

REPORT

Loneliness and Health: Opportunities and Challenges of Technological Interventions

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ABSTRACT

Chronic loneliness is a significant clinical risk factor, associated with a 26% increase in dementia risk and elevated cardiovascular morbidity. Despite the proliferation of digital communication tools, many individuals experience a persistent sense of disconnection. This literature review explores the extent to which digital technologies—including AI-based platforms, social robots, virtual reality (VR) and mobile applications—can contribute to reducing loneliness, while addressing associated ethical and privacy concerns. Following PRISMA guidelines, this review synthesizes 23 peer-reviewed studies published between 2015 and 2025. Findings were grouped into three thematic areas: health impacts of loneliness, technological interventions and ethical challenges. Evidence confirms that loneliness is associated with elevated risks of depression, anxiety, cardiovascular disease and cognitive decline. Interventions such as social robots and emotionally intelligent chatbots have demonstrated potential in fostering emotional well-being, especially among older adults. Among younger populations, cognitive-behavioural approaches and peer-based digital platforms appear promising. However, the review also highlights important risks. Recent studies show that intensive emotional use of AI chatbots may increase users' feelings of isolation and emotional dependence, particularly among heavy users. Ethical concerns include algorithmic bias, lack of informed consent, and potential erosion of real-life human connection. This review concludes that while digital tools offer valuable opportunities to combat loneliness, they are not a replacement for genuine human relationships. Thoughtful design, ethical safeguards, and long-term evaluation are essential. Effective interventions require an integrated approach that pairs technological innovation with established psychosocial frameworks to ensure sustainable, human-centred solutions.

KEYWORDS

loneliness, technological interventions, digital platforms, ethical concerns, ethical safeguards, cognitive-behavioural approaches

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1 INTRODUCTION

Loneliness has become an increasingly prominent issue in contemporary society. Despite the abundance of digital communication tools, many individuals report a deep sense of social disconnection. This phenomenon is not merely emotional in nature, but it has serious consequences for our health and society in general.

The study examines the increasing social issue of loneliness which exists in contemporary society. Although social media and digital platforms provide more opportunities than ever to stay in touch, they often fall short of facilitating meaningful social connection. Research indicates that using social media—especially as a substitute for in-person relationships—can increase feelings of loneliness [1]. The state of loneliness can affect both emotional and psychological wellbeing and leads to multiple serious health problems, including depression, cardiovascular disease, and cognitive impairment, according to Valtorta et al. [24] and Cené et al. [25].

This research investigates how AI-driven platforms integrated with specialist apps and social robots create emerging digital solutions to break social boundaries that cause loneliness and solitude. The research evaluates the problem of digital intervention challenges through the examination of data protection issues and algorithmic prejudice and superficial interaction risks [6, 17]. Digital technology offers diverse opportunities for social connection. However, many applications are primarily designed to maximize user engagement and economic returns, often at the expense of fostering meaningful interpersonal relationships [1]. This has led to a paradoxical situation in which increased digital communication correlates with heightened feelings of loneliness for some users. As the boundary between artificial interaction and genuine social connection continues to blur, it becomes increasingly important to critically assess how technology is used to meet fundamental human social needs. Loneliness is not only a pressing public health concern, but also a phenomenon with broader implications for societal cohesion and the public health system [3]. Recent evidence suggests that even in younger populations, social isolation can significantly impair health literacy and overall well-being [8].

- What causes loneliness, and what are its health consequences?
- How can technology foster real, meaningful connections?
- What design strategies in digital products are helpful in ending loneliness?
- What are the primary challenges and ethical concerns of digital interventions?

The aim of this literature review is to identify evidence-based interventions that are both effective in reducing the health impact of loneliness but also ethical. To achieve this, the paper has the following main sections: First, the effects of loneliness and social isolation on health are presented; second, a review of technological interventions is presented with both positive and negative effects being considered; ethical issues are covered in a standalone chapter; and finally, the concluding discussion summarizes the main findings and offers implications for future practice.

