

DIGITAL INNOVATIONS IN SUICIDE PREVENTION: TOWARD A PARADIGM SHIFT

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SUMMARY

Despite the implementation of various suicide prevention strategies - such as means restriction, school-based education and follow-up interventions - their overall effectiveness remains limited, particularly in early detection, continuity of care and user engagement. The rapid advancement of digital technologies presents a unique opportunity to transform suicide prevention by enabling timely, scalable and personalized interventions. This article presents a narrative review of emerging digital solutions for suicide prevention, based on a structured literature search (2015–2025) across PubMed, Medline and Google Scholar. Five main categories of tools were identified: (1) mobile applications, (2) empathic chatbots, (3) machine learning-based risk prediction models, (4) passive sensing combined with ecological momentary assessment (EMA), and (5) simulations and embodied conversational agents (ECAs). These technologies show significant promise in enhancing risk identification, user engagement and continuity of care. Among them, blended care models - integrating digital tools with clinician-delivered interventions - emerge as particularly effective, improving adherence, therapeutic alliance and clinical outcomes. However, challenges remain, including algorithm transparency, user dependency and ethical management of acute crises. This paper advocates for a paradigm shift in suicide prevention: from reactive, episodic approaches to proactive, data-driven and human-centered care pathways. Ensuring safety, equity, and clinical relevance will require co-designed development, rigorous validation and governance frameworks tailored to real-world mental health systems

Key words: digital health - suicide prevention - blended care

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INTRODUCTION

Suicide represents a major global public health concern and ranks among the leading causes of premature mortality, especially in adolescents and young adults aged 15 to 29 years. According to the World Health Organization, over 720,000 people die by suicide annually, with the highest burden affecting low- and middle-income countries, which account for more than 70% of all suicides worldwide. For every individual who dies by suicide, many more attempt it, highlighting the scale and complexity of the phenomenon (WHO Suicide Fact Sheet 2023).

Although various prevention strategies have been implemented - including the restriction of access to lethal means, school-based mental health education, gatekeeper training and structured follow-up after suicide attempts - their overall effectiveness remains limited. Key barriers include limited accessibility, delayed intervention, fragmented care and persistent social stigma (WHO 2021; Mann et al. 2021).

With the increased use of the Internet and mobile devices, digital technologies offer a unique opportunity to innovate primary, secondary and tertiary prevention of suicide. From mobile health applications and ecological momentary assessments to machine learning-based predictive models and interactive virtual agents, digital technologies are reshaping the landscape of suicide prevention, helping to fill critical gaps in detection, engagement and continuity of care. These tools may address longstanding challenges in the field such as delays in

detection, limited user engagement and fragmentation in the continuity of care (Torous et al. 2021, 2025).

This paper aims to provide an overview of current and emerging digital solutions for suicide prevention, offering both a conceptual framework and practical guidance for their implementation within real-world mental health strategies.

METHODS

This article is based on a structured literature search aimed at synthesizing current knowledge on digital tools for suicide prevention. A comprehensive search was conducted in the databases PubMed, Medline and Google Scholar, covering the period from January 2015 to March 2025. Boolean combinations of terms such as "suicide prevention", "digital mental health" and "mobile applications" were used. In addition to peer-reviewed studies, the search included position papers, policy documents and technical reports from professional organizations (e.g., EPA, WPA). Publications were selected for relevance, originality and practical applicability.

RESULTS

Digital Technologies for Suicide Prevention: An Overview

Based on the reviewed literature, digital tools that may prove promising in suicide prevention can be categorized into five main categories:

Table 1. Categories of Digital Technologies for Suicide Prevention

Category	Key Examples	Core Functions	Current Limitations
Mobile Applications	Virtual Hope Box, Stay Alive, Suicide Safe	Coping tools, safety plans, crisis support links	Low user engagement, poor clinical integration
Empathic Chatbots	Woebot, Replika	CBT-based dialogue, empathic 24/7 support	Emotional dependency, limited crisis management
Machine Learning	Tina, NLP models, Irish dashboard	Risk prediction, automated screening	Ethical validation, model transparency
Passive Sensing EMA	Wearables, Screenomics	Real-time monitoring, early warning systems	Moderate predictive power when used alone
Simulations ECAs	Kognito, HelPath	Training, support, stigma reduction	Risk of over-attribution of empathy, crisis response limitations

- Mobile Applications: The Substance Abuse and Mental Health Services Administration;
- Empathic Chatbots;
- Machine Learning for Risk Prediction;
- Passive Sensing and Ecological Momentary Assessment (EMA);
- Simulations and Virtual Humans (ECAs).

