70-74	650 (19.4)	508 (19.9)	142 (18.1)	0.288
75-79	441 (13.2)	265 (10.4)	176 (22.5)	$<0.001^*$
80+	327 (9.8)	144 (5.6)	183 (23.4)	$<0.001^*$
SEP: Educational Attainment, n (%)				
$\leq$ Primary Level	1166 (34.9)	829 (32.4)	337 (43.0)	$<0.001^*$
Secondary Level	1207 (36.1)	936 (36.6)	271 (34.6)	0.316
Third Level	969 (29.0)	794 (31.0)	175 (22.3)	$<0.001^*$
SEP: Wealth Quartile, n (%)				
Q1- Highest	830 (24.8)	686 (26.8)	144 (18.4)	$<0.001^*$
Q2	841 (25.2)	652 (25.6)	189 (24.1)	0.449
Q3	823 (24.6)	616 (24.1)	207 (26.4)	0.179
Q4 - Lowest	848 (25.4)	605 (23.6)	243 (31.0)	$<0.001^*$
Body Mass Index (kg/m^2), n (%)				
Underweight (≥ 15 -18.5)	19 (0.6)	10 (0.4)	9 (1.1)	0.025*
Healthy Weight (≥ 18.5 -25)	702 (21.0)	509 (19.9)	193 (24.6)	0.004*
Overweight (≥ 25 -30)	1433 (42.9)	1128 (44.1)	305 (39.0)	0.011*
Obese (≥ 30)	1188 (35.5)	912 (35.6)	276 (35.2)	0.842

Physical Activity Level, n (%)				
Low	1094 (32.7)	755 (29.5)	339 (43.3)	<0.001*
Moderate	1191 (35.6)	922 (36.0)	269 (34.4)	0.392
High	1057 (31.6)	882 (34.5)	175 (22.3)	<0.001*
Smoking status, n (%)				
Never smoked	1496 (44.8)	1151 (45.0)	345 (44.1)	0.652
Past smoker	1409 (42.2)	1068 (41.7)	341 (43.6)	0.368
Current smoker	437 (13.1)	340 (13.3)	97 (12.4)	0.514
Alcohol consumption, n (%)				
Alcohol consumer	2156 (70.4)	1700 (72.1)	456 (64.7)	<0.001*
Non-consumer	908 (29.6)	659 (27.9)	249 (35.3)	<0.001*
Long-term conditions, n (%)				
0	626 (18.7)	523 (20.4)	103 (13.2)	<0.001*
1	904 (27.0)	731 (28.6)	173 (22.1)	<0.001*
≥2	1812 (54.2)	1305 (51.0)	507 (64.8)	<0.001*
Osteoarthritis, n (%)	587 (17.6)	417 (16.3)	170 (21.7)	<0.001*
Receives state home care services, n (%)	164 (4.9)	77 (3.1)	87 (11.1)	<0.001*

¹ did not meet the criteria for probable sarcopenia based on the EWGSOP2 cut-offs for weak hand grip strength. Chi-squared χ^2 and independent student t-test used for comparisons between groups (*p <0.05).

3.3.2 Prevalence of probable sarcopenia overall and according to socioeconomic position

The prevalence of probable sarcopenia was 23.4% (n= 783) as defined by the EWGSOP2 cut-off criteria for weak hand grip strength (**Table 3.1**). Analysis of SEP based on educational attainment shows probable sarcopenia was highest (28.9%, n= 337) among older adults with primary education only and lowest in those with tertiary education (18.1%, n= 175, p<0.001) (**Table 3.2; Figure 3.2**). Probable sarcopenia was documented for 22.5% (n= 271) of those with secondary level education. A similar trend was observed when SEP was operationalised by wealth quintiles, with a greater proportion of Q4 participants, signifying the lowest value wealth quintile, meeting the criteria for probable sarcopenia (28.7%), compared to Q1 (17.3%, p<0.001).

Table 3.2: Crude prevalence of probable sarcopenia based on SEP and age (n= 3342)

%Probable Sarcopenia ^a	SEP: Educational Attainment			p-Value	
	Third-Level (n= 969)	Secondary-Level (n= 1207)	Primary-Level (n= 1166)		
Overall, n (%)	175 (18.1)	271 (22.5)	337 (28.9)	<0.001*	
Age Category, n (%)					
60-69	77 (12.5)	104 (14.3)	101 (17.3)	0.019*	
70-79	72 (24.6)	114 (29.8)	132 (31.7)	0.046*	
80+	26 (42.6)	53 (53.5)	104 (62.3)	0.007*	
%Probable Sarcopenia	SEP: Wealth Quartile ^b				
	Q1 (n= 830)	Q2 (n= 841)	Q3 (n= 823)	Q4 (n= 848)	
Overall, n (%)	144 (17.3)	189 (22.5)	207 (25.2)	243 (28.7)	<0.001*
Age Category, n (%)					
60-69	57 (10.4)	70 (14.0)	83 (17.6)	72 (17.7)	<0.001*
70-79	64 (26.9)	80 (29.2)	73 (27.9)	101 (31.9)	0.254
80+	23 (50.0)	39 (58.2)	51 (56.7)	70 (56.5)	0.632

^a Crude prevalence of participants meeting the criteria for probable sarcopenia.

^b Q1 signifies highest wealth quartile and Q4 the lowest wealth quartile.

* Denotes Mantel-Haenszel test for trend $p < 0.05$

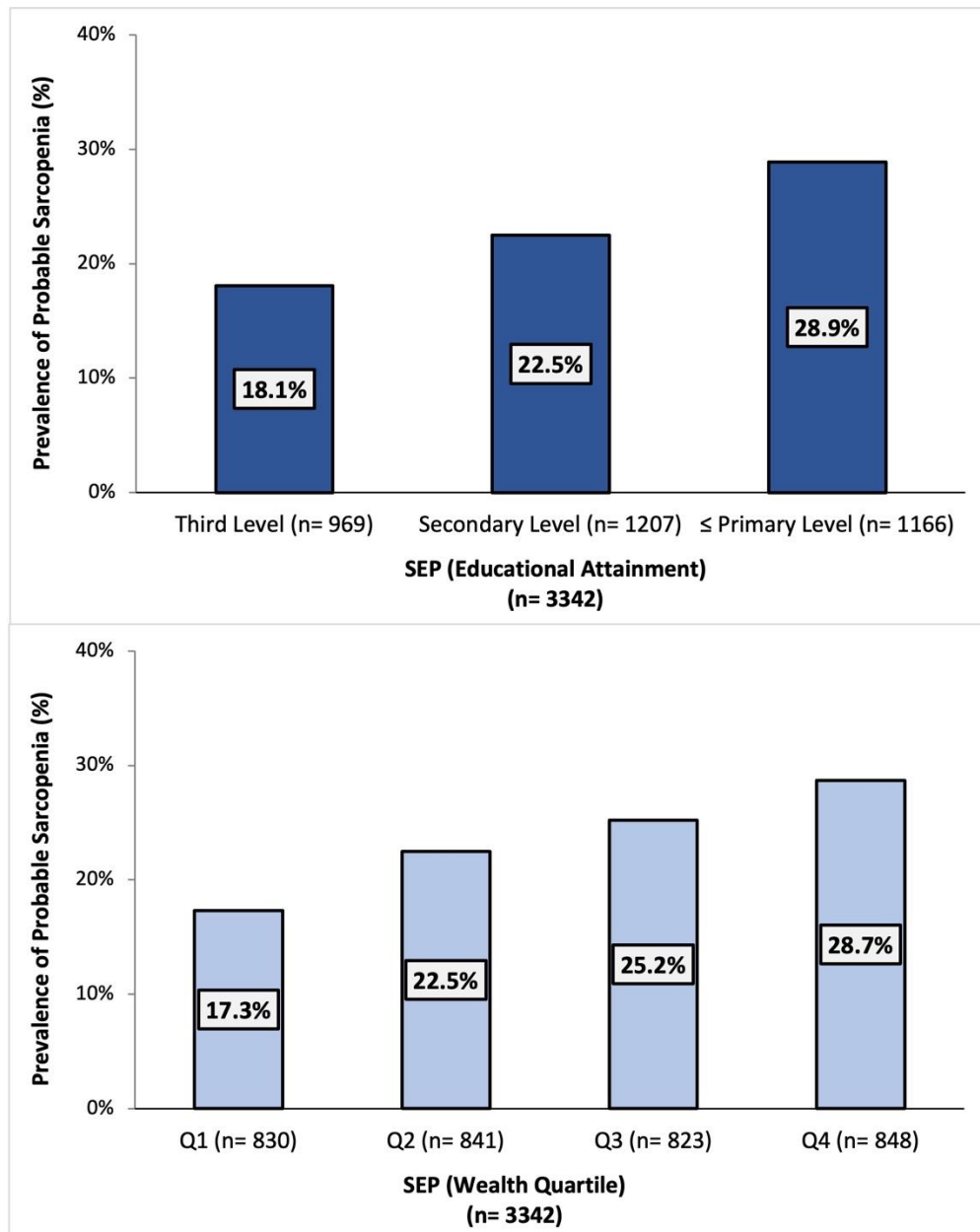


Figure 3.2: Crude prevalence (%) of probable sarcopenia in community older adults based on socioeconomic position (educational attainment and wealth). Q1 signifies highest wealth quartile and Q4 the lowest wealth quartile.

3.3.3 Characteristics of older adults with probable sarcopenia

The profile of the study population with probable sarcopenia is shown in **Table 3.1**, including educational attainment and wealth quartiles, as markers of SEP. A significantly higher proportion of participants with probable sarcopenia exited formal education at primary level (43.0% v 32.4%, $p < 0.001$) and fewer had completed a third-level qualification compared with the reference group (22.3% vs 31.0% $p < 0.001$). Similarly, a significantly higher proportion of the probable sarcopenic group were in the most

disadvantaged SEP wealth quartile (Q4) when compared to the reference group (31.0% vs 23.6%, $p<0.001$) and fewer were in the least disadvantaged wealth quartile (Q1) (18.4% vs 26.8%, $p<0.001$).

The findings support other known risk factors of sarcopenia, namely advanced age, osteoarthritis, and low physical activity levels. Participants with probable sarcopenia were significantly older (mean age 72.3 ± 6.7 v reference group 67.9 ± 5.9 years, $p<0.001$) and more physically inactive (43.3% vs 29.5%, $p<0.001$). Among those with probable sarcopenia, a significantly greater number of participants had a BMI in the healthy range (24.6% vs 19.9%, $p=0.004$) compared to the reference group, and fewer were overweight (39.0% vs 44.1%, $p=0.011$). Long-term chronic conditions (2 or more) were more prevalent among those with probable sarcopenia (64.8% vs 51.0%, $p<0.001$) compared to the reference group. Of note, osteoarthritis was more common amongst the probable sarcopenia group (21.7% vs 16.3%, $p<0.001$). The group meeting the criteria for probable sarcopenia had a significantly higher proportion of participants in receipt of state-funded home care services (11.1% vs 3.1%, $p<0.001$). Probable sarcopenia did not differ between the groups based on gender or smoking status.

3.3.4 Multivariate analysis of factors associated with probable sarcopenia

Following univariate analysis, SEP indicators including educational attainment and wealth were entered into the logistic regression model with other risk factors for sarcopenia, namely age, gender, body mass index (BMI), physical activity level, smoking status, alcohol consumption status, osteoarthritis, number of long-term conditions and receipt of formal care services. The significant association persisted between SEP and probable sarcopenia following multivariate regression analysis (**Table 3.3**). Older adults with primary level education only, were 1.36 times more likely to have probable sarcopenia [OR, CI 1.36 (1.06, 1.74), $p=0.014$] than those who completed third-level education. No significant association between wealth and probable sarcopenia was observed when adjusted for demographic and behavioural factors. The model supported associations of low physical activity [OR, CI 1.58 (1.25, 2.00), $p<0.001$], older age [OR, CI 1.09 (1.07, 1.11, $p<0.001$], comorbidity [OR, CI 1.10 (1.03, 1.18, $p=0.003$], osteoarthritis [OR, CI 1.31 (1.03, 1.66), $p=0.026$], and receipt of state-funded home care services [OR, CI 1.53 (1.05, 2.22), $p=0.027$] with probable sarcopenia. Overweight and obese BMI were associated with a lower risk of probable sarcopenia compared to a BMI in the healthy range [OR, CI 0.72 (0.57, 0.91), $p=0.006$ and 0.67 (0.52, 0.86), $p=0.002$, respectively].

Table 3.3: Multivariable logistic regression model of risk factors for probable sarcopenia (n= 3,342)

Risk Factor	Association between probable sarcopenia and risk factor			
	B	Odds Ratio (OR)	95% CI for OR (Lower-Upper)	p-Value
Age (years, continuous)	0.09	1.09	1.07-1.11	<0.001*
Gender (female)	0.01	1.01	0.81-1.25	
SEP: Educational Attainment				0.004*
Third Level	<i>Reference</i>			
Secondary Level	0.19	1.20	0.95-1.52	
≤ Primary Level	0.31	1.36	1.06-1.74	0.014*
SEP: Wealth Quartile				
Q1 - Highest	<i>Reference</i>			
Q2	0.12	1.13	0.86-1.47	
Q3	0.24	1.27	0.96-1.66	
Q4 - Lowest	0.24	1.27	0.96-1.67	
Physical Activity Level				
High	<i>Reference</i>			
Moderate	0.22	1.24	0.99-1.57	
Low	0.46	1.58	1.25-2.00	<0.001*
Body Mass Index (kg/m²)				
Healthy Weight (≥18.5-25)	<i>Reference</i>			
Overweight (≥25-30)	-0.33	0.72	0.57-0.91	0.006*
Obese (≥30)	-0.40	0.67	0.52-0.86	0.002*
Underweight (≥15-18.5)	0.72	2.06	0.76-5.54	
Smoking status				
Never smoked	<i>Reference</i>			
Past smoker	0.03	1.03	0.77-1.38	
Current smoker	0.10	1.10	0.82-1.49	
Alcohol Consumption				
Non-consumer	<i>Reference</i>			
Alcohol consumer	0.01	1.00	0.82-1.22	
Chronic conditions (continuous)	0.10	1.10	1.03-1.18	0.003*
Osteoarthritis	0.27	1.31	1.03-1.66	0.026*
Receives home care	0.42	1.53	1.05-2.22	0.027*

Abbreviations: CI: Confidence Intervals; OR: Odds Ratio; BMI: Body Mass Index.

* denotes only (*p<0.05)

3.4 Discussion

The muscle disease sarcopenia is a public health issue and is a major preventable cause of disability amongst older populations globally ³⁷. The decline in muscle strength alone is a marker of probable sarcopenia and was the focus of the present study. We showed that disadvantaged socioeconomic position (SEP), measured as educational attainment, was an independent predictor of probable sarcopenia in a large study of community dwelling adults aged 60 years and older (n= 3,342). Overall, 23% of the study population had probable sarcopenia, and this was significantly higher in participants with the fewest years in formal education (29%) compared to those with third level education (18%). The findings suggest that specific attention should be given to socioeconomic disadvantage in the design of screening and prevention strategies for sarcopenia in community-dwelling older adults.

We assessed the prevalence of probable sarcopenia based on the EWGSOP2 guidelines for hand grip strength. In 2018, the EWGSOP2 updated the definition of sarcopenia and introduced the concept of probable sarcopenia to reflect up-to-date scientific and clinical evidence ³⁷. Overall, we identified probable sarcopenia in 23.4% of the study population aged 68.9 ± 6.3 years. This is broadly in agreement with previous studies of probable sarcopenia based on EWGSOP2 guidelines. Some authors, in assessing muscle weakness for probable sarcopenia, used hand grip strength ^{82,86}, while others also included performance on chair rise test ^{80,81}. Wearing et al, reported a prevalence of 26.3% and 28.0% for probable sarcopenia in females and males, respectively (n= 219), although this study was conducted in a study population of advanced age (84.1 ± 5.7 years) ⁸⁶. In an analysis of the Korean Frailty and Ageing Cohort Study (n= 2099, mean age 75.9 ± 4.0 years) ⁸¹, 24% of participants had probable sarcopenia. While Dodds et al, estimated a prevalence of 19% amongst the 1946 British birth cohort aged 69 years (n= 1686) ⁸⁰. Pérez-Sousa et al, reported a prevalence of 47% amongst a representative sample of Colombian older-adults however, the prevalence of low socioeconomic status (76%) and physical inactivity (83%) were strikingly higher than in other studies of probable sarcopenia. Assessment of hand grip strength is a simple and inexpensive screening tool for sarcopenia in community-dwelling older populations, given that sarcopenia diagnosis requires more complex diagnostic measures of muscle mass or muscle quality ³⁷.

The present study specifically aimed to investigate the prevalence of sarcopenia in older adults with disadvantaged SEP. There is an abundance of evidence showing an association between disadvantaged SEP and a higher prevalence and earlier onset of

adverse health outcomes with specific evidence available for this cohort based on educational attainment and wealth ^{220,228,229}. In the present study, we showed the prevalence of probable sarcopenia was significantly greater in participants with the fewest years in formal education (28.9%) compared to those with third-level education (18.1%). Similarly, the prevalence of probable sarcopenia was significantly higher among those in the lowest (28.7%) compared to those in the highest wealth quartile (17.3%). This trend between decreasing wealth and sarcopenia did not persist when adjusted for other demographic, behavioural and health risk factors. The use of wealth as an indicator of SEP in older adult populations has known limitations, including a need to encompass several economic indicators such as investment returns and government payments that were not included in the present study ⁹². The application of total net asset wealth as an indicator of SEP, which includes the value of primary residence, a subjective measure in TILDA ²²⁴, may be further complicated by the number of household members with shared ownership. The findings suggest that the materialist pathway, through which wealth is hypothesised to influence health ⁹², may be less pronounced for probable sarcopenia, although this requires further study.

Few studies have examined probable sarcopenia in terms of socioeconomic position. Dodds et al, utilized occupation class as a measure of SEP but found that no significant association persisted when controlled for other known risk factors ⁸⁰. Pérez-Sousa et al, reported that individuals of high SEP, defined as social class, were significantly less likely to meet the criteria for probable sarcopenia compared to those of disadvantaged SEP ⁹. Previous studies have examined associations between low muscle strength and SEP employing a range of indicators. In contrast to the present study, associations between low hand grip strength and SEP, when measured by wealth, have previously been reported however, the authors included measures of material wealth including the value of jewellery, cars and businesses ²²⁰. It is important to note, education and wealth are proxy measures of SEP ⁹², and links between socioeconomic indicators and sarcopenia may go beyond financial resources, including access to physical activity initiatives, green open recreational space, safe neighbourhoods and opportunities to engage in muscle strengthening activities ^{230–232}, as demonstrated for other high risk disease groups ^{233,234}. Given there are several relatively simple and inexpensive markers for both socioeconomic disadvantage and probable sarcopenia, identifying and targeting those most at risk of sarcopenia would likely yield benefits.

The present study identified educational attainment as a determinant of probable sarcopenia when adjusted for other known risk factors. Older adults with fewest years of

education (<8 years) had a 37% increased risk of probable sarcopenia when compared to those with tertiary education. The model confirmed other known risk factors of sarcopenia, namely, older age, physical inactivity, number of chronic conditions, and osteoarthritis. Osteoarthritis was an independent predictor of probable sarcopenia which has previously been shown to increase the risk of low grip strength ²³⁵. Overweight and obese BMI suggested protective effects when compared to those of healthy range BMI. This is in line with previous studies which found a positive association between overweight and obese BMI with HGS ²³⁶. One hypothesis is that older adults with obese or overweight BMI may have greater muscle mass and less fat mass than those with weak hand grip strength ²³⁷. Few participants were underweight (0.6%). Similar to previous findings, low physical activity was identified as the most important modifiable risk factor, with physically inactive older adults 1.6 times more likely to have probable sarcopenia ⁸². Resistance training has been shown as an effective tool for the management and treatment of sarcopenia however, this study's findings suggest specific attention should be given to low SEP groups who have been identified as less likely to engage in physical activity programmes ^{37,238}.

In the present study, we identified that older people with the fewest years of education had the highest prevalence of probable sarcopenia and represent an important group for future interventions. This is important, as the Covid-19 pandemic has exposed and amplified existing inequalities in society, with individuals of disadvantaged SEP most affected ²³⁹. Furthermore, the implementation of movement confinement measures in response to the ongoing pandemic has the potential to accelerate sarcopenia amongst this vulnerable group ²⁴⁰. The findings suggest that specific attention should be given to socioeconomic disadvantage in the design and implementation of detection and prevention strategies for sarcopenia in the community. Given that educational attainment, or other markers of disadvantaged SEP, are relatively easy to collect routinely, population groups with indicators of disadvantaged SEP should be considered as priority for screening probable sarcopenia in older adults. Studies have shown, a decline in muscle strength, probable sarcopenia is observed as early as middle age ²⁴¹. This may present opportunity for timely intervention which could prevent or delay further decline amongst those most at-risk of probable sarcopenia onset ³⁷. The findings highlight the importance of forming inclusive intervention practices which take socioeconomic position into account.

This study included analyses of an open-access dataset of The Irish Longitudinal Study on Ageing, a nationally representative sample of community-dwelling older adults in

Ireland ²²⁴. This is the largest study to specifically focus on SEP and the prevalence and predictors of probable sarcopenia amongst community-dwelling older adults in Ireland. Educational attainment was selected as a robust indicator of SEP in the present study as it has been shown that longer duration of education predicts several health advantages which includes improved physical function amongst older adults ^{108,242}. Previous research has identified educational attainment as a robust indicator of SEP amongst older adult populations ⁹². Some study limitations must be acknowledged. It is important to note, that this was a cross-sectional study and therefore, cannot show cause and effect for the higher prevalence of probable sarcopenia amongst older adults with disadvantaged SEP. Furthermore, previous analysis has shown that older adults of disadvantaged SEP were less likely to participate in the health assessment component of TILDA ²⁴³ and statistical weightings were not available in the public-version of Wave 1 data, used in this study, to account for this disparity. Given the complexity of measuring wealth in older adult populations ⁹², specifically in community-based settings, future work should examine other practical measures of SEP that could be embedded in routine settings. Additionally, the dataset did not specify ethnicity or nutritional factors, including protein, energy intake and Vitamin D, which may also influence sarcopenia and muscle function ^{52,244,245}. These limitations may result in an underestimation of the prevalence of probable sarcopenia. Similar to previous studies, probable sarcopenia was defined by hand grip strength however, future work could include other measures of muscle strength such as chair rise test and explore the application of the SARC-F screening tool ^{82,86}. Furthermore, future work should seek to actively include those living with socioeconomic disadvantage in sarcopenia research.

In summary, the prevalence of probable sarcopenia was 23.4% in a large sample of community-dwelling older adults in Ireland (n= 3342). Probable sarcopenia was most prevalent amongst older adults with disadvantaged SEP, identifying an important group for future intervention. Our findings suggest that disadvantaged SEP, older age, physical inactivity, comorbidity, osteoarthritis and receipt of state-funded home care services are associated with increased risk of probable sarcopenia. The findings highlight the importance of forming inclusive intervention practices which take socioeconomic position into account.

Chapter 4 - An exploration of probable sarcopenia and socioeconomic disadvantage in community-dwelling older adults in England

4.1 Introduction

In Chapter 3, we evidenced associations between socioeconomic disadvantage and probable sarcopenia, defined by hand grip strength, in cross-sectional analysis of community-dwelling older adults aged 60 years and older in Ireland. This is in line with growing evidence highlighting the impact of social determinants of health across the life course ^{228,246}. Research shows socioeconomic disadvantage is associated with accelerated ageing, multimorbidity, poorer health outcomes and reduced access to healthcare ^{9,150,247,248}. Recent findings suggest associations between socioeconomic disadvantage and sarcopenia ^{82,87,168}, however there is a paucity of research in this area.

Sarcopenia is a muscle condition characterised by the accelerated loss of muscle strength, mass and function ³⁷. This condition is a major public health issue and contributor to limitations in physical function, frailty, disability, hospitalisation and mortality amongst older populations ^{249–251}. In 2019, the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) introduced the concept of ‘probable sarcopenia’ defined by low muscle strength ³⁷. Sarcopenia is probable when upper or lower limb muscle strength is deemed low, defined by hand grip strength less than 16 kg in women or 27 kg in men, or completion of 5 chair rises in a time greater than 15 seconds ³⁷. To date, most studies have defined probable sarcopenia by hand grip strength alone, with few reporting outcomes for poor chair rise test performance. Probable sarcopenia can readily be measured in large populations with simple, cost-effective approaches and is the focus of the present study. Importantly, the detection of probable sarcopenia is considered sufficient evidence to initiate appropriate interventions ³⁷.

Probable sarcopenia affects an estimated 19-73% of community-dwelling older adults, with the highest occurrence observed amongst cohorts of older age (80+ years old) ^{80–83,221}. Arguably, variation in prevalence estimates may be due to mode of assessment of probable sarcopenia ⁸⁰. Older age, physical inactivity and multimorbidity are documented risk factors for probable sarcopenia, though few studies have examined socioeconomic factors ²²¹. The present study uses indicators of SEP which may reflect different time points across the life course. Educational attainment may represent SEP in childhood and into adulthood, while Subjective Social Status (SSS), self-reported at the time of interview, represents participants’ current perception of SEP as older adults ²⁵². Socioeconomic disadvantage shows geographic variations, and we explored if probable sarcopenia prevalence may mirror the identified regional patterns for health inequality reported in England ^{253,254}.

Findings on SEP and sarcopenia are emerging however, the results remain inconsistent. Brennan-Olsen et al, in a 6-year longitudinal analysis of older adults in Australia, reported low hand grip and lower limb strength in groups with disadvantaged SEP, classified by educational attainment and occupation class, in a population aged under 80 years old⁸⁷. Pérez-Sousa et al, in a study in Columbia, reported that older adults with disadvantaged SEP, defined by social class, had a greater prevalence of probable sarcopenia, however this was not examined in multivariable analysis⁸². Dodds et al included a measure of occupation class in a large study of UK older adults all aged 69 years old, but an association with probable sarcopenia was not apparent when controlled for other known risk factors⁸⁰. In Chapter 3, we found that socioeconomic disadvantage, defined by educational attainment, was an independent predictor of probable sarcopenia in a large population of Irish older adults (n= 3342)¹⁶⁸. There remains a gap in the literature for studies specifically focusing on probable sarcopenia, applying EWGSOP2 guidelines for low hand grip strength or poor chair rise test performance. A better understanding of sarcopenia and socioeconomic disadvantage may be useful in the provision of screening, interventions, and resource allocation for those most at risk of sarcopenia.

In the present chapter we investigated if disadvantaged SEP, defined by educational attainment and SSS, was a determinant of probable sarcopenia in a large population of community-dwelling older adults aged 60 years and older, based on data from the English Longitudinal Study of Ageing (ELSA). We hypothesised that probable sarcopenia would be more prevalent in older adults with the most vs least disadvantaged SEP, defined by educational attainment and subjective social status.