2 METHODOLOGY

2.1 Search strategy

A systematic PubMed database search was conducted to identify peer-review articles examining loneliness's impact on health and technological interventions to treat loneliness. The search was executed in March 2025 and included literature

from 2015 to 2025. Search terms included: “loneliness”, “social isolation”, “health outcomes”, “digital interventions,” “technology,” and “mental health.” Boolean operators were used to generate all possible combinations (e.g., “loneliness” AND “digital interventions”; “social isolation” AND “technology” AND “health outcomes”). The search was restricted to peer-reviewed articles published between 2015 and 2025.

All stages of study selection—including title/abstract screening and full-text review were carried out by a single reviewer. Although a second independent reviewer was not available, efforts were made to minimize bias by strictly adhering to predefined inclusion and exclusion criteria. In cases of ambiguity, notes were taken to justify inclusion decisions based on relevance to the research questions.

Aside from PubMed, screening was also performed through research sites such as Consensus, Nature.com, and Wiley Online Library for this kind of study not indexed by PubMed. They were cross-checked against each other to eliminate duplicates and overlaps.

2.2 Eligibility criteria

The studies were eligible if they met the following criteria:

- Published in a refereed journal between 2015 and 2025
- Written in English
- Interested in loneliness with its interconnectivity with health or examined technological interventions into loneliness
- Involved human subjects
- With empirical evidence (quantitative, qualitative, or mixed methods)

Exclusion criteria were:

- Non-peer-reviewed publications, editorials, conference abstract
- There are various studies focusing solely on social isolation without mentioning loneliness
- There are few full-text articles available
- Studies with low methodological transparency

2.3 Screening process

The relevant studies were selected based on PRISMA 2020 guidelines. The database searches and screening tools yielded 552 records. The duplicates were removed, and exclusion and inclusion criteria were applied, and 55–60 full-text articles were screened, and 23 studies were included in the synthesis.

A flow chart (see Figure 1) illustrates the selection process. The following are reasons why papers were ruled out:

- Irrelevant focus (e.g., studies addressing social media use without reference to loneliness)
- Inappropriate population (i.e., animal study or study with paediatric patients with no relevance to target population)
- Methodological limitations (e.g., lack of measures of health or effectiveness of interventions)
- Non-peer-reviewed

2.4 Data extraction and analysis

- Study design (e.g., systematic review, RCT, meta-analysis)
- Sample characteristics (age group, country, population type)
- Type of intervention (e.g., chatbot, robot, VR, phone app)
- Health outcomes measured (e.g., depression, cognitive function, quality of life)
- Main findings and conclusions
- Limitations and ethical considerations

2.5 Data synthesis and analysis

The extracted data were subjected to a thematic analysis, allowing for the identification of recurring patterns across the heterogeneous study designs. The findings were clustered into three primary parts: (1) the physiological and psychological effects of loneliness, (2) the efficacy of specific technological solutions, and (3) emerging ethical or privacy concerns. Due to the significant variation in methodology and outcome measures among the included studies, a descriptive synthesis was performed rather than a formal meta-analysis.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only

