



Systematic Review and Meta-Analysis: Effectiveness of Stand-Alone Digital Suicide Preventive Interventions for the Self-Management of Suicidality

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Abstract

Suicide is a global issue accounting for more than 700,000 deaths annually, with low- and middle-income countries being disproportionately affected. Technology-enhanced interventions have been suggested as a preventive method with various benefits—e.g., increased scalability and sustainability, making them relevant for developed and especially for developing nations. However, despite the increasing number of such interventions, their effectiveness is seldom appropriately evaluated. The current review aims to tackle this need by synthesizing the evidence with the goal of answering whether these interventions can be recommended for the self-management of suicidality. A systematic review was carried out across multiple databases (PubMed/Medline, Global Index Medicus, PsychINFO, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, and Cumulative Index to Nursing and Allied Health Literature), identifying 4520 individual reports up to November 2021. Ten of these were deemed sufficient to inform the evaluation, but only four were included in the meta-analyses. Quality assessment via GRADE reveals some concerns, primarily regarding selection of reported results. Results suggest negligible effect on the outcomes of deaths by suicide, suicide attempts, and a small effect on suicidal ideation—favoring digital interventions over no intervention. Conclusively, there is not enough evidence to allow for the recommendation of digital interventions as stand-alone care, but they are promising if developed on the grounds of evidence-based practices. The review also highlights the challenges of evaluation, by discussing excessive safety procedures and considering parallelly ongoing treatment. Additionally, the need to involve low- and middle-income countries is emphasized as currently these regions are underrepresented, even though they have a high potential for benefiting from stand-alone digital interventions.

Keywords Suicide prevention · Technology · Digital · Intervention · Review

Introduction

Suicide poses a global challenge, leading to over 700,000 deaths annually, particularly impacting low- and middle-income countries (WHO, 2021). Technology-based interventions have been proposed as a viable way of prevention, offering various benefits, such as improved scalability and sustainability (Grist et al., 2017; Kreuze et al., 2017; Melia et al., 2018). Despite the growing number of such

interventions, their effectiveness is seldom appropriately evaluated leaving uncertainty about their suitability for recommendation, especially as stand-alone care. This report aims to tackle this gap by synthesizing the available evidence to inform recommendations regarding standalone digital interventions for the self-management of suicidality and self-harm.

Suicidality and self-harm are pervasive problems globally; nevertheless, their disproportionate burden should not be neglected. Based on the most recent report of the World Health Organization (2021), 7 to 8 out of 10 individuals who lost their life due to suicide in 2019 were from low- and middle-income countries. Regardless of geographical location, suicide has multi-level impacts. Beyond leading to the premature death of an individual, the negative impact extends to the family (Cerel et al., 2008), friends,

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and broader communities (Young et al., 2012) and reaches a societal level through the loss of a productive member, as concluded around the world (McDaid et al., 2010; O’Dea & Tucker, 2005; Rockett et al., 2023). All these examples showcase that the prevalence and burden of suicide warrant the need for effective prevention strategies. Such prevention is essential, not least to save lives and promote mental health, but also to support those affected by suicide and decrease the toll taken on the healthcare system and the overall economic burden.

By today, several suicide preventive interventions exist—including public and physician education, media strategies, screening, restricting access to suicide means, pharmacological and psychological treatments, and internet or hotline support (Zalsman et al., 2016), as well as school-based interventions raising awareness about mental health and enhancing coping strategies. However, access to these is not guaranteed due to various barriers, such as limited availability of human resources, geographical obstacles, and social stigma. Digital interventions have been proposed as a possible way to overcome at least some of these barriers (Christensen et al., 2014; Grist et al., 2017; Kreuze et al., 2017; Melia et al., 2018). Technology can increase accessibility for those living in rural and remote areas or provide an alternative to those refusing hospitalization and an anonymous solution to those affected by stigma and discrimination. Additionally, if fully automatized, digital interventions can be free from limitations of human resources and are not dependent on an established healthcare system either—meaning that they have the potential to provide immediate and ongoing support, potentially even tailored to individual needs.

At the same time, digital solutions are not free from limitations. While some populations, such as adolescents are inclined to welcome technology-based solutions (Forte et al., 2021; Grist et al., 2017; Szlyk & Tan, 2020), others, for example, the elderly might have resistance or difficulties “going digital” and losing the human connection due to lower levels of e-Health literacy (Verma et al., 2022). One might also consider the unequal access to technology leading to further health inequality due to the technical barriers—where the lack of digital devices or reliable internet will also mean inaccessibility of technology-dependent health care. Moreover, ethical concerns might arise regarding data privacy and security, as well as potential biases in algorithms that have been reported before (Thomasian et al., 2021).