The aims of the present chapter:

- To describe the prevalence of probable sarcopenia in community-dwelling older adults in England, overall and according to SEP, defined by educational attainment and subjective social status
- To examine the proportion of older adults meeting the criteria of probable sarcopenia according to geographic area of residence in England
- To explore SEP indicators, in addition to pre-defined health, demographic and behavioural factors, as determinants of probable sarcopenia

4.2 Methods

4.2.1 Study Design and Population

This study was a cross-sectional analysis of data from Wave 6 of the English Longitudinal Study of Aging (ELSA), which is an ongoing nationally representative longitudinal study of older adults in England. Wave 6 was conducted in 2012-2013 and included 10,601 community-dwelling adults aged 50 years and over, recruited from the Health Survey of England cohort. Of these, 8,054 participants enrolled in a nurse-led health assessment. Further details regarding the study design have been previously reported ²⁵⁵.

For the present study, the inclusion criteria were as follows: adults living in private households, aged 60 years and older, participation in the study health assessment and available data on hand grip strength or chair rise test performance (**Figure 4.1**). Written informed consent was obtained from all participants and ethical approval was granted from the National Research Ethics Service (MREC/01/2/91).

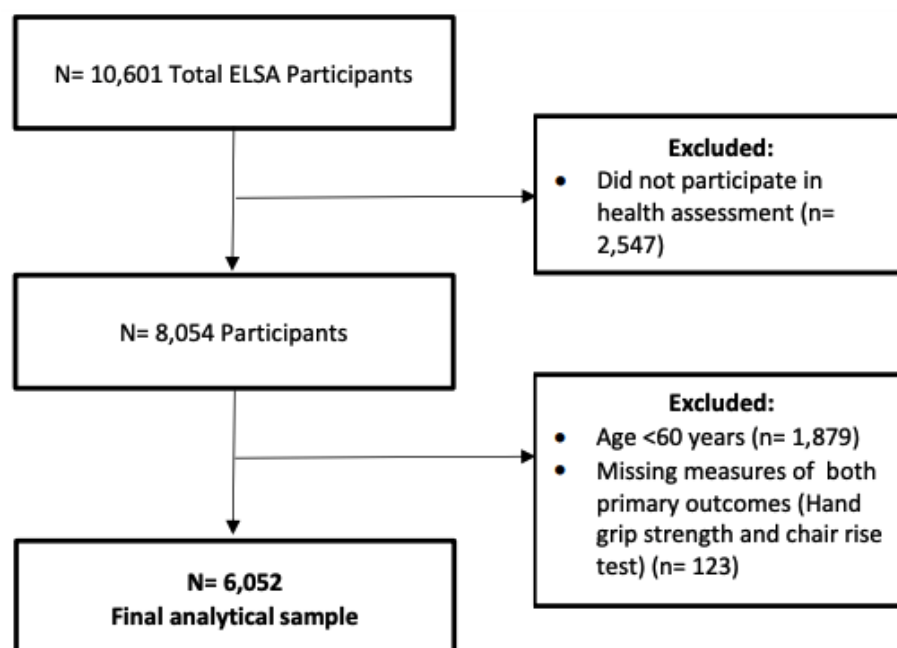


Figure 4.1: Study inclusion and exclusion criteria

4.2.2 *Assessing Probable Sarcopenia*

Probable sarcopenia was defined according to the European Working Group on Sarcopenia in Older People (EWGSOP2) guidelines for low hand grip strength or poor chair-rise test performance ³⁷. Grip strength was assessed using a Smedley dynamometer (Stoelting Co, IL, USA) with three measurements taken for each hand and the maximum value for the dominant hand used in analyses, similar to previous studies ²⁵⁶. We applied the EWGSOP2 gender-specific cut-off values for low hand grip strength defined as less than 16 kg in women or 27 kg in men ³⁷.

Chair rise test performance, an indicator of lower body strength, was recorded as the time taken by a participant to stand up from a firm chair, without using their arms, 5 times. A time greater than 15 seconds to complete 5 chair rises was classified as probable sarcopenia ³⁷. Participants unable to complete the chair rise test unassisted by arms or feeling unsafe were categorised as having poor chair rise test performance (n= 677, 11.2%). In line with EWGSOP2 guidelines, probable sarcopenia was defined by a participant meeting the criteria for low hand grip strength or poor chair rise performance ³⁷.

4.2.3 *Determining Socioeconomic Position (SEP)*

Educational attainment was used as a marker of SEP. Four SEP groups were derived according to the self-reported highest level of formal education completed at Wave 6. Qualifications were classified as previously described ^{257,258}, as *Group 1*) no formal educational qualifications or completion of a Level 1 National Vocational Qualification (NVQ). *Group 2*) secondary school lower: completed O-Levels or equivalent, a Level 2 NVQ or a non-coded internationally obtained qualification. *Group 3*) secondary school upper: completion of GCE A-Levels or equivalent, NVQ Level 3, or a professional qualification below degree level. *Group 4*) completion of a third-level degree or NVQ levels 4-5.

Subjective Social Status (SSS) was a self-reported measure of perceived position within the proposed social hierarchy ¹⁷⁶. Participants were asked to mark their perceived social standing on a ladder, where the highest rung represented 'the best off, with the best education, income and jobs' and the bottom of the ladder represented the position of the 'worst off'. Participants were asked to mark a cross on the ladder rung which they perceived to reflect their position relative to society. Possible scores on the ladder ranged

from 5 to 100, with lower scores indicating greater socioeconomic disadvantage. The ladder rung scores were classified into four groups, where Q1 represented the least disadvantaged (score 75-100) and Q4 the greatest subjective disadvantage (score 5-25)

²⁵⁹.

4.2.4 *Health and Lifestyle Risk Factors*

Demographic variables included sex (dichotomous variable); age (continuous variable) top-coded at 91 years old to preserve anonymity. Information on ethnicity was available as a dichotomous variable described as white or ethnic minority group. We used the area of residence within England to describe the geographical spread of probable sarcopenia; this was categorized using Government Office Region (GOR).

Health and lifestyle risk factors for probable sarcopenia were selected based on current published evidence. Self-reported physical activity data were collected, with participants asked about the frequency of vigorous, moderate, and mild intensity physical activities. Participants were shown prompt cards illustrating examples of activities associated with each level of physical intensity. Subjective physical activity was classified into vigorous, moderate, and low levels. Self-reporting vigorous activity at least once per week was classified as high physical activity. Moderate physical activity was indicated by no vigorous activity, but moderate activity at least once per week. Low physical activity was present if the frequency of vigorous or moderate activity was lower than once per week²⁶⁰. Chronic conditions were classified according to the modified Functional Comorbidity Index (FCI) which produced a continuous score (0-14) of long-term conditions²⁰⁶. Self-reported smoking status was recorded as current smoker, past smoker or never smoker. Osteoarthritis was documented as present if a diagnosis was confirmed from previous waves, or if newly reported in Wave 6.

Anthropometric measurements, collected during the nurse health visit, included Body Mass Index (BMI) and Waist Circumference (WC). Body Mass Index (BMI), calculated by weight (kg) and height (m²) was classified according to standard criteria: underweight (≤ 18.5 kg/m²), healthy weight (≥ 18.5 -25 kg/m²), overweight (≥ 25 -30 kg/m²) and obese (≥ 30 kg/m²)²⁶¹. Waist circumference was classified based on gender-specific cut-off values for females: normal fat distribution (<80 cm), moderate central fat accumulation (80-87.9 cm) and high central fat accumulation (≥ 88 cm) and males: normal fat distribution (<94 cm), moderate central fat accumulation (94-101.9 cm) and high central fat accumulation (≥ 102 cm)²⁶².

4.2.5 Statistical Analysis

Descriptive statistics are reported as means $\pm$ SD or percentages. Normality was assessed for all variables by Shapiro-Wilks tests. Cross-sectional weights were applied to the study population to minimize bias arising from differences in participation rates in the nurse visit. The Wave 6 cross-sectional weight was modelled on age, sex, region, housing tenure, educational qualifications, and marital status to bring the study population in line with 2012 population estimates for England. Similarly, the nurse-visit weighting strategy was calibrated for 2012 population estimates in England across the previously described sociodemographic indices. The nurse-visit final weight was a combination of the estimated probability of nurse-visit response and the wave 6 cross-sectional weight. Further details on the nurse-visit weighting strategy applied are described elsewhere ²⁶³. The final nurse-visit weight was applied to the multivariable logistic regression.

Chi-square test for independence was applied to compare demographic, health and lifestyle variables of interest between the probable sarcopenic and reference groups. Continuous variables were compared between groups using Independent Student t-tests. Pre-selected risk factors of probable sarcopenia, low hand grip strength and poor chair rise test performance, respectively, were assessed using multivariable logistic regression analysis. Multicollinearity was assessed using correlation matrices and Variance Inflation Factors (VIFs). Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) are reported for multivariable analyses. All analyses were performed using IBM SPSS Statistics V24 software

4.3 Results

4.3.1 Study Population

At Wave 6, nurse-led health assessments were conducted with 8,054 participants (**Figure 4.1**). Of these, 6,052 were aged 60 years and older with measured hand grip strength or chair rise test performance. Thus, the analytical sample comprised 6052 community-dwelling older adults of mean age (SD) 70.7 (7.7) years, 54.4% were female and 14.5% were aged 80 years or older. Most were of white ethnicity (97.7%) (**Table 4.1**). Based on education as a marker of SEP, 27.4% completed no formal qualifications (n= 1658), 28.9% lower secondary (n= 1748), 25.6% upper secondary (n= 1550) and 18.0% a third-level degree (n= 1088). Additionally, 3.0% reported SSS in the most disadvantaged ladder rungs (n= 160) and 16.8% (n= 899) as least disadvantaged. The study population had a high frequency of overweight and obesity (73.4%), physical inactivity (25.1%) past cigarette smoking (54.5%), co-morbidity (47.5%) and osteoarthritis (30.2%).

Table 4.1: Characteristics of the study population overall and based on the presence of probable sarcopenia as defined by EWGSOP2 criteria (n= 6052).

	Overall (n= 6052)	Reference * No probable Sarcopeni a (n= 4015)	Probable Sarcopeni a (n= 2037)	p-Value
Gender, n (%)				
Female	3295 (54.4)	2095 (52.2)	1200 (58.9)	<0.001*
Male	2757 (45.6)	1920 (47.8)	837 (41.1)	<0.001*
Age, mean $\pm$ SD (years)	70.7 $\pm$ 7.7	68.9 $\pm$ 6.7	75.6 $\pm$ 8.2	<0.001*
Age Categories, n (%)				
60-69	3081 (50.9)	2496 (62.2)	585 (28.7)	<0.001*
70-79	2095 (34.6)	1266 (31.5)	829 (40.7)	<0.001*
80-89	755 (12.5)	242 (6.0)	513 (25.2)	<0.001*
90+	121 (2.0)	11 (0.3)	110 (5.4)	<0.001*
SEP: Educational Attainment a, n (%)				
Degree	1088 (18.0)	864 (21.5)	224 (11.0)	<0.001*
Upper Secondary	1550 (25.6)	1104 (27.5)	446 (21.9)	<0.001*
Lower Secondary/ other qualification	1748 (28.9)	1162 (28.9)	586 (28.8)	0.865
No formal qualification	1658 (27.4)	878 (21.9)	780 (38.3)	<0.001*
Subjective Social Status (SSS) b, n (%)				
Q1 – <i>least disadvantaged</i>	899 (16.8)	678 (18.5)	221 (13.1)	<0.001*
Q2	2417 (45.2)	1702 (46.5)	715 (42.3)	0.005*
Q3	1877 (35.1)	1208 (33.0)	669 (39.6)	<0.001*
Q4 – <i>most disadvantaged</i>	160 (3.0)	76 (2.1)	84 (5.0)	<0.001*
Body Mass Index (kg/m²) c, n (%)				
Underweight (≤ 18.5)	53 (0.9)	24 (0.6)	29 (1.6)	<0.001*
Healthy weight (≥ 18.5 -25)	1487 (25.7)	1041 (26.4)	446 (24.3)	0.086
Overweight (≥ 25 -30)	2464 (42.6)	1728 (43.8)	736 (40.0)	0.007*
Obese (≥ 30)	1779 (29.4)	1152 (29.2)	627 (34.1)	<0.001*
Waist Circumference d, n (%)				
Normal Fat Distribution	1228 (20.6)	876 (22.0)	352 (17.8)	<0.001*
Moderate Central Fat Distribution	1484 (24.9)	1051 (26.3)	433 (21.9)	<0.001*
High Central Fat Distribution	3251 (53.7)	2062 (51.7)	1189 (60.2)	<0.001*
Physical Activity Level, n (%)				
Low	1519 (25.1)	564 (14.0)	955 (46.9)	<0.001*
Moderate	2847 (47.0)	2053 (51.1)	794 (39.0)	<0.001*
High	1686 (27.9)	1398 (34.8)	288 (14.1)	<0.001*
Smoking status, n (%)				
Never smoked	2162 (35.7)	1486 (37.0)	676 (33.2)	0.003*
Past smoker	3301 (54.5)	2157 (53.7)	1144 (56.2)	0.072
Current smoker	589 (9.7)	372 (9.3)	217 (10.7)	0.085
Long-term conditions, n (%)				
0	1367 (22.6)	1147 (28.6)	220 (10.8)	<0.001*
1	1808 (29.9)	1382 (34.4)	426 (20.9)	<0.001*
≥ 2	2877 (47.5)	1486 (37.0)	1391 (68.3)	<0.001*

		Reference *		
	Overall (n= 6052)	No probable Sarcopeni a (n= 4015)	Probable Sarcopeni a (n= 2037)	p-Value
Osteoarthritis, n (%)	1827 (30.2)	1014 (25.3)	813 (39.9)	<0.001*
Ethnicity, n (%)				
White	5911 (97.7)	3931 (97.9)	1980 (97.2)	0.085
Ethnic minority group	141 (2.3)	84 (2.1)	57 (2.8)	0.085
Government Office Region, n (%)				
North-East England	369 (6.1)	217 (5.4)	152 (7.5)	0.002*
North-West England	682 (11.3)	475 (11.8)	207 (10.2)	0.052
Yorkshire and The Humber	636 (10.5)	448 (11.2)	188 (9.2)	0.021*
East Midlands	639 (10.6)	406 (10.1)	233 (11.4)	0.113
West Midlands	665 (11.0)	401 (10.0)	264 (13.0)	<0.001*
East of England	785 (13.0)	529 (13.2)	256 (12.6)	0.506
London	476 (7.9)	319 (7.9)	157 (7.7)	0.745
South-East England	1011 (16.7)	709 (17.7)	302 (14.8)	0.005*
South-West England	767 (12.7)	493 (12.3)	274 (13.5)	0.195

*Did not meet the criteria for probable sarcopenia based on the EWGSOP2 cut-offs for low hand grip strength or poor chair rise test performance; Chi-squared χ^2 and independent student t-test used for comparisons between probable sarcopenic and reference groups (*p <0.05); Complete case analysis; Missing data, n (%); ^a 8 (0.1%), ^b 699 (11.5%); ^c 269 (4.4%); ^d 89 (1.5%)

4.3.2 Prevalence of Probable Sarcopenia overall and by SEP

Probable sarcopenia was detected in 33.7% of this study population (weighted 36.1%), as defined by the EWGSOP2 guidelines (**Table 4.1**). When examined based on educational attainment, probable sarcopenia was over 2-fold higher among participants who reported no formal educational qualifications (47.0%, weighted 49.4%) compared with those with a third-level qualification (20.6%, weighted 20.3%, $p < 0.001$) (**Figure 4.2**). The prevalence of probable sarcopenia in the intermediate SEP groups, upper secondary qualifications and lower secondary/other qualifications was (33.5%, weighted 35.2% and 28.8%, weighted 29.1%, respectively). Similarly, probable sarcopenia was highest among older adults with disadvantaged SSS (52.5%, weighted 57.3%) and lowest in older adults with greater SSS (24.6%, weighted 25.8%).

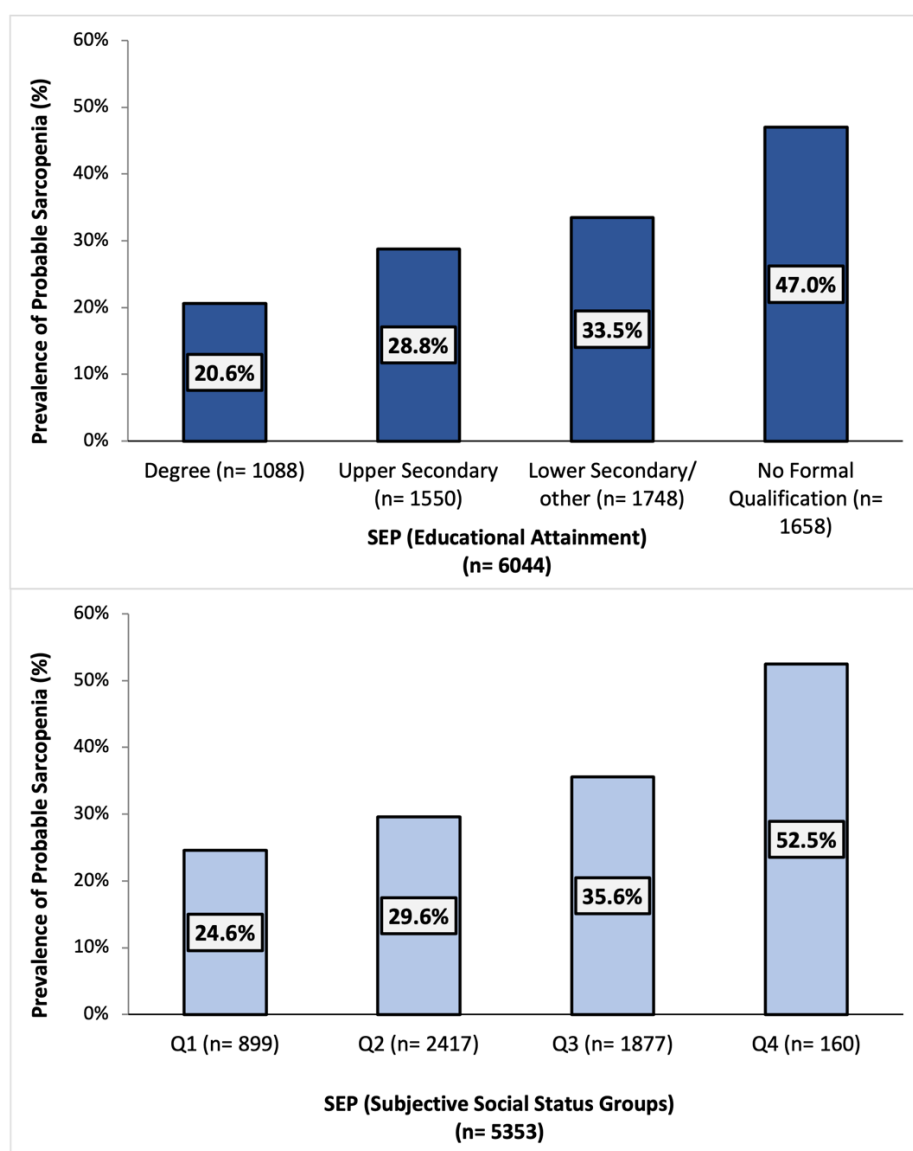


Figure 4.2: Crude prevalence (%) of probable sarcopenia in community-dwelling older adults based on subjective social status and educational attainment

When mapped to participants' region of residence in England, probable sarcopenia was highest in the North-East of England (41.2%, weighted 43.0%) and lowest in Yorkshire and the Humber (29.6%, weighted 32.7%) and the South East of England (29.9%, weighted 31.9%) (**Figure 4.3**).

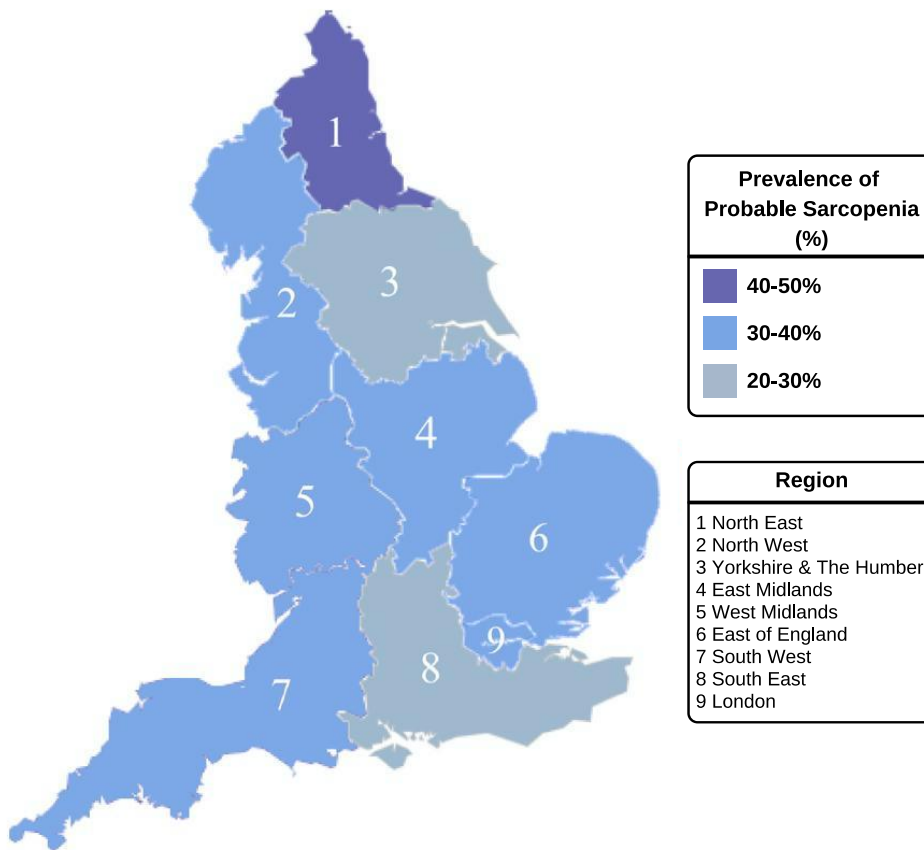


Figure 4.3: Probable sarcopenia, defined by EWGSOP2 guidelines, in community-dwelling older adults by geographic region in England (n= 6030)

Overall, 18.0% of the population met the criteria for probable sarcopenia based on low hand grip strength alone (weighted 19.9%) and 26.1% by poor chair-rise test performance alone (weighted 28.5%). There was some degree of intersectionality with 26.4% of those with probable sarcopenia meeting the criteria for both low hand grip strength and poor chair rise test performance.

4.3.3 *Characteristics of older adults with probable sarcopenia*

The characteristics of older adults with probable sarcopenia compared with those who did not meet the EWGSOP2 criteria (reference group) are described in **Table 4.1**. Significantly more older adults with probable sarcopenia reported no formal education (38.3% v 21.9%, $p<0.001$) and fewer reported completion of a third-level qualification (11.0% vs. 21.5%, $p<0.001$) compared with the reference group, respectively.

The probable sarcopenia group was significantly older (75.6 ± 8.2 vs reference 68.9 ± 6.7 , $p<0.001$) with a higher proportion of females (58.9% vs 52.2%, $p<0.001$). Physical inactivity (46.9% vs 14.0%, $p<0.001$), obesity (34.1% vs 29.2%, $p<0.001$), central adiposity (60.2% vs 51.7%, $p<0.001$), co-morbidity (68.3% vs 37.0%, $p<0.001$) and osteoarthritis (39.9% vs 25.3%, $p<0.001$) were significantly more common in the probable sarcopenia group compared with those with preserved muscle strength. Underweight ($\text{BMI} \leq 18.5 \text{ kg/m}^2$) was higher in probable sarcopenia relative to the reference group (1.6% vs 0.6%, $p<0.001$), though the number of participants classified as underweight in the study population overall was small ($n=53$). No significant differences in probable sarcopenia were noted on analysis by ethnicity, however, the population sample was not ethnically diverse ($n=141$, 2.3% ethnic minority group).

4.3.4 *Determinants of probable sarcopenia and markers of low muscle strength – weighted multivariable regression analyses*

Pre-selected risk factors of probable sarcopenia were entered into the logistic regression model. In the model, associations persisted between probable sarcopenia and the following predictors: disadvantaged SEP (educational attainment and SSS), older age, physical inactivity, a greater number of chronic conditions, osteoarthritis, and minority group ethnicity (**Table 4.2**). Older adults with the most disadvantaged SEP (no formal qualifications) were 1.67 times more likely to have probable sarcopenia [OR, CI 1.67 (1.27, 2.21), $p<0.001$] than the least disadvantaged (third level degree). Similarly, disadvantaged SSS predicted probable sarcopenia [OR, CI 1.87 (1.18, 2.96), $p=0.008$]. The model supported an increased likelihood of probable sarcopenia for physical inactivity [OR, CI 3.37 (2.68, 4.24), $p<0.001$], older age [OR, CI 1.10 (1.08, 1.11), $p<0.001$], chronic conditions [OR, CI 1.29 (1.21, 1.37), $p<0.001$] osteoarthritis [OR, CI 1.35 (1.13, 1.60), $p<0.001$] and minority ethnicity [OR, CI 1.74 (1.13, 2.69), $p=0.012$].

A sub-analysis was performed to explore if makers of SEP remained independent determinants of probable sarcopenia when low muscle strength was identified by low hand grip strength alone or poor chair rise test performance alone (**Table 4.2**).

Consistent with earlier findings, disadvantaged SEP, measured by educational attainment and SSS, were significantly associated with probable sarcopenia, irrespective of the mode of assessment: low hand grip strength [OR, CI 1.83 (1.28, 2.64), $p < 0.001$ and 2.04 (1.23, 3.39), $p = 0.006$, respectively] and poor chair rise test performance [OR, CI 1.40 (1.03, 1.91), $p = 0.033$ and 1.99 (1.21, 3.28), $p = 0.007$, respectively]. Older age, physical inactivity, chronic conditions, and osteoarthritis remained predictors of probable sarcopenia irrespective of the mode of assessment. Associations between BMI, smoking status, and ethnicity with likelihood of probable sarcopenia differed based on the marker of low muscle strength applied.