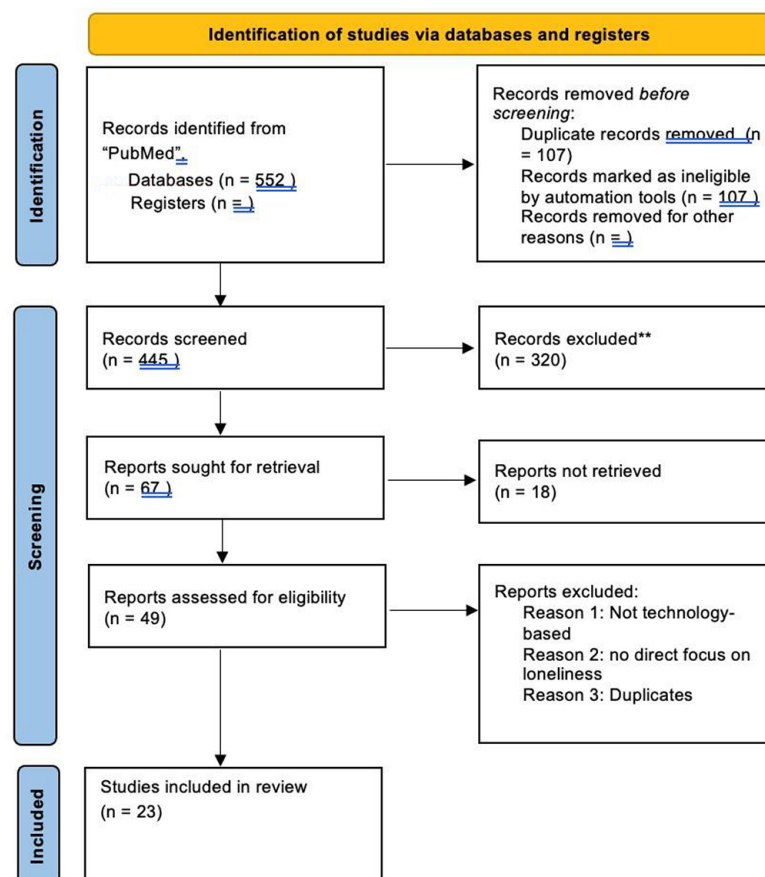


Fig. 1. PRISMA 2020 flow diagram

Figure 1 illustrates the identification, screening, and inclusion process for studies on digital interventions targeting loneliness.

3 RESULTS

This literature review included a total of 23 peer-reviewed studies, primarily from PubMed, with additional sources identified through systematic screening of relevant academic databases. The findings were synthesized and grouped into three main thematic categories:

Health outcomes of loneliness: Numerous studies confirm that loneliness is a significant biological and psychological stressor. For older populations, a large-scale meta-analysis [21] involving over 700,000 participants quantifies these risks: lonely individuals show a **26% higher risk of developing dementia** and are three times more likely to experience clinical paranoia. Beyond psychological symptoms, persistent social isolation is linked to significant alterations in brain structure and neural function [9], suggesting that loneliness acts as a catalyst for neurobiological deterioration.

The physical toll is equally distinct. Research by **Valtorta et al. (2016)**, supported by [2], indicates that social isolation significantly correlates with cardiovascular disease, specifically increasing the risk for **coronary heart disease (RR = 1.29)** and **stroke (RR = 1.32)**. These outcomes are likely driven by prolonged activation of the HPA axis, resulting in elevated cortisol levels and increased systemic inflammation [11].

The impact on younger demographics is equally severe. **Park et al.** [16] establish a direct link between chronic isolation and distinct psychiatric outcomes, such as clinical depression. Furthermore, research by **Klinner et al.** [8] indicates that loneliness significantly impairs **health literacy in young adults**, potentially hindering their ability to navigate health information and seek appropriate support during periods of isolation. This necessitates interventions that go beyond simple social contact to include cognitive-behavioural strategies [15].

Technological interventions and their impact: In recent years, a broad range of technological interventions has been explored to mitigate loneliness, particularly among vulnerable populations such as older adults and young people. These technologies include social robots, virtual reality (VR) platforms, mobile applications, and conversational agents. While initial findings suggest promising effects in promoting social connectedness and emotional support, the long-term effectiveness and broader societal implications of these interventions remain areas of ongoing investigation.

Ethical and privacy concerns: A significant portion of the literature focuses on the “double-edged sword” of digital connection. Key concerns identified include algorithmic bias, the risk of emotional over-dependence on AI, and the potential for digital tools to erode authentic human interaction.

3.1 Social robots and computer agents

Social robots have gained significant traction as tools for mitigating loneliness. A comprehensive scoping review [5] demonstrates that robots designed for emotional responsiveness provide vital companionship and cognitive stimulation for older adults. Furthermore, evidence suggests that home-based robotics can foster a renewed sense of purpose, particularly when the design aligns with cultural frameworks such as *ikigai* [18]. These findings indicate that the success of social robotics depends heavily on thoughtful, user-centric integration rather than mere functional assistance.

