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Wearables, sensors and the future of technology to detect and infer loneliness in older adults

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Abstract

Loneliness is a growing concern affecting the health and quality of life of older adults living in the community. Addressing loneliness in ageing populations is an important policy priority. Central to this is the detection of type and severity of loneliness. Advancement in technology provides an opportunity for loneliness to be inferred through physiological and behavioural changes. In this article, we provide an overview of the current evidence on wearable and sensor technologies to detect loneliness in older adults including reviewing physiological measures of loneliness. Two recent reviews have highlighted how loneliness in older adults can be inferred using in-home sensors and smartphones. However, ethical and privacy issues remain an unaddressed issue in the development of technologies to measure loneliness in this population. Ongoing research is working to address this through the development a new multi-functional sensor which can be used in fabrics and textiles in the home to measure loneliness in people age 65 and over. We present an overview of the DEsign for healthy ageing: A smart system to decrease LONELINESS for older people (DELONELINESS) study.

Keywords: loneliness, older adults, ageing, technology, measurement

Introduction

Loneliness is a global public health issue (Cacioppo & Cacioppo, 2018). Distinct from social isolation, loneliness is a subjective feeling and can mean different things to different people. Psychometric questionnaires might assess loneliness by asking about feeling a general sense of emptiness or if a person lacks companionship (Maes et al., 2022). Certain people may resonate with a sense of separateness from others, or a loneliness felt by the presence or absence of a specific relationship (Mansfield et al., 2021). The Campaign to End Loneliness define loneliness as a "subjective, unwelcome feeling or lack or loss of companionship, which happens when there is a mismatch between the quantity and quality of the social relationships that we have, and those that we want" (Perlman & Peplau, 1981).

Whatever the definition, many older adults experience feelings of loneliness (Kitzmüller et al., 2018) notwithstanding with social and health consequences from COVID-19 related lockdowns and service closures (Popa, 2021). In 2018, Age UK noted 1.4 million older people classed themselves as often lonely (Age UK, 2018). This can lead to poorer health, both physical and mental, higher risk of mortality, and more healthcare usage (Leigh-Hunt et al., 2017). Furthermore, there are public health and societal implications of loneliness. A report from the UK's Department for Digital, Culture, Media and Sport suggests that the wellbeing, health and productivity cost of loneliness are approximately £2.5 billion per person-year (GOV.UK, 2018). Aspects such as a person's age, marital status, health and even pet ownership can combine with life events, such as retirement, moving home or death of a loved one, and lead to a person's experience of loneliness (Campaign to end loneliness, 2020).

The use of digital technologies to detect loneliness has the exciting potential to identify when support is needed and to deliver early, targeted intervention to improve quality of life for older adults. To date, researchers have used in-home sensors (including cameras) and smartphones (including GPS locations) to measure sleep quality, phone or computer use, activity levels, and time spent outside home to infer loneliness in older adults (Latikka et al., 2021). When such behavioural patterns are correlated with subjective measurement of loneliness, algorithms can be used to predict future instances of loneliness.