The digital format can be used in many ways; to transform existing preventive strategies (e.g., digitalization of cognitive behavior therapy) or to establish new ones (e.g., suicide risk assessment via machine learning algorithms based on social media activity). Franco-Martín et al. (2018) for example provide a systematic review of the technologies used for the purpose of suicide prevention and discuss mainly web technologies, mobile applications, social networks, and

machine learning solutions. When conducting a review specifically on smartphone tools, Larsen et al. (2016) identified five main categories of preventive strategies already tested in a digital format—public health strategies, screening, accessing support, mental health strategies, and follow-up strategies. As promptly pointed out by Kreuze et al. (2017), some of these digital interventions are designed to provide stand-alone care, but most are meant to be adjunctive treatments to usual care and require input that extends beyond the individual user, e.g., from a mental health professional.

Aim

The objective of this review is to analyze existing evidence in order to provide recommendations and advice on guidelines concerning the use of standalone digital interventions for the self-management of suicidality and self-harm among those with pre-existing suicidality.

Methodology

The review follows the 2nd edition of the Guideline Development Process proposed by the WHO (2014). This process entails the formulation of key questions in the PICO format (population, intervention, comparator, and outcomes). This is followed by conducting a scoping review to identify existing systematic reviews that might be able to answer the key questions and be the grounds for recommendations/guidelines. Depending on the outcomes of this scoping review, one should decide between three outcomes: (1) whether such a review exists; (2) or there is a relevant review, but it should be updated; (3) or an entirely new review should be conducted.

During the scoping review, multiple systematic reviews were identified (Chen & Chan, 2020; Franco-Martín et al., 2018; Grist et al., 2017; Kreuze et al., 2017; Sander et al., 2021; Torok et al., 2020; Witt et al., 2017). However, these either did not limit to the standalone nature (Kreuze et al., 2017); imposed additional criteria such as the need for therapeutic content (Sander et al., 2021; Torok et al., 2020), specifically targeted adolescents (Grist et al., 2017), considered only randomized controlled trials (Chen & Chan, 2020) or did not cover self-harm (Franco-Martín et al., 2018). Only one review - published by Witt et al. (2017) - specifically targeted standalone interventions for suicidality, with inclusion criteria that aligned with the current review. Due to its relatively recent publication, high quality, and alignment with the key question this review was chosen as the foundational source for this evidence profile. Since the key question specifically focuses on individuals with pre-existing suicidal ideation and/or prior self-harm, which was not a selection criterion in the review by Witt et al. (2017), all the studies included in their review were

thoroughly screened to ensure they meet the requirements of this systematic review. Nevertheless, all studies included in the other identified reviews were screened for inclusion on an individual basis.

Given that the identified systematic review only encompassed literature up until April 2017, and the rapid proliferation of technology-enhanced interventions, we decided to update the search by including new reports published up until and including November 2021. The search was also expanded to encompass additional databases as detailed later and without imposing any language restrictions. We hope this comprehensive update will facilitate a fresh quantitative synthesis of the available evidence, allowing for a more up-to-date assessment, specific to those with pre-existing suicidal ideation and/or prior self-harm.

The PICO Framework

As introduced above, the guideline development process includes the definition of the PICO framework, leading to the definition of the key questions. Table 1 showcases the components on which the following key question was formulated:

“Are digital interventions for the self-management of suicidality or self-harm effective - in reducing deaths from suicide, suicide attempts, acts and thoughts of self-harm - among persons with pre-existing suicidal ideation and/or prior acts of suicide/self-harm?”

Search Strategy

To ensure comprehensive coverage, a systematic literature search was conducted across multiple online databases, including well-established sources such as PubMed/Medline, PsychINFO, Cochrane Central Register of Controlled Trials (CENTRAL), Cochrane Database of Systematic Reviews (CDSR), and Cumulative Index to Nursing and Allied Health Literature (CINAHL). In addition, the Global

Index Medicus, which combines repositories from developing regions such as the African Index Medicus, Index Medicus for the Eastern Mediterranean Region, Index Medicus for the South-East Asian Region, Latin American and Caribbean Health Sciences Literature, and Western Pacific Region Index Medicus, was included to adequately represent low- and middle-income countries. This comprehensive approach aimed to capture a wide range of relevant literature sources. The following highly inclusive search terms were used across all databases:

(self-injur* OR self-harm* OR self-poison* OR self-cut* OR self-mutilat* OR auto-mutilat* OR NSSI OR DSH OR “deliberate self-harm*” OR “intentional self-harm*” OR self-poison OR “drug overdose” OR suicid*) AND prevent* AND ((technology OR digital) OR (mhealth OR ehealth) OR (internet OR online OR web) OR (phone OR mobile) OR (application OR app) OR (social media OR social network) OR (gaming OR game) OR (virtual OR augmented OR immersive))