3.2 Mobile apps and AI-driven platforms

Beyond hardware, software-centric solutions offer a more scalable approach. The integration of large language models (LLMs) has enabled conversational agents to deliver personalized mental health support [12, 20]. A significant study on GPT-enabled chatbots among students [13] found that while users often experience higher levels of loneliness, they perceive these “Intelligent Social Agents” as multi-faceted figures—acting as friends, therapists, or intellectual mirrors. Critically, Maples et al. [13] reported that 3% of participants credited these AI interactions with halting suicidal ideation, highlighting their life-saving potential.

However, peer-based platforms such as *Helpcity* attempt to move beyond the “illusion of connection” by matching users based on shared lived experiences rather than simple algorithms. This reflects a trend toward designing interventions that emphasize empathy and sustained engagement.

3.3 Virtual reality and emotionally intelligent chatbots

Virtual reality technologies offer immersive avenues for combating isolation. Sutskova et al. [22] demonstrated that virtual companions can significantly improve feelings of social presence. Meanwhile, Westermann et al. [23] proposed plug-and-play emotion recognition systems for chatbots to improve the responsiveness of virtual companions, suggesting that emotional depth is critical for digital success.

3.4 Tailoring interventions to specific populations

The effectiveness of technological interventions often depends on how well they are tailored to the needs of different demographics. [15] emphasised that interventions for young people should incorporate cognitive-behavioural strategies and social skills training to be truly effective. In contrast, [10] found that technology-based interventions for older adults during medical pandemics improved mental health outcomes but highlighted the importance of individualized adaptation and long-term support structures.

3.5 Challenges and critical reflections

Despite the promising developments, several challenges persist. User acceptance remains a significant barrier, especially among older populations who may be less familiar with advanced technologies. Furthermore, ethical concerns related to privacy, emotional dependency and digital surveillance must be carefully addressed to ensure that technological interventions empower users without compromising their autonomy or dignity.

Taken together, these studies suggest that while technology holds substantial promise for mitigating loneliness, its success ultimately hinges on thoughtful design, ethical safeguards and a nuanced understanding of users’ emotional and social realities. These considerations set the stage for a deeper exploration of ethical implications, discussed in the following section.

3.6 Ethical and privacy concerns

As technological solutions gain momentum in the fight against loneliness, ethical considerations have come increasingly into focus. Tools such as AI-driven platforms, social robots, and digital health applications offer significant promise—but they also raise critical concerns regarding transparency, data protection, emotional autonomy, and fairness. These aspects must be accounted for from the earliest stages of design and implementation.

[6] conducted a scoping review that highlights the urgent need for ethical standards in digital mental health tools. Their research points to the potential for algorithmic bias, lack of regulatory clarity and unequal access—factors that may unintentionally reinforce social disparities. They argue that transparency and accountability must be built into every stage of the development and deployment process, especially when dealing with vulnerable populations.

Privacy is another key concern. [17] discuss how health-related technologies often collect and process sensitive personal data. They emphasize the risks of data misuse, breaches and insufficient consent mechanisms. To ensure ethical soundness, developers should establish robust data protection frameworks and always uphold the principle of informed consent.

[4] adds another dimension by reflecting on the psychological implications of technological companionship. While digital companions can offer comfort, there is a risk that users—especially older adults—may become overly reliant on them. This could lead to a false sense of connection, potentially deepening isolation rather than improving it. Findings from [14] study support this concern, showing that heavy users who frequently engage emotionally with AI-based chatbots like ChatGPT report increased feelings of loneliness and emotional dependency. Although the researchers note that such use cases are still limited to a minority of users, the potential for psychological overreliance is clear. Ethical design must therefore also consider emotional balance and the reinforcement of real-world relationships.

Finally, [19] go into the use of digital footprint data to track loneliness. While such data can offer insights into behavioural patterns, its collection raises ethical red flags. Users may not be fully aware of how their data is used or may not have the opportunity to opt out. The study underscores the need for transparent communication and strict ethical oversight in research involving digital behaviour analysis.

Altogether, these findings make it clear that ethics in loneliness-targeting technologies go beyond legal compliance. They involve a deep commitment to dignity, autonomy, and equity. As digital tools continue to evolve, a proactive and principled approach will be essential to ensure that they empower rather than exploit the people they aim to support.