Table 4.2: Weighted logistic regression model of risk factors of probable sarcopenia (n= 5146), low hand grip strength (n= 5078) and poor chair-rise test performance (n= 4811)

Risk Factor	Probable Sarcopenia (n= 5146)			Low Hand Grip Strength (n= 5078)			Poor Chair-Rise Test Performance (n= 4811)		
	B	OR	95% CI	B	OR	95% CI	B	OR	95% CI
Age (continuous)	0.09	1.10	1.08-1.11*	0.09	1.10	1.08-1.11*	0.08	1.09	1.07-1.10*
Gender (reference: female)	-0.04	0.96	0.81-1.12	0.01	1.01	0.83-1.23	-0.05	0.95	0.80-1.14
Educational Attainment									
Degree	Reference								
Upper Secondary	0.27	1.31	0.99-1.73	0.38	1.46	1.01-2.13*	0.13	1.14	0.83-1.56
Lower Secondary qualification	0.38	1.46	1.11-1.91*	0.64	1.93	1.35-2.78*	0.18	1.20	0.88-1.64
No formal qualification	0.49	1.67	1.27-2.21*	0.63	1.83	1.28-2.64*	0.31	1.40	1.03-1.91*
Subjective Social Class									
Q1 – least disadvantaged	Reference								
Q2	-0.03	0.97	0.77-1.24	0.03	1.03	0.76-1.39	-0.03	0.97	0.75-1.27
Q3	0.03	1.03	0.80-1.32	-0.01	1.00	0.73-1.36	-0.01	0.99	0.75-1.30
Q4 – most disadvantaged	0.63	1.87	1.18-2.96*	0.71	2.04	1.23-3.39*	0.69	1.99	1.21-3.28*
Physical Activity									
High Level	Reference								
Moderate Level	0.28	1.33	1.09-1.62*	0.28	1.33	1.02-1.74*	0.37	1.45	1.14-1.84*
Low Level	1.22	3.37	2.68-4.24*	0.98	2.67	1.99-3.55*	1.40	4.07	3.14-5.26*
Body Mass Index (kg/m²)									
Healthy range (≥ 18.5 -25)	Reference								
Overweight (≥ 25 -30)	-0.03	0.97	0.80-1.19	-0.33	0.72	0.57-0.91*	0.23	1.26	1.01-1.58*
Obese (≥ 30)	-0.04	1.04	0.84-1.28	-0.38	0.68	0.53-0.88*	0.45	1.56	1.23-1.98*
Underweight (≤ 18.5)	0.72	2.06	0.94-4.49	-0.01	1.00	0.42-2.37	0.96	2.62	1.20-5.74*

Chronic conditions (continuous)	0.26	1.29	1.21-1.37*	0.20	1.22	1.14-1.31*	0.26	1.29	1.21-1.38*
Osteoarthritis	0.30	1.35	1.13-1.60*	0.30	1.34	1.10-1.65*	0.22	1.25	1.03-1.51*
Ethnicity									
White	<i>Reference</i>								
Minority Ethnic Group	0.56	1.74	1.13-2.69*	0.52	1.69	1.02-2.80*	0.29	1.33	0.83-2.13
Smoking status									
Never smoked	<i>Reference</i>								
Past smoker	0.07	1.07	0.90-1.27	0.01	1.00	0.81-1.23	0.07	1.07	0.88-1.29
Current Smoker	0.21	1.23	0.93-1.63	-0.17	0.85	0.59-1.21	0.56	1.74	1.28-2.36*

Binary logistic regression analysis was used to determine the Odds Ratio (OR) and 95% Confidence Intervals (CI) for associations between health and sociodemographic variables and probable sarcopenia, low hand grip strength and poor chair rise test performance, respectively. BMI: Body Mass Index;

*p<0.05

4.4 Discussion

Few studies have investigated socioeconomic determinants of probable sarcopenia. In the present study, we report a 2-fold higher prevalence in older adults with the most, compared with the least, disadvantaged SEP (47% vs 21%, respectively) based on educational attainment and similar findings by subjective social status (53% vs 25%). Furthermore, both markers of disadvantaged SEP were independent determinants of probable sarcopenia when controlled for other known risk factors. The findings are in keeping with the established evidence that socioeconomic disadvantage is associated with negative health outcomes^{9,150,247,248} and suggest that sarcopenia places an unequal burden on socioeconomically disadvantaged communities. The findings suggest that socioeconomic indicators, in addition to health factors, are important considerations in determining the risk profile and prevention strategies for sarcopenia in older populations.

Current evidence remains inconsistent, Pérez-Sousa et al reported a high prevalence of probable sarcopenia (47%) in Colombian older adults (mean age 70 years, n= 5237) and noted that individuals in the most disadvantaged socioeconomic groups had the highest prevalence of probable sarcopenia (76%)⁸². Dodds et al, however, observed no association between probable sarcopenia and occupation class in the 1946 British Birth Cohort⁸⁰. While these studies provide context, neither study aimed to specifically examine SEP. In contrast, Brennan-Olsen et al, in a study of older adults in Australia across six years, noted a greater decline in hand grip strength and lower limb strength in groups with lower educational attainment and occupation class⁸⁷. We previously reported that socioeconomic disadvantage, defined by a single marker of SEP (educational attainment) was an independent predictor of probable sarcopenia in Irish community-dwelling older adults¹⁶⁸. The present study extends this finding to a large population of English older adults with objective and subjective markers of SEP.

The findings suggest a North-South gradient in the regional distribution of probable sarcopenia. This mirrors the growing body of evidence reporting regional health disparities in England, with a greater prevalence of markers of poor health, including frailty, observed among older adults in the North of England^{254,264}. The findings, however, are descriptive and would need to account for population demographics and socioeconomic data of the regions, which was beyond the scope of the present study. Future research could include markers of both area-level deprivation along with individual-level SEP when examining probable sarcopenia. As noted in the frailty literature, mapping populations can assist in matching services and resources to peoples' needs²⁶⁵. Given that the identification of probable sarcopenia warrants the

initiation of interventions, our findings may help inform healthcare policy, service planning and resource allocation to prevent and treat sarcopenia in regions with the greatest socioeconomic need.

There was consistent evidence of significantly greater odds of probable sarcopenia for older adults living with disadvantaged SEP defined by educational attainment or SSS. Older adults with no formal qualifications had 1.7 times greater odds of probable sarcopenia when compared to those with a third-level qualification. Similarly, older adults who perceived their SSS to be disadvantaged relative to society had significantly greater odds of probable sarcopenia. As noted in the sub-analysis, SEP and SSS remained independent determinants of probable sarcopenia in older adults, irrespective of the mode of assessment used to identify low muscle strength. This expands previous work showing associations between SEP and probable sarcopenia defined exclusively by low hand grip strength ¹⁶⁸. While the prevalence of probable sarcopenia varies based on the mode of assessment, low hand grip (18%; weighted 20%) and poor chair-rise test (26%; weighted 29%), SEP remains an independent predictor of both measures of low muscle strength.

The findings are in line with previous research which has reported links between disadvantaged SSS and greater functional decline in older adults ²⁶⁶. Moreover, SSS has been identified as an important predictor of mortality in participants of ELSA ¹⁷⁶. Similarly, low educational attainment has been linked with weaker hand grip strength across the life course ¹³². With accumulating evidence suggesting an association between SEP and low muscle strength, the inclusion of markers of SEP in further research and prevention strategies for probable sarcopenia warrants attention ^{9,82,168}.

Other determinants of probable sarcopenia included older age, physical inactivity, chronic conditions and osteoarthritis. Physical inactivity is a well-documented modifiable risk factor for sarcopenia ^{80,267}. Minority group ethnicity was a significant determinant of probable sarcopenia, which has been previously suggested ^{268,269}. This cohort, however, was not ethnically diverse, and most participants were white (97.7%). There is a need to investigate ethnic, as well as socioeconomic, differences in probable sarcopenia given that most studies to date have been conducted on White/Caucasian older adults populations ^{78,80,168,270}. Greater diversity would benefit future large scale ageing studies.

The present study identified probable sarcopenia in 34% of community-dwelling English older adults (weighted 36%). The etiology of sarcopenia is complex, probable sarcopenia

represents a practical and measurable target (e.g. muscle strength), it represents a point to intervene, and the 'prescription' treatment is exercise and diet ³⁷. Across the life course, socioeconomic disadvantage is associated with acquiring lower peak muscle strength in adulthood and experiencing earlier decline, compared with less disadvantaged communities ^{132,236}. Recently, Guo et al, reported that higher educational attainment was associated with a slower decline in markers of muscle mass, in a 15-year longitudinal study ²⁷¹. The physiological mechanisms underpinning the links between SEP and sarcopenia were beyond the scope of the present study, but current evidence suggests that socioeconomic disadvantage is associated with mediators of chronic disease, including inadequate physical activity, inflammation, poor nutritional status, environmental and occupational hazards, and inaccessibility of health care ^{228,246,272}. Importantly, evidence of a substantial socioeconomic gradient throughout the life course has also been shown for physical activity ¹⁴³.

While our findings suggest that socioeconomic disadvantage is associated with greater likelihood of probable sarcopenia, previous research has suggested disadvantaged SEP may impede engagement with physical activity and adequate diet, which are the primary treatment and preventative prescription for sarcopenia ^{143,267}. Socioeconomic indicators, in addition to health variables, would assist understanding sarcopenia, to develop more inclusive and targeted prevention strategies. These are important considerations given that probable sarcopenia and confirmed sarcopenia have been recently characterised as dynamic and reversible conditions ⁴⁷.

This study has several strengths and limitations. The findings are derived from the English Longitudinal Study of Ageing (ELSA), which is a large nationally representative study of community-dwelling older adults in England. In addition to markers of socioeconomic disadvantage, geographic region of residence and ethnicity were included. The highest formal educational qualification completed was operationalized as a marker of SEP, which has previously been shown as a robust indicator among older adults ⁹². Ideally, future studies would include a marker of area deprivation in addition to individual-level SEP. Other information relevant to sarcopenia such as nutritional status and protein intake may benefit future studies ^{165,244,245}. Physical activity level is self-reported which may be influenced by recall bias, however, the threshold selected for each activity level has shown associations with mortality in ELSA participants ¹⁹⁹. Essentially, this study was cross-sectional in design and therefore, cannot show cause and effect for the higher prevalence of probable sarcopenia in older adults with disadvantaged SEP. Many studies in this area are not ethnically diverse, and in the

present study minority group ethnicity was low (2.3%)^{78,80,168,270}. Future studies are needed that are more socioeconomically and ethnically diverse and include underserved groups in research¹⁶⁷.

In summary, the findings suggest a high burden of probable sarcopenia among older populations with socioeconomic disadvantage. In the present study, 47% and 53% of older adults with disadvantaged SEP had probable sarcopenia, assessed by educational attainment and by subjective social status, respectively. Disadvantaged SEP was an independent determinant of probable sarcopenia, and this finding was consistent for both measures of SEP and irrespective of how probable sarcopenia was measured. The results support associations between probable sarcopenia and other risk factors including physical inactivity, older age, chronic conditions, osteoarthritis, and ethnicity. The findings highlight a need and opportunity to address socioeconomic disadvantage in research, policy and practice for sarcopenia prevention and treatment. Future research is required in populations that are socioeconomically diverse, including older adults commonly underserved in traditional health research.

Chapter 5 – Socioeconomic Position and physical function in community-dwelling older adults with ADL-dependency in Ireland

Part A – An investigation of area-level socioeconomic position (SEP) in community-dwelling older adults with ADL-dependency: An analysis of health administrative data in Ireland

5.1 Introduction

Findings from Chapters 3 and 4 suggest community-dwelling older adults with disadvantaged socioeconomic position (SEP), defined by individual-level factors such as educational attainment and subjective social status, experience a greater burden of probable sarcopenia. Similarly, the association between socioeconomic disadvantage and adverse health outcomes is observed for aggregate-level indicators of SEP including neighbourhood deprivation, housing conditions and environmental indicators ^{273–276}. Populations living in socioeconomically deprived areas observe reduced life expectancies and spend a greater proportion of life in ill health ^{7,8,276}. In the United Kingdom (UK), adults living in areas with high socioeconomic deprivation are reported to have a ‘healthy life expectancy’ of 52.3 years compared to 70.7 years in the least deprived areas ⁷. Similar differentials in life and healthy life expectancy have been reported in Ireland and elsewhere ^{8,277,278}. There is good evidence that long-term health-limiting conditions are more prevalent among the most disadvantaged older populations accounting, in part, for a greater proportion of life lived with disability ^{89,279}.

Current evidence of health inequality in ageing is largely derived from populations aged under 80 years ²¹. The impact of health inequality is less clear in cohorts of more advanced age and physical dependency. This remains an important evidence gap, given that adults over 80 years represent one of the fastest-growing age demographics ²⁸⁰. Some evidence suggests that the influence of socioeconomic disadvantage may be lost as age-related dependency increases ²⁸¹. Consistent with this, research examining transitions in frailty in the Newcastle 85+ study showed that individual-level socioeconomic determinants did not influence the likelihood of moving from one frailty state to another ²⁸². Addressing this area is complex, due to several issues including, the underrepresentation of older adults with socioeconomic disadvantage, older age (80+ years) or functional limitations in research ¹⁶⁷, combined with potentially higher study attrition rates and survivorship bias ^{283,284}. This suggests opportunities to investigate health disparities in dependant older adults through other means, such as the use of health administrative datasets; while the latter is likely to represent age and socioeconomic diversity, specific markers of socioeconomic indicators may not be routinely recorded ²⁸⁵.

Several markers of SEP have been applied in research examining health inequalities in ageing ²⁸⁶. These include individual-level measures, for example, education, employment, income, wealth, and subjective social status as well as area-level deprivation indices. Geographic area-level deprivation indices are composite measures,

capturing multiple inputs such as unemployment, housing tenure, material deprivation and educational attainment to estimate the socioeconomic conditions of a defined residential area. Importantly, area-level socioeconomic indicators show strong correlations with individual-level SEP markers, when constructed at small-area level ¹⁷³. The HP Pobal Index, applied in the present study to determine residential area deprivation, divides Ireland into uniform populations of mean 100 households classified as 'small-areas' ¹⁷¹. Small-area-based socioeconomic indicators appear to be robust, showing strong correlations with morbidity, mortality, and a range of adverse health outcomes ^{173–175}.

In the present chapter, we analysed a large administrative health and social care dataset, previously described ²⁸⁷, with a high proportion aged 80 years and older (70%) and dependant in ADLs, indicated by the receipt of formal home support. We aimed to examine pre-specified health variables: physical dependency, acute hospitalisation, polypharmacy, cognitive impairment, and mental health conditions, according to area-level socioeconomic deprivation among community-dwelling older adults with ADL-dependency in Ireland. We aimed to examine whether associations between disadvantaged SEP and adverse health outcomes, observed in Chapters 3 and 4, persist in a population of older adults with advanced age and increased physical dependency. The findings of this study are anticipated to have important implications for future health and social care planning in areas of high socioeconomic deprivation.

Hypothesis 1: The demographic, health, and dependency characteristics of older adults in receipt of formal home support will differ significantly based on SEP, defined by residential area deprivation.

Hypothesis 2: Older adults residing in areas with disadvantaged residential area deprivation will observe a greater prevalence of the pre-specified health variables, when compared to affluent areas.

5.2 Methods

5.2.1 *Study Design and Population*

We conducted a cross-sectional analysis of an anonymised dataset comprised of community-dwelling adults aged 65 years and older living within a defined health administrative urban area in Ireland in 2017 (n= 1,591). The dataset is described in detail elsewhere ²⁸⁷ and includes data extracted from Common Summary Assessment Reports (CSARs) between January-December 2017. This is a mandatory form completed in the formal home support referral and review process by a nurse or healthcare professional. Participants were described as dependant as all were in receipt of formal home support services representing dependency in activities of daily living (ADLs). Currently, state-funded home support is assigned based on a clinician-led assessment of need, and at the time of this study is not income assessed in Ireland. Analysis of the data and its results were approved by the Health Policy and Management/Centre for Global Health Research Ethics Committee, Trinity College Dublin (Application: 02/2019/01).

5.2.2 *Health and Demographic Variables*

Available demographic and health variables, detailed in the methods Chapter 2, included age, gender, living alone and marital status. Health variables included physical dependency, polypharmacy, acute hospitalisation, cognitive impairment, and mental health conditions. Physical dependency was assessed using the Barthel Index which produces a numerical score (0-20), with higher scores indicating greater independence. Barthel Index was classified by maximum dependency (score 0-4), high dependency (score 5-8), moderate dependency (score 9-11), mild dependency (score 12-19) and independence (score 20), as per previous studies ²⁰⁰. Polypharmacy was defined as 5 or more prescribed medications ^{288,289}. Acute hospitalisation was recorded, where this was documented as the reason and source of the referral to home support for ADL assistance. Mental health condition was recorded as present, based on a recorded diagnosis of depression, anxiety, schizophrenia, or bipolar disorder by allied healthcare professionals. Cognitive impairment was classified as previously described ^{287,290}, based on a documented diagnosis of dementia or if a validated screening tool was employed and produced a score indicative of dementia or mild cognitive impairment. Information pertinent to home care utilisation was noted.

5.2.3 *Residential Area Deprivation*

Residential area deprivation was calculated using the HP Pobal Deprivation Index ¹⁷¹, as described in the methods Chapter 2, this tool measures the relative affluence or

disadvantage of residential small-areas in Ireland ¹⁷¹. The HP Pobal Deprivation Index uses data from the Irish 2016 Census to determine an area's relative socioeconomic deprivation, classified as one of the following: affluent, marginally above average, marginally below average or disadvantaged.

5.2.4 *Statistical Analysis*

Descriptive statistics were used to compare health and social factors across each of the defined residential deprivation categories: affluent, marginally above average, marginally below average, and disadvantaged. Normality was assessed visually using histogram plots in addition to normal probability plots and Shapiro-Wilks test. Continuous variables were examined using ANOVA analysis or Kruskal-Wallis tests to examine differences between groups. Mantel-Haenzel test for trend was used to examine trends between categorical variables and residential area deprivation. All analyses were performed using IBM SPSS Statistics V27 software.

5.3 Results

5.3.1 Study population

Characteristics of the study population (n= 1591) are presented in **Table 5.1**. Overall, the study group were of mean age 83.9 ± 7.1 years, the majority (70%) were aged 80 years and older, female (64%), had mild to moderate dependency (83.9%) and lived alone (54.3%). Based on residential area deprivation, 31.7% of older adults lived in areas described as affluent, while 11.2% lived in areas with disadvantaged residential deprivation. The prevalence of polypharmacy (67.6%), acute hospitalisation (33.4%), documented cognitive impairment (43.0%) and mental health conditions (19.7%), was high in the study population.

Table 5.1: Health and demographic characteristics of the study population (n= 1,591)

	N (%)
Demographics	
Age, mean $\pm$ SD ^a	83.9 $\pm$ 7.1
Gender, n (%)	
Female	1013 (63.7)
Male	578 (36.3)
Marital Status, n (%)	
Married	471 (29.6)
Divorced/ Separated	67 (4.2)
Single	313 (19.7)
Widowed	680 (42.7)
Lives Alone, n (%)	864 (54.3)
Health and Dependency	
Barthel Index Score ^b, mean $\pm$ SD ^a	13.1 $\pm$ 3.9
Barthel Category, n (%)	
Maximum dependency	45 (3.0)
High dependency	138 (9.2)
Moderate dependency	298 (19.9)
Mild dependency	959 (64.0)
Independent	59 (3.9)
Polypharmacy, n (%)	
Prescribed $\geq$ 5 medications	1076 (67.6)
Prescribed $\geq$ 10 medications	519 (32.6)
Median number of medications ^c	7 (9)
Documented Cognitive Impairment	686 (43.1)
Documented Mental Health Condition ($\geq$1)	313 (19.7)
Acute hospitalisation, n (%)	531 (33.4)
Died, n (%)	148 (9.3)

^a Mean $\pm$ Standard Deviation

^b Missing values n= 92 (5.8%); Barthel Index Score ranges from 1 to 20 with lower scores indicating dependency

^c Median (IQR)

5.3.2 *Health variables according to residential area deprivation*

High physical dependency was significantly more common among older adults in disadvantaged compared with affluent areas (16.2% vs 6.9%, $p<0.009$) (**Table 5.2, Figure 5.1**). In line with this, mild dependency was lowest in disadvantaged areas. Acute hospitalisation-associated dependency was highest (41.6%) in the most socioeconomically disadvantaged areas, while significantly lower in affluent settings (29.1%, $p<0.001$).

Polypharmacy (≥ 5 medications) was significantly higher among older adults living in the most socioeconomically disadvantaged (74.7%) compared with the least deprived areas (64.5%, $p=0.030$). Similarly, excessive polypharmacy (≥ 10 medications) and the median number of medications (IQR) prescribed were higher in disadvantaged compared to affluent settings (8 (8) vs 7 (10), $p=0.034$). No significant differences, however, were observed for recorded cognitive impairment or for mental health conditions according to residential deprivation. (**Table 5.2, Figure 5.1**).

While all older adults were accessing state home support for assistance with ADLs, those residing in disadvantaged areas were on average 6.5 years younger compared to affluent areas (79.1 ± 7.3 vs 85.6 ± 6.7 , $p<0.001$, respectively) (**Table 5.2**). The proportion of the population who had died during the study period of 2017 overall was 9.3%, ranging from 6.9% to 12.1% in affluent areas relative to areas marginally below average for socioeconomic disadvantage ($p=0.033$).

Table 5.2: Health and demographic characteristics of community-dwelling older adults according to residential area deprivation (n= 1,591)

Residential Deprivation	Area	Affluent (n= 505)	Marginally above average (n= 568)	Marginally below average (n= 340)	Disadvantaged (n= 178)	p-Value
Demographics						
Age, mean $\pm$ SD ^a		85.6 $\pm$ 6.7	84.6 $\pm$ 7.0	82.8 $\pm$ 6.6	79.1 $\pm$ 7.3	<0.001*
Gender, n (%)						
Female		341 (67.5)	373 (65.7)	203 (59.7)	96 (53.9)	<0.001*
Male		164 (32.5)	195 (34.3)	137 (40.3)	82 (46.1)	<0.001*
Marital Status, n (%)						
Married		152 (30.1)	138 (24.3)	125 (36.8)	56 (31.5)	0.112
Divorced/ Separated		11 (2.2)	18 (3.2)	17 (0.1)	21 (11.8)	<0.001*
Single		137 (27.1)	139 (24.5)	57 (16.8)	40 (22.5)	0.007*
Widowed		205 (40.6)	273 (48.1)	141 (41.5)	61 (34.3)	0.223
Lives Alone, n (%)		283 (56.0)	328 (57.7)	162 (47.7)	91 (51.1)	0.029*
Health and Dependency						
Barthel Index Score ^b, mean $\pm$ SD ^a		13.2 $\pm$ 3.9	13.0 $\pm$ 3.9	13.2 $\pm$ 4.1	12.9 $\pm$ 3.9	0.688
Barthel Category, n (%)						
Maximum dependency		17 (3.5)	13 (2.4)	11 (3.4)	4 (2.4)	0.610
High dependency		33 (6.9)	54 (10.2)	24 (7.5)	27 (16.2)	0.009*
Moderate dependency		83 (17.3)	110 (20.7)	70 (21.7)	35 (21.0)	0.151
Mild dependency		329 (68.7)	332 (62.5)	202 (62.7)	96 (57.5)	0.008*
Independent		17 (3.5)	22 (4.1)	15 (4.7)	5 (3.0)	0.889
Polypharmacy, n (%)						
Prescribed ≥ 5 medications		325 (64.5)	390 (68.7)	228 (67.1)	133 (74.7)	0.030*
Prescribed ≥ 10 medications		139 (27.5)	198 (34.9)	111 (32.6)	71 (39.9)	0.005*
Median number of medications ^c		7 (10)	7 (8)	7 (9)	8 (8)	0.034*
Documented Cognitive Impairment		205 (40.6)	248 (43.7)	152 (44.7)	81 (45.5)	0.170
Documented Mental Health Condition (≥ 1)		97 (19.2)	106 (18.7)	65 (19.1)	45 (25.3)	0.190
Acute hospitalisation, n (%)		147 (29.1)	182 (32.0)	128 (37.6)	74 (41.6)	<0.001*
Died, n (%)		35 (6.9)	54 (9.5)	41 (12.1)	18 (10.1)	0.033*

^a Mean $\pm$ Standard Deviation; One-way ANOVA test

^b Missing values n= 92 (5.8%); Barthel Index Score ranges from 1 to 20 with lower scores indicating dependency

^c Median (IQR); Kruskal-Wallis H Test

* Denotes p<0.05

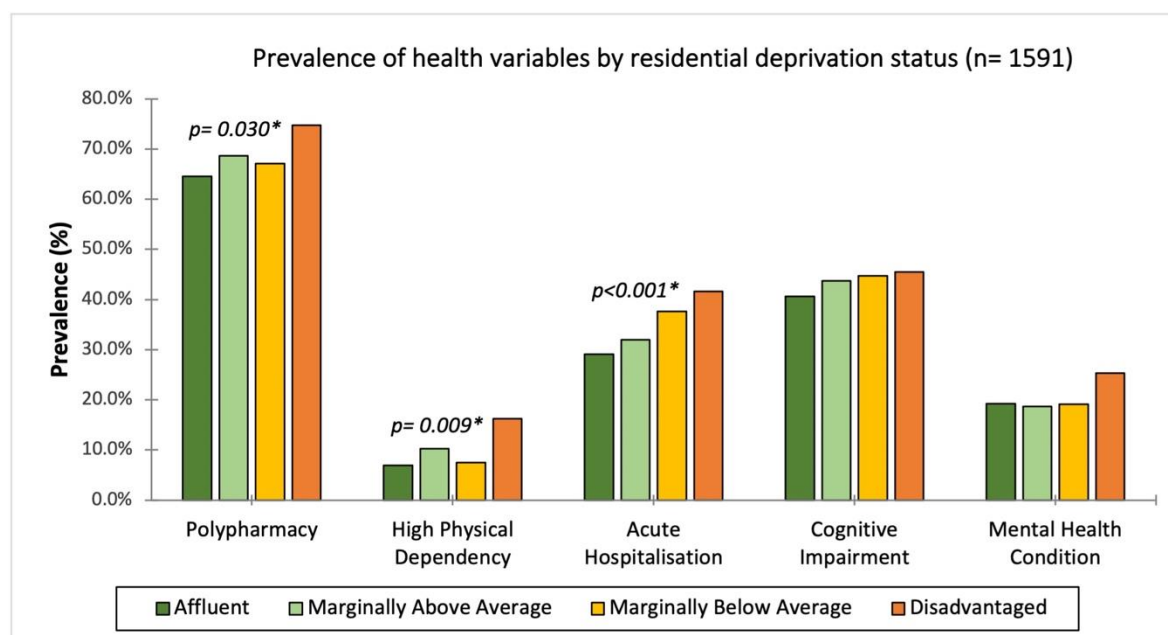


Figure 5.1: Prevalence (%) of health variables in community-dwelling dependant older adults based on residential area deprivation (n= 1591). * Denotes Mantel-Haenzel test for trend $p < 0.05$

5.3.3 Multivariable regression analyses of residential area deprivation and pre-specified health outcomes

In multivariable logistic regression analyses, adjusted for age and gender (**Table 5.3**), disadvantaged residential area deprivation was associated with an increased likelihood of polypharmacy [OR, CI 1.75 (1.18, 2.61), $p = 0.006$]. When compared to those living in affluent areas, older adults in areas of disadvantaged residential deprivation status observed an increased likelihood of high physical dependency [OR, CI 2.60 (1.47, 4.58), $p = 0.013$] and previous acute hospitalisation [OR, CI 1.59 (1.10, 2.30), $p < 0.001$]. Consistent with bivariate analyses no significant associations were observed between residential area deprivation with cognitive impairment or mental health conditions.