Inclusion and Exclusion Criteria

We used the following inclusion criteria: (1) type of studies: systematic reviews/meta-analyses, primary studies with quantitative empirical data including experimental (e.g., RCTs or C-RCTs) as well as quasi-experimental designs (e.g., pre-post studies with or without controls). (2) Types of participants: individuals with suicidal thoughts, behaviors, and/or other forms of suicide/self-harm. (3) Types of interventions: interventions delivered through digital technology, i.e., mobile applications, or the internet, virtual and augmented reality, gaming, and social media. Management without significant external human interference was also a requirement, which led to the exclusion of for example chat lines, adjuvant therapies, or screening interventions with referrals to healthcare, etc. (4) Types of outcome measures: suicide, suicide attempt, suicidal ideation, and non-suicidal self-injury. (5) Published language of study: no restriction. (6) Date range: April 1, 2017–November 30, 2021.

Identification and Selection of Records

We used a multi-stage process to assess the eligibility of all reports. During the initial stage of study selection, records obtained from bibliographic databases were evaluated based on their titles and abstracts. In the second stage, relevant articles were retrieved, and their full texts were examined.

During full-text assessment, a decision was made whether the studies meeting all criteria should be included in GRADE tables and quantitative synthesis or only in the narrative summary. Studies where there were concerns about the independent nature of the interventions or if factors other