4 CONCLUSIONS

The literature reviewed in this study demonstrates that loneliness is more than a short-term emotional state, but is an emerging public health concern with measurable psychological, physiological, and social consequences. While many studies highlight its correlation with negative health outcomes, they also show that digital technologies—when thoughtfully and ethically deployed—hold promise for mitigating its impact.

Technological tools such as social robots, VR platforms and conversational agents can strengthen social bonds, particularly when tailored to the emotional and cultural needs of their users. However, success depends on more than technical precision. Emotional intelligence, human-centred design and cultural sensitivity are critical to ensuring these tools do not merely simulate connection, but truly support it.

What raises concern is the increasing speed of adoption. While digital tools evolve rapidly, human emotional adaptation is slower. The recent findings from [7] suggest that emotionally intense AI interactions are no longer niche. As more people turn to AI for emotional support, the risk of overdependence—and thus deeper loneliness—grows. This mismatch between technological pace and human resilience must be addressed.

Ethical and legal considerations are equally urgent. Without transparency, data security, and safeguards for psychological autonomy, digital solutions may inadvertently reinforce exclusion or distrust. Ethical responsibility should not be reactive, but must guide design from the beginning.

Ultimately, combating loneliness requires more than innovation. It calls for a collaborative, interdisciplinary approach that connects technology with psychology, public health, and social policy. The goal should not be to replace human connection, but to empower and rebuild it. Only then can digital interventions become part of a truly sustainable solution.

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6 REFERENCES

- [1] T. Bonsaksen *et al.*, "Associations between social media use and loneliness in a cross-national population: Do motives for social media use matter?" *Health Psychology and Behavioral Medicine*, vol. 11, no. 1, p. 2158089, 2023. <https://doi.org/10.1080/21642850.2022.2158089>
- [2] E. Courtin and M. Knapp, "Social isolation, loneliness and health in old age: A scoping review," *Health & Social Care in the Community*, vol. 25, no. 3, pp. 799–812, 2017. <https://doi.org/10.1111/hsc.12311>
- [3] C. L. Crowe, L. Liu, N. Bagnarol, and L. P. Fried, "Loneliness prevention and the role of the public health system," *Perspectives in Public Health*, vol. 144, no. 1, pp. 31–38, 2024. <https://doi.org/10.1177/17579139221106579>
- [4] G. Demiris, "Social isolation and loneliness: The pros and cons of technological interventions," *Innovation in Aging*, vol. 4, no. S1, p. 714, 2020. <https://doi.org/10.1093/geroni/igaa057.2515>
- [5] N. Gasteiger, K. Loveys, M. Law, and E. Broadbent, "Friends from the future: A scoping review of research into robots and computer agents to combat loneliness in older people," *Clinical Interventions in Aging*, vol. 16, pp. 941–971, 2021. <https://doi.org/10.2147/CIA.S282709>
- [6] P. Gooding and T. Kariotis, "Ethics and law in research on algorithmic and data-driven technology in mental health care: Scoping review," *JMIR Mental Health*, vol. 8, no. 6, p. e24668, 2021. <https://doi.org/10.2196/24668>