Table 5.3: Multivariable logistic regression analyses for residential area deprivation with prespecified health variables, adjusted for age and gender

	Polypharmacy (n= 1591)		Physical Dependency (n= 1499)		Acute hospitalisation (n= 1591)		Mental condition (n= 1591)		health	Cognitive Impairment (n= 1591)	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95%		OR	95% CI
Residential Area Deprivation											
Affluent	<i>Reference</i>										
Marginally Above Average	1.23	0.95-1.58	1.53	0.97-2.41	1.14	0.87-1.47	0.92	0.68-1.26	1.15	0.90-1.47	
Marginally Below Average	1.16	0.86-1.50	1.09	0.63-1.88	1.41*	1.05-1.90	0.89	0.63-1.28	1.24	0.94-1.65	
Disadvantaged	1.75*	1.18-2.61	2.60*	1.47-4.58	1.59*	1.10-2.30	1.10	0.72-1.68	1.35	0.94-1.93	

Binary logistic regression analysis was used to determine the Odds Ratio (OR) and 95% Confidence Intervals (CI) for associations between residential area deprivation status and health outcomes of interest, when adjusted for age and gender. *Denotes $p < 0.05$

5.4 Discussion

We examined pre-specified health characteristics in a large population ($n= 1591$) of ADL-dependant older adults of mean age 83.9 ± 7.1 years, according to residential area deprivation. High physical dependency, polypharmacy and acute hospitalisation were significantly more common in older adults with disadvantaged residential deprivation. Differences in cognitive impairment and mental health conditions were not observed in this study, contrary to our hypothesis. The findings indicate evidence of health inequalities, specifically in markers of physical health, in populations of more advanced age and dependency.

In socioeconomically disadvantaged areas, the prevalence of high physical dependency was twice that observed in affluent areas (16% vs 7%, $p= 0.009$), while mild dependency was the lowest. This association persisted when adjusted for age and gender, with those residing in areas of high socioeconomic deprivation observing a 2.6 times increased likelihood of high physical dependency when compared to individuals with affluent residential area deprivation. The association between area-level socioeconomic disadvantage and poor physical function is well evidenced ^{273,291,292}. In the English Longitudinal Study of Ageing (ELSA), lower socioeconomic status was independently associated with an accelerated decline in markers of physical function, including grip strength, gait speed and physical activity ²²⁰. Similarly, other population studies report an increased burden of sarcopenia, frailty, and ADL-impairment among older adults with socioeconomic disadvantage ^{168,188,293}. It is argued, however, that chronological 'age is a leveller' and that differences in physical function between socioeconomic groups plateau as age-related decline outweighs the influence of social and economic factors ²⁹⁴. Our findings provide evidence of health inequality for physical dependency amongst an older population with a mean age of 84 years.

Polypharmacy, an indicator of multiple long-term conditions in older adults ²⁸⁹, was observed more frequently in disadvantaged (75%) compared with affluent areas (65%), with a similar pattern noted for excessive polypharmacy and the mean number of medications prescribed. When adjusted for age and gender, older adults living in areas with disadvantaged socioeconomic deprivation had a 75% increased likelihood of polypharmacy when compared to the least deprived areas. This is consistent with findings in younger ageing cohorts, utilising individual-level SEP indicators. In the Irish Longitudinal Study on Ageing (TILDA), polypharmacy was significantly associated with lower educational attainment and wealth in adults over 50 years ²⁹⁵. Other studies using routine administrative data report higher rates of polypharmacy among adults aged 45-

64 years with residential area deprivation ²⁹⁶. These associations are often attributed to a higher prevalence, and earlier onset, of chronic conditions and multimorbidity ^{296,297}. Polypharmacy, however, is also independently associated with multiple adverse outcomes including the risk of hospitalisation, mortality, adverse drug events, and potentially inappropriate prescribing ^{288,296,298,299}. While our findings may reflect multimorbidity, further investigation is needed to confirm and explore medication management and deprescribing approaches in deprived settings.

In the present study, acute hospitalisation, as the trigger for increased dependency, was more common in older adults with residential deprivation. Associations between socioeconomic disadvantage and risk of hospitalisation and greater emergency department utilisation have previously been reported ³⁰⁰. Analysis of the EPIC-Norfolk cohort showed that residential area deprivation was a predictor of future hospitalisation, length of stay and the number of admissions ²⁸⁶. In the current study, we found that 42% of older adults residing in socioeconomically disadvantaged areas had a documented acute hospitalisation necessitating the initiation of formal home support for ADLs on discharge, compared to 29% in affluent settings. It is plausible that acute hospitalisation represented a tipping point for older adults in deprived settings, which may be amplified by lower access to and engagement with community health and social care supports and services ^{150,301}, although this was beyond the scope of the present study.

While all participants were accessing state-funded home care to support ADLs, the present study observed that those in socioeconomically deprived areas were on average 6.5 years younger than in affluent areas. Interestingly, the findings mirror patterns in life expectancy in Ireland, with a 5-year differential observed between adults in the most vs least deprived residential areas ⁸. This finding fits with published evidence that health inequality is associated with more years living with disability or limiting chronic conditions ²⁷⁹, along with the premature onset of multimorbidity by up to 10-15 years compared with the least deprived areas ²⁹⁷. This adds to the growing evidence of reduced healthy life expectancy in areas of high socioeconomic deprivation ⁷.

Several potential pathways between area-level socioeconomic deprivation and adverse health outcomes have been hypothesised including a greater frequency of detrimental environmental factors such as air pollution, in addition to poor housing conditions, access to healthcare, availability of healthy foods, open space for physical activity and behavioural factors ^{302,303}. McCann et al., examined area-level socioeconomic deprivation and cognitive function in older adults in Ireland and found a significantly

higher prevalence of high blood pressure, diabetes risk, obesity, alcohol consumption and smoking in areas of high socioeconomic deprivation³⁰⁴. The findings add to previous research on the impact of area-level socioeconomic deprivation in older adult populations in Ireland³⁰⁴, suggesting a greater burden of adverse health outcomes in areas of socioeconomic disadvantage.

Based on limited administrative data, the findings collectively begin to build a consistent picture of health inequality in physical health (i.e., greater physical dependency, polypharmacy, and acute hospitalisation) among dependant community-dwelling older adults. Contrary to our hypothesis, associations between residential area deprivation and mental health conditions or cognitive impairment were not observed in this study, in contrast to younger ageing cohorts^{305,306}. While it is possible that differences in these conditions across socioeconomic groups plateau with chronological age, there are notable challenges in the use of routine data relating to cognition and mental health³⁰⁷, including under-reporting, underutilisation of validated screening tools and difficulties performing data linkage due to the absence of dementia registries in Ireland^{308,309}. Furthermore, the present study applied an aggregate-level socioeconomic indicator meaning that the hypothesised associations between residential socioeconomic disadvantage with cognition and mental health may be less clear at area-level. Embedding the collection of more robust data on cognitive and mental health, along with physical health variables and individual-level socioeconomic indicators would strengthen the useability of administrative datasets.

This study has several strengths, including access to a large administrative data set (n=1591) of community-dwelling older dependant adults predominantly aged over 80 years, representing a rapidly growing age demographic often underrepresented in traditional health research^{167,243}. We applied the HP Pobal area-level deprivation Index, which could be a practical addition to other routine health data and is increasingly utilised in government and population reports⁸. Equally, administrative datasets have known limitations, including a lack of comprehensive and detailed health variables and covariates which impeded the full specification of multivariable models controlling for known risk factors of the prespecified health variables. The health administrative data analysed in this study was extracted from CSARs completed by nurses or other health care professionals in both acute and community-based settings and therefore, may vary based on the assessor or the setting in which the assessment was completed, increasing the risk of bias. Furthermore, while the proportion of missing data is relatively low, with just under 6% of CSARs having incomplete data on physical dependency (Barthel

Index), this may have resulted in a loss of information. Additionally, this was a cross-sectional descriptive study and therefore, does not show cause and effect. Given the absence of electronic health records and limited primary care data in Ireland, the present study reflects the real-world data for dependant older adults of advanced age in Ireland and is relevant to health and social care planning and resourcing. Ideally, administrative health datasets would capture simple, practical valid measures of physical, cognitive and mental health, that serve health care needs, research and complement longitudinal studies ²²⁰.

In summary community-dwelling older adults with ADL-dependency and living in socioeconomically disadvantaged areas experienced greater polypharmacy, high physical dependency, acute hospitalisation and a 6.5 year earlier need for state home support than in affluent areas. The findings suggest that health inequality persists in a population of mean age 84 years with physical dependency. Future work should explore the collection of comprehensive health and socioeconomic variables in this population group. The study highlights the need for community-based health and social care initiatives that address this inequality gap in community-dwelling older adults in Ireland.

**Part B - Assessing probable sarcopenia, frailty and malnutrition
in community-dwelling older adults with ADL-dependency: An
exploratory home-based study**

5.5 Introduction

It is widely acknowledged that some population groups are not proportionally represented in public health and medical research¹⁶⁷. Research in ageing observe lower engagement among people with socioeconomic disadvantage, older age, and impaired physical function^{167,243}. This is an important consideration when examining age-related conditions, such as sarcopenia and frailty, in older adult populations. To date, the evidence is predominately based on older adult cohorts under the age of 80 years, with the exception of the Newcastle 85+ study which has added to the evidence³¹⁰. The present study focuses on older adults in receipt of government-funded home support, a population that includes a high proportion of adults aged 80 years and over, with a moderate to high degree of frailty and a need for assistance with activities of daily living (ADLs)²⁸⁷.

Sarcopenia, frailty, and malnutrition, independent predictors of greater healthcare utilisation, hospitalisation and mortality^{42,251,311}, are becoming increasingly prevalent in older adult populations³¹². Yet, these conditions are potentially reversible^{47,313}. Sarcopenia, a condition characterised by the loss of muscle strength, mass, or function, contributes to functional limitations and mortality in older adults^{42,251}. In 2019, the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) updated their diagnostic criteria to include 'probable sarcopenia' defined by low muscle strength³⁷. Probable sarcopenia is deemed present if low hand grip strength (women <16 kg and men <27 kg) or poor chair rise test performance (>15 seconds), markers of upper and lower extremity strength, is detected³⁷. The introduction of probable sarcopenia is advantageous, as it can readily be measured in community-based settings, and once detected, is an appropriate timepoint to initiate interventions³⁷. Frailty, a distinct entity to sarcopenia with overlapping properties, is a state of increased vulnerability with multi-system impairment and reduced capability to respond to external stressors⁶⁵. While sarcopenia and frailty are linked to adverse health outcomes, both conditions are shown to be modifiable by targeted interventions, including physical activity and nutritional support^{37,314}.

Malnutrition, an important modifiable factor in sarcopenia and frailty³¹⁵, has a reported two-year incidence of 11% in older adult participants of The Irish Longitudinal Study on Ageing (TILDA) (n= 1841, mean age: 72 years)³¹⁶. While the receipt of social support at home was found to significantly increase the risk of malnutrition in older adults³¹⁶. Previous research with older adults in receipt of formal home support in Sweden (n= 353, mean age 82 years), reported that about half of this population were malnourished

or at risk of malnutrition over 3-year follow-up ³¹⁷. The Mini Nutritional Assessment Short Form (MNA-SF) represents a practical tool for the assessment of malnutrition risk and is recommended for use in community-based settings ³¹⁸. The MNA-SF requires body mass index, or a proxy, when determining malnutrition risk ³¹⁸ and the practicality of collecting such measures in-home with dependant older adults remains unclear.

Sarcopenia, frailty and malnutrition may co-exist in older populations ³¹⁹. A recent systematic-review and meta-analysis of sarcopenia, frailty and malnutrition reported a high overlapping prevalence in hospitalised older adult populations ³¹⁹. Previous findings, derived from administrative data, report a high prevalence of frailty (42%) and moderate functional dependency (48%) in older adults in receipt of formal home support services ^{287,320}. Similarly, we identified a 34% prevalence of probable sarcopenia in community-dwelling Irish older adults of mean age 66.9 years (n= 3342) ¹⁶⁸. Given frailty and sarcopenia predict future disability and mortality ^{42,65}, potentially at-risk groups, such as those receiving routine care services, warrant formal screening and assessment ³¹⁴. In a recent study, the implementation of sarcopenia and frailty screening was assessed within an acute day-unit ³²¹. Dodds et al suggest it is possible to implement routine sarcopenia assessment in an acute setting and identify a high prevalence of probable sarcopenia (84%) and frailty (66%) in a group of older adults with mean age 80.1 ± 7.7 years (n= 552) ³²¹. In community-based settings, sarcopenia, frailty and malnutrition are rarely systematically documented and likely remain undetected and under-treated ^{322,323}. Little is known about older adults in the community, receiving formal home support. The introduction of probable sarcopenia in the updated EWGSOP2 guidelines may represent a simple practical approach to identifying older adults at high risk of sarcopenia in community-based settings and once detected, is deemed an appropriate timepoint to commence intervention ³⁷. We sought to assess probable sarcopenia, along with practical measures of frailty and malnutrition among older adults in receipt of formal home care.

We conducted an exploratory home-based study in a small sample of the population described in Chapter 5A, including community-dwelling older adults supported by formal home care. Firstly, we aimed to examine markers of sarcopenia, frailty, malnutrition. Secondly, we aimed to examine the practicality of conducting in-home assessments for probable sarcopenia, frailty, and malnutrition risk with older adults with ADL-dependency. It is anticipated that the findings of this study may provide learnings for future in-home research with this group.

Hypothesis 1: It will be practical to conduct in-home assessments of probable sarcopenia, frailty, and malnutrition with community-dwelling older adults with ADL-dependency.

Hypothesis 2: A majority of the small study group will meet the criteria for probable sarcopenia and frailty.

5.6 Materials and Methods

5.6.1 Study Design and Population

This study included in-home assessments of probable sarcopenia, frailty and malnutrition and qualitative post-study feedback surveys with older adults with ADL-dependency. Full details on the study design and population are provided in Chapter 2. Briefly, participants were invited to take part in the study based on the following inclusion criteria: aged 65 years and older, living at home and in receipt of state-funded home care services. Moderate to severe cognitive impairment or inability to provide informed consent and those in receipt of palliative care or medically unstable were excluded from the eligible recruitment pool (**Figure 5.2**).

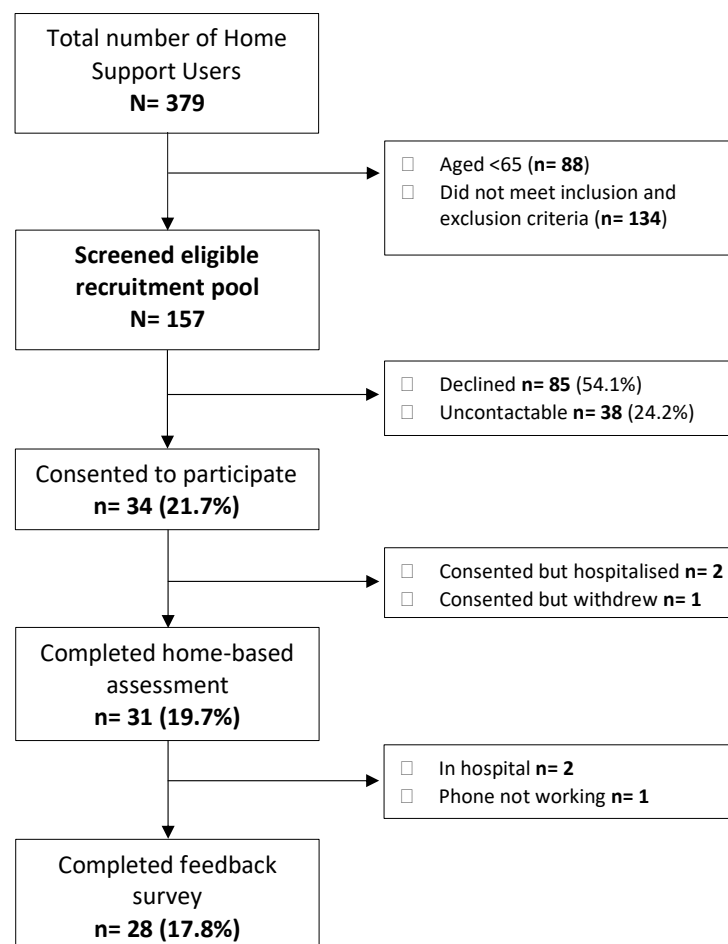


Figure 5.2: Flow diagram of participants in the home-based assessments and follow-up interviews

Convenience sampling was employed to recruit participants from a single government-funded not-for-profit home care organisation in Ireland, acting as the study gatekeeper. To ensure diversity of participants, an organisation operating in areas of high and low

socioeconomic deprivation was selected, with associations between younger age and receipt of formal home support in areas with high socioeconomic disadvantage previously reported ²²⁷. Home support in Ireland is allocated based on a health professional assessment of need and is not income assessed. Study recruitment flyers were sent by post to service users meeting the inclusion and exclusion criteria by the study gatekeeper (n= 157). Participation was self-selecting, with the research team notified of an expression of interest by the study gatekeeper (n= 34). Written informed consent was obtained from all participants and ethical approval was granted by Trinity College Dublin's Faculty of Health Sciences Ethics Committee (FREC/210909).

Assessments were completed in the participants home by a community nurse embedded in the health system and an health researcher (n= 31), between December 2021-March 2022. With permission, participants with communication difficulties were aided by family caregivers or through use of close-ended questions.

Participant feedback surveys were conducted by telephone at the end of the study (March 2022), which included reasons for partaking in the study, future research, and preferred mode of contact (n= 28/31). All feedback surveys were conducted by the study gatekeeper to maintain objectivity, audio recorded and transcribed verbatim. Feedback surveys were selected as the appropriate tool to collect feedback on participant's experience of in-home research based on the study aims and in line with the qualitative research experience of the study gatekeeper. Surveys questions are included in **Appendix 9**. Detailed fieldnotes were maintained by the research team to document completion rates of assessments and issues arising during each research visit, similar to Hall et al ³²⁴. All qualitative responses, including fieldnotes, were analysed using content analysis ³²⁵, to identify themes pertinent to the practicality of conducting in-home research with older adults with ADL-dependency. Qualitative content analysis allows for the identification of themes and patterns of meaning within text data ³²⁵, suitable to both fieldnotes and feedback surveys. Two experienced qualitative researchers independently applied inductive reasoning to condense fieldnote and feedback survey data into themes related to the practical considerations for conducting in-home research. This application of content analysis in the present study included the following steps: the preparation of data including transcription of audio recordings of feedback surveys by a health researcher, identification of codes or patterns of meaning in the data and the development of overarching themes pertinent to the practicality of conducting in-home research ³²⁵. Identified themes were discussed by both independent researchers to ensure that codes were development in a consistent and reliable manner.

5.6.2 Demographic Variables

As described in Chapter 2, demographic information included age, gender, living alone and socioeconomic position (SEP). SEP was defined using three indicators: highest educational qualification, residential area socioeconomic deprivation, and Subjective Social Status (SSS). Educational attainment was classified as four groups: no formal qualifications, secondary school lower, secondary school upper and third-level qualification, as previously reported ¹⁷. The HP Pobal Deprivation Index ¹⁷¹, which uses data from the 2016 Irish Census, was used to determine the relative affluence or disadvantage of small residential areas (classified as affluent, marginally above average, marginally below average or disadvantaged). Subjective Social Status (SSS), was defined using the MacArthur scale of perceived position in the social hierarchy ¹⁷⁶. SSS scores ranged from 1-10 with lower scores indicating greater socioeconomic disadvantage.

5.6.3 Assessing Sarcopenia, Frailty, and Malnutrition

We assessed probable sarcopenia according to the EWGSOP2 guidelines, using hand grip strength and chair rise test performance. Hand grip strength was measured using a Jamar Dynamometer (IL, USA) and standardised using the procedure described by Roberts et al ¹⁸¹. Three measurements were taken from each hand with the maximum value used in analyses and gender-specific cut off values for low hand grip strength were applied: <16 kg for women and <27 kg for men ³⁷. Chair rise test performance was measured as the time taken to complete 5 chair rises using the protocol developed by Dodds et al for home-based assessments with older adults ³⁹. Those unable to complete the chair rise test due to the use of a walking aid or without the use of arms were classified as having poor chair rise test performance ³⁹. As per EWGSOP2 guidelines, a time taken to complete 5 chair rises greater than 15 seconds was classified as poor chair rise test performance ³⁷. Additionally, the 5-item SARC-F tool assessing strength, assistance in walking, rising from a chair or bed, climbing stairs and falls was employed ¹⁸⁹, with a cut-off score ≥ 4 indicating sarcopenia onset ³⁷.

Frailty was assessed using the Clinical Frailty Scale (CFS) ²¹⁰, a tool used to quantify the degree of disability from frailty through the assessment of independence in ADLs, physical function and cognition. Physical dependency was indicated by the Barthel Index, a 10-item scoring tool assessing assistance required to complete ADLs and classified by maximum dependency (score 0-4), high dependency (5-8), moderate dependency (9-11), mild dependency (12-19) and independence (20) ²⁰⁰. Hospitalisation in the previous 12 months and attendance of a day centre was self-reported.

The Mini Nutritional Assessment Short Form (MNA-SF), a validated 6-item tool used in the screening of malnutrition, produced a continuous score (0-14 points) and was classified as healthy nutritional status (12-14), at-risk of malnutrition (8-11) or malnourished (0-7) ¹⁹⁶. Anthropometric measurements, components of the MNA-SF, included weight (kg), height (m²) and calf circumference (cm), if the measurement of BMI was not feasible. Weight was measured using a portable digital scale, with height assessed using a portable stadiometer. BMI was classified by the WHO criteria: underweight (≥ 15 – 18.5 kg/m²), healthy weight (≥ 18.5 – 25 kg/m²), overweight (≥ 25 – 30 kg/m²) and obesity (≥ 30 kg/m²) ¹⁹². We further applied the alternative ESPEN age-specific BMI cut offs for low BMI, recommended for use in the assessment of malnutrition risk: <20 kg/m² if aged less than 70 years old and <22 kg/m² if aged 70 years or older ³²⁶. For the measurement of calf circumference, lower limb swelling (suspected oedema) was noted as present if identified visually and confirmed by the participant.

5.6.4 Health Variables

The International Physical Activity Questionnaire – Short Form (IPAQ-SF), was used to categorise activity in the previous 7 days as high, moderate, or low physical activity levels ^{198,327}. Behavioural factors including self-reported smoking and alcohol consumption. Self-reported health was rated as excellent, very good, good, fair or poor. Long-term conditions were assessed using the functional comorbidity index, producing a continuous count (range: 0-18) ²⁰⁶. Number of medications prescribed per day was self-reported, confirmed with products or prescriptions within the home and excluded nutritional supplements and over the counter medications. Polypharmacy was defined by taking 5 or more medications per day and excessive polypharmacy was indicated by 10 or more prescribed medications ²⁰⁷.

5.6.5 Assessing the practicality of conducting in-home assessments

Completion rates for probable sarcopenia, frailty and malnutrition assessments were recorded. Pragmatic challenges to conducting in-home research were recorded in study fieldnotes. Post-study assessment, feedback surveys were conducted with participants to examine reasons for partaking in the study, future research, and preferred mode of contact (n= 28/31). Furthermore, the practicality of completing remote or online assessments, was examined using previously defined criteria for low technology readiness ¹⁹⁷, 1) inability to use a telephone due to hearing impairment, 2) verbal communication difficulties 3) visual impairment causing difficulty in reading or watching

television, 4) owning no internet-enabled devices and 5) no use of email, texting or internet in the previous month.

5.6.6 Data Analysis

Descriptive statistics are presented as proportions and mean $\pm$ standard deviation. The overlap between sarcopenia, frailty and malnutrition was visualised by means of Venn diagram. Fieldnotes and post-study feedback surveys were analysed by research team members AW and MOS. This included data pertinent to assessment completion rates, related challenges and older adults' preferences for future in-home sarcopenia, frailty, and malnutrition research engagement. All analyses were performed using IBM SPSS Statistics V27 software.

5.7 Results

5.7.1 Demographic and health characteristics of the study group

The study population ($n=31$) was of mean age 83.2 ± 8.2 years, and the majority were female (74.2%), aged 80 years or older (67.7%) and lived alone (74%) (**Table 5.4**). Overall, 22.6% of participants lived in socioeconomically disadvantaged areas, with a similar proportion (25.8%) reporting no formal educational qualifications, indicative of disadvantaged SEP.

Low physical activity was reported among most participants ($n=22/31$, 71.0%), reporting a mean daytime average of 11.4 ± 1.6 hours spent sitting. Polypharmacy (71.0%, $n=22/31$), comorbidity (96.8%, $n=30/31$) and reported hospitalisation in past 12 months (58.1%, $n=18/31$) were prevalent. All participants received support with ADLs, and 87.1% had a Barthel Score indicative of mild physical dependency ($n=27/31$). Of those with complete BMI measurement, based on WHO criteria, 71.4% had overweight or obesity ($n=20/28$). No participant met the criteria for underweight BMI, based on WHO criteria. Low BMI, defined by ESPEN criteria, was identified in 10.7% of participants ($n=3/28$). Based on MNA-SF calf circumference criteria for malnutrition risk, 4 participants (16.0%) had a calf circumference measurement less than 31 cm (**Table 5.4**).