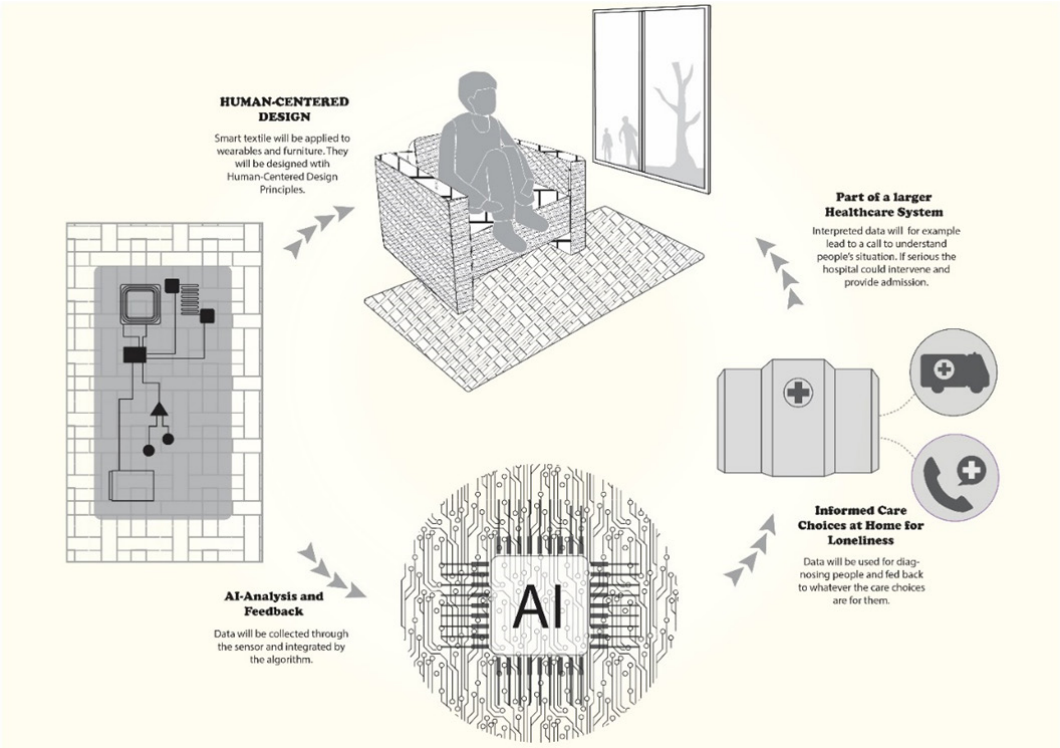

Figure 1. Conceptualisation of smart system for loneliness in older adults

With the development of such technological advances, future research is required to test predictive models of loneliness in robustly designed studies with representative samples. There are also important ethical challenges to address when developing and designing technologies to measure loneliness in older adults (Qirtas et al., 2022). Digital exclusion is one factor. Older adults can experience barriers to accessing technology through lack of experience, lack of financial means, and lack of education in the use of technologies. Furthermore, passive sensors like infrared sensors or cameras might not be acceptable to older people and may induce stress about being monitored at home.

The benefit of technologies is the ability to personalise measurement. For example, one person may pace more when feeling lonely while another may spend more time in their bedroom. The principle of machine learning highlights that anything with a 'ground truth' can be measured. Previous research has used such techniques with information from wearable sensors to detect stress (Gedam & Paul, 2021). Wearable sensors provide an opportunity for continuous, real-time data collection of heart rate, skin temperate, blood pressure and respiratory rate. These early signs and symptoms of stress can therefore be detected and correlated with relevant environmental triggers using machine learning techniques.

Future research is required to identify the signs and symptoms of loneliness which can be detected using sensor-based technologies to develop machine learning models of loneliness. To date, research has demonstrated the bi-directional relationship between consequences and risk factors of loneliness (Crewdson, 2016). Increased blood pressure and poorer sleep quality are factors consistently associated with loneliness in older adults (Cacioppo et al., 2002; Hawkley & Cacioppo, 2010) in addition to greater sedentary time and reduced consumption of fruit and vegetables (Kobayashi & Steptoe, 2018; Schrempft et al., 2019). The impact of such health compromising behaviours and increased stress (Christiansen et al., 2016) accrue over time which has significant implications for older adults experiencing loneliness and social isolation (Hawkley & Cacioppo, 2010).

A recent review of loneliness across the lifespan described physical symptoms of loneliness to include chest tightness, body aches and stiffness, changes in appetite and anxiety responses (McKenna-Plumley et al., 2023). These descriptions were identified from phenomenological qualitative studies which provide insights into the embodied experience of loneliness. For example, one study described the 'pain' created by the phenomenon of loneliness including a sense of 'hurt' and 'emptiness' which one feels 'deep inside' experienced as a 'gnawing feeling'

(Dahlberg, 2007). Another study described a sense of 'numbness' associated with such pain being found to lessen with age (Rokach, 2000). Physiological reactions to such distress included headaches, weakness, nausea, tiredness; while behavioural associations included increased sleeping and having stooped shoulders (Rokach, 1999). Only one article focused on the loneliness experiences of older adults specifically, with symptoms including pain or tightness in chest, being upset or crying to themselves, self-neglect and changes in appetite, and an increased sense of anxiety at times of increased social isolation such as evenings, weekends and winter months (McInnis & White, 2001). In the section below, we outline how current research is working towards identifying novel ways of detecting or inferring levels of loneliness in older adults.

Project outline

The DEsign for healthy ageing: a smart system to decrease LONELINESS for older people (DELONELINESS) study is being led by researchers at King's College London, the University of Sussex and the University of Leeds. The study aims to develop a smart monitoring and communication system with multifunctional electronics built into textiles used as wearables and home furniture to measure loneliness levels in older people. This will enable people to receive the right kind of support at the right time.

The first stage of the DELONELINESS study is currently ongoing. As outlined in the study protocol, up to sixty people in later life are being interviewed about their experiences of loneliness and preferences for sensor-based technology usability and engagement. Analysis will focus on which context and circumstance will a smart system for loneliness detection be most useful for people age 65 and over (Rees et al., 2023). Perspectives of older adults on preferences for technologies to detect loneliness will be incorporated into product design. For example, acceptable body positioning of wearable sensors or conditions for use of sensors integrated into furniture or clothing. Through interviewing people age 65 and over about their experiences of loneliness, we aim to develop a more detailed understanding of the signs and symptoms of loneliness in this population. We will then develop sensors to detect physiological measures of loneliness and psychosocial behaviours associated with loneliness. Finally, such data will be used to create machine learning models to predict degree of loneliness in older adults. See *Figure 1* for a visualisation of the concept of a smart system to detect loneliness in older adults.

Conclusion

In this article we have outlined the future of technologies to detect and infer loneliness in older adults. We provided an overview of the ethical issues, such as privacy concerns and digital ability, which have arisen from previous research in the area of gerontechnology. Qualitative research into the embodied experiences of loneliness provides important evidence on the physiological reactions and behavioural associations of loneliness. Future work needs to identify the signs and symptoms of loneliness in older adults. We outlined how the DELONELINESS study aims to address this gap, by developing a smart monitoring and communication system to detect levels of loneliness in older adults.

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