- [7] M. Zao-Sanders, "How people are really using Gen AI in 2025," *Harvard Business Review*, 2025. <https://hbr.org/2025/04/how-people-are-really-using-gen-ai-in-2025>
- [8] S. Vasan, N. Eikelis, M. H. Lim, and E. Lambert, "Evaluating the impact of loneliness and social isolation on health literacy and health-related factors in young adults," *Frontiers in Psychology*, vol. 14, p. 996611, 2023. <https://doi.org/10.3389/fpsyg.2023.996611>
- [9] J. A. Lam *et al.*, "Neurobiology of loneliness: A systematic review," *Neuropsychopharmacology*, vol. 46, pp. 1873–1887, 2021. <https://doi.org/10.1038/s41386-021-01058-7>
- [10] M. Li *et al.*, "Psychological interventions for loneliness and social isolation among older adults during medical pandemics: A systematic review and meta-analysis," *Age and Ageing*, vol. 52, no. 6, 2023. <https://doi.org/10.1093/ageing/afad076>
- [11] M. H. Lim, J. Holt-Lunstad, and J. C. Badcock, "Loneliness: Contemporary insights into causes, correlates, and consequences," *Social Psychiatry and Psychiatric Epidemiology*, vol. 55, no. 7, pp. 789–791, 2020. <https://doi.org/10.1007/s00127-020-01891-z>
- [12] Z. Ma, Y. Mei, and Z. Su, "Understanding the benefits and challenges of using large language model-based conversational agents for mental well-being support," *arXiv preprint arXiv:2307.15810*, 2023. <https://doi.org/10.48550/arXiv.2307.15810>
- [13] B. Maples, M. Cerit, A. Vishwanath, and R. Pea, "Loneliness and suicide mitigation for students using GPT3-enabled chatbots," *npj Mental Health Research*, vol. 3, no. 1, p. 4, 2024. <https://doi.org/10.1038/s44184-023-00047-6>
- [14] J. Phang *et al.*, "Investigating affective use and emotional well-being on ChatGPT," *arXiv preprint arXiv:2504.03888*, 2025.
- [15] T. Osborn, P. Weatherburn, and R. S. French, "Interventions to address loneliness and social isolation in young people: A systematic review of the evidence on acceptability and effectiveness," *Journal of Adolescence*, vol. 93, pp. 53–79, 2021. <https://doi.org/10.1016/j.adolescence.2021.09.007>
- [16] C. Park *et al.*, "The effect of loneliness on distinct health outcomes: A comprehensive review and meta-analysis," *Psychiatry Research*, vol. 294, p. 113514, 2020. <https://doi.org/10.1016/j.psychres.2020.113514>
- [17] M. Pyrrho, L. Cambraia, and V. F. de Vasconcelos, "Privacy and health practices in the digital age," *The American Journal of Bioethics*, vol. 22, no. 7, pp. 50–59, 2022. <https://doi.org/10.1080/15265161.2022.2040648>
- [18] N. Randall *et al.*, "Understanding the connection among ikigai, well-being, and home robot acceptance in Japanese older adults: Mixed methods study," *JMIR Aging*, vol. 6, p. e45442, 2023. <https://doi.org/10.2196/45442>
- [19] D. Reedman-Flint, J. Harvey, J. Goulding, and G. Priestnall, "I wandered lonely in the cloud: A review of loneliness, social isolation and digital footprint data," in *Proceedings of the 6th International Conference on Computer-Human Interaction Research and Applications – CHIRA*, 2022, pp. 225–235. <https://doi.org/10.5220/0011578500003323>
- [20] S. G. S. Shah, D. Nogueras, H. van Woerden, and V. Kiparoglou, "Effectiveness of digital technology interventions to reduce loneliness in adults: A protocol for a systematic review and meta-analysis," *BMJ Open*, vol. 9, no. 9, p. e032455, 2019. <https://doi.org/10.1136/bmjopen-2019-032455>
- [21] M. Solmi *et al.*, "Factors associated with loneliness: An umbrella review of observational studies," *Journal of Affective Disorders*, vol. 271, pp. 131–138, 2020. <https://doi.org/10.1016/j.jad.2020.03.075>
- [22] O. Sutsikova, A. Senju, and T. J. Smith, "Cognitive impact of social virtual reality: Audience and mere presence effect of virtual companions," *Human Behavior and Emerging Technologies*, vol. 2023, p. 6677789, 2023. <https://doi.org/10.1155/2023/6677789>
- [23] N. K. Valtorta, M. Kanaan, S. Gilbody, S. Ronzi, and B. Hanratty, "Loneliness and social isolation as risk factors for coronary heart disease and stroke: Systematic review and meta-analysis of longitudinal observational studies," *Heart*, vol. 102, no. 13, pp. 1009–1016, 2016. <https://doi.org/10.1136/heartjnl-2015-308790>

- [24] L. Westermann, P. Eberle, and G. Lu, “Plug-and-play text-based emotion recognition for chatbots as virtual companions for older people,” in *WiMob 2023: 19th International Conference on Wireless and Mobile Computing, Networking and Communications*, 2023, pp. 72–77. <https://doi.org/10.1109/WiMob58348.2023.10187822>

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