Table 1 summarizes the five main categories of digital technologies for suicide prevention, outlining their core functions and current limitations.

Mobile Applications

In recent years, several mobile applications have been developed to assist individuals experiencing suicidal ideation or emotional distress. Tools such as Virtual Hope Box, Stay Alive, Suicide Safety Plan and Suicide Safe offer accessible psychoeducation, personalized safety plans and rapid links to crisis support. Each app is tailored to different user needs - from the general population to healthcare professionals. Virtual Hope Box (Bush et al. 2017), developed by the U.S. Department of Veterans Affairs, combines evidence-based coping tools (e.g., relaxation, distraction, support reminders) with user-customizable content to enhance emotional regulation. Suicide Safe, by SAMHSA (Substance Abuse and Mental Health Services Administration), is aimed at clinicians and provides structured guidance on risk assessment using the SAFE-T model (Jacobs et al. 2009), including case examples and referral resources. Meanwhile, Stay Alive addresses the public with a multilingual interface and features like “LifeBox” for storing hope-inspiring content. The Suicide Safety Plan app allows users to create and access safety plans quickly and intuitively, alone or with a provider. However, as noted by the American Psychological Association (2023), these apps face significant challenges. Common limitations include weak integration into clinical care pathways, limited cultural adaptability, lack of rigorous validation and poor long-term engagement - especially when human support is absent.

Empathic Chatbots

Empathic chatbots are conversational agents that use natural language to simulate therapeutic dialogue and

are increasingly explored for their potential in reducing depressive symptoms, particularly among younger populations. Tools like Woebot deliver brief, structured CBT-based interactions and have demonstrated rapid efficacy in reducing depressive symptoms in young adults (Fitzpatrick et al. 2017). However, concerns persist about their application in suicide prevention. Maples et al. (2024) highlighted low engagement rates across many apps and reported a case where interaction with the early chatbot ELIZA coincided with emergent suicidal ideation. More advanced agents like Replika, powered by GPT-3/4, allow for context-sensitive and emotionally nuanced interactions. In a large-scale survey, some users credited Replika with preventing suicide attempts, citing its constant availability and empathic responsiveness. Interestingly, those reporting such benefits often anthropomorphized the chatbot, perceiving it as a friend or emotional mirror.

Despite these promising reports, empathic chatbots are not without risk. Overreliance, emotional dependency and the inability to manage acute crises remain major ethical and clinical challenges. These findings underscore the importance of integrating chatbot use with clinical services, ensuring appropriate safeguards and developing ethical guidelines to prevent harm (Maples et al. 2024).

Machine learning (ML) in suicide risk prediction

Machine learning (ML) has emerged as a powerful tool for enhancing suicide risk prediction and early intervention. For example, Cohen et al. (2022) applied natural language processing to open-ended interviews in emergency settings, producing a model capable of accurately classifying individuals at risk. Building on this, Cohen et al. (2023) introduced Tina, a virtual agent using the Mental Health Hopes Secrets Anger Fear and Emotional Pain (MHSAFE) framework to conduct multi-modal interviews that integrate speech, facial expression and textual analysis. Among 68 participants, the fusion of these modalities yielded good predictive accuracy (AUC = 0.76), with textual features being the most informative. Notably, users reported high levels of comfort interacting with the virtual agent, supporting its potential for remote mental health screening. On a broader scale, a meta-

analysis by Hopkins et al. (2022) including over 11 million individuals across 31 studies confirmed the high accuracy of ML models in suicide risk prediction (AUC \approx 0.87), with comparable performance between structured and unstructured data. These findings underscore the potential of AI to support clinical decision-making, while also calling for attention to ethical standards, model transparency and contextual validation. Another promising innovation involves digital dashboards for real-time suicide mortality monitoring. In a pilot study from Ireland, Benson et al. (2022) developed an intelligent dashboard that integrates longitudinal epidemiological data with automated detection of spatiotemporal clusters. The system enables public health teams to identify emerging trends and respond quickly to local surges, transforming raw data into actionable insights. Together, these tools exemplify how AI and real-time data visualization can make hidden patterns visible, enabling proactive and informed suicide prevention strategies.

Passive Sensing and Ecological Momentary Assessment (EMA)

Recent advances in digital psychiatry have highlighted the value of combining passive sensing and Ecological Momentary Assessment (EMA) for more dynamic and individualized suicide risk monitoring. While passive sensing - through smartphones and wearables - can unobtrusively track parameters like sleep, geolocation and activity, its predictive value remains modest when used alone. However, when integrated with EMA, which captures real-time subjective experiences, predictive accuracy improves significantly (Kivelä et al. 2022; Ernst et al. 2022). These studies reveal that suicidal ideation can fluctuate within hours and is often preceded by early signs such as insomnia or hopelessness, making EMA particularly useful for detecting high-risk windows.

Additional innovations in digital phenotyping have also shown promise. For instance, Ammerman et al. (2025) used screenomics to analyze over 7 million smartphone screenshots, finding that exposure to suicide-related or hopelessness-themed content was linked to both ideation and planning, even at the individual level. Similarly, Melia et al. (2025) demonstrated that wearable sensors can be used to continuously monitor psychiatric patients, enabling machine learning models to detect early clinical deterioration, including suicidal ideation. Together, these findings suggest that the integration of passive data collection and real-time assessments may represent a paradigm shift in suicide prevention - toward interventions that are timely, personalized and scalable.

Simulations and Virtual Humans (ECAs)

Embodied Conversational Agents (ECAs) are emerging technologies in digital mental health, designed to engage users through sustained and empathic interaction. Their applications span two primary domains:

early detection support for individuals at risk of suicide and clinical training through simulation of suicidal behavior. As virtual counselors, ECAs can provide real-time support, reduce stigma and enhance access to care - particularly among youth and marginalized groups. For example, the HelPath app was positively evaluated for its usability and preventive potential in managing suicidality (Martínez-Miranda et al. 2017). In training contexts, platforms like Kognito offer game-based simulations using motivational interviewing and emotion regulation, resulting in improved self-efficacy and increased referral intentions across diverse user groups, including educators and healthcare providers (Albright et al. 2016). Despite their promise, ECAs raise critical ethical concerns. These include the transparency of decision-making algorithms, the handling of acute crises and the risk of users over-attributing emotional understanding to simulated empathy. As highlighted by Rahsepar Meadi et al. (2025), active human oversight and rigorous validation standards remain essential for their safe and effective implementation.

The Blended Model in Suicide Prevention: Toward a Paradigm Shift?

A growing body of evidence supports blended care models - combining digital tools with human therapeutic support - as one of the most promising innovations in suicide prevention. Unlike stand-alone self-help apps, blended approaches integrate digital interventions (e.g., mobile apps, video therapy, psycho-educational modules) within structured, clinician-guided pathways. A large systematic review by Diano et al. (2023) demonstrated that these models significantly improve adherence and clinical outcomes. Clinical studies in vulnerable adolescent populations in Chile showed reductions in suicidal ideation and improvements in anxiety and depression through school-based blended interventions (Gaete et al. 2025; Nuñez et al. 2024). Similarly, Büscher et al. (2023) developed and tested the GO-ONline program, combining remote video therapy with digital CBT modules, reporting good acceptability and clinical feasibility.

The adoption of blended care models is advocated by the European Psychiatric Association which also emphasizes the establishment of certification systems for digital technologies in psychiatry and the digital competencies of clinicians, supported by secure and interoperable systems that respect privacy standards (Kalman et al. 2023). Concurrently, the World Psychiatric Association underscores the need to bridge the persistent gap between technological innovation and clinical practice by promoting shared ethical frameworks, equitable access and enhanced digital literacy among stakeholders (Volpe et al. 2023).

CONCLUSIONS

The integration of human and digital elements represents a radical shift toward continuous, personalized and scalable suicide prevention pathways, where the empathic dimension of care is enhanced by the efficiency and precision of digital technologies. These tools may improve accessibility, reduce dropout risk and enable rapid, tailored interventions - supporting clinicians in reaching individuals at the right time and in the right context. However, the future of suicide prevention will depend not only on innovation, but on our ability to ethically and systematically embed these tools within human-centered mental health systems.

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