

Digital Safety Plan Activation Reduces Subsequent Emergency Departments Visits Following an Initial Suicide Attempt

María Luisa Barrigón, Carlos Schmidt, Matilde Elices, Alejandro Porras-Segovia, Ana María de Granda-Beltrán, Antonio Artés-Rodríguez, Philippe Coarte, Víctor Pérez-Sola, Enrique Baca-García

Submitted to: JMIR Mental Health
on: December 18, 2024

Disclaimer: © The authors. All rights reserved. This is a privileged document currently under peer-review/community review. Authors have provided JMIR Publications with an exclusive license to publish this preprint on its website for review purposes only. While the final peer-reviewed paper may be licensed under a CC BY license on publication, at this stage authors and publisher expressly prohibit redistribution of this draft paper other than for review purposes.

Table of Contents

Original Manuscript..... 5

Supplementary Files..... 27

 Figures 28

 Figure 1..... 29

 Figure 2..... 30

 Figure 3..... 31

 Figure 4..... 32

Digital Safety Plan Activation Reduces Subsequent Emergency Departments Visits Following an Initial Suicide Attempt

María Luisa Barrigón^{1*} PhD; Carlos Schmidt^{2*} PhD; Matilde Elices^{2*} PhD; Alejandro Porras-Segovia^{3*} PhD; Ana María de Granda-Beltrán^{4*} PhD; Antonio Artés-Rodríguez^{5*} PhD; Philippe Coarte^{6*} PhD; Víctor Pérez-Sola^{7*} PhD; Enrique Baca-García^{8*} PhD

¹Institute of Psychiatry and Mental Health, Hospital General Universitario Gregorio Marañón, IiSGM School of Medicine, Universidad Complutense de Madrid Universidad Complutense de Madrid Madrid ES

²Hospital del Mar Research Institute, IMIM Hospital del Mar Research Institute Barcelona ES

³Fundacion Jiménez Díaz Health Research Institute Department of Psychiatry, Rey Juan Carlos Hospital Móstoles Madrid ES

⁴Department of Psychiatry, Fundacion Jiménez Díaz University Hospital Madrid ES

⁵Centro de Investigación Biomédica en Red (CIBERSAM) Department of Signal Theory and Communications, Universidad Carlos III de Madrid Instituto de Investigación Sanitaria Gregorio Marañón Madrid ES

⁶Department of Emergency Psychiatry and Acute Care, Centre Hospitalier Universitaire Montpellier, University of Montpellier Montpellier FR

⁷Centro de Investigación Biomédica en Red (CIBERSAM) Hospital del Mar Research Institute (IMIM) Universidad Pompeu Fabra (UPF) Barcelona ES

⁸Centro de Investigación Biomédica en Red (CIBERSAM); Fundacion Jiménez Díaz Health Research Institute; Department of Psychiatry, Rey Juan Carlos Hospital Móstoles Department of Emergency Psychiatry and Acute Care, Centre Hospitalier Universitaire Montpellier, University of Montpellier, Montpellier, France Departamento de Psiquiatría, Universidad Autónoma de Madrid; Hospital Central de Villalba Villalba; Hospital Universitario Infanta Elena Valdemoro Madrid ES

*these authors contributed equally

Corresponding Author:

Carlos Schmidt PhD

Hospital del Mar Research Institute, IMIM

Hospital del Mar Research Institute

Dr. Aiguader 88

Barcelona

ES

Abstract

Background: Suicide is a significant global public health concern. Individuals with suicidal behaviors often seek help in emergency departments (ED), making mental health providers critical in suicide prevention. Brief interventions, such as safety planning, are essential in these settings. However, there is a limited understanding of how mobile digital applications of safety planning could enhance the effectiveness of in-person care provided by mental health professionals while simultaneously reducing their workload.

Objective: This study evaluated the effectiveness of a digital safety plan, delivered through the MEmind app, in reducing ED visits for suicide-related concerns.

Methods: A one-year follow-up was conducted on individuals who presented to the ED after a suicidal crisis (n = 78). Participants were provided with a digital safety plan on their mobile devices and instructed to activate it during future suicidal crises.

Results: Participants who activated the digital safety plan showed a 50% lower likelihood of returning to ED.

Conclusions: These findings suggest that digital safety planning may be a scalable and accessible intervention with the potential to significantly contribute to suicide prevention efforts.

(JMIR Preprints 18/12/2024:70253)

DOI: <https://doi.org/10.2196/preprints.70253>

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**

Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.

Only make the preprint title and abstract visible.

No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**

Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain visible to all users.

Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <http://www.jmir.org/>

No. Please do not make my accepted manuscript PDF available to anyone. I understand that if I later pay to participate in <https://www.jmir.org/>

Original Manuscript

Digital Safety Plan Activation Reduces Subsequent Emergency Departments Visits Following an Initial Suicide Attempt

María Luisa Barrigón^{1,2}, Carlos Schmidt^{*,3}, Matilde Elices^{*2,3}, Alejandro Porras-Segovia⁴, Ana María de Granda-Beltrán⁵, Antonio Artés-Rodríguez^{2,6,7,8}, Philippe Courtet⁹, Víctor Pérez-Sola^{2,3,10}, Enrique Baca García^{2,4,5,9,11,12,13}.

*Carlos Schmidt and Matilde Elices share the corresponding author position equally. Correspondence to: Carlos Schmidt (cschmidt@researchmar.net) or Matilde Elices (melices@researchmar.net), Dr. Aiguader 88, 08003, Barcelona, Spain.

¹Institute of Psychiatry and Mental Health, Hospital General Universitario Gregorio Marañón, IISGM, School of Medicine, Universidad Complutense, Madrid, Spain.

² Centro de Investigación Biomédica en Red (CIBERSAM), Madrid, Spain.

³ Hospital del Mar Research Institute (IMIM), Barcelona, Spain.

⁴ Fundacion Jiménez Díaz Health Research Institute, Madrid, Spain; Department of Psychiatry, Rey Juan Carlos Hospital Móstoles, Madrid, Spain.

⁵ Department of Psychiatry, Fundacion Jiménez Díaz University Hospital, Madrid, Spain.

⁶ Department of Signal Theory and Communications, Universidad Carlos III de Madrid, Leganés, Madrid, Spain.

⁷ Evidence-Based Behavior (eB2), Madrid, Spain.

⁸ Instituto de Investigación Sanitaria Gregorio Marañón, Madrid, Spain.

⁹ Department of Emergency Psychiatry and Acute Care, Centre Hospitalier Universitaire Montpellier, University of Montpellier, Montpellier, France.

¹⁰ Universidad Pompeu Fabra (UPF), Barcelona, Spain.

¹¹ Departamento de Psiquiatría, Universidad Autónoma de Madrid, Spain.

¹² Departamento de Psiquiatría, Hospital Central de Villalba Villalba, Madrid, Spain.

¹³ Departamento de Psiquiatría, Hospital Universitario Infanta Elena Valdemoro, Madrid, Spain.

Abstract

Background: Suicide is a significant global public health concern. Individuals with suicidal behaviors often seek help in emergency departments (ED), making

mental health providers critical in suicide prevention. Brief interventions, such as safety planning, are essential in these settings. However, there is a limited understanding of how mobile digital safety planning apps can aid in secondary suicide prevention.

Objective: This study evaluated the effectiveness of a digital safety plan, delivered through the Memind app, in reducing ED visits associated with suicidal behavior (i.e., suicidal ideation or attempt).

Methods: A one-year follow-up was conducted on individuals who presented to the ED for an index event related to suicidal behavior ($n = 78$). Participants were provided with a digital safety plan on their mobile devices and instructed to activate it during future suicidal crises.

Results: At follow-up, participants who chose to activate the digital safety plan showed a 50% lower likelihood of returning to ED, when compared to those who did not activate the safety plan. These findings suggest that digital safety planning may be a scalable and accessible intervention with the potential to significantly contribute to suicide prevention efforts.

KEYWORDS

suicide prevention; digital safety plan; brief interventions; emergency department

Introduction

Suicidal behavior is a complex and multifactorial phenomenon that constitutes a public health concern. The World Health Organization estimates that over 700,000 individuals die by suicide annually, with data suggesting that there are more than 20 attempted suicides for each suicide death [1,2]. Globally, suicide rate is estimated at 9.4 per 100,000 people, particularly among those aged 15 to 34, with a higher prevalence in males than females [3]. In Spain, the estimated suicide rate is 8.4 per 100,000 people, representing the second

leading cause of non-natural death by external causes, with approximately 11 suicides occurring daily [4].

The consequences of suicidal behavior have a significant impact on individuals, families, and society, emphasizing the urgent need for health systems to prioritize prevention and implement effective strategies [5]. However, there remains a need to enhance the effectiveness of current suicide interventions, particularly for individuals presenting to emergency departments (ED) and those hospitalized due to suicidal ideation or behaviors, who exhibit a high risk of re-attempt within the initial months' post-discharge [6]. This increased risk of re-attempt is further amplified when individuals have a history of suicide attempts and a diagnosed psychiatric disorder [7].

