

Table 1: Distribution of main codes (n=139)

Code	Frequency	(%)
Development cycle		
Requirements and Context	50	(36.0%)
Design and Development	31	(22.3%)
Non-clinical Evaluation	42	(30.2%)
Clinical Evaluation	16	(11.5%)
Main stakeholder		
Adult sufferers	84	(60.4%)
Children sufferers	12	(8.6%)
Peers and Significant others	3	(2.2%)
Caregivers	4	(2.9%)
Clinical staff	5	(3.6%)
Researchers	31	(22.3%)
User journey		
Prevention	4	(2.9%)
Diagnosis and Triage	29	(20.9%)
Treatment/intervention	37	(26.6%)
Self management and maintenance	32	(23.0%)
No specific stage	37	(26.6%)
Outcome		
Clinical	18	(12.9%)
Proximal	27	(19.4%)
Adherence	8	(5.8%)
Other	18	(12.9%)
No outcome measured	68	(48.9%)
Primary system function		
Diagnosis	33	(23.7%)
Self-tracking	28	(20.1%)
Biofeedback	12	(8.6%)
Structured psychological interventions	13	(9.4%)
Social support	14	(10.1%)
Mindfulness	9	(6.5%)
Other	30	(21.6%)
Ethical principles		
Autonomy	25	(18.0%)
Nonmaleficence	18	(12.9%)
Beneficence	3	(2.2%)
Justice	2	(1.4%)
No mention of ethics	91	(65.5%)

a transistor — or 3) the terms are used in "general sense", as the name of the metrics or a short-term mood.

One coder downloaded the full text of each paper in the initial corpus (2775), and interpreted the text against the relevance criteria, yielding 139 relevant papers and 2636 irrelevant papers. We then followed a two-step process. First, the 139 papers considered relevant were divided into 5 groups of 2 coders (10 independent coders in total) for deductive coding,

using the manual described below (see Table 1 for code distribution). Secondly, following the initial coding, each set of papers within a code was subsequently inductively analyzed by the same coding teams in order to extract commonalities and differences, e.g. papers marked as clinical evaluations were analyzed for common themes and compared to papers who report non-clinical evaluations.

Development cycle. **Requirements and context** refers to studies aimed at informing design work, **design and development** presents novel designs but lack validation. When there is validation, some work performed **non-clinical evaluation**, i.e. typical user studies, whereas **clinical evaluation** studies involve people with mental health difficulties and typically in a clinical setting.

Main stakeholder. We distinguished between two types of primary target user: **adult** or **children and adolescents**. Some work was aimed at **significant others** or **peers** of sufferers, whereas some research was aimed at **caregivers** or **clinical staff** dealing with sufferers. Finally, papers aimed at informing future research were marked for **researchers**.

User Journey. We constructed a simple taxonomy for steps, based on health care models [121]. Systems can be used for **prevention, diagnosis and triage, treatment/intervention** or **self management and maintenance**.

Outcome. Outcomes of systems can be measured through **clinically** validated tools, although the use of a clinically validated tool does not mean that a clinical trial procedure was followed. Outcomes could also be measured through **proximal** indexes (e.g. sleep) impacting mental health, or through **adherence**, which measures engagement with a particular system or following through a particular therapy.

Primary system function. As for characterizing the main function of the systems, some were aimed at automatic **diagnosis**, whereas others aimed at intervening in sufferers' lives, either by supporting **self-tracking, biofeedback** training, implementing **structured psychological interventions**, e.g. computerized cognitive behavior therapy tools, encouraging **mindfulness** or promoting **social support**.

Ethical principles. We applied a coding scheme of four principles informed by healthcare ethics [18]: **autonomy**, capturing the respect for the decision making ability of autonomous persons through supporting information, its understanding and consent; **non-maleficence** or the explicit intention of not causing harm; **beneficence** focusing not only on preventing harm but also on providing benefits and on balancing benefits against risks and costs; and **justice** which captures fair distribution of benefits, risks and costs to all people irrespectively of social class, race, gender or other forms of discrimination.

Structured Psychological Interventions. The category describes technological projects and studies built upon different interventions. The majority of the publications (8 out of 13) refer to CBT as the therapy of choice in their studies. Among those, several authors turn their attention to more specific CBT subsets – CBT for insomnia [182], computerized CBT [131] or common CBT components such as mood charting [107], as well as using context-aware CBT [12] and CBT with life coaches [144]. Other structured psychological interventions in the categories are Assessment and Commitment Therapy (ACT) [94] and Virtual Reality Exposure Therapy [29, 87], as well as generic tools, not assigning them to particular therapies [162, 176].