Table 5.4: Characteristics of the study population (n= 31)

	Overall (n= 31)
Demographics	
Gender, n (%)	
Female	23 (74.2)
Male	8 (25.8)
Age, mean $\pm$ SD (years)	83.2 $\pm$ 8.2
Age Categories, n (%)	
65-69	1 (3.2)
70-79	9 (29.0)
80-89	16 (51.6)
90+	5 (16.1)
Lives Alone, n (%)	23 (74.2)
Socioeconomic Position	
Educational Attainment, n (%)	
Degree	4 (12.9)
Upper Secondary	13 (41.9)
Lower Secondary	6 (19.4)
No formal qualification	8 (25.8)
Residential Socioeconomic Deprivation, n (%)	
Affluent	12 (38.7)
Marginally Above Average	8 (25.8)
Marginally Below Average	4 (12.9)
Disadvantaged	7 (22.6)
Subjective Social Status, mean $\pm$ SD	6.3 $\pm$ 1.8
Screening Assessments	
Probable Sarcopenia, n (%)	29 (93.5)
Low Hand Grip Strength, n (%)	19 (61.3)
Poor Chair Rise Test Performance, n (%)	28 (90.3)
SARC-F Positive Score, n (%)	24 (77.4)
Clinical Frailty Scale (CFS), n (%)	
CFS3 – Pre-frail	1 (3.2)
CFS4 – Vulnerable	7 (22.6)
CFS5 – Mild Frailty	11 (35.5)
CFS6 – Moderate Frailty	10 (32.3)
CFS7 – Severe Frailty	2 (6.5)
Mini Nutritional Assessment Category, n (%)	
Normal nutritional status	23 (74.2)
At risk of malnutrition	8 (25.8)
Body Mass Index (BMI, kg/m²)^a	
World Health Organization (WHO) criteria, n (%)	
Underweight (≤ 18.5 kg/m ²)	0 (0.0)
Healthy weight (≥ 18.5 -25 kg/m ²)	8 (28.6)
Overweight (≥ 25 -30 kg/m ²)	13 (46.4)
Obesity (≥ 30 kg/m ²)	7 (25.0)
ESPEN criteria, n (%)	
Low BMI ^b	3 (10.7)
Calf Circumference, mean $\pm$ SD (cm)^c	34.6 $\pm$ 4.4
Suspected oedema in lower limbs, n (%)	6 (19.4)
MNA Calf Circumference Category, n (%)^c	
Calf circumference <31 cm	4 (16.0)
Calf circumference ≥ 31 cm	21 (84.0)

Lifestyle Factors	
Physical Activity Level, n (%)	
Low	22 (71.0)
Moderate	8 (25.8)
High	1 (3.2)
Daytime hours spent sitting daily, mean $\pm$ SD	11.4 $\pm$ 1.6
Smoking status, n (%)	
Never smoked	14 (45.2)
Past smoker	16 (51.6)
Current smoker	1 (3.2)
Alcohol consumer, n (%)	12 (38.7)
Health Factors	
Self-rated Health, n (%)	
Excellent	0 (0.0)
Very Good	4 (12.9)
Good	15 (48.4)
Fair	11 (35.5)
Poor	1 (3.2)
Long-term conditions, n (%)	
0	1 (3.2)
1	0 (0.0)
≥ 2	30 (96.8)
Mental health conditions, n (%)	10 (32.3)
Polypharmacy, n (%)	
Prescribed ≥ 5 medications	22 (71.0)
Prescribed ≥ 10 medications	7 (22.6)
Mean number of medications $\pm$ SD	7.0 $\pm$ 2.9
Barthel Index Score, mean $\pm$ SD	15.0 $\pm$ 3.5
Barthel Index Category, n (%)	
Maximum dependency	1 (3.2)
High dependency	1 (3.2)
Moderate dependency	2 (6.5)
Mild dependency	27 (87.1)
Independent	0 (0.0)
Health and Social Care Utilisation	
In receipt of state-funded home support services	31 (100.0)
Hospitalisation in previous 12 months, n (%)	18 (58.1)
Attends day centre, n (%)	3 (9.7)
Technology	
Technology Unreadiness, n (%)	
Hearing difficulties	4 (12.9)
Visual impairment	2 (6.5)
Communication difficulties	1 (3.2)
No internet/ internet-enabled devices	17 (54.8)
No use of email, texting, or internet in previous month	19 (61.3)

^a Missing data n=3 (9.7%). ^b Low BMI was defined as $<20 \text{ kg/m}^2$ in those aged less than 70 years old and $<22 \text{ kg/m}^2$ if aged 70 years or older. ^c Excludes those with suspected lower limb oedema (n= 6, 19.4%). Abbreviations: SD, Standard Deviation; cm, centimetres; MNA, Mini Nutritional Assessment.

5.7.2 Identifying probable sarcopenia, frailty, and malnutrition

Probable sarcopenia was detected in almost all (93.5%, 29/31) participants as defined by EWGSOP2 criteria (**Figure 5.3**). Probable sarcopenia defined by low hand grip strength alone was identified in 61.3% (n= 19/31) of participants and in 90.3% by poor chair rise test performance (n= 28/31). The latter included 19 participants who were unable to complete the chair rise test due to an inability to stand without use of their arms (n= 3) or use of a walking aid (n= 16). 77.4% had a positive SARC-F score equal to a score of four or more (n= 24/31).

Based on the Clinical Frailty Scale (CFS), most of the group were classified as either frail or vulnerable (n= 30/31, 97%). Specifically, 74.2% had frailty (n= 23/31), predominantly in the mild to moderate category (n=21/31, 67.7%) (**Table 5.4**). According to the MNA-SF, over a quarter (25.8%, n= 8/31) were at-risk of malnutrition. There was a high degree of intersectionality in the screening of probable sarcopenia, frailty, and malnutrition risk, detected in 22.6% of the study population (n= 7/31) (**Figure 5.3**).

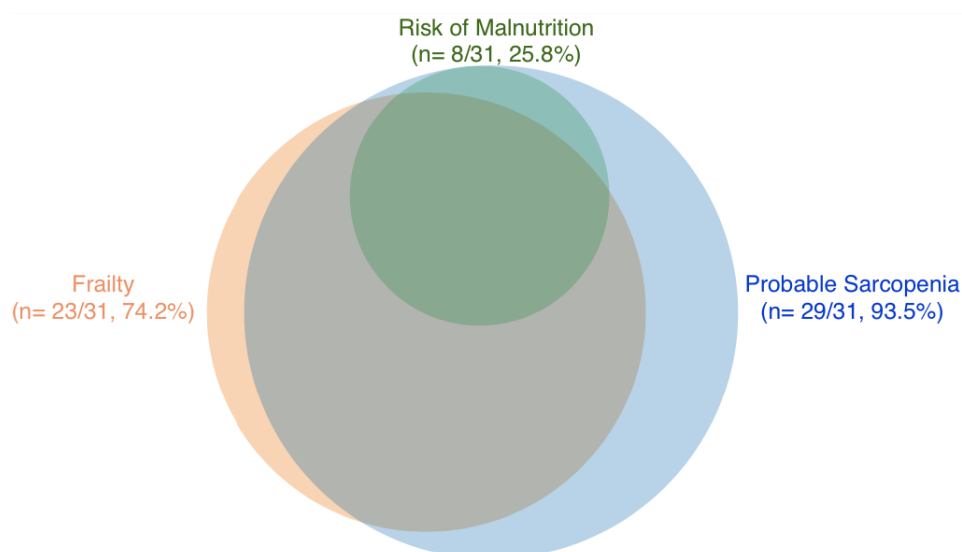


Figure 5.3: Venn diagram of overlap between probable sarcopenia, frailty and risk of malnutrition in older adults with ADL-dependency (n= 31)

5.7.3 Completion rates of in-home sarcopenia, frailty, and malnutrition screening tools

The SARC-F tool, CFS and MNA-SF had full completion rates (100%) in-home. Probable sarcopenia assessed by hand grip strength and chair rise test were completed in 90% and 61%, respectively (**Table 5.5**). In 3 cases only dominant hand readings were obtained due to neurological conditions or injury. It was not possible to conduct the chair rise test with individual who were unable to stand safely without the use of an aid or use of arms (n= 19). Where weight or height measurement was not viable, due to mobility

limitations (n= 3, 9.7%), calf circumference measurements were available to calculate the MNA-SF, though measurement issues were noted for participants with suspected lower limb oedema (n= 6, 19.4%). The study group included participants (n= 7, 22.6%) with visual, hearing or communication impairments. This did not impact completion rates and with participants accommodated as appropriate, as outlined in the methods.

Table 5.5: Completion rates and reason for non-completion of home-based assessments of probable sarcopenia, frailty and malnutrition (n = 31)

Assessment	Possible to complete n, (%)	Reasons for incompletion
Probable Sarcopenia Screening		
SARC-F	31 (100.0)	
Hand grip strength test ^a	28 (90.3)	- Neurological condition (n= 2) - injury/pain (n= 1)
Chair rise test	12 (38.7)	Could not stand safely without the use of: - an aid (n= 16) - arms (n= 3)
Frailty Screening		
Clinical Frailty Scale	31 (100.0)	
Malnutrition Risk		
MNA-SF	31 (100.0)	
BMI (height/weight)	28 (90.3)	- wheelchair user (n= 2) - reduced mobility (n= 1)
Calf circumference ^b	25 (80.6)	lower limb oedema (n= 6)

^a Defined by 3 measurements obtained for both dominant and non-dominant hands

^b Used to compute MNA-SF score in the absence of valid BMI data. Excludes participants with lower limb oedema (n= 6, 19.4%)

5.7.4 Practical issues relating to in-home research and assessments

During the study visits, issues were raised by the participants relating to unmet needs. The fieldnotes showed that over a third of participants (n= 11/31, 35.5%) had one or more referrals made by the research team to health and social care services including public health nursing (n= 5), formal home support providers (n= 5), community physiotherapy (n= 2), occupational therapy (n= 1), disability services (n= 1), day centre (n= 1), as well as advising participants to speak with their GP (n= 4). In total, 15 referrals were made by the research team. Several issues related to complex social environments, including neighbourhood anti-social behaviour, social isolation, the absence of informal support, factors relating to complex family relationships including substance use. In addition, everyday issues raised, primarily related to technology use, were addressed, e.g. assistance with televisions, telephones, accessing mobile phone credit, email, and helplines for online services. The average duration of an in-home assessment visits was 78.5 minutes (range 40-150 minutes).

5.7.5 Potential for future engagement in sarcopenia, frailty, and malnutrition research

The study feedback survey showed that almost all the participants agreed to be contacted about future studies (n= 26, 92.9%) (**Table 5.6**). Participants stated a preference to be contacted by postal leaflets 46.4%, telephone 32.7% or via a primary care healthcare worker 17.9%. In exploring the possibility of using online assessments in future studies, we noted that indicators of technology unreadiness were common (74.2%, n= 23/31), for example not owning an internet-enabled device or no access to the internet (n= 17, 54.8%) (**Table 5.4**). Similarly, 61.3% reported no use of email, texting, or internet in the previous month (n= 19). Participants provided practical suggests for future in-home research with community-dwelling older adults with ADL-dependency (**Table 5.7**).

Table 5.6: Participant Feedback on Engaging in Future Research Studies (n= 28)

	N (%)
Motivation for partaking in this study	
Willingness to help others	11 (39.3)
Concerned or interested in the topic i.e., muscle strength	8 (28.6)
Opportunity for a nurse visit	7 (25.0)
Family encouragement	1 (3.6)
Other reason	1 (3.6)
Agreed to be contacted about future studies	26 (92.9)
Preferred contact method for research	
Postal leaflet	13 (46.4)
Telephone	9 (32.1)
Community healthcare worker	5 (17.9)
Email	1 (3.6)

Missing Data (n, %); (n= 3, 9.7%)

Table 5.7: Learnings for future in-home research engaging community-dwelling older adults with ADL-dependency based on participant feedback (n= 28)

Learning Points	Supporting Data	Considerations for future research
Engaging Older Adults in Research		
Recruitment: Involving community healthcare staff, e.g. home care workers and Public Health Nurses (PHNs), with existing relationships in the population of interest may be an effective approach to engaging older adults in research	<i>"If you wanted more people, you should be asking the [home care workers] to feedback to the people they're visiting about the research study"</i> P002	Community representatives may enhance engagement of older adults in research
Participants were concerned about their physical capabilities prior to the research visit	<i>"I was worried that there would be lots that I couldn't do. I use a three-wheeler to stand and a stick to get around so I was worried that I wouldn't be physically able for it"</i> P021	Prospective participants may be concerned about their physical capability to engage in research. Researchers may need to alleviate concerns through highlighting the adaptability of assessments and their voluntary nature. There is a need to develop plans for reasonable accommodations, including adaptable and accessible assessments.
Older people, including those supported to live independently through home care, are willing to participate in research	Almost all participants (93%) agreed to be contacted about future studies	Future studies should actively aim to engage older adults currently underserved in health research
Participants recommended promoting the benefits of research	<i>"I think you need to get across the long-term benefit of research to old people. You need to tell them that this is what we have to do if we want to improve care for people in the community"</i> 003	There is a need for greater awareness around the value, potential benefits, and applications of research to improve engagement in underserved groups.
Conducting in-home Research		
Conducting research in the participants' homes is complex and may identify considerable unmet need.	36% of participants (n= 11) had one or more referrals made on their behalf to health and social care services following the research visit.	Researcher teams should be aware of their duty of care, including the importance of having strategies in place to respond to identified unmet needs or other

	The opportunity for a nurse visit was reported as motivating factor to engage in the research study by 25% of participants.	potential issues arising (e.g., safeguarding) during research visits. The inclusion of an experienced healthcare professional, embedded within the primary care system, within the research team was essential in our study to action identified unmet needs.
There was additional time associated with the completion of in-home research visits. In some cases, this was due to assistance with a range of everyday tasks inside the home such as providing support with technology.	The average duration of an in-home assessment visit was 78.5 minutes (range 40-150 minutes).	Researchers should acknowledge the additional complexity associated with conducting studies in a participant's home, and allocate sufficient time, flexibility, and resources. It's their homes, into which we, as researchers, have been invited.
There was a need to adapt our approach to completing assessments for participants with communication difficulties, such as including an informal caregiver in the research visit, with the participant's permission.	The study group included participants (n= 7, 22.6%) with visual, hearing or communication impairments.	Conducting research with older adults who may have additional communication needs requires an adaptable and person-centered approach

5.8 Discussion

We assessed sarcopenia, frailty and malnutrition in a group of ADL-dependant community-dwelling older adults (mean age 83.2 ± 8.2) in receipt of formal home support. Most participants met the criteria for probable sarcopenia and frailty, and over a quarter were identified as at risk of malnutrition. Furthermore, low physical activity was prevalent, with participants reporting an estimated 11 daytime hours spent sitting. While these chronic conditions and patterns of sedentary behaviour have been reported in older people in acute settings and in longitudinal datasets ^{168,321,328,329}, few studies have focused on older populations supported by formal home care ²²⁷. The findings suggest opportunities for appropriate physical activity and dietary intervention to address sarcopenia, frailty, and malnutrition in this group.

Probable sarcopenia (94%, $n = 29/31$) and frailty (74%, $n = 23/31$) were present in a majority of the study population, although the sample size limits extrapolation of the findings. When assessed by low hand grip strength alone, probable sarcopenia was present in over half of participants ($n = 19/31$) and almost all by poor chair rise test performance (90%, $n = 28/31$). In a relatively similar cohort to our study group, Dodds et al ³²¹ found similar patterns, with 84% of patients meeting the criteria for probable sarcopenia based on low hand grip strength, and 66% were frail based on Fried phenotype ³²¹. The latter was a large study of older adults attending an acute day unit in the UK ($n = 552$) with a mean age of 80.1 ± 7.7 years. In the present study, a majority of participants had a positive score (4+ points) on the SARC-F tool (77%, $n = 24/31$) suggesting high risk of sarcopenia onset and a prognostic indicator of mortality ¹⁸⁹, mirroring patterns observed by Dodds et al in an acute day setting (66%) ³²¹. The Newcastle 85+ study reported just under half of older adults aged 85 years and older have probable sarcopenia (48%), defined by low hand grip strength, in a population in which 22% report no dependency in ADLs ³¹⁰. Few studies have explored sarcopenia, frailty and malnutrition risk in populations of older age (mean age 80+ years) with dependency in ADLs. The findings build on previous work ^{321,329}, suggesting older adults accessing aged care services, including formal home support, represent an important group for sarcopenia assessment and intervention strategies.

Previous research, examining frailty by the CFS in a population of older people in receipt of home support, classified 80% of the population as vulnerable or frail ($n = 1312$, mean age 82.1 ± 7.3 years) ³²⁰. In contrast, a prevalence of frailty (24%) and pre-frailty (45%) was observed in younger participants of The Irish Longitudinal Study on Ageing (TILDA) ($n = 3507$, mean age 74 years) ³¹¹. Importantly, the authors identified frailty as a significant predictor of higher health and social care service utilisation, specifically home care

services ³¹¹. The findings suggest older adults accessing formal care services are an important group for preventative intervention, with previous findings identifying case management and rehabilitative services as effective strategies in this group ³³⁰.

Similarly, use of formal home care services has been identified as a determinant of malnutrition risk in Irish older adults ³¹⁶. In the present study, over a quarter of participants were identified using the MNA-SF as at risk of malnutrition. The findings mirror those from a large multi-centre study of home care recipients in Germany (n= 878, mean age 78.5 ± 12.2 years), which found 20% of participants were at risk of malnutrition based on MNA-SF ³¹⁷. Lahmann et al recommended the implementation of regular data collection and monitoring of weight as part of routine home care assessments ³¹⁷, however the practicality of performing such in-home measurements with older adults in receipt of home care remained unclear.

Designing research studies to include in-home assessments has been shown to reduce barriers to participation ³³¹, however there is limited data on the use of pragmatic assessments and their completion rates in the home ³⁸. We found that assessment of probable sarcopenia (by hand grip strength), sarcopenia case-finding using the SARC-F tool, malnutrition (MNA-SF) and frailty (CFS) was possible for all participants. The assessment of probable sarcopenia by chair rise test performance was possible for only 39% of participants, due to use of mobility aids or requiring the use of arms to stand. This is in line with previous research identifying 51% of home care clients in Finland were unable to complete this test in home-based assessments (n= 267, mean age 84.5 ± 5.2 years) ³⁸. Anthropometric components of the malnutrition assessment (MNA-SF), specifically the measurement of BMI, presented challenges due to wheelchair use or reduced mobility. While the measurement of calf circumference was possible in these cases, suspected lower limb oedema, identified in 19% of the study population, may have inhibited the validity of this measure. Overall, it was possible to complete screening assessments for sarcopenia, frailty and malnutrition in-home with ADL-dependant older people, similar to findings in acute settings ^{321,329}.

While an in-home study design with older people represented a complex research environment, it was not a barrier to completing the assessments, however, the research team unearthed considerable unmet need. Over a third of participants had referrals made by the research team to health and social care services, namely public health nursing, formal home support providers, community physiotherapy, occupational therapy services and disability services. Along with assisting with everyday issues including technology. In

addition to high levels of physical dependency detected in this group, previous findings, mostly derived from administrative data, identify mental health conditions, social isolation and socioeconomic disadvantage ^{227,287}. Despite this complexity, the study population expressed a willingness to engage in research, with 93% agreeing to be contacted about future studies. In line with previous studies ³³², altruistic factors were identified as motivators of research participation including a willingness to help others. Future research may be facilitated by embedding the assessments and research within routine primary care, or through the establishment of recruitment registries ³³³. While technology may represent a useful tool, the findings show most of the study group were not technology ready.

The assessments applied in the present study had high completion rates and described a high proportion of the study group as meeting the criteria for probable sarcopenia, frailty, malnutrition and physical inactivity. Although the sample size was low, limiting the generalisability of the findings, the initial observations suggest a future larger study is merited. For example, the identification of probable sarcopenia alone, is deemed sufficient evidence to initiate targeted interventions ³⁷, specifically physical activity and nutritional support ^{37,314}. Ideally, future studies would assess frailty using other validated tools such as Fried phenotype ⁶⁴. Participants reported an average of 11 daytime hours spent sitting, relevant to the design and delivery of interventions in this group. While the introduction of mandatory screening strategies into existing older person services have been previously recommended ^{314,333}, a tailored response including the delivery of timely treatment and interventions is required. Hendry et al, in a systematic review of interventions for frailty prevention, recommend targeted delivery in high-risk frail community dwelling older adults ³³⁴. Previous research examining the delivery of a physical activity programme within formal home care services in Ireland reported improvements in physical function, however the high degree of frailty observed among this group required a customised approach ²¹⁴. Psychosocial factors, including social isolation and a lack of informal support, suggest a need for multi-dimensional approaches and support the potential of social prescribing initiatives for this population group ³³⁵.

This study has several strengths, including the application of validated questionnaires and screening tools with a study population of mean age 83 years, with frailty (74%) and socioeconomic disadvantage (26%), characteristics of underserved groups in research ¹⁶⁷. We collected data on sarcopenia, frailty and malnutrition, which could be practical additions to other routine health data collected in the delivery of formal home support services. Limitations include the small sample size, with the study designed to assess the

practicality of conducting assessments in home-based research. Importantly, given the absence of e-health records and harmonised primary care data in Ireland, the present study represents one of the first to collect markers of sarcopenia, frailty and malnutrition in addition to demographic, socioeconomic and health data for older adults accessing formal home support services in Ireland.

In summary, most community-dwelling older adults in receipt of home support, assessed in this exploratory study, met the criteria for probable sarcopenia, frailty, and low physical activity, with over a quarter at risk of malnutrition. Conducting in-home assessments of probable sarcopenia, frailty and malnutrition risk was possible and had high completion rates. Although a group considered underserved by research, encouragingly, participants expressed a willingness to engage in future research. Our initial findings provide practical data for large scale studies and may inform the development of intervention studies, such as physical activity initiatives, aiming to support ageing in place.

**Chapter 6 - Embedding physical activity within
community home care services for older adults in
Ireland: Results from a qualitative study of barriers and
enablers**

6.1 Introduction

Findings from Chapter 3 and 4 suggest a high proportion of community-dwelling older adults in Ireland (23%) and England (34%) meet the criteria for probable sarcopenia, indicating higher risk of impaired physical function ⁴⁷. As evidenced in Chapters 3 and 4, an increased likelihood of probable sarcopenia was observed with older age, disadvantaged socioeconomic position (SEP), comorbidity and physical inactivity, and among Irish older adults, receipt of home support services. Chapter 5, through analysis of routine health administrative data and exploratory in-home research, suggests older adults in receipt of formal home support are an important group for intervention strategies aiming to delay or reverse physical decline. Evidence from a small exploratory study (n= 31) with older adults in receipt of formal home support, suggests a majority meet the criteria for probable sarcopenia, frailty, and physical inactivity (Chapter 5B). Physical activity is commonly prescribed as a primary treatment in sarcopenia and frailty, with positive effects observed ^{156,336}. Few studies however, have examined the role of physical activity in the home, engaging populations of older age with functional dependency ^{337,338}.

In 2021, an estimated 23.9 million hours of government funded home support services were delivered to over 55,000 people aged 65 years and older in Ireland ³³⁹. State-funded home support encompasses assistance with activities of daily living (ADLs), most commonly personal care ³⁴⁰, allocated based on a needs assessment, and not currently income assessed in Ireland. Previous studies, utilising administrative data, have identified a high prevalence of frailty (42%) among older adults in receipt of formal home care services ³²⁰. Frailty refers to the gradual loss of in-built reserves giving rise to vulnerability to external stressors ³⁴¹. Older adults with frailty have a higher prevalence of sedentary behaviour and may avoid physical activity due in part, to risk aversion ^{342,343}. Recent guidelines, however, recommend physical activity in older age, specifically to reverse or delay the onset of frailty ^{344,345}. Evidence supports the importance of light intensity activity to health, a message that is particularly important to communicate to those who are currently physically inactive and/or frailer ^{346,347}. Older adults in receipt of formal home support services have expressed a preference for being physically active through the activities they enjoy, such as walking and gardening, rather than engaging in structured exercise programmes ³⁴⁸. Consistent with this, frail older adults have been shown to benefit from home-based one-to-one approaches aimed at maintaining physical function at home ^{349–351}. Most research to date, however, has examined the delivery of short-term physical activity interventions by interdisciplinary teams ³⁵², with few focussing on embedding initiatives within community-based care.

This work forms part of the feasibility study of embedding the Care to Move (CTM) programme into a care at home setting in Ireland ^{215,353}. This programme comprised of physical activity training delivered to formal Health Care Assistants (HCAs), who became trained ‘movement motivators’, encouraging older adults in receipt of formal care services to do more ‘movement’ associated with self-care activities and integrating strength and balance activities within their daily routine. The published study protocol and results are detailed elsewhere ^{214,215}. In brief, 35 older adults with mean age 82.8 (SD 7.8) years participated in baseline assessments with 13 completing assessments at around 6 month follow-up. Retention was severely affected by the impact of the Covid-19 pandemic, which crossed the timeline of the feasibility study. Of those completing baseline assessments, 86% were female (30/35), most required use of a mobility aid (n= 23/35, 66%) and 11.2% resided in areas with disadvantaged residential deprivation. At around 6-month follow-up, small to medium effect sizes in quality of life, physical function, balance confidence and self-efficacy were reported.

The results suggest embedding physical activity within formal home care services was acceptable and feasible. Given an estimated 40,000 Health Care Assistants (HCAs), are employed in the delivery of formal home-based care in Ireland ³⁵⁴, engaging HCAs may provide a potential pathway to promote physical activity and retention in home-based programmes due to their frequent and sustained contact with older adults ³⁵⁵. The experience and acceptability of delivering the programme, including the delivery of ‘movement prompts’ by HCAs to their home support clients, however, is not known. As part of the larger feasibility, we hypothesised that embedding physical activity within formal care services would be feasible, to which this sub-study would contribute evidence. Therefore, this qualitative study aims to examine the HCA-perceived barriers and enablers of embedding physical activity approaches within formal home support services. The overall goal was to better understand the feasibility of translating this initiative into practice. It is anticipated that the findings will assist the design of evidence-based care through proactive approaches to support ageing in place.

The aims of the present chapter:

- To explore barriers and enablers to the delivery of a physical activity intervention with formal home care services for older adults in Ireland
- To capture feedback from Health Care Assistants (HCAs) on the future delivery of physical activity interventions within home care services and the potential role of technology.

6.2 Methods

6.2.1 Study Design

Full study details are available in Chapter 2. In brief, this study was conducted as part of a multidisciplinary collaborative feasibility study, aiming to examine the implementation of a physical activity program, Care to Move (CTM), within formal home care services for community-dwelling older adults with ADL-dependency in Ireland ²¹⁴. The programme comprised of physical activity training delivered to formal Health Care Assistants (HCAs), who became trained 'movement motivators', encouraging older adults in receipt of formal care services to do more 'movement' associated with self-care activities and to integrate some strength and balance activities into their daily routine ²¹⁴. 'HCA' is used in Irish healthcare, though, several other terms are in use nationally and internationally in practice and research to describe the staff who participated in this study (including home support worker, home care worker, home care assistant, home help, caregiver, domiciliary care worker).

As described in Chapter 2, the Care to Move programme was not a structured physical activity programme, rather it was a whole workforce based approach which aimed to embed consistent language around promoting movement within formal home support services. A total of 47 HCAs completed CTM training between March 2019 and February 2020. The training was completed in a phased-approach with full-time HCAs initially selected to participate by the management team within the home support provider, but then expanded across the organisation on an 'opt-in' basis. This training was led by a Senior Community Physiotherapist and a qualified CTM trainer. The CTM training applied communication skill and confidence building techniques to promote purposeful conversations related to the delivery of physical activity prompts. The training promoted behaviour change techniques, including goal setting, that could be applied to promote movement within community health services. Importantly, the delivery of the CTM programme was led by a Senior Community Physiotherapist, who assessed all home support service users for inclusion in the feasibility study and led the initial goal-setting exercise with participants and HCAs were encouraged to motivate and empower participants to achieve these goals. Additionally, the CTM training focussed on balance and strength-building activities that could be embedded within home support recipients' daily routine. Although a total of 47 HCAs were trained in the CTM programme between March 2019-February 2020, HCA workforce retention was severely impacted by the Covid-19 pandemic ²¹⁴. A total of 22 HCAs, who participated in CTM training, remained employed with the home support organisation and were actively providing home support services

between August-September 2020 and all agreed to participate in semi-structured interviews.

The semi-structured interviews explored the HCAs' experiences and views of promoting physical activity, barriers, and enablers to the CTM approach, delivery of the programme and suggestions for the future. The latter included views on the potential role of technology (i.e., smartphones and online applications). All interviews were conducted by telephone between August and September 2020, audio-recorded, and transcribed verbatim. The average length of interview was 16 minutes (range from 11 to 24 minutes). Written informed consent was obtained from all participants which included publication of anonymised responses.