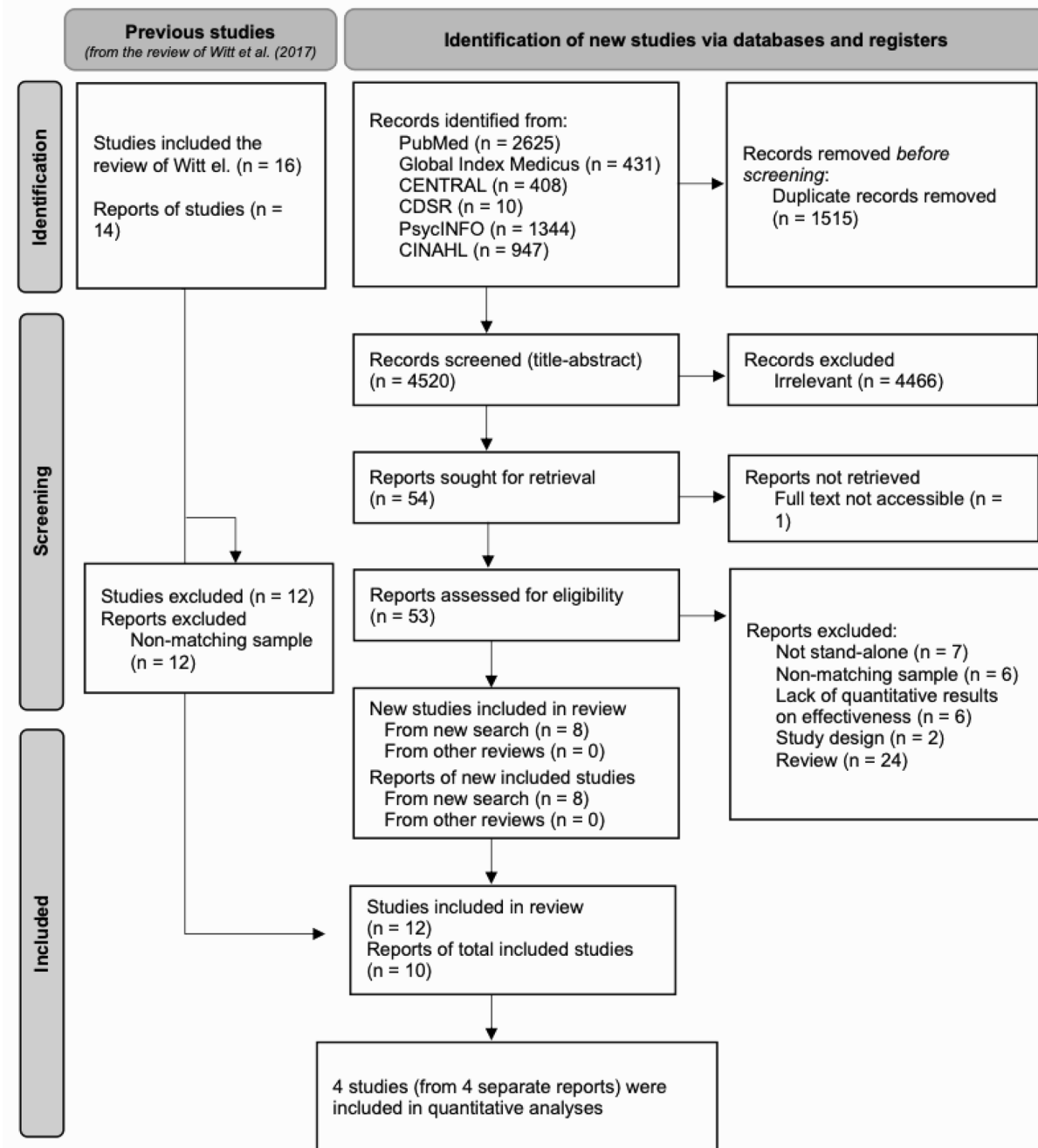
Table 1 The PICO framework

P	Population	Persons with thoughts, plans, or prior acts of suicide/self-harm
I	Intervention	Digital interventions for the self-management of suicidality/self-ham
C	Comparator	No digital interventions
O	Outcomes	Critical: <ul style="list-style-type: none"> • Death by suicide • Suicide attempt Important: <ul style="list-style-type: none"> • Suicidal ideation • Non-suicidal self-injury (NSSI)

than the standalone intervention could strongly influence the results (e.g., extensive safety procedures involving human contact) were only included in the narrative synthesis.

If a systematic review was identified during the search, all reports included in that review were examined separately.

At least two independent reviewers assessed the eligibility of the studies, and any disagreements that arose during the screening and assessment phases were resolved through discussions. The PRISMA flow diagram (Fig. 1) provides an overview of the magnitude of reports that were considered,



Note. CDSR, Cochrane Database of Systematic Reviews; CENTRAL, Central Register of Controlled Trials; CINAHL.

Fig. 1 Modified Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) diagram, outlining the systematic literature search and reasons for exclusion

including the number of excluded articles and the reasons for exclusions during the full-text screening stage.

Data Collection, Analysis, and Synthesis

We extracted relevant data from the original publications, including the sample sizes of the control and experimental groups, effect sizes of the intervention for the closest follow-up time, standard errors of the effect, and the incidence of suicide attempts among both the control and intervention groups.

Two different approaches were taken when synthesizing data depending on the nature of the outcome variable. When the data followed a categorical structure (deaths by suicide and number of suicide attempts), odds ratios (OR) were reported with their corresponding 95% confidence intervals (CI). Considering the outcome of suicidal ideation, we used a continuous outcome of decrease in the intensity of suicidal ideation (as measured by self-report scales) and thus report standard mean differences (SMD) accompanied by 95% CIs. For the outcome of self-harm, no study was identified from which quantitative data was extracted.

When synthesizing results across studies, a random-effects model was utilized. Between study heterogeneity was assessed and quantified using the I^2 statistic and was found to be low (below 25%) for both outcomes where meta-analyses were performed.

Quality Assessment

For each study included in the quantitative analysis, a quality assessment was conducted using the revised Cochrane Risk of Bias tool, RoB 2 (Sterne et al., 2019). The findings from the quality assessment were then combined across studies for each specific outcome. The process involved considering factors such as risk of bias, inconsistency, indirectness, and imprecision in order to determine the certainty of the effect estimates for all outcomes of interest.

Software Infrastructure

The Covidence software (2022) was used to identify and categorize relevant records. Group members collaborated and engaged in discussions during the full-text assessment phase with additional support from the Papers reference manager application (<https://www.papersapp.com>). The meta-analyses were conducted separately for each outcome, by using the Jamovi statistical software (2021) which was also used for the creation of figures. For quality assessment purposes, the GRADEproGDT application (2022) was used.

Results

Narrative Synthesis of the Studies Excluded from Quantitative Synthesis

Eight studies (from six reports) were found relevant to answer the research question but judged not suitable to be included in the quantitative synthesis (see reasons in Supplementary Material 1). Both Boudreaux et al. (2017; USA) and Jeong et al. (2020; South Korea) evaluated safety planning interventions delivered through a computer and a mobile application, respectively. The studies reported some positive effects, such as decreased suicide intensity and increased ability to cope with suicidal thoughts. However, most outcomes were non-significant, and usability problems were identified. Boudreaux et al. (2017) recommended using the intervention as an adjunct to usual clinical contact due to some confusion among participants and the need for clarification from clinical personnel.

Pauwels et al. (2017; the Netherlands) examined a mobile application called BackUp, which combined multiple modules with different preventive strategies. The study showed a small, non-significant decrease in suicidal ideation among participants. Mental health experts found the app valuable, particularly the safety planning feature, but emphasized the need for clearer instructions—further highlighting the importance of available support when such interventions are utilized.