Nine of the articles describe the design and evaluation process of novel technological solutions [12, 31, 41, 53, 94, 107, 144, 162, 176]. These include the design of a wearable device for public speaking anxiety [31], an intervention system with biosensing, self-reporting and decision support [176], a clinical study of a CBT-based therapeutic programme for depression [53] and a coach-supported CBT platform [144]. Two papers study contextual aspects of using computerized CBT [131, 182], and three discuss design options for future systems: a smartphone-based CBT system for unipolar and bipolar disorders [12], or a system for treatment of social phobias [29] and anxiety disorders [87]. We note that CBT is constantly being developed and specialized for different settings, making it an active and important research area. However, other well established and emerging therapies (ACT, DBT, Interpersonal therapy) have received relatively less attention from the community and could hold promise for future designs.

Mindfulness. Mindfulness can be defined [181] as acceptance of the moment through non-judgment. In this category, five papers are novel designs [14, 133, 146, 154, 168], two are studies of previously developed applications [137, 153] and two present studies for understanding how to better design mindfulness in general, outside of therapeutic settings [80, 181].

Research engaging more seriously with therapeutic settings proposes mindfulness as a complement to different therapies. Thieme et al. [153, 154] talk about how to design for a clinical setting for mental health patients (women in a secure unit). The focus is on a method to innovate outside traditional healthcare practices, with a focus on complex mental health conditions. Here, mindfulness appears within a context of issues such as acceptance and distress tolerance, through teaching the person to accept the things they cannot change. Seo et al. [146] developed a system aimed at promoting calmness and a feeling of being at ease through touching and interacting with plants. It was tested in children with autism and older adults living in a senior home. Although mindfulness was not a very prominent category in the papers we reviewed, we were pleased to see innovative work integrating mindfulness into the specificities of therapeutic contexts.

Social Support. Work in this category is motivated by research showing that belonging to a community of mutual obligations has mental health benefits. Specifically, interaction with family and friends can significantly contribute to positive health outcomes for people with depression [118].

A majority of the papers (10) present results of studies rather than designing or developing a novel system. They present characteristics of social support in patient-caregiver dyads [4, 19, 156, 178] and how patients look for social support via social media [50, 71, 73, 132]. Some recommend using preventative diagnostics to direct the conversation between patients or moderate their content consumption. Four papers specifically investigate cultural aspects of mental health [30, 73, 100, 178].

Four present novel systems, of which three describe the design and development of assistive social robots [98] or conveying empathy towards the patient by either "being in the same misery" [164] or emulating symptoms [97]. Wallbaum et al. [170] propose a tangible interface that allows for implicit communication between patients and their relatives to emulate social support.

Overall, we found that research on social support systems has revealed patterns in different cultural contexts while investigating social support with the help of, for example, participatory design methodology [19, 30, 98]. However, we would like to see more novel designs of systems that foster and support beneficial human interactions.

Other functions. In the 'other'-category, comprising 30 papers, nine describe novel design ideas that do not fall into the other categories above [28, 29, 57, 93, 114, 167, 171, 173, 174] – the rest (21 papers) mainly focus on providing design requirements. Out of the novel design ideas, some stick out as particularly interesting. For example, there are two systems engaging with our somatic selves. The first one, the art piece *the rest is construction*, lets participants emulate the experience of living with anxiety, exploring one particular somatic symptom: impaired motor performance (shaking, trembling, tremors) through haptics and visualizations, to enhance empathy [174]. The second paper engaging with somatics presents three haptic systems: one emulates touch therapy, the second is a vest that hugs the wearer, distributing pressure in ways that have been shown to lessen panic attacks in autistic children, and the third generates controlled pain as a form of sensory grounding for persons with tendencies towards self-harm [167].

Three papers present systems for users with autism [28, 114, 171] – none of these are addressing affective disorder as such, but rather ways of *coping*. One was developed in a participatory design process, bringing out a down-to-earth solution to panic attacks through a mobile app with a "panic button", allowing the user to get in contact with someone trusted to talk them through the situation at hand [114]. Living with affective disorders will, for many, not be a state to be cured, but rather a life-long adjustment, which is why the design space for coping-strategies is an interesting and underdeveloped area in HCI.

Ethical principles

A striking finding is that from the total of 139 papers, two thirds (91 papers) do not mention any ethical concerns or values. Such limited emphasis is disconcerting given the heightened vulnerability of people with mental ill health. One explanation is that such vulnerability is considered accounted for through the institutional ethics approval processes, but this assumption may hide specific ethical concerns relating to affective disorders or the system at hand.