6.2.2 Data analysis

As outlined in Chapter 2, all transcripts were analysed using a reflexive approach to thematic analysis which followed the 6 phase guide provided by Braun and Clarke to identify themes within the data ^{217,218}. Interviews were read in their entirety. Following this, inductive coding commenced, wherein segments of data were systematically highlighted including words and phrases relevant to each code ²¹⁹. Codes with similar meaning were grouped and collapsed to form themes pertinent to enablers and barriers to implementation of the programme. These themes were then reviewed, and the research team conferred to discuss overarching themes. Following refinement of the identified themes, other authors were consulted for feedback and consensus based on the interview data, ensuring that over-arching themes and sub-themes accurately reflected the supporting data. All authors provided feedback on the written manuscript. Authors who conducted the qualitative analyses did not partake in the CTM training delivered to the HCAs, to maintain objectivity and reduce bias. Finally, the findings from qualitative interviews were shared with HCA participants through a monthly newsletter distributed by the home support organisation.

6.3 Results

6.3.1 Older Adult and Health Care Assistant (HCA) Participant Characteristics

In total, 35 older adult participants participated in baseline assessments with 13 completing assessments at around 6 month follow-up. Retention was severely affected by the impact of the Covid-19 pandemic, including social restrictions and changes in home care service delivery. Of those completing baseline assessments, 86% were female (30/35) with mean age 82.8 (SD 7.8) years and most required use of a mobility aid (n= 23/35, 66%). At around 6-month follow-up, small to medium effect sizes in quality of life, physical function, balance confidence and self-efficacy were observed.

In the present qualitative study, a total of 22 HCAs participated in the study interviews and were predominantly female (21/22, 96%) with a mean age of 49.0 ± 10.7 years. The group were experienced in care provision for older adults, having been employed in their current organisation for an average of 10.5 ± 6.5 years (range 1.4 to 20.7 years). HCAs delivered CTM for a minimum of seven months at the time of interview. Older adults in receipt of CTM, with characteristics detailed in full elsewhere ²¹⁴, were of mean age 82.8 ± 7.8 years, 68.6% lived alone, 88.6% had mild to moderate frailty based on the Clinical Frailty Scale and 11.4% resided in areas with disadvantaged socioeconomic deprivation status.

6.3.2 Barriers and Enablers to Embedding Physical Activity within Home Care Services

Perceived barriers and enablers to the delivery of the programme within home support were identified across three main themes (**Figure 6.1**). Namely, the programme's approach, the home support setting and views around physical activity and older people. 'Delivering care in a crisis' was further identified, due to the impact of the COVID-19 pandemic which crossed the study's timeline. Finally, participants shared practical suggestions and opportunities for the future direction of embedding physical activity within formal care services.

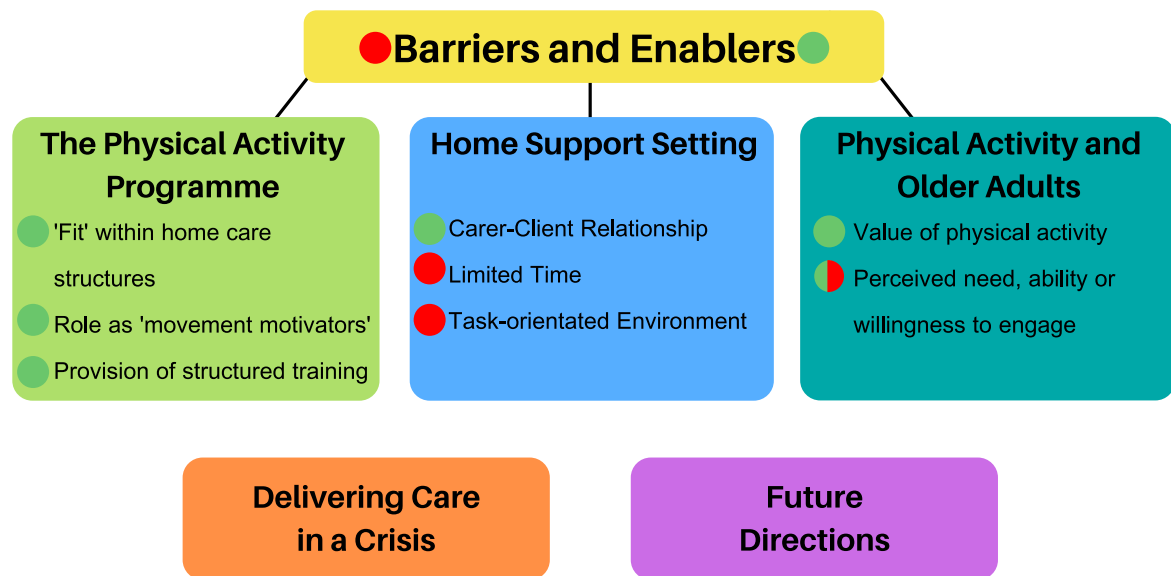


Figure 6.1: Factors affecting the delivery of the Care to Move programme within formal care services

Theme 1: The Programme's Approach

Overall, there was a positive perception of the programme's 'fit' within the home support environment, the focus on 'movement prompts' and 'motivators' and the structured training provided to staff.

The programme 'fit' within home care structures

The physical activity programme was considered a relatively practical approach to embed into the daily routine of home support visits. *"When you know the steps and the routine, [CTM] becomes very easy"* HCA007. The method of incorporating the intervention into the clients' routine was viewed as central to its integration within current care delivery, resulting in enhanced levels of activity. *"If you're going to implement it into their daily routine, [clients] don't even know that they're doing [physical activity]"* HCA024.

The role of HCAs as 'movement motivators'

The HCAs role as 'movement motivators', was viewed as a positive concept that encouraged older adults to participate in the programme. *"A lot of [clients] sit down all day and they need someone to lead them"* HCA029. HCAs perceived an ability to disrupt periods of sedentary behaviour through the application of movement prompts *"Like a lot of people when you go in, they are just sitting on the chair doing nothing. ... if you can get them up, if you can motivate them, it's great."* HCA021. Some HCAs discerned the difference between physical activity and exercise, and their intended benefits. *"You don't say exercise because it's not really, it's about promoting movement you know?"*

Provision of structured staff training

The provision of the structured training was largely viewed as sufficient and practical. *"I thought it was a very good course ... for the 2 days ... there was loads in it that you are able to do"* HCA020. Although, a need for additional on the ground support throughout the programme was also identified *"I think it would be good to have someone that you can ring even call in and give us an idea of what to do"* HCA010 and further commented that *"... we are not qualified to do physio even though we do help some of the older people out"* HCA010. The applicability of 'movement prompts' was again reflected, as well as practical aspects such as employing a 'stand-to-move' approach, where unaided standing is promoted with prompts on foot placement. *"Before I was doing Care to Move ... I was actually helping everybody to stand up with the help of the crutch or the frame, with one hand under the arm... Just to give them a hand, it is definitely way better to stand to move"* HCA007.

Theme 2: The Home Support Setting

The potential for relationship building and interaction with clients was identified, however, the 'time and task nature of home support' was a recurring challenge in embedding physical activity within the current formal support structures.

The Carer-Client Relationship

A persistent thread across all interviews was the value of the relationship between the HCA and the client. *"It makes me feel good knowing that I'm helping her"* HCA023. For some HCAs, their relationship with the client, was perceived to enable personalising the delivery of CTM. *"I know how far to push with one and then how far to push with the other"* HCA022 and *"Sometimes she says 'oh I'm so tired, I can't do it today' and I say 'that's ok don't worry we will leave it ...you don't say you have to do [CTM]'"* HCA029. Others observed an opportunity in CTM to increase interaction with the client. *"If [clients are] willing to participate in [CTM], it would be great for them because it's interaction with them"* HCA024 and *"I took part when they were doing [CTM]. I was doing [CTM] with them"* HCA008.

Limited Time

The limited time available to HCAs to complete the existing essential tasks, as outlined in the formal care plan, was viewed as a key and recurrent barrier to programme delivery. *"You probably get a half an hour call which is at lunchtime but by the time you go in and*

make the lunch, sure the half is up ... it can be a bit difficult to try and fit them exercises in as well" HCA005. Workload issues were described as an ongoing challenge within home support services, irrespective of the delivery of the intervention. *"You don't actually have the time even to be doing what you're doing, do you know what I mean?"* HCA003. The burden of the research study paperwork (aimed at capturing daily goals of the intervention) was noted to impact further on an already time-limited visit. *"You barely get time to fill in your daily log and what you [have] done with that client today without doing all that paperwork."* HCA002 and *"... you haven't got time to be doing all of that [paperwork]"* HCA003.

Task-Orientated Environment

The task-orientated nature of home support services emerged as a barrier to delivery, where assistance with activities of daily living were a priority over the intervention. *"It can be difficult if you're getting them out of bed and you're getting them washed and you're getting them dressed and you're giving them their breakfast. Like it does take up your whole hour. Even a little bit of an extra on to that hour"* HCA005. This task-focused method of care delivery combined with limited time was frequently cited in home visits with personal care duties. *"Some clients, you wouldn't have a minute to yourself like, you could be getting them washed and dressed, you wouldn't have a minute"* HCA003.

Theme 3: Physical Activity and Dependant Older Adults

Both positive and negative perceptions of the role of physical activity in older adults were evident among some HCAs. Some perceived value in enabling physical activity, while other comments broadly suggested that older adults *'couldn't, wouldn't, or shouldn't'* engage in physical activity, i.e., due to refusal, poor functional ability or that this activity was not suitable for adults of more advanced age ^{356,357}.

Perceived value of physical activity for older adults

Many HCAs reported a positive attitude towards the approach and viewed that it translated into improvements in physical function and activity among older adults. *"I can see the benefits of [CTM] and it makes me feel good knowing that I'm helping her and that she is happy and confident then because she is more active and she is moving more muscles, working her body the way she should be"* HCA023. HCAs further highlighted buy-in from the service users and positive behaviour change in response to the intervention. *"The minute I go in she'll say 'are we doing the exercises?'"* HCA005 and *"[Clients] used to say we have got to do a little bit of movement today"* HCA008. An understanding of the importance of physical activity and movement for older adults was noted *"[HCAs] are doing*

[CTM] to get the older people moving so that it helps them with their stiffness and keeps them going” HCA010

Older adults need, ability or willingness to engage in physical activity

HCA010 identified the clients’ willingness to engage in the physical activity approach as central to the success of the programme. *“Care to Move can be the carer’s duty but it really depends on them, it really depends on the clients”* HCA006. However, others commented on clients’ reluctance to participate in the intervention. Reasons for this lack of engagement were perceived to be lack of interest, dislike of ‘being told what to do’ or fatigue. *“You are talking about probably 70 or 80-year old’s, and taking them up and down on the chair, moving their feet, and some people did feel it a bit tiresome to keep asking an 80-year old to have to do that”* HCA002. Other subthemes identified may reflect negative perceptions around physical activity in older age, for example, the need or ability of older adults to partake due to advanced age, dementia, co-morbidities, or frailty, suggesting a need for more tailored physical activity regimens. Some HCAs, however, commented on the perceived risks, such as causing injury or pain.

Theme 4: Delivering Care in a Crisis - Impact of the COVID-19 Pandemic

The study interviews were conducted between August-September 2020, and therefore the impact of the COVID-19 pandemic on health and social care was reflected throughout the interviews. The HCAs described completing only essential tasks and keeping visits as short as possible. *“I was only bringing her shopping, so I wasn’t able to do any of [CTM] at all ... I couldn’t do anything there. I was just in and out”* HCA020. The loss of physical activity, an increase in anxiety and a general decline in physical and cognitive function of the older adults during COVID-19 was widely described *“[Clients] were afraid and they haven’t been going out and getting as much exercise”* HCA023 and *“When COVID started happening that’s when we kind of stopped [CTM] because she had other worries on her mind”* HCA024. *“She lives on a top floor apartment ... she was using the stairs but now she’s not using them, so she has really slowed down, so I just take her for a walk out onto the landing”* HCA001 and *“She was isolated and wasn’t going out ... she was absolutely isolated”* HCA001.

Theme 5: Future Directions

During the interviews, HCAs were asked to offer suggestions for delivering the programme within home support services and to share their views on the potential role of technology. Given that the most commonly cited barrier was limited time, HCAs proposed that additional time should be allocated to deliver this specific initiative within each home support visit. Other opportunities for future improvement included full workforce training in the programme and designated CTM programme ‘champions’ or support personnel. Learnings and considerations for future studies are described in **Table 6.1**.

Embed the programme into formal workforce training

Participants reported that CTM training should be delivered to all HCA employees and embedded into workforce training. *“I think everyone should do [CTM]. I think it is essential for everyone to take part in it. It’s not just like select people, it would great if everyone did it at the start ... I think they would see a lot of results from [CTM] if everyone did it”* HCA024. HCAs described an opportunity to integrate CTM training into the mandatory Care Skills modules required for their role. *“I think going forward that [CTM] definitely should be part of a module rather than a training, that shows the benefits if you get in at the right time”* HCA026.

Designate champions of the programme

HCAs commented on the potential benefits of having designated local CTM coordinators or advisors within their organisation. *“... You know, if you were kind of stuck and say ‘well I do this exercise but she’s finding this exercise more difficult than the rest. Is there an easier way or another way that we could, do it?’”* HCA005. *“It would be great to have someone to have a chat with about [CTM]”* HCA024. Others suggested that a designated person may have a potential role in client motivation. *“It might help when you have some clients who do not want to do [CTM], you know having someone else there to try motivate them”* HCA027. This aligns with earlier views of a perceived lack of on the ground support, as a potential barrier.

The role of technology

In response to the ongoing COVID-19 pandemic, HCAs were asked about the potential of using technology to assist with delivering the programme. HCAs did not perceive technology readiness among most of their clients. *“Well, most of them wouldn’t have a phone like they wouldn’t be able to do much because they don’t know what technology is.”* HCA023 and *“They can’t even turn their telly [television] on or use the remote control.”* HCA022. HCAs perceived that being familiar with, or owning a smartphone or computer

was viewed as an exception among their clients, and potentially relevant to one client in their full caseload (not specifically in the study). *“Yeah, like one comes to mind, she has a phone, and she uses WhatsApp so she is the only one that would have an idea of what Zoom is and all of that.”* HCA023, *“One has the laptop and a mobile phone”* HCA006 and *“One can. Just the one. she can go on to Facebook and she can write a message on her touchscreen and, emails and all that she wouldn’t be able to do that.”* HCA025. Notably, the absence of technology proficiency was also reflected among the HCAs. *“I can’t even turn on a computer”* HCA010 and *“I can answer, send a text message and hang up and that’s about it. I have it all on my phone, but I can’t use it. I don’t even know how to send an email”* HCA022.

Table 6.1: Learnings for embedding physical activity within formal support services for community-dwelling older adults based on the experience of HCAs

Theme	Summary of findings	Considerations at organisational and policy level
The physical activity programme	The CTM approach appeared to be a good fit within home support services The staff training was practical and of sufficient duration, but additional supports were suggested.	- A programme that encourages older people to 'move more and sit less', appears to fit with home support services for community-dwelling frail older people - Provide initial staff training. - Embed the training across the full workforce - Provide additional on the ground staff supports (e.g., leaders and champions)
The home support setting	The time and task-oriented routine of home support were challenges to embedding the initiative into services.	- Explore the feasibility of prescribing 'movement prompts' in the care plans for older adults receiving home support - Review the time needs and costs for care visits with physical activity initiatives - A system change to reconfigure home support beyond a 'task' based nature to more broadly support health, well-being, and quality of life approaches
Physical activity and older adults	Positive and negative perceptions of the value of physical activity for older frail adults were identified	- Awareness raising for staff and more widely, around the role and benefits of physical activity in frail older people

6.4 Discussion

We investigated the feasibility of delivering a physical activity programme to older adults through existing home support services. National and international policies support both strategies for ageing in place and the benefits of physical activity among all older populations ^{358,359}. The present qualitative study aimed to explore the experience and perceptions of HCAs who were trained in and delivered the programme. The overall goal was to better understand the feasibility of translating this initiative into practice and to move home support beyond its traditional task-based focus. Barriers and enablers to the delivery of the intervention were identified across three main themes. Namely, 1) the physical activity programme, 2) the home support setting, and 3) physical activity for older adults. Enablers included the 'fit' of the approach, the role of movement motivators, provision of structured training, carer-client relationship, and the perceived value of physical activity for older adults. Recurring barriers included limited-time, the task-orientated nature of home support services and the older adults' need, ability, or willingness to engage in physical activity. 4) 'Delivering care in a crisis', reflecting the ongoing Covid-19 pandemic and 5) 'Future directions' outlining practical suggestions shared by HCAs are further noted.

With respect to the programme, the qualitative evidence indicated that the approach was a good 'fit' within the home support setting, where the HCAs' role was to encourage physical activity through movement prompts. More strenuous activities are less likely to be feasible in this group, because of the prevalence of fatigue and deconditioning, and a programme of activities that focusses instead on reducing sedentary behaviour may be more appropriate ¹⁶⁰. The findings indicated that older adults partook in the movement activities with the HCA, suggesting a potential to support and further develop the carer-client relationship. It was generally perceived that the programme was adequately supported by staff training at onset, though more on the ground support or local 'champions', within the organisation, for the programme was suggested. The time-limited and task-orientated nature of home support were cited as recurring barriers to embedding the programme within home support. Given the time constraints and competing tasks, the necessity to prioritise assistance with ADLs, specifically personal care, over promoting physical activity was clearly articulated. Ideally, future work would examine the feasibility of embedding physical activity initiatives and prompts within the formal care plan. Previous studies, for example, have identified collaborative goal setting and personalised support plans as central to the implementation of restorative home care interventions ³⁵².

Importantly, many HCAs perceived the programme as having practical benefit for their clients, for example in maintaining mobility, and in relationship-building. This is supported

by findings from the feasibility study which reported small to medium effect sizes in quality of life, physical function, balance confidence and self-efficacy ²¹⁴. However, this benefit was not perceived as universal by HCAs, with a view identified suggesting that older adults ‘couldn’t, wouldn’t or shouldn’t’, engage in physical activity. This was attributed to several reasons including reduced ability (i.e., due to impaired physical or cognitive function), unwillingness or resistance to partake and a perception that older adults ought not to participate in physical activity. The latter, may reflect negative perceptions around physical activity in ageing which have been similarly reported elsewhere ^{360,361}, often reflecting views that older people should ‘rest’. While evidence to the contrary is now vast, and physical inactivity is strongly associated with muscle loss (sarcopenia) ^{37,168} and poorer physical and mental health outcomes ³⁶¹. Current guidelines recommend physical activity for all older adults, including people living with frailty or disability ³⁵⁹. The findings of the present study highlight an opportunity for further awareness raising as part of the standardised HCA training to highlight the role of physical activity for adults aged 80+ years, living with frailty or disability. The present study, however, cannot discern the degree to which the HCAs own values and views on physical activity in general impacted their perceptions in the study. The practical risk of inducing pain or injury while administering the programme was noted, though interestingly, falls risk was not specifically mentioned, in contrast to findings in acute-based settings ^{356,357}.

The original study did not set out to specifically investigate the impact of the COVID-19 pandemic on the intervention. Given that the study crossed the timeline of the pandemic, the impact of delivering care in a crisis was evident throughout interviews. There was consistent reporting of high levels of physical decline among the older adults, fear and isolation and challenges in delivering home support. These findings mirror the national and international evidence on COVID-19 ^{362,363}. The pandemic generated heightened interest in the potential role of using technology (smartphones, tablets, videocalls) in supporting older populations ¹⁹⁷. Our findings suggest that technology readiness was the exception in this older cohort. Notably, the HCAs viewed the older adults and their own ability to use technology as poor. This could be attributed in part, to the high prevalence of cognitive impairment and possibly vision or hearing impairments in this age group ^{197,364}. The HCA views may be a confounder, and input from the older adults or their family members would be required to give further context.

The present study suggests that promoting physical activity among older adults through formal home support services is feasible, but implementation would require changes in the home support structure and the workforce (**Table 6.1**). Barriers identified include limited

time and the task-orientated nature of home support, reflecting ongoing challenges within HCA workforce trajectories. It is unclear how practical this approach would be at scale, given the current challenges in the provision of home support including staff shortages, retention of personnel, inadequate employment conditions, varying levels of training, and structural differences between voluntary and private providers ^{365,366}. HCAs play a critical role in enabling older adults to remain ageing in place and engaging in additional training and skill development, in line with recommendations from public consultations on home support ^{365,366}, should be met with increased recognition of this contribution. Ideally, future work would examine the feasibility of including informal caregivers in structured physical activity training, of which there were an estimated 500,000 people providing unpaid care in Ireland ³⁶⁷. While the present approach was led by a Senior Physiotherapist, further consideration should be given to different and more flexible models of delivery, overseen by other health and social care professionals. For example, Primary Care Occupational Therapists (OTs) assist older adults to re-engage in functional movement and promote independence in ADLs at home, in line with the overarching aim of the current approach. Additionally, potential models could be further explored beyond physical activity components.

There is growing evidence of reablement, reactivation, rehabilitation, and restorative (4R) interventions within home care services however, many are short-term initiatives and delivered by interdisciplinary teams, while few have examined the experience of HCAs delivering these approaches ³⁵². A recent systematic review of physical activity programs for older people within home care services highlighted a need for further research around factors that influence adherence and effectiveness ¹⁶⁰. Evidence to support such initiatives is strong, the benefits of physical activity in ageing are consistent, physical activity is the treatment ‘prescription’ for muscle loss (sarcopenia) and current guidelines recommend physical activity for older people, including people with disability and frailty ^{267,346}. The initiative is in line with policies nationally and internationally to support ageing in place, and with the desire of older people to live at home in their community. The current estimated 23.9 million care hours delivered annually in Ireland offers opportunities to move to more personalised supports, including promoting physical activity ³³⁹. This is timely in Ireland, as the Department of Health is currently developing a statutory scheme for the financing and regulation of home support services ³⁶⁸.

This study has several strengths and limitations. To the best of the authors’ knowledge this is the first study to examine the experience of HCAs embedding physical activity within home support services in Ireland. The physical activity programme was designed to

encourage older adults to 'move more', rather than as a structured exercise program. Results from the feasibility study suggest it was acceptable and feasible for home support clients and staff, but requires personalisation and a more tailored approach ²¹⁴. The HCAs interviewed in this study represented an experienced workforce in the care of older people. Limitations must be noted, the use of close-ended interview questions may have impacted the ability to explore related ideas and provide appropriate depth however, the interview guide was developed based on previous research ³⁵⁵. As a feasibility study and compounded by COVID-19, the sample size was relatively small, interviews with HCAs were conducted by phone rather than face to face, and perceptions may be unintentionally influenced by the broader challenges in delivering community-care at the time. Additionally, the feasibility study excluded older adults with moderate to severe cognitive impairment, limiting the generalisability of the findings. Nonetheless, consistent with previous studies, our findings suggest embedding physical activity initiatives within home support services is feasible but challenges remain ^{160,355}.

In summary, the present study examined the experience of HCAs delivering a home-based physical activity program. The findings suggest that embedding physical activity initiatives within home support services is feasible. Overall, there was a positive perception of the programmes 'fit' within home support services and perceived value and benefit of physical activity for older adults. Restructuring of services, review of time needs, engaging HCAs, and moving beyond traditional 'task orientated' care models to more personalised proactive approaches may facilitate this initiative and support ageing in place.

Chapter 7 - General Discussion

7.1 Summary of Findings

The World Health Organization (WHO), through the Sustainable Development Goals (SDGs), outlines a commitment to ‘ensure healthy lives and promote well-being for all at all ages’ (SDG 3) ³⁶⁹, recognising the importance of maintaining good health throughout the life course. A growing body of evidence shows socioeconomic disadvantage is associated with shorter life expectancies and a greater proportion of life spent in poor health ^{7,370,371}. Indeed, accumulating evidence suggests older adults with disadvantaged socioeconomic position (SEP) experience ‘accelerated ageing’ in the domains of physical and cognitive health ^{9,372}. While evidence is emerging, there is a paucity of research examining health inequalities across markers of physical function that are amenable to change by intervention ³⁷³. In the context of a global ageing population ³⁷⁴, developing an evidence-base that may inform strategies which support ageing in place and tackle the social determinants of health remains an urgent priority.

This thesis sought to explore socioeconomic determinants of physical function in community-dwelling older adults, with implications for ageing in place. While several markers of physical function are explored in this thesis, initial studies largely focussed on probable sarcopenia, a precursor of the muscle condition sarcopenia and a predictor of impaired physical function ³⁷. Firstly, we aimed to identify socioeconomic determinants of probable sarcopenia, in two cross-sectional studies of large nationally representative population datasets in Ireland (Chapter 3) and England (Chapter 4). This thesis further explored whether associations between SEP and adverse health outcomes persist in populations of older age with increased physical dependency; this was achieved through analysis of an Irish health administrative dataset, comprised of a large population of community-dwelling older adults (mean age 84 years) receiving ADL support through formal home care (Chapter 5A). Further aims within a small sample of this population group explored a prospective descriptive study examining the practicality of conducting in-home assessments of physical function, including sarcopenia and frailty, in addition to markers of SEP (Chapter 5B). Finally, the thesis sought to address potential strategies to maintain physical function and support ageing in place; to this end a qualitative study of barriers and enablers to embedding an in-home physical activity intervention for community dwelling older people supported by home care services was conducted (Chapter 6). Overall, across the body of work, in populations of contrasting older age, a greater burden of probable sarcopenia or other markers of impaired physical function was observed in older adults with greater socioeconomic disadvantage.

Chapters 3 and 4 aimed to examine socioeconomic determinants of probable sarcopenia, in two large populations of community-dwelling older adults in Ireland and England. This was achieved through analysis of community-dwelling older adult aged 60 years and older in The Irish Longitudinal Study on Ageing (TILDA) and the English Longitudinal Study of Ageing (ELSA). In both studies, probable sarcopenia was defined by the recently published European Working Group on Sarcopenia in Older People 2 (EWGSOP2) guidelines, and deemed present if low hand grip strength or poor chair rise test was detected. In TILDA, probable sarcopenia was defined by hand grip strength alone, however both EWGSOP2-recommended markers were available in ELSA ³⁷. Collectively the studies suggested a higher prevalence of probable sarcopenia in older adults with disadvantaged SEP, defined by educational attainment (TILDA and ELSA) or subjective social status (ELSA). Importantly, in both population cohorts, the association between probable sarcopenia and disadvantaged SEP persisted, when controlled for other known risk factors of sarcopenia.

In TILDA (Chapter 3, n= 3342), 23% of participants met the criteria for probable sarcopenia, significantly higher in older adults with the most vs least disadvantaged SEP, when defined by educational attainment (29% vs 18%). Similarly, in ELSA (Chapter 4, n= 6052), probable sarcopenia was identified in 34% of participants, significantly higher in older adults with disadvantaged SEP defined by educational attainment (47% vs 21%) and subjective social status (53% vs 25%), respectively. Collectively, findings from two robust datasets, analysed in this thesis, involving over 9000 older people, suggest that socioeconomic disadvantage is associated with an increased likelihood of probable sarcopenia. While this is consistent with considerable evidence highlighting the impact of SEP on health in later life ^{9,372}, it is the first reporting of socioeconomic disparities for probable sarcopenia, to our knowledge. Therefore, there are few studies to directly compare the prevalence of probable sarcopenia based on socioeconomic position.