Franklin et al. (2016; USA) assessed the Therapeutic Evaluative Conditioning (TEC), a mobile application targeting individuals with a history of self-injurious thoughts and behaviors. The studies reported significantly reduced self-cutting episodes and decreased suicide plans and suicidal behaviors. However, the number of suicide attempts did not differ considerably. Effects on non-suicidal self-injury and suicidal ideation varied across the three sub-studies.

Jaegere et al. (2019; Belgium) investigated a web-based intervention called ThinkLife, combining elements of various therapies. The digital intervention group showed a significantly greater reduction in suicidal ideation compared to a waitlist control. There were recorded suicide attempts in both groups, but no significant difference between them.

Finally, Hooley et al. (2018; USA) focused on an online daily diary intervention called Autobiographical Self-Enhancement Training (ASET) for non-suicidal self-injury. After 30-day use, participants showed decreased suicidal ideation compared to an Expressive Writing control group, which remained significant after a 3-month follow-up. However, there was no treatment effect on suicide plans, suicidal behaviors, desire to discontinue self-injury, or likelihood of future self-injury.

Overall, these studies consistently reported small changes in suicidal ideation but did not indicate a reduction in suicidal behaviors such as death by suicide or suicide attempts. Specific usability concerns were reported in three out of the six reports, and all studies had either excessive safety procedures or a large proportion of participants already undergoing treatment. These circumstances might have influenced the effects attributed to the digital interventions or at least question the safety of the interventions as standalone care, without the parallel supervision of a mental health professional. Additionally, the studies were likely underpowered to detect potential small effects on the relatively rare suicidal behaviors.

Narrative Overview of the Studies Included in Quantitative Analyses

Three of the four studies (Mühlmann et al., 2021; van Spijker et al., 2014, 2018) that were included in the quantitative synthesis were based on the same protocol developed by Van Spijker et al. (2010). Differences between these three were minor, primarily in the intervention's content, the type of control group used, and the follow-up period. All three had a website based primarily on cognitive behavioral therapy (CBT), but also incorporating elements of dialectical behavior therapy (DBT), problem-solving therapy (PST), and mindfulness. The intervention took six weeks to complete and was composed of six modules (including theory, exercises, assignments, and FAQ section). The completion required about 30 min of engagement per day. The intervention evaluated by Wilks et al. (2018) also followed a modular structure, but was based primarily on DBT skills training. It required the completion of eight modules over eight weeks, which incorporated educational videos, written key points, practice, and assignments. A brief overview of the four studies is presented in Table 2.

Meta-Analytic Synthesis of the Evidence

Death by Suicide

There was only one study found suitable for quantitative analyses that measured the outcome of deaths by suicide and thus

meta-analysis was not performed. The results of Mühlmann et al. (2021) suggest negligible difference in the number of deaths. Both the intervention ($n = 196$) and the control ($n = 206$) groups had one death over the 6-month follow-up period, leading to an odds ratio of 0.95 with a 95% confidence interval between 0.06 and 15.32—indicating large uncertainty and the possibility of an effect being favorable and unfavorable as well (see Table 3).

Suicide Attempt

Three out of the four studies reported on the number of suicide attempts (Mühlmann et al., 2021; van Spijker et al., 2014, 2018). As shown in Fig. 2, the pooled results suggest an odds ratio of 1.08 (0.64–1.82), which yields a non-significant finding ($p = 0.53$), with no indication of between-study heterogeneity ($I^2 = 0\%$). Overall, the certainty of the evidence is graded very low as argued in the GRADE table (Table 3).

Suicidal Ideation

All four studies compared the reduction in suicidal ideation following the completion of the intervention. As shown in Fig. 3, the pooled results indicate a small, but favorable effect, where those in the intervention group reported enhanced reductions in self-reported suicidal ideation compared to the control groups (SMD = 0.24 [0.09; 0.40]; $p < 0.01$). The between-study heterogeneity was again negligible ($I^2 = 20.5\%$), and overall, the evidence is graded low (see Table 3).

Non-Suicidal Self-Injury

There was no study deemed suitable for quantitative analyses that investigated the outcome of non-suicidal self-injury. While the study of Franklin et al. (2016) above was identified by the literature search, data were not extracted as majority of the sample reported ongoing psychiatric treatment parallel to participating in the evaluation of the intervention. Nevertheless, the outcomes of the three studies reported were favorable regarding reduced self-cutting episodes and decreased suicide plans and behaviors.