Studies indicate that face-to-face psychological interventions are effective in reducing suicidal behavior compared to treatment-as-usual. However, the anticipated outcomes are primarily observed in intensive and long-term intervention approaches [8]. Conversely, there is a growing interest in digital and brief interventions for managing suicidal behavior, driven by their cost-effectiveness and particularly relevant when immediate access to mental health care is limited [9]. Brief interventions, administered in acute care settings by trained professionals, aim to provide tools for managing suicidal crises and reduce suicide risk, and have demonstrated effectiveness in reducing subsequent suicide attempts [10].

Among brief interventions for suicide prevention, Safety Planning Intervention (SPI) is commonly used [11]. SPI is a brief therapeutic practice, typically lasting 20-45 minutes, aimed at reducing the imminent risk of suicidal behavior. This is accomplished through a collaborative process between clinicians and clients, where a personalized plan is developed. This plan guides individuals to identify their thoughts, feelings, and experiences immediately preceding a crisis, as well as establishing coping strategies and support resources to activate upon the recurrence of suicidal thoughts. SPI includes personal warning signs, strategies for self-management, social supports, emergency contacts, reasons for living and measures to restrict access to lethal means [12]. Systematic reviews support the effectiveness of traditional SPI in reducing suicidal behaviors [11,13,14] with studies showing that SPI can decrease suicidal behaviors by up

to 45% [15].

Safety planning is framed within a participatory care model, which emphasizes active collaboration between clinicians and patients to co-design personalized strategies for managing suicidal crises. This model fosters patient empowerment, shared decision-making, and tailored interventions, and enhances patient satisfaction, improves treatment adherence and reduces costs [16]. The participatory care model has been effectively applied in several suicide-specific interventions [17].

Despite the potential benefits of safety planning in reducing suicidal behavior, limited information exists regarding its usability outside of treatment settings. For example, it has been observed that individuals seeking help for suicide-related concerns are largely unaware of what a safety plan is and have not incorporated it into their treatment plans [18]. Additional barriers related to safety plan usage include its implementation in the presence of depressive mood, particularly when collaborative development of the safety plan with the referring clinician is not perceived [19]. Furthermore, as traditional SPIs are often completed on paper, access barriers may arise during crisis situations due to difficulties in retrieving the information.

Digital Safety Planning (DSP) via mobile-app presents a viable alternative to overcome these limitations, enhancing immediate and ubiquitous accessibility through personal mobile devices, and offering a more dynamic and accessible platform. Through such apps, functions can be incorporated to enable access to videos, photos, import of significant contacts, or location-based access to emergency services [20]. For instance, within DSP strategies, individuals can integrate family photos or directly access contact information for significant others or healthcare professionals/centers, potentially triggering coping strategies related to suicide more directly and effectively. These strategies embody a participatory care model, actively engaging patients in their treatment [21]. Moreover, the utilization of Ecological Momentary Interventions (EMIs) through mobile applications facilitates real-time monitoring and usability tracking of the DSP [22]. This data collection can provide insights into who uses the safety plan, when, and which strategies are most beneficial.

Previous studies have shown that mobile-app based safety plans demonstrate

high acceptability and feasibility, although evidence regarding the effectiveness of DSP is still limited [20]. In fact, to date, few studies have evaluated the effectiveness of a digital safety plan. Two pilot studies found that the use of a DSP reduced suicidal ideation [23,24]. A subsequent study with a larger sample found that the use of a DSP increased suicide-related coping, which was associated with a reduction in suicidal ideation, and that greater perceived utility of the DSP (e.g., customizable content) was associated with higher suicide-related coping [25]. However, the follow-up period in these studies was limited to three months, thereby precluding an evaluation of the long-term efficacy of digital safety plans and whether their usage translates to a reduction in ED visits for recurrent suicidal behavior.

In this study, a one-year follow-up was conducted on individuals who presented to ED after a suicidal behavior (i.e., suicidal ideation or attempt). Participants were provided with a DSP on their mobile devices and instructed to activate it during future suicidal crises. The study aimed to assess whether activating the DSP reduced subsequent ED visits associated with suicidal behavior.

Methods

A quasi-experimental design and an EMI were employed to monitor the use and activation of a DSP through the Memind app [26].

Participants

The data were collected in the ED of two hospitals in Madrid, Spain, between September 2022 and August 2023. Participants were adults (18 years of age or older) presenting to the ED for suicidal behavior were included. Suicidal behavior was defined as any action or self-injurious act with the intent to die, encompassing both suicidal ideation and/or suicide attempts. Once potential participants received standard emergency care and were deemed medically stable, they were offered the opportunity to participate in the study prior to discharge. Those who consented to participate met with a psychiatrist for 30-40 minutes to receive a detailed explanation of the study, install the study app on their smartphones, and complete the DSP. The inclusion criteria were: (i) having visited the ED for suicidal behavior; (ii) owning a smartphone with internet

connection; (ii) speaking and understanding Spanish; and (iv) being able to give informed consent. Exclusion criteria included unwillingness to install the app or limited smartphone access. The study was approved by the Research Ethics Committee of the Fundacion Jimenez Diaz Hospital (Ref: EC005-21_FJD).