Our overall figures are higher, for example, than the prevalence of probable sarcopenia reported in participants of the 1946 British Birth Cohort, wherein a prevalence of low hand grip strength (7%) and poor chair rise test performance (15%) was reported however, all participants were aged 69 years and, therefore, the findings are not directly comparable with our study populations ⁸⁰. In a population of Greek community-dwelling older adults of similar mean age (71 years), a 25% prevalence of probable sarcopenia, defined by low hand grip strength, was detected ⁸⁵. Findings from ELSA, add to a limited body of research identifying probable sarcopenia using both EWGSOP2-recommended markers ^{80,81,83}. The findings are in line with previous studies reporting higher rates of poor chair rise test

performance and a low degree of intersectionality between both markers ⁸⁰, highlighting the value and importance of including both criteria, where feasible.

Chapters 3 and 4 represent the first studies with the primary aim of exploring socioeconomic determinants of probable sarcopenia, to our knowledge. We identified associations between disadvantaged SEP, defined by educational attainment, and an increased likelihood of probable sarcopenia in community-dwelling older adults in Ireland and England. Furthermore, subjective social status (SSS) was identified as a determinant of probable sarcopenia in English community-dwelling older adults. In contrast to the findings, Dodds et al, in analyses of the 1946 British Birth Cohort ⁸⁰, found no associations between SEP, defined by occupational class, and probable sarcopenia when adjusted for known risk factors, however, occupation class was recorded at age 53 only, with previous studies, utilising life course occupational trajectories, reporting associations with lower hand grip strength in later life ^{87,375}. Other studies report similar findings, in 2020 Brennan-Olsen et al found disadvantaged SEP, defined by educational attainment and occupation class, was associated with low hand grip strength at 6-year follow-up in Australian older adults ⁸⁷. Our findings show associations between SEP and probable sarcopenia persisted, irrespective of the mode of assessment used to identify low muscle strength, whether by low hand grip strength or poor chair rise test performance, or how SEP was defined. The findings add to emerging evidence highlighting a need to develop appropriate and accessible sarcopenia treatments and interventions for older adult populations with disadvantaged SEP ⁸⁷.

The findings suggest that probable sarcopenia can readily be measured in large populations with simple, cost-effective approaches. Some researchers, however, have questioned whether the introduction of probable sarcopenia may represent an opportunity for early intervention or overdiagnosis ³⁷⁶. Haase et al, argue that the risk of sarcopenia overdiagnosis may outweigh any intended benefit, arguing that the prescription treatment does not differ from general health guidelines, specifically physical activity recommendations ^{346,376}. Yet, research shows sarcopenia is underdiagnosed in clinical practice ³²², leading to increased difficulty in prescribing targeted interventions, with tailored resistance exercise guidelines recently introduced ³¹⁴. Moreover, findings from the SPRINTT study, a multicentre randomised controlled trial, reported a multicomponent physical activity and dietary intervention prevented mobility disability and improved muscle strength in older adults with sarcopenia and physical frailty ¹⁵⁶. The introduction of EWGSOP2 guidelines aimed to alleviate challenges in identifying sarcopenia in routine clinical and community-based settings, and recommend prioritising individuals with

probable sarcopenia in tailored interventions and further muscle assessment³⁷. Sayer and Cruz-Jentoft, in a recent editorial on the future consensus of sarcopenia research, suggest muscle strength, rather than mass, will play a primary role in the development of a future global definition³⁷³, as part of the Global Leadership Initiative in Sarcopenia³⁷⁷.

Given that the identification of probable sarcopenia warrants the initiation of targeted interventions³⁷, our findings may inform healthcare policy and resource allocation aiming to prevent or treat sarcopenia in community-dwelling older adults. Chapters 3 and 4 identify associations between older age, physical inactivity, comorbidity, osteoarthritis and receipt of home support with an increased likelihood of probable sarcopenia, in line with previous findings^{37,79,80,82}. Moreover, the findings suggest a need to prioritise older adults with disadvantaged SEP, defined by educational attainment or SSS, in the design and delivery of tailored interventions aiming to maintain or improve muscle strength, such as physical activity initiatives⁶⁷. The detection of low muscle strength below the thresholds recommended by EWGSOP2³⁷, applied in the present thesis, show associations with adverse health outcomes^{75–77}, and should not be considered a natural phenomenon of ageing. There is a need to identify population groups at higher risk of impaired physical function, including individuals with probable sarcopenia, that may inform the delivery and delivery of appropriate treatment and intervention strategies. While TILDA and ELSA provide important evidence of the need for timely intervention, participants represented a relatively younger cohort of older adults, with less known about whether associations between disadvantaged SEP and physical function persist in populations of older age with dependency in ADLs. Therefore, we aimed to explore physical function, using an area-level socioeconomic indicator, using a health administrative dataset comprised of an older adult population mostly aged 80 years and older (70%).

It is suggested that routine health data will play an important role in progressing sarcopenia research in the decades ahead³⁷³. Although not designed for research purposes, routine health administrative data often encompass large populations³⁷⁸, and capture groups characterised as underserved in traditional health research such as older adults with advanced age, physical dependency or socioeconomic disadvantage¹⁶⁷. Of note, disadvantaged SEP and greater physical disability predicted non-participation in the centre-based health assessment component of TILDA²⁴³. In Chapter 5A, we aimed to examine whether socioeconomic disparities in adverse health outcomes persist in populations with older age and physical dependency. We analysed routine health administrative data, comprised of 1591 community-dwelling older adults with mean age 84

years, including 1,114 people aged 80 years and older (70%), with increased dependency in ADLs as indicated by the receipt of formal home support. This population may be considered underrepresented in health research due to the proportion with advanced age, with a high degree of frailty (42%) and cognitive impairment (43%) previously reported ^{287,320}.

We identified community-dwelling older adults with ADL dependency living in areas with high socioeconomic deprivation experienced greater polypharmacy and high physical dependency and were more likely to be referred for home support following an acute hospitalisation, when compared to affluent settings. Importantly, patterns of a 6.5 year earlier need for state-funded home support in the most disadvantaged areas were noted. Limitations associated with the use of routine administrative data include the narrow scope of health and socioeconomic information, with no data related to sarcopenia available and Barthel Index representing the only measure of physical function routinely collected in this setting. While further research is required, administrative data is valuable and has the potential to be supplemented with simple practical measures of physical function, including markers of sarcopenia, in addition to SEP indicators that capture individual-level socioeconomic conditions. The findings may have implications, suggesting a need to prioritise older adults with disadvantaged SEP in designing and delivering interventions, irrespective of older age and physical dependency.

The findings provide evidence of health inequality for variables related to physical function in populations of older age with ADL-dependency. While age-as-a-leveiler theories have previously been proposed ³⁷⁹, suggesting that health disparities plateau as age-related decline begins to outweigh the influence of socioeconomic factors, findings from the Newcastle 85+ study provide evidence to the contrary ³⁷². Kingston et al, in analysis of the Newcastle 85+ study cohort, report steeper trajectories of decline in a range of functional abilities, including ADLS and IADLs, in adults with disadvantaged SEP ³⁷². Based on administrative data, the findings support cumulative disadvantage theory, which posits socioeconomic disadvantage accumulates over the life course resulting in amplified health disparities in later life ¹²⁴. The use of administrative data has inherent limitations, however, given the absence of electronic health records and limited primary care data in Ireland, the findings may have implications for community-based supports aiming to enable ageing in place for older adults in Ireland.

In Chapter 5A, we identified associations between SEP and physical function in a study population of mean age 84 years and supported by home care. Although comprised of a

large group of older adults (n= 1591) the routine data lacked comprehensive health and socioeconomic information. In contrast to longitudinal datasets such as ELSA and TILDA, utilised in this thesis, which had a comprehensive suite of variables. In Chapter 5B, we conducted exploratory fieldwork which aimed to explore the practicality of collecting more comprehensive measures of physical function, including in-home assessment completion rates, in addition to individual-level and aggregate-level SEP indicators in a small sample of the population group described in Chapter 5A (n= 31). Additionally, we explored the motivations and preferences for future research engagement in this study group. Although the sample size was low, as recruitment was impeded by public health protection measures related to the Covid-19 pandemic, the findings suggest a majority of this study group met the criteria for probable sarcopenia (94%) and frailty (74%) and over a quarter had disadvantaged SEP based on educational attainment (26%). The low sample size, however, limited any analysis of health outcomes based on SEP and should form part of future work.

The in-home study design represented a complex research environment, with considerable unmet needs unearthed. Over a third of participants had one or more referrals made by the research team to health and social care services, in addition to assistance with everyday issues, including technology support. Despite the described challenges, the findings suggest it is practical to complete in-home research with this study group, with high completion rates in assessment tools for sarcopenia, frailty and malnutrition observed. The findings add to consistent evidence identifying older adults receiving formal home care as at high risk of adverse health outcomes, including frailty, malnutrition and low muscle strength ^{38,311,317,320}. Notably, a high proportion of respondents reported low physical activity levels, including a mean number of 11 daytime hours spent sitting, relevant to the design and implementation of intervention and prevention strategies for these potentially reversible conditions in community-based supports ^{47,313}.

The thesis findings show a higher burden of markers of impaired physical function in older adults with disadvantaged SEP, whether defined by educational attainment, subjective social status or residential area deprivation. The delivery of tailored physical activity programmes represents one intervention however, few studies have explored embedding approaches within formal care services ¹⁶⁰. In Chapter 6, we explored the barriers and enablers to embedding physical activity within formal home support services for community-dwelling older adults with mean age 83 years and a high degree of frailty (89%). Of note, a recent systematic review of physical activity programmes delivered to

home care recipients, identified a need for future studies to explore factors that may influence the effectiveness and delivery of interventions within this population group ¹⁶⁰.

Chapter 6 included qualitative interviews with Health Care Assistants (HCAs), trained in the delivery of a physical activity programme, who encouraged older adults to do more 'movement', including self-care, strength and balance activities ³⁵³. Overall, the findings suggest that embedding physical activity initiatives within home support services is feasible however, several barriers were noted including limited time and the task-orientated nature of home support service delivery. While the findings were generally positive, it is unclear how practical this approach would be to implement at scale. Currently, there are several challenges within home support service delivery, including staff shortages, retention of personnel, inadequate employment conditions, varying levels of training, and structural differences between voluntary and private providers ^{365,366}. While the previously described feasibility study reported small to medium effect sizes in quality of life, physical function, balance confidence and self-efficacy ²¹⁴, findings from this thesis work suggest a one-dimensional approach to the design of interventions aiming to support ageing in place for community-dwelling older adults may not be sufficient. In line with previous research ¹⁶⁰, positive and negative perceptions of the value of physical activity for older frail older adults were identified among HCAs, suggesting a need for awareness raising around the benefits of physical activity in frail older people.

The thesis findings suggest an opportunity to develop tailored interventions for community-dwelling older adults that take socioeconomic disadvantage into account. The findings show a significantly higher burden of probable sarcopenia in older adults with disadvantaged SEP. This should be considered in the design and delivery of effective interventions, as individuals with disadvantaged SEP report significant barriers to engaging in health research, including physical activity programmes ³⁸⁰. The findings show associations between socioeconomic disadvantage and markers of impaired physical function persisted in a population of older age and increased physical dependency, however this analysis was limited by the limited scope of available variables. We explored the practicality of collecting more comprehensive markers of physical function and SEP in a small sub-group of this population which unearthed significant unmet need and provided key learnings for future research. The findings have implications for conducting research in populations of older age with physical dependency and highlight a need for larger studies in this group.

Further research with ADL-dependant community-dwelling older adults is integral to the development of a robust evidence-base, however, it is critical that research outputs translate into improvements in health and social care delivery for study populations. In 2021, an estimated 23.9 million hours of government-funded home support services were delivered to over 55,000 older adults aged 65 years and older in Ireland ³³⁹. Despite accumulating evidence suggesting high levels of frailty and impaired physical function among older adults in receipt of formal home support ^{38,287,320,381}, few studies to date have examined embedding interventions within community-based supports ¹⁶⁰. In the recently published resistance exercise guidelines for sarcopenia treatment, Hurst et al argue in favour of implementing mandatory sarcopenia screening within aged-care services ³¹⁴. Yet, the delivery of targeted interventions, namely physical activity programmes, within community-based aged-care services has not achieved the same consensus. Most ageing research to date has focussed on delivering single-component interventions to relatively healthy older adult populations, with an emphasis on disease-based conceptualisations of healthy ageing ³⁸². There is a need to move beyond this, exploring multimodal approaches to support physical function in underserved populations, including older adults with advanced age, physical dependency and socioeconomic disadvantage.

7.2 Potential Public Health Implications

The thesis findings demonstrate that probable sarcopenia is prevalent in community-dwelling older adults aged 60 years and older in Ireland (23%) and England (34%), with a significantly higher burden observed among older adults with socioeconomic disadvantage. Similarly, in a population of older age (mean age 84 years) with ADL-dependency, supported by formal home care, we observed that individuals living in socioeconomically disadvantaged areas observed greater polypharmacy, high physical dependency and recent acute hospitalisation. Collectively, the studies suggest that socioeconomic disadvantage influences health in later life, in both younger-old and older-old populations. The detection of probable sarcopenia represents a point to intervene ³⁷, and the prescription treatment is resistance exercise and nutritional support ^{67,314}. Individuals with disadvantaged SEP, however, face significant barriers to engaging in physical activity including, cost, competing time demands and a lack of awareness of supports ³⁸⁰. While physical activity represents one potential strategy to support healthy ageing, the thesis findings in populations of older adults in receipt of home support suggest a unidimensional approach will not be sufficient. In-home research with a small sample of older adults unearthed significant unmet needs, which were actioned by the research team. While more extensive studies are required, initial findings in this small study

population suggested a majority met the criteria for probable sarcopenia, frailty and physical inactivity. The findings suggest a need to develop tailored multimodal approaches to support ageing in place for older adults with disadvantaged SEP.

The findings begin to build a picture of older adults utilising formal home support services, an important consideration in the ongoing development of a Statutory Home Support Scheme in Ireland ³⁸³. Additionally, the findings may assist the ongoing national implementation of the Single Assessment Tool (SAT) ²¹², specifically home care assessments, suggesting the collection of individual-level and area-level socioeconomic information may represent practical additions. This is relevant to the SAT which aims to “identify older people at risk of decline/ acute hospital admissions and poor health outcomes” ²¹². The findings of the thesis work add to a growing body of evidence suggesting older adults with socioeconomic disadvantage and physical dependency, including a need for home care, may be at high risk of physical functional decline, including probable sarcopenia ^{9,38,372}. The findings may have implications for health and social care planning and resourcing in areas with high socioeconomic disadvantage in Ireland.

While we identified adverse health outcomes among older adults with disadvantaged SEP, it was not possible to examine the in-home study group based on socioeconomic profile. Additionally, just 13% of older adults participating in the home-based physical activity programme resided in socioeconomically disadvantaged areas. Further research is required to explore acceptable interventions for older adults with disadvantaged SEP. A recent multicomponent intervention study with socioeconomically disadvantaged older adults with frailty in Korea provides an example of potential approaches to prevent sarcopenia, frailty and malnutrition in the community ³⁸⁴. Jang et al, delivered a multimodal intervention comprised of physical activity, nutritional counselling, medication management, social support, and home hazard reduction through a multidisciplinary team for 24 weeks ³⁸⁴. At 6 month follow-up, older adults in receipt of the intervention showed significant improvements in SPPB, sarcopenia, frailty and malnutrition risk, which were sustained at 12-months ³⁸⁴. The study utilised local public health workers and engaged town representatives, highlighting the need for participatory approaches to intervention design ³⁸⁴. The findings suggest one potential approach to supporting ageing in place in socioeconomically disadvantaged older adults.

Ireland's population is ageing, with a 19% increase in the number of individuals aged 65 years and older between 2011-2016 ³⁸⁵. By 2031, it is predicted that the number of people aged 65 years and older will reach one million ³⁸⁶. While this increased longevity is a

success of our times, the societal challenge is to preserve independence, disability-free years, and quality of life in older populations. There is a paucity of literature examining the delivery of programmes which support healthy ageing in populations with older age and increased physical dependency. While the Care to Move programme, detailed in this thesis, represents a one-dimensional approach to the delivery of supports to older adults at high risk of functional decline, it provides a useful starting point in the development of more targeted interventions. Several barriers to the delivery of the programme were noted and in the absence of system-wide change, future interventions delivered by HCAs in the community may likely face similar challenges. There is a need to explore multimodal approaches to support physical function in underserved populations, including older adults with advanced age, physical dependency and socioeconomic disadvantage.

7.3 Strengths and Limitations

Strengths of this body of work include the analysis of two robust large representative studies of ageing in Ireland and England, the use of a large administrative dataset to include groups who may be underserved in research, in addition to prospective exploratory fieldwork with a small sample of this group, and the delivery of a physical activity programme within community-based care services in Ireland. This thesis adapted to the public health guidelines issued in response to the Covid-19 pandemic, which impacted the size and depth of research conducted in-home with ADL-dependant older adults. Despite the low sample size, the preliminary work provided valuable real-world practical research insights. The inclusion of qualitative work exploring the delivery of an in-home physical activity programme, added unique insight into these study populations. We also aimed to capture the experience of older adults participating in home-based research through post-study feedback questionnaires, providing important guidance for future studies.

A number of limitations should be noted. While we aimed to apply consistent measures of SEP across studies, individual-level socioeconomic information was not available in routine health administrative data, wherein an area-level SEP indicator was used. Secondly, this thesis applied the recently published EWGSOP2 guidelines for probable sarcopenia and did not explore confirmed sarcopenia using measures of muscle mass. Ideally, similar markers of physical function would have been analysed across studies however, the availability of data impeded this. In response to a lack of information on sarcopenia in routine administrative data, we explored collecting more comprehensive measures of physical function through in-home research. Although we conducted post-study feedback surveys with older adult participants, there is limited capturing of the perspective of people living with disadvantaged SEP, in terms of their wants and needs

around potential interventions. Future work should explore this through in-home qualitative research with this group, who expressed a willingness to engage in research.

Finally, the in-home research study and the delivery of a physical activity programme within formal care services, excluded older adults with moderate to severe cognitive impairment. Previous findings, derived from administrative data, estimate a 43% prevalence of cognitive impairment among older adults in receipt of formal home support and therefore, our findings may not be representative of this population group ²⁸⁷. This thesis aimed to explore socioeconomic determinants of physical function in community-dwelling older adults; however, we conducted cross-sectional analyses of large population datasets and do not show cause and effect, with only associations between disadvantaged SEP and adverse health outcomes inferred.

7.4 Conclusion and Future Directions

The thesis findings demonstrate that the prevalence of probable sarcopenia is significantly higher in community-dwelling older adults aged 60 years and older with socioeconomic disadvantage in Ireland and England. Analysis of routine health administrative data suggests health disparities in markers of physical function persist in populations of advanced age and increased physical dependency. Conducting in-home research with ADL-dependant community-dwelling older adults and the delivery of a physical activity programme in the home was deemed feasible, with implications for future research with this group.

Further research is required, including longitudinal analysis of the association between socioeconomic disadvantage and probable sarcopenia in later life. Future research should actively aim to engage populations currently underserved in traditional health research, including older adults with advanced age, physical dependency and socioeconomic disadvantage. There is a need for larger studies examining the practicality of conducting in-home research with such groups, which may inform the development of future randomised controlled trials for socioeconomically disadvantaged older adult populations. There is a need to explore the needs and wants of older adults with disadvantaged SEP, in terms of potential interventions for physical function. The effectiveness of multicomponent interventions aiming to prevent or delay functional decline in community-dwelling older adult populations with ADL-dependency remains largely unknown. Future work should examine approaches that are most likely to improve quality of life and support ageing in place.

Biography

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Appendices

Appendix 1. Ethical approval



Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin

Ollscoil Átha Cliath | The University of Dublin

Ms. Lauren Swan,
Department of Clinical Medicine,
Trinity Centre for Health Science,
St James' Hospital Campus for Health Science,
James Street,
Dublin 8

19th October 2021

Ref: 210909

Title of Study: Sarcopenia and associated risk factors among community-dwelling dependent older adults.

Dear Lauren,

Further to a meeting of the Faculty of Health Sciences Ethics Committee held in September 2021. We are pleased to inform you that the above project has ethical approval to proceed.

This study has been ethically approved. We would advise you to seek review and comments on your DPIA from the DPO if required prior to study commencement'

As a researcher you must ensure that you comply with other relevant regulations, including DATA PROTECTION and HEALTH AND SAFETY.

Yours sincerely,

A handwritten signature in dark ink, reading 'Jacintha O'Sullivan'.

Prof. Jacintha O'Sullivan
Chairperson
Faculty Research Ethics Committee

Dámh na nEolaíochtaí Sláinte
Foirgneamh na Ceimice,
Coláiste na Tríonóide,
Ollscoil Átha Cliath,
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North Dublin
HOME CARE

**COMPANY CERTIFICATE OF
ATTENDANCE**

This is to certify that

Lauren Swan

**Has attended their
Company Manual Handling & Patient
Moving and Handling Training**

**Venue: North Dublin Home Care
2 Malahide Road, D03 A6Y0**

Training Instructor: 
Lisa Murphy

Issue Date: 23rd March 2022

Appendix 3. Study Protocol

Title: Sarcopenia and associated risk factors among community-dwelling older adults with ADL-dependency – An In-home Exploratory Study.

Protocol Version: 1

Date: 31/11/2021

Research Team Members:

Ms. Lauren Swan PhD Candidate, Department of Clinical Medicine, Trinity Centre for Health Sciences, St. James' Hospital, Dublin 8, Ireland	Prof. Maria O'Sullivan, PhD, Associate Professor in Human Nutrition, Department of Clinical Medicine, Trinity Centre for Health Sciences, St. James' Hospital, Dublin 8, Ireland
Dr Austin Warters, PhD, Manager of Services for Older People, Older Person Services CHO9, Health Services Executive (HSE), Dublin, Ireland	Ms. Niamh Martin Clinical Nurse Manager, Older Person Services CHO9, Health Services Executive (HSE), Dublin, Ireland

Funding Sponsors: North Dublin Home Care PhD Stipend

Current Study Site: North Dublin Home Care, Dublin, Ireland

1. Introduction

Sarcopenia is a muscle condition characterised by the accelerated loss of muscle strength and mass. This condition is a major public health issue as associated with functional impairment, frailty, disability, hospitalisation, and mortality amongst older adult populations. This programme of research aims to examine markers of sarcopenia, frailty and malnutrition in dependant community-dwelling older adults, often considered underrepresented in traditional health research. This includes older adults with increased physical dependency (e.g. supported at home by HSE formal home-support), aged 80+ years and living in residential areas with socioeconomic disadvantage. Although we have previously estimated the prevalence of probable sarcopenia of 23% and 34% among Irish and English populations (mean age 68.9 and 70.9 years, respectively), evidence shows that adults with increased functional dependency and socioeconomic disadvantage are less likely to engage in research studies.

In this study, we propose to use practical tools to examine 'probable sarcopenia', defined by low muscle strength measures and apply a short five item questionnaire (SARC-F) case finding tool. These assessments are recommended by the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) guidelines and are considered practical for a homecare setting. An estimated 53,000 older adults receive government-funded home support services in Ireland, little is known about this group and research to date has utilised administrative data. Our previous work has characterised this group as of advanced age (mean age 83.9), a relatively high degree of frailty and physical dependency, with the latter commonly observed in areas with socioeconomic disadvantage. This study will provide insight on the practicality of collecting routine clinical measurements (grip strength/ chair rise test), Clinical Frailty Scale (CFS) and Mini Nutritional Assessment-Short Form through in-home research. The study's findings will inform future intervention studies aimed at preserving muscle strength and independence in this group

2. Study Aims

1. To examine markers of sarcopenia, frailty, and malnutrition through in-home assessments with community-dwelling dependant older adults
2. To explore the practicality of conducting in-home assessments, including assessment completion rates, challenges, and participant recommendations for future research

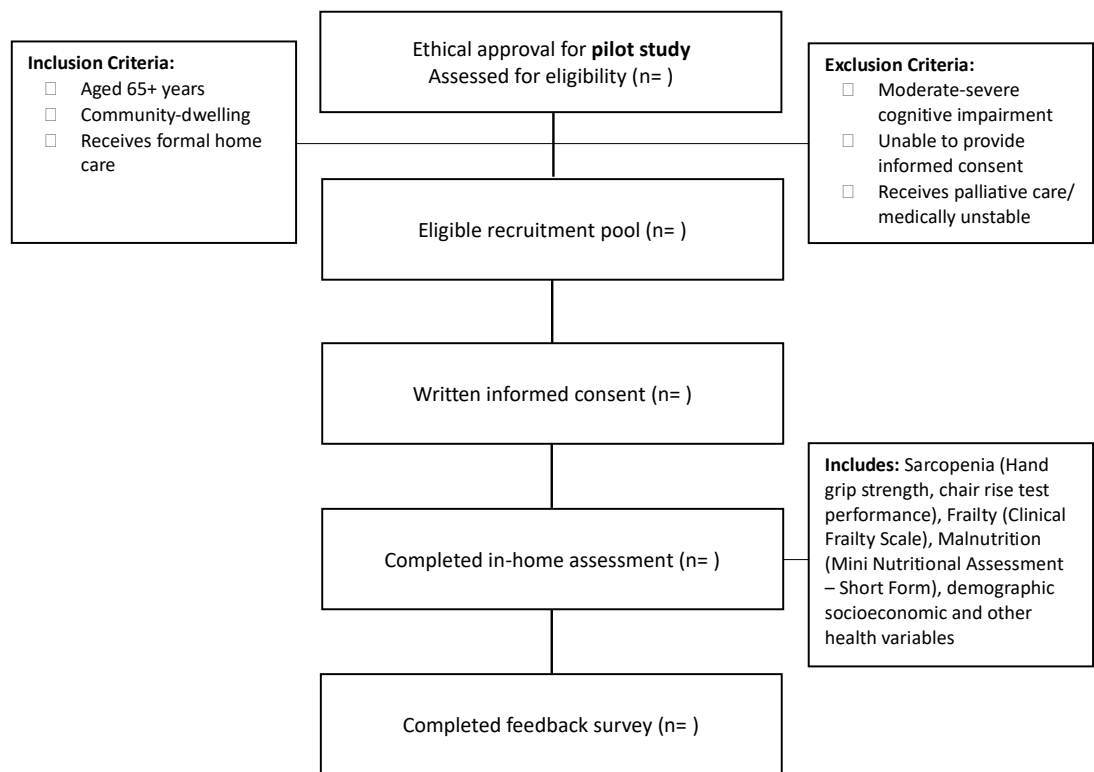
3. General Study Design

3.1 Study Design

This pilot study will complete in-home assessments of sarcopenia, frailty and malnutrition with community-dwelling dependant older adults in receipt of formal home care services in Ireland. Participants will be recruited, using convenience sampling, from a non-profit home care organisation in Dublin. Older adults will be invited to take part in the study based the following criteria: aged 65 years and older, living in the community, and in receipt of state-funded home care services (**Figure 1**). Participants will be excluded if they have moderate to severe cognitive impairment, are unable to provide informed consent, in receipt of palliative care or are medically unstable. The study gatekeeper, a home care supervisor based in the host home care organisation, will screen active service users based on the inclusion and exclusion criteria to form an eligible recruitment pool.