Table 2 Overview of the four studies included in quantitative syntheses

Study	Country of study	N		Control	Follow-up
		Intervention	Control		
Mühlmann et al. (2021)	Denmark	196	206	Waitlist	6 months
Van Spijker et al. (2014)	The Netherlands	116	120	Waitlist (informative website)	Post-intervention
Van Spijker et al. (2018)	Australia	207	211	Attention control	6 and 12 months
Wilks et al. (2018)	United States of America	30	29	Waitlist	2 months

Table 3 GRADE table—assessment of the evidence. Question: Can standalone digital interventions be recommended for the self-management of suicidality and self-harm among those with pre-existing suicidal thoughts or previous suicidal or self-harm behaviors? Setting: Non-clinical

Certainty assessment		No. of patients			Effect		Certainty		Importance			
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Intervention	Control	Relative (95% CI)	Absolute (95% CI)		
Death by suicide (Mühlmann et al., 2021*)												
1	Randomized trials	Serious ^a	Not serious	Not serious	Extremely serious ^b	None	1/196 (0.5%)	1/206 (0.5%)	OR 0.95 (0.06 to 15.32)	0 fewer per 1000 (from 5 fewer to 53 more)	Very low	Critical
Suicide attempt (Mühlmann et al., 2021*; van Spijker et al., 2014**, 2018*)												
3	Randomized trials	Serious ^a	Not serious	Not serious	Very serious ^c	All plausible residual confounding would reduce the demonstrated effect	31/519 (6.0%)	30/537 (5.6%)	OR 1.08 (0.64 to 1.82)	4 more per 1000 (from 19 fewer to 41 more)	Low	Critical
Suicidal ideation (Mühlmann et al., 2021*; van Spijker et al., 2014**, 2018*; Wilks et al., 2018*)												
4	Randomized trials	Serious ^a	Not serious	Serious ^d	Not serious	None	549	566	-	SMD 0.24 lower (0.09 lower to 0.40 lower)	Low	Important
Non-suicidal self-injury (NSSI)												
0	-	-	-	-	-	-	-	-	-	-	-	Important

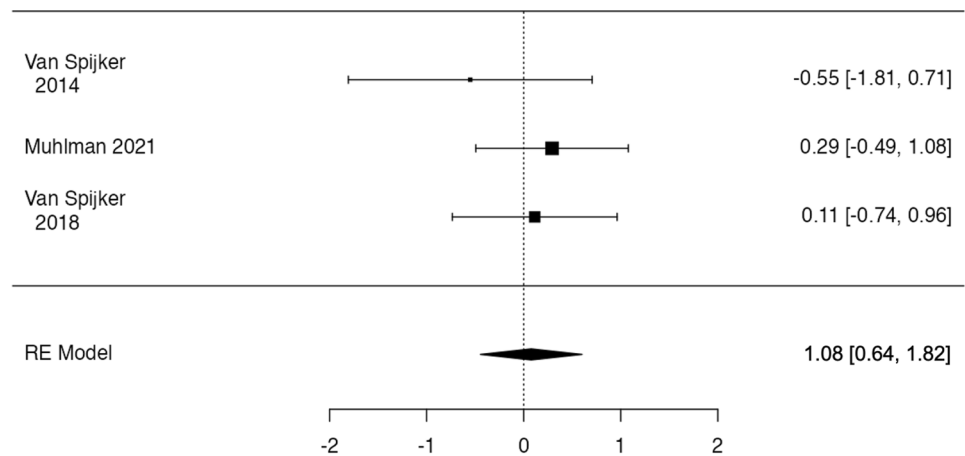
*Source of the study is the new literature search; **Source of the study is the review of Witt et al. (2017)

^aAccording to RoB 2, all studies were categorized as having “some concerns”

^bOnly one study with low power and the event rate being very low

^cRelatively low number of studies and with low power

^dDowngraded one level since suicidal ideation is only a precursor of the main outcomes of interest (suicidal behavior)

Fig. 2 Forest plot for the outcome of suicide attempts

Quality Assessment

Quality assessment of the four studies deemed suitable for quantitative analyses revealed some concerns, primarily related to the selection of reported results—as detailed in Table 4.

Discussion

Both the narrative overview and quantitative synthesis pointed to a small, but favorable effect of standalone digital interventions for the self-management of suicidality among individuals with pre-existing suicidality or prior suicidal/self-harm behaviors. However, this effect was primarily concerning thoughts of suicide but not suicide attempts or death by suicide. There was no effect detected when it comes to the critical outcomes of deaths by suicide or number of suicide attempts, nor did we see a consistent effect from the three sub-studies reporting on non-suicidal self-injury. Parallely, many of the included studies made remarks about usability concerns, and some concluded that the interventions should be used when professional support is available.

Even though the quantity of evidence and therefore the certainty of the results was limited, one should not neglect the difference seen in the effectiveness depending on the

outcome measure. While the results regarding suicidal ideation are promising, especially considering the many potential advantages of (standalone) digital interventions, we do not currently have the evidence to claim these interventions generally safe as a standalone treatment for suicidal populations. The main reason is that most of the relevant studies use extensive safety procedures due to the vulnerable population—the lack of which however in real-life implementation is a cause for concern. The difference depending on the outcome measures also shines a light on the challenge to clinically identify different subgroups of suicidal individuals. It is possible that those more inclined to have suicidal ideation should be distinguished from those (also) at elevated risk for suicide attempts—as the former is more related to depression while the latter is to borderline personality traits (Söderholm et al., 2020). Such a distinction, hypothetically, could be used among other things to inform specialized treatment. For example, standalone interventions might be suitable for those with suicidal ideation. On the other hand, those at elevated risk for an attempt would require professional guidance. There is also a possibility to embed the systems employed as a safety net beyond duration of the evaluation studies—even if it means that the intervention is not “standalone” anymore.

Several factors might have contributed to the scarcity of evidence. First, as noted by Kreuze et al. (2017), the majority of technology-enhanced suicide preventive interventions

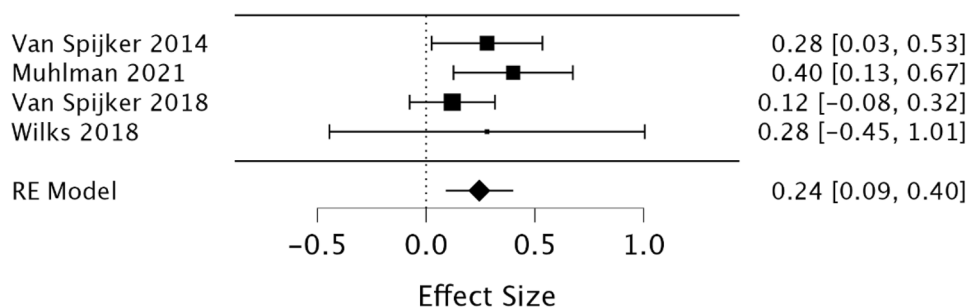
Fig. 3 Forest plot for the outcome of reduction in suicidal ideation

Table 4 Risk of bias assessment of studies included in the quantitative syntheses (RoB 2)

	Mühlmann et al. (2021)*	Van Spijker et al. (2014)**	Van Spijker et al. (2018)*	Wilks et al. (2018)*
Randomization process	Low	Some concern	Low	Low
Deviations from the intended interventions	Some concern	Low	Some concern	Low
Missing outcome data	Low	Low	Low	Low
Measurement of the outcome	Low	Low	Low	Low
Selection of the reported results	Low	Some concern	Some concern	Some concern
Overall	Some concern	Some concern	Some concern	Some concern

Possible judgments: low; some concern, high risk

Source of the study: *from the new literature search; **from the review of Witt et al. (2017)

is designed to complement standard care as opposed to providing a standalone solution. Second, there is great variety when it comes to the inclusion or exclusion criteria for participants with whom the interventions are tested. For safety reasons, some studies excluded individuals exceeding a threshold of suicidality or who had a history of suicidal behavior (Dickter et al., 2019). While caution for an elevated risk of (repeated) suicidal acts is warranted, excluding such individuals may threaten the ecological validity of the studies. Conversely, for the few studies that include such high-risk individuals, the effect of the intervention as a “stand-alone” treatment is difficult to entangle due to the need to include additional safety procedures (e.g., receiving a phone call from a professional upon exceeding a suicidality threshold (Pauwels et al., 2017)). Other confounding factors may include more receipt of standard psychological, psychiatric, or pharmacological treatment (Franklin et al., 2016; Hooley et al., 2018; Jaegere et al., 2019). Additional complexity comes from the varying follow-up periods; from a couple weeks to 12 months, which, given the relative rarity of suicide attempts and deaths might be worthy of prolonging to gather sufficient data.

Another dimension of challenges comes from the need to separate the format from the content of the interventions. Interventions being digital only refers to the “format” or “medium” of delivery but does not in any way restrict the content or preventive strategy of the intervention. In order to advance our understanding of digital suicide preventive interventions, it is crucial to separate between the format and the content of the interventions and consider both. For example, one might question whether the lack of effectiveness stems from unsuccessful intervention strategies or from the digital format in which these are delivered.

Additionally, digital interventions—the here included being no exception—are often composed of multiple modules, utilizing numerous strategies. This might be favorable overall, but it also introduces the difficulty to understand what module drives what effect. Conducting sub-analyses based on different

formats, strategies, and modules within the digital context could yield valuable insights into the mechanisms driving the effect, if any. We could identify the strengths and limitations of each approach, determine their respective efficacies, and inform evidence-based recommendations. Such efforts could also help to identify strategies with the best potential to be effectively translated into a digital format. This would involve minimizing the risks associated with the transfer process and addressing the challenges arising from the digital nature—e.g., the absence of a mental health professional that typically accompanies traditional interventions.