Measures

Digital Safety Plan

Participants received access to a DSP for suicidal crises through the Memind app [26] (Figure 1). Memind is designed to be compatible with Android and iOS operating systems and can be downloaded for free from the Apple App Store and Google Play. After installation, they collaborated with psychiatrists to configure the plan, which included seven customizable tabs (i.e., warning signs, internal and external coping strategies, personal and professional contacts, safe environments and reasons to live). The app, validated in prior studies, demonstrated good feasibility and acceptability [27]. Participants were instructed to activate the plan during subsequent suicidal crises. Data on DSP configuration and activation were collected during a one-year follow-up. Specifically, the frequency of DSP configuration and activation of each of the seven incorporated tabs or functions was recorded. Configuration allowed participants to use the "Configure Safety Plan" feature, enabling them to review or add new information to each tab or function outside of crisis periods. Activation involved participants using an in-app feature labeled "Activate Safety Plan," which provided access to the information within the seven previously configured tabs or functions, aimed at implementing coping strategies during suicidal crises. Participants were encouraged to configure the DSP as needed and to activate it during crises triggered by the onset of suicidal behavior.

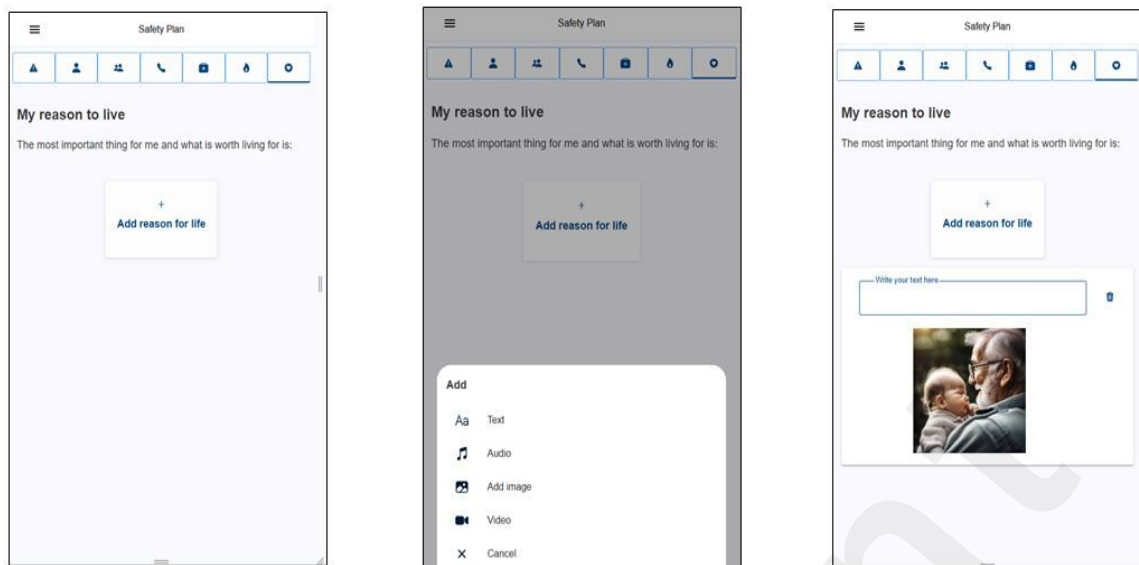


Figure 1. Example of Memind app Safety Plan configuration

Suicidal Behavior

Baseline assessments used the Spanish version of the Columbia Suicide Severity Rating Scale (C-SSRS) [28]. The C-SSRS is a semi-structured interview that evaluates the occurrence, severity, and frequency of suicidal ideation and behavior [29]. Information regarding the severity of ideation (most severe ideation, intensity, frequency, duration, controllability) and the previous history of suicide attempts was collected.

Statistical analyses

A Cox proportional hazards model with random effects was used to investigate the association between DSP activation and subsequent ED visits for suicidal behavior (i.e., suicidal ideation or attempt) during one-year follow-up. The outcome variable was ED visits for suicidal behavior (yes vs. no), with time measured in days over a 365-day follow-up period. The primary predictor variable was DSP activation (yes vs. no). Specifically, the analysis assessed whether participants who activated the safety plan during the follow-up period experienced fewer ED visits for suicidal behavior compared to those who did not (i.e., quasi-control group). Age and sex were included as covariates. Random effects were specified for each participant, with participant ID and days of DSP use (i.e., configuration or activation) included as random intercepts. Analyses

were conducted using the "survival" and "