The gatekeeper will post study information flyers (Appendix 4) to service users in the eligible recruitment pool. Participation will be self-selecting, with service users instructed to call the study gatekeeper if interested in participating in the study. The study gatekeeper will inform the research team of an expression of interest. Researcher LS will call the interested participant to explain the study in full and answer any questions. Upon agreement, prospective participants will be receive a Participant Information Leaflet (Appendix 5) and consent forms (Appendix 6), with pre-paid postage envelopes included addressed to the study gatekeeper. Following the receipt of a completed consent form, participants will receive a call from LS to arrange a time to commence the research visit. At the beginning of the visit LS will describe the components of the research visit and ask for confirmation to proceed, in cases where

participants no longer wish to participate the research visit will cease. Following the completion of the in-home research visit, participants will be contacted by the study gatekeeper to complete a post-study feedback survey by telephone.



Study Design Schematic

3.2 Sample Size

This pilot study aims to examine the practicality of conducting in-home assessments of sarcopenia, frailty and malnutrition with dependant community-dwelling older adults. No formal power calculations were performed given the study intends to recruit all eligible participants from a single-site, a large non-profit home care organisation in Ireland. Recent estimates describe the number of older adults receiving formal care in Ireland as 53,000. Based on this figure, a 90% confidence interval and 10% margin of error, an ideal sample size of n= 68 will be required for generalisability of the findings.

4. Participant Withdrawal from Study

4.1 When and how to withdraw subjects

Participants will be informed in the PIL and at the beginning of the research visit of their right to withdraw from the study at any time without consequence. Participants will be provided with the contact details of the research team and asked to contact Researcher LS or the study gatekeeper if they decide to voluntarily withdraw from the study. If a participant decides to withdraw, the data related to this participant will be deleted in its entirety from the study. A confirmation letter confirming the deletion of data will be sent to the participant by the study gatekeeper upon completion.

5. Study Assessments

5.1 Physical Performance Measurements

Hand grip strength will be measured using a Jamar Plus+ Digital Hand Dynamometer (IL, USA) and standardised using the procedure described by Roberts et al ¹⁸¹:

1. Participants are screened for recent injury, pain or discomfort in hands or arms and excluded from the hand grip test if reported
2. The assessor describes the hand grip strength and demonstrates how to correctly hold the dynamometer
3. The dynamometer is set to the second handle position, unless this setting is too wide for the participant, in which the first handle position is used
4. The assessor receives confirmation from the participant to continue. Participants unable to complete the test, for example due to inability to understand the instructions or inability to hold the dynamometer (pain/ arthritis), will have the reason for non-completion noted in the participant assessment pack
5. Participants are asked to sit upright in a chair with their forearms supported by armrests and instructed to sit with their hips and knees at a 90-degree angle
6. The assessor places the dynamometer in the testing forearm, starting with the dominant hand, with the base supported by the assessor to control for gravitational effects
7. Participants are asked to squeeze the dynamometer using maximum effort for approximately 3 seconds
8. Three measurements per forearm are performed with 30 seconds of rest between trials

9. Readings displayed in kilograms on the digital analogue are noted in the participant assessment pack
10. The maximum hand grip strength value will be used in analyses
11. Any complications, pain or discomfort resulting from the hand grip strength test will be recorded as adverse events, with details noted in an adverse event form and issues responded to by the Research Clinical Nurse Manager

Chair rise test performance will be measured as the time taken to complete 5 chair rises using the Newcastle protocol proposed by Dodds et al for home-based assessments with older adults:

1. Participants are screened for recent pain or injury in legs, those requiring the use of a wheelchair or mobility aids to stand or rise from a chair are excluded. The reason for test non-completion is noted in the participant assessment pack
2. Participants are asked to sit upright in a firm straight-backed chair, with their feet placed flat on the floor and arms crossed diagonally across chest
3. The assessor asks participants if they feel safe to stand up from a chair without the use of arms
4. Following agreement, the participant completes a single chair rise with the assessor and research nurse standing on both sides of the chair in case of unsteadiness
5. Participants are asked to return to the starting test position, and asked by the assessor if they feel safe to complete the same procedure five times as quickly as possible while being timed
6. Following agreement, the participant begins the test, with each complete sit to stand counted aloud by the assessor. The stopwatch is stopped when the participant stands straight for the fifth time
7. If the participant appears tired, breathless, or if the assessor is concerned for the participants safety, the test is stopped and the reason for non-completion is noted
8. The time taken to complete five chair rises is noted in the participant assessment pack
9. If the participant was unable to complete a single or multiple chair rise, the reason was recorded

10. Any complications, pain or discomfort resulting from the chair rise test will be recorded as adverse events, with details noted in an adverse event form and issues responded to by the Research Clinical Nurse Manager

6. Participant Safety & Adverse Events (AE)

6.1 Adverse Event (AE)

An adverse events is defined as an untoward medical occurrence, unintended disease, injury or clinical symptoms in research participants, whether or not related to the research study. In this study, the risk of adverse events was deemed low given this is not an interventional study however, there is a risk of pain or discomfort resulting from the completion of physical performance tests. For example, the Jamar dynamometer has been shown to cause stress to weak joints and in some cases, results in mild discomfort or pain. Additionally, there is a risk of falls associated with the completion of the chair rise test in frail older adults. In the case of an Adverse Event, the participant will be examined by the research nurse, with all details described and recorded on the appropriate Adverse Event form.

6.2 Recording an Adverse Event

Participants will be provided with contact details of the research team in addition to the study gatekeeper and asked to report any subsequent events that might be related to participation in the study. Post-study feedback surveys will be completed with participants by the study gatekeeper, wherein the study gatekeeper will seek information on Adverse Events by questioning.

Following notification of an Adverse Event, this will be followed up by the Research Nurse until the event(s) are resolved. Details of the Adverse Event will be recorded in the Adverse Event form and the participant's GP will be notified, if appropriate. If during an assessment a participant indicates that they are experiencing harm, upset or distress this will be referred to Dr Austin Warters, who as a Commissioner of Older Person Services and former qualified social worker, will immediately respond. Contact details for CNM Niamh Martin are included on the PIL. Additionally, Clinical Nurse Manager Niamh Martin, who will attend home-based assessments, will liaise with

appropriate the multidisciplinary professional(s) as needed should any health or social issues arise.

7. Data Protection

7.1 Data Protection & Handling

A Data Protection Impact Assessment (DPIA) was carried out which deemed a low level risk. Digital personal data, including participant contact details and health assessment data will be stored on an encrypted Trinity College Dublin-approved device. Other personal data, including participant consent forms, will be stored in a locked cabinet with access restricted to research team members Lauren Swan and Maria O’Sullivan.

The research team has a log in place to record who accesses, changes, discloses or erases the data. The data will be stored in a password protected excel database, on One Drive in a Trinity College Dublin approved device which has end to end encryption. Participant names will be given a unique identifier before input electronically. Access will be restricted to TCD internal research team members Lauren Swan and Maria O’Sullivan. All research team members have up to date GDPR training.

7.2 Confidentiality

Precautions will be taken to protect the confidentiality of research participants. Prior to the receipt of a signed consent form, prospective participants will be assigned a unique identifier code which will be documented on hard copies of the assessment material. Following the completion of each home-based assessment, all remaining identifiers such as date of birth or address of residence will be anonymised by Lauren Swan. Date of birth will be replaced with single year of age. Address of residence will be replaced with a deprivation quintile, with each address coded each using the HP Pobal Deprivation Index. The keycode for individuals who will participate in the home-based assessment will be retained by researchers Lauren Swan and Maria O’Sullivan and stored in a password protected database. This will be deleted when recruitment has ceased and data has been input electronically into the anonymised dataset.

7.3 Document Retention

In line with best practice recommendations, any documents containing personal non-anonymised data will be stored for 7 years from the date of study completion. Hard copies of health assessment data will be retained for a maximum of one year or until the data has been input electronically. If a participant decides to withdraw from the study, all of the data relating to this participant will be deleted in its entirety from the study.

8. Study Monitoring, Auditing, and Inspecting

8.1 Study Monitoring, Auditing, and Inspection Plan

The Principal Investigator (PI), Prof. Maria O’Sullivan, will allocate adequate time to reviewing the health assessment data collected, ensuring that data entry is timely and examining the accuracy of data input through cross-checking with hard copy material.

9. Ethical Considerations

This study will only commence following the receipt of ethical approval from Trinity College Dublin’s Faculty of Health Science Ethics committee. This study will be conducted in accordance with the Declaration of Helsinki 2008. All of the study material, including the participant flyers, participant information leaflets and consent forms will be approved by the ethics committee. Written informed consent will be provided by all participants prior to study commencement. A study gatekeeper has been designated within the host home care organisation. Participants of the prospective assessments will be accessed through their home care provider, but the data they provide will be accessible by the research team only. No information that participants provide during the course of the study will have any impact on their engagement with their home support provider.

10. Study Finances

10.1 PhD Stipend

This research will be funded in part, by North Dublin Home Care, a non- profit organisation in Ireland (Registered Charity Number: 20076245).

10.2 Conflict of Interest

North Dublin Home Care provides a PhD funding bursary for researcher LS only, and does not have a role in the study design, collection, analysis or interpretation of results.

10.3 Participant Financial Incentives

None

Appendix 4. Study Recruitment Flyer (Page 1)



Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin



Study Information Flyer:

Study Title: Sarcopenia (low muscle strength) and associated risk factors among community-dwelling older adults



We would like to invite you to take part in a research study which will involve an assessment of your muscle strength and overall health status.

Why is this study being done?

This study is being carried out to learn more about the health status and needs of home support users so that services can be improved going forward. This study is being carried out by researchers from Trinity College Dublin (Researcher Lauren Swan and Associate Professor Maria O'Sullivan) and the HSE (Dr. Austin Warters and Clinical Nurse Manager Niamh Martin), with support from North Dublin Home Care. Participation in the study is completely voluntary and a decision to take part or not, will not affect your home support or care.

Appendix 4. Study Recruitment Flyer (Page 2)

What will I have to do?

Taking part in this study will involve a visit from a researcher who will measure your hand grip strength, this test is very similar to squeezing an object in your hand. We will ask about your health and what activities you may find easy or difficult. If you agree to take part in this study, you will receive a visit from researcher Lauren Swan and Clinical Nurse Manager Niamh Martin who will carry out a routine health assessment. This visit will last around 1 hour.



What happens to the information I provide?

The information you provide will be stored under a Code ID, not under your name or any contact details. Only the research team will be able to link your name to the information you provide during the study. You are free to skip any part of the assessment that you do not want to participate in, and you can withdraw from the study at any time.

If you would like more information or if you are interested in taking part, please contact:

Sinead Collins, North Dublin Home Care

Telephone: 01 554 9060

Email: sinead.collins@ndhc.ie

Appendix 5. Participant Information Leaflet (PIL)



Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Participant Information Leaflet

Name of Study: Sarcopenia and associated risk factors among community-dwelling older adults with ADL-dependency

Site	
Principal Investigator(s) and Co-Investigator(s) (insert names, titles and contact details)	Associate Professor Maria O’Sullivan E: maria.osullivan@tcd.ie Ms. Lauren Swan E: swanla@tcd.ie Tel: +353 857 824 606 Dr. Austin Warters PhD E: austin.warters@hse.ie T: +353 1 846 7176 Ms. Niamh Martin, CNM2 E: niamhr.martin@hse.ie T: +353871140669
Study Organiser/ Sponsor (if applicable)	North Dublin Home Care
Data Controllers	Trinity College Dublin Ballymun Healthcare Facility, HSE
Data Protection Officer	Data Protection Officer Secretary’s Office Trinity College Dublin Dublin 2 Data Protection Officer of HSE: Jim O’Sullivan Room 102 Phoenix Hall St. Mary’s Campus D20 CK33

Introduction:

We would like to invite you to take part in a research study that is being conducted by Trinity College Dublin (Associate Professor Maria O'Sullivan and Researcher Ms. Lauren Swan) and the Health Services Executive (Dr. Austin Warters PhD and Clinical Nurse Manager Niamh Martin). The purpose of this study is to examine probable sarcopenia and the health factors associated with muscle strength and function in community-dwelling older adults in Ireland who are in receipt of formal home support services.

Before you decide whether or not you wish to take part, please read this information sheet carefully. Please ask Researcher Lauren Swan any questions using the contact details on the previous page of this document. Don't feel rushed or under pressure to make a quick decision. You should understand the risks and benefits of taking part in this study so that you can make a decision that is right for you.

This leaflet has four main parts:

- Part 1 – The Study
- Part 2 – Data Protection
- Part 3 – Costs, Funding and Approval
- Part 4 – Further Information

Part 1 – The Study

Why is this study being done?

The purpose of this study is to examine probable sarcopenia and the health factors associated with muscle strength and function in community-dwelling older adults in Ireland who are in receipt of formal home support services. While it is normal for everyone to lose some muscle strength with age, sarcopenia is a condition which can accelerate the loss of muscle strength leading to a decrease in independence or not being able to complete the tasks you usually do. To identify if someone is at a higher risk of developing sarcopenia, we can measure a person's hand grip strength and the time taken to stand up from a seated position five times. As part of this study, we will ask you to take part in routine assessments such as measuring your hand grip strength, chair rise test performance and answer health-based questionnaires. It is hoped that the findings from this study will guide future service improvements and health policies on how to best support older adults to remain living well at home.

Why have I been invited to take part?

You have been invited to take part in this study as you are aged 65 years and older and are currently in receipt of HSE-funded home support services.

Do I have to take part? Can I withdraw?

- Participation in this study is completely voluntary and if you decide not to participate it will have no adverse consequences
- You are free to withdraw from the study at any time, even if the study has started. You are also free to withdraw your data at the conclusion of your participation should you wish to do so. You do not have to provide a reason for not taking part in the study or opting out of the study.
- If you decide to withdraw from the study, please contact Lauren Swan at 0857824606 or swanla@tcd.ie. Receipt of any request for withdrawal will result in your data being deleted in its entirety from the

What will happen to me if I decide to take part?

If you agree to participate in the study, you will be asked to sign a consent form (copy attached). After we receive your completed consent form, a researcher (Lauren Swan) will contact you by telephone to arrange a home-based assessment at a time that is convenient for you. The researcher (Lauren Swan) and a Clinical Nurse Manager (Niamh Martin) will be present for the home-based assessment. We expect this home-based assessment to last around 60 minutes.

What will happen to the information I provide?

All of the information you provide will be treated in the strictest confidence. You will be assigned a study code, and the information you provide will be stored under this ID code, not under your name or any contact details. The assessment material including questionnaires will be stored securely in locked cabinets in the office of Associate Professor Maria O'Sullivan in the Department of Clinical Medicine, Trinity College, Dublin, which only the research team will have access to. Any data stored on you in digital format will be stored on a secure Trinity College approved device and server which is encrypted appropriately. Any identifying information you may provide during the assessment will be removed in order to protect your confidentiality. You are free to decline or to provide some or all of the information requested at any time during the session without needing to provide a reason for doing so. Any identifying information we collect during this study will never be made available to anyone other than the members of the research team.

Are there any benefits to taking part in this research?

Taking part in this study will not directly benefit you. However, the information provided by participating in the health assessment will help us to better understand how to improve existing services aimed at supporting older adults to remain living well at home.

Are there any risks to me or others if I take part?

Since this study aims to gather information on your muscle strength and function there is a small risk that this may cause discomfort for some participants. Before we ask you to complete a hand-grip or chair-rise test, we will demonstrate what is involved and only proceed if you feel safe to do so. We will remind you at every stage of the study that you are under no obligation to answer any questions that you do not feel comfortable with and we can cease the assessment at any time. If any issues arise post-assessment, we ask that you contact Clinical Nurse Manager Niamh who can respond immediately to any concerns (Telephone: 01 846 7123 or Email: Niamh.martin@hse.ie).

Will I be told the outcome of the study?

If you wish to be debriefed on the study's findings you can contact Researcher Lauren Swan or Sinead Collins in North Dublin Home Care. The findings of this study will be shared at local and national conferences. A manuscript will be submitted to a relevant journal and will be publicly available. Data will be analysed as a group so no information which reveals your identity will be disclosed. Contact details of the research team will be provided if you have any further questions prior to or following the assessment.

Part 2 – Data Protection

What information about me (personal data) will be used as part of this study? Will my medical records be accessed?

As part of this study, some of your personal data will be collected. This will include your name, date of birth and address. All of this data will be anonymised by the research team.

What will happen to my personal data?

All of your data will be stored securely under a unique study ID code. Only the research team will be able to link your name to the information you provide during the study. The file linking your name to your study ID will be kept separately from your data, in a secure location (Trinity College Dublin). Details linking your name to your data will never be released. All personal data that you may provide will be deleted after 7 years.

We will analyse the information provided by all research participants to examine the health status of home support recipient. We will aim to publish the findings of the study in a scientific journal, which will be made available to all participants when it is complete. The information we publish will be presented as a group.

Who will access and use my personal data as part of this study?

Researcher Lauren Swan (Department of Clinical Medicine, Trinity College Dublin), Associate Professor Maria O’Sullivan (Department of Clinical Medicine, Trinity College Dublin), Dr Austin Warters (Health Services Executive) and Ms Niamh Martin (Clinical Nurse Manager, HSE) form the research team and will therefore, have access to your data as part of the study.

We aim to analyse the data collected in group form and publish the findings in a scientific journal.

Will my personal data be kept confidential? How will my data be kept safe?

Your privacy is important to us. We take many steps to make sure that we protect your confidentiality and keep your data safe.

- Each member of the research team has completed relevant training in data protection.
- A data protection impact assessment was carried out that indicated a low level of risk.
- The information you provide will be stored in digital form on a Trinity College Dublin encrypted device in a password protected file. Hard copies will be stored in a locked filing cabinet in a secure location (Dep. Clinical Medicine, Trinity

College Dublin). The personal data you provide will not leave the study site (Dep. Clinical Medicine, TCD)

What is the lawful basis to use my personal data?

We will use the information you provide (personal data) for scientific research¹ that is in the public interest². We will also ask for your explicit consent to use your data as a requirement of the Irish Health Research Regulations.

What are my rights?

Under the GDPR, you are entitled to:

- The right to access to your data and receive a copy of it
- The right to restrict or object to processing of your data
- The right to object to any further processing of the information we hold about you (except where it is de-identified)
- The right to have inaccurate information about you corrected or deleted
- The right to request deletion of your data

unless the request would make it impossible or very difficult to conduct the research (for example if the data has already been pooled for analysis prior to publication).

You can exercise these rights by contacting the study researcher Lauren Swan on +353 857 824 606 or at swanla@tcd.ie or the Trinity College Data Protection Officer, Secretary's Office, Trinity College Dublin, Dublin 2, Ireland. Email: dataprotection@tcd.ie.

Website: www.tcd.ie/privacy.

¹ Article 9(2) (j))

² (Article 6(1)(e))

Part 3 – Costs, Funding and Approval

Has this study been approved by a research ethics committee?

Yes, this study has been approved by Trinity College Dublin's Faculty Research Ethics Committee (FREC/210909).

Who is organising and funding this study? Will the results be used for commercial purposes?

This study is partially funded by North Dublin Home Care, a HSE-funded non-profit home support organisation. All procedures relating to the study design, data analysis and conclusions reported will be independent of this funding source. North Dublin Home Care provide a PhD bursary for researcher Lauren Swan and the findings of this study will be used towards this researcher's academic qualification. The results of this study will not be used for commercial purposes.

Is there any payment for taking part? Will it cost me anything if I agree to take part?

No, we are not paying participants who take part in the study.

Part 4 – Further Information

Who should I contact for information or complaints?

If you have any concerns or questions, you can contact:

- Sinead Collins, North Dublin Home Care, Dublin 3. Email: sinead.collins@ndhc.ie
Telephone: 01 554 9060
- Data Protection Officer, Trinity College Dublin: Data Protection Officer,
Secretary's Office, Trinity College Dublin, Dublin 2, Ireland. Email:
dataprotection@tcd.ie. Website: www.tcd.ie/privacy.

Under GDPR, if you are not satisfied with how your data is being processed, you have the right to lodge a complaint with the Office of the Data Protection Commission, 21 Fitzwilliam Square South, Dublin 2, Ireland. Website: www.dataprotection.ie.

Will I be contacted again?

If you would like to take part in this study, you will be asked to sign the Consent Form on the next page. You will be given a copy of this information leaflet and the signed Consent Form to keep. If you decide to take part in the study and return the consent form attached, you will be contacted by researcher Lauren Swan by phone to arrange a home-based visit at a time that is convenient to you.

Appendix 6. Participant Consent Forms



Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

STUDY NAME:

Sarcopenia and associated risk factors among community-dwelling dependent older adults

Identification Number for study:

Consent Form

There are 9 statements in this form. Each statement asks you to initial if you agree. The end of this form is for the researchers to complete.

Please ask any questions you may have when reading each of the statements if there is something you do not understand.

Thank you for participating.

General Understanding	Initial box
I confirm I have read and understood the Information Leaflet for the above study. The information has been fully explained to me and I have been able to ask questions, all of which have been answered to my satisfaction.	
I understand that this study is entirely voluntary, and I do not have to take part . I understand that deciding not to take part will not affect my future medical care	

I understand that information provided by me during the assessment will be examined by the research team. I understand that all information will be kept private and confidential and that my name will not be disclosed. I understand that this information will be stored for no longer 7 years and then deleted	
I understand that there are no direct benefits to me from participating in this study.	
I understand that I will not be paid for taking part in this study.	
I know how to contact the research team if I need to.	
Consent	Initial box
I agree to take part in this research study having been fully informed of the risks, benefits and alternatives which are set out in full in the information leaflet which I have been provided with.	
I agree to being contacted by researchers by phone as part of this research study, and I agree to a home-visit by researcher Lauren Swan and Clinical Nurse Manager Niamh Martin as part of this study	
I agree that the information I provide to the research team (personal data) can be used for this research study.	

Participant Name (Block Capitals) Signature Date

Witness Name (Block Capitals) Signature Date

Appendix 7. Ethical Approval HCA Qualitative Interviews (Chapter 6)

Royal College of Surgeons in Ireland
The Research Ethics Committee
121 St. Stephens Green, Dublin 2, Ireland.
Tel: +353 1 4022205 Email: recadmin@rcsi.ie

Dr David Smith, Acting Chair
Dr Niamh Clarke, Convenor

5th June 2018

Prof Frances Horgan,
RCSI School of Physiotherapy,
123 St. Stephens Green,
Dublin 2



Ethics Reference No:	REC1489
Project Title:	Enhancing existing formal home support to improve and maintain Functional Status and physical activity in older adults: A feasibility study on the implementation of the Care to Move (CTM) programme
Researchers Name (lead applicant & PI):	Prof Frances Horgan (RCSI School of Physiotherapy)
Other Individuals Involved:	Dr Austin Waters, Ms Barbara Rooney and Ms Vanda Cummins (Physiotherapy Department, Ballymun Primary Care Center).

Dear Prof Horgan,
Thank you for your Research Ethics Committee (REC) application. We are pleased to advise that ethical approval has been granted by the committee for this study.

This letter provides approval for data collection for the time requested in your application and for an additional 6 months. This is to allow for any unexpected delays in proceeding with data collection. Therefore this research ethics approval will expire on 5th December 2020.

Where data collection is necessary beyond this point, approval for an extension must be sought from the Research Ethics Committee.

This ethical approval is given on the understanding that:

- All personnel listed in the approved application have read, understand and are thoroughly familiar with all aspects of the study.
- Any significant change which occurs in connection with this study and/or which may alter its ethical consideration must be reported immediately to the REC, and an ethical amendment submitted where appropriate.
- A final report will be submitted to the REC upon completion of the project.

Please liaise with the relevant Data protection Officer before commencing this study, with a view to ensuring compliance with any institutional data protection policies. A new data protection regulation will take effect on the 25th May 2018.

We wish you all the best with your research.

Yours sincerely,

PP Dr Niamh Clarke (Convenor)
Dr David Smith (Acting Chair)

Appendix 8. HCA Qualitative Interview Guide (Chapter 6)

Interview Guide

Thank you very much for taking this call. I wanted to talk to you about your experience with Care To Move (CTM), the pros, the cons and where we are now with CTM and the COVID-19 pandemic. Is it ok if I record our call - if YES, Turn on Dictaphone and confirm start. Note start time.

1. Tell me about your experience with the Care to Move training? Could anything be improved to make it easier?
2. How did you find delivering Care to Move with your clients?
3. Did you feel confident delivering Care to Move? And *why*?
4. How was the time taken to deliver Care to Move to your clients?
5. Tell me about your experience filling out the Care to Move paperwork?
6. Could anything be improved to make it easier for HCAs to deliver Care to Move?
7. What did your clients think of the Care to Move program?
8. Did you enjoy delivering Care to Move with your clients? And *why*?
9. Has the COVID-19 pandemic affected your clients? How does their general health/ physical activity levels compare to pre-COVID-19?
10. On a scale of 1-10, with 0 not confident and 10 confident, how are your clients at using technology? Do they currently use any form of technology?
11. How are you at using technology? Have you used Zoom or other video-chat software?
12. In your view, do you think Care to Move should be part of induction training for staff? *Why*?
13. Would you encourage your colleagues who have not done Care to Move training to do it? *Why*?
14. Would it help if there was a supervisor designated to Care to Move within your organization?
15. Are there any aspects of Care to Move that you think we should change to help home care workers or community care clients in the future? *What are they*?
16. Why do you think we are trialling the Care to Move programme with home support clients?
17. Did you enjoy being part of this research project? And *why*?
18. Is there anything else you would like to mention about Care to Move/ research study?

Thank you. Turn off Dictaphone and note finish time.

Appendix 9: Chapter 5B: Exploratory Study Feedback Survey Questions

Study ID: _____

Introduction: Thank you very much for taking this call. I wanted to talk to you about your experience in taking part in the recent research study in your home, what you might have enjoyed about taking part and what you would change. I would also like to ask you about how you think we could encourage more older people to take part in research. As you know all calls to this line are recorded, is it ok if we use this recording for research purposes, to capture the feedback you give throughout this call? If yes, confirm and note start time.

1. Why did you decide to take part in the research study?
(What made you decide to take part? Was there a particular reason or did anything motivate you to take part?)
2. Was there anything that worried or concerned you about taking part in the study?
3. How did you find taking part in the study at home?
 - Were there any parts that you found difficult or did not like?
 - Were there any parts you liked, found easy or thought worked well?
 - Is there anything you would change or recommend that the research team do differently for future research studies?
4. What do you think would encourage more older people to take part in research studies like this one? Do you have any suggestions?
5. We sent you a leaflet in the post to tell you about the study, how do you feel about being contacted in this way? How would you prefer to be contacted about research (potential prompt: post, telephone, email, or social media)
6. Would you like to be contacted about future research studies?

Thank you. Note finish time.