Within the remaining 48 papers addressing ethical issues, more than half (25 papers) referred to the topic of autonomy, one third (18 papers) touched upon the issue of non-maleficence, i.e., not causing harm to the others, and only a few papers mentioned the ethical value of beneficence, i.e., providing benefits which are balanced benefits against risks and cost (3 papers), and justice, i.e., fair distribution of benefits, risks and costs to all people (2 papers). With respect to the value of autonomy, 14 papers focus on supporting the decision making ability of autonomous persons, 6 papers touched upon the privacy of personal data, while 5 papers acknowledged that the opinions of multiple stakeholders have been considered in the design. We now discuss the key findings for each of these ethical principles.

Autonomy. Papers addressing the ethical principle of autonomy focused on two main areas: respect for the voice of people living with affective disorders, and for their data privacy.

The majority of the 48 papers touching on ethics focused on the voice of adults living with affective disorders (26 papers), and to a lesser extent on children (5 papers). Studies engaging adults included people living with serious mental illness, their caregivers and clinicians [163], people living with depression [26] or anxiety, and their clinicians [115, 168], or people with the experience of self-harm [22]. Fewer papers have engaged with the age [112], or gender aspects [154] of mental health, while the focus on children or teenagers included autism [58, 114], or cyberbullying [7]. Participatory design methods are the dominant approach, often involving several stakeholders. Novel approaches have started to emerge, such as methodologies for transforming hackathons into safe spaces for engaging with vulnerable users throughout the entire design process [22].

Most papers addressed the value of autonomy with respect to the *privacy of sensitive data*. Such data could be extracted from one's digital footprint, or captured explicitly through self tracking technologies.

Although public, user generated data shared on social media or online forums is highly personal and sensitive, addressing mental health concerns and being shared for the main purpose of accessing social support. As several papers indicated [35, 45, 49, 124], when such data is repurposed for the different goal of academic research, the issue of volunteering consent and protecting the anonymity of people who generated the data becomes important.

Good practices addressing these issues have started to emerge, with emphasis on protecting anonymity rather than on informed consent. Two noticeable exceptions include Pater et al. [124] who contacted and asked permission from the owners of public pictures to be analyzed, and Homan et al. [74] who also used informed consent combined with a respondent-driven sampling method to protect data owners' privacy at the recruitment stage. Their study explored signs of depression in a social network designed to support LGBT youth at risk of self harming [74]. An important work is that of Manikonda and De Choudhury [104] who have developed guidelines to support the design of interventions for mental health on social media; guidelines which include seeking voluntary consent, and developing privacy and security protocols to protect people being studied throughout the entire research process, from data gathering and analysis to the development of interventions.

Good practices for protecting the anonymity of users of social media whose public content is analyzed include de-identification [35, 36, 104, 172] and paraphrasing [6] of personal data, or recreation of such data [6]. For example, De Choudhury et al. [46] applied de-identification of mothers' public expression on Twitter posts used to predict postpartum changes, De Choudhury et al. [49] paraphrased Twitter posts in their exploration of gender and cultural differences in social disclosure, while Andalibi et al. [6] paraphrased quotes and recreated Instagram images in their analysis of instagramers' experiences of depression. A similar approach was taken for the exploration of social media communities focused on mental health and suicide support such as Reddit [48], where public posts analyzed to identify individuals likely to engage in suicidal ideation, were previously de-identified and paraphrased.

Apart from data shared on social media, autonomy concerns have been also raised with regard to tracking technologies. The additional challenge of some vulnerable groups is that their autonomy could be claimed by their social support network, collectivized by healthcare services, or both [15]. For example, mobile apps for self-reporting symptoms of depression must be designed carefully due to the risks to the autonomy of individuals or groups of users such as pregnant women [15], while people living with depression raised privacy concerns regarding the uncertainty of who may be able to access their data [53]. In addition, privacy controls for tracking devices to support aging in place has been also critiqued [112] highlighting the risk of older adults' data getting shared with their social support network without fully informed consent.

Privacy concerns regarding mobile-based interventions for mental health were also raised among user groups where the sharing of mobile phones is an accepted norm, i.e., teenagers [107], or where the ownership of such devices is limited due to socio-economic status [22].

Non-maleficence. The principle of non-maleficence was targeted through: participant recruitment, diagnostic claim, and providing feedback of negative states.