A majority of the studies evaluating digital interventions do so in high-income countries even though the involvement of low- and middle-income countries is scientifically essential and has high potential for practical impact. These countries host a significant portion of the global population, who are also at an elevated risk for suicide (WHO, 2021). Their participation in the development, implementation, and evaluation of these interventions ensures that they are more representative of diverse populations and their unique needs, as well as allowing for the investigation of the cultural context, thereby potentially informing on the need for cultural adaptation/tailoring (see e.g. Jorm et al., 2018). Furthermore, specific barriers can become visible through localization efforts, perhaps related to language, digital literacy, and technology. By engaging a more diverse range of countries, we all benefit from gaining insights into addressing challenges specific to resource-constrained settings, while possibly leveraging opportunities unique to these contexts (Phillips, 2004). Learning from studies in diverse settings contributes to the advancement of suicide prevention strategies globally. From an ethical perspective, we should strive for equitable access and aim to reduce global health disparities. Ultimately, this inclusive approach contributes to the development of effective, culturally adapted, and accessible digital interventions for diverse populations worldwide, promoting global mental health equity.

Limitations and Future Directions

We aimed to overcome the challenges faced by previous efforts when synthesizing the evidence. Nonetheless, this review has some limitations that warrant consideration. First, the scope of the search was highly specific (stand-alone interventions, adult population with pre-existing suicidal thoughts or behaviors) which led to stringent inclusion/exclusion criteria and a relatively low number of included studies. However, the compromise on generalizability was necessary to adequately assess the safety and effectiveness of digital interventions for the self-management of suicidality. The low quantity of evidence might also be at least partly explained by the private nature of some interventions and subsequent proprietary data restrictions. The lack of open access to these systems and their data might thus result in their omission when synthesizing the evidence. Second, generalizability of results to real-world settings might be limited due to the challenges of study design, which lead to excessive safety procedures and parallelly ongoing treatment in many cases. Notwithstanding the fact that these interventions have only been tested in high-income countries. Third, as introduced earlier, it is a challenge to detangle the (digital) format, from the content of the intervention. While analyzing the effectiveness of the digital format is worthwhile, guidelines may need to be specific—e.g., such that only evidence-based interventions delivered via a specific digital solution can be recommended. The restriction solely on the digital format led to the heterogeneity of the preventive strategies utilized by the interventions. Heterogeneity was also present in the way the outcome variables were measured and the duration of the follow-up periods. Fourth, the review assessed the quality of the included studies using the revised Cochrane Risk of Bias tool, which indicated some concerns. One might consider the limitations and potential biases of each study when interpreting the overall results. Lastly, we must emphasize that the scarcity of evidence at this point in the literature does not equal the lack of an effect. As suicide is a relatively rare event, studies would require large sample sizes and long study periods to have the power to observe an effect. In the future, these constraints on feasibility might be mitigated by considering additional outcome variables known to be related to suicidality, such as coping self-efficacy (e.g., Bush et al., 2017) on the protective side or burdensomeness (e.g., Hill & Pettit, 2016) on the side of risk factors. Such interventions and outcomes are deserving of their own synthesis.

Conclusion

Digital interventions hold significant potential for enhancing suicide prevention by virtue of their numerous advantages, such as increased accessibility and 24/7 availability. However,

there is a lack of (quality) scientific evidence to substantiate any specific recommendations regarding the utilization of these interventions. The small number of studies currently available suggests promising results for managing suicidal thoughts but there is a lack of evidence regarding whether these interventions have any impact on suicidal behavior.

Moreover, interventions being digital only refers to the format of delivery but not the content of the intervention. As such, making conclusions and thus recommendations based on the format of the intervention would be misguided. Consequently, there is a need to entangle the format and the content of an intervention, which in turn would allow the iterative assessment and development of future interventions.

The scientific investigation of digital interventions in suicide prevention is challenging in many ways, primarily perhaps due to the necessary emphasis on safety measures, which in turn complicate the study of these interventions in an isolated manner (without parallelly ongoing treatment or support/input provided by a mental health professional).

Finally, it is essential to emphasize the importance of incorporating low- and middle-income countries in the development and research of these interventions. Despite their high potential to benefit from digital interventions, these countries are currently underrepresented in research. By including diverse socioeconomic and cultural backgrounds, the development and investigation of these interventions can address a broader range of societal needs and ensure that the benefits are more widely accessible.

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Declarations

Ethical Approval On the grounds that this study was restricted to the review of existing literature and thus did not involve data collection, no ethical approval was sought.

Competing Interests The authors declare no competing interests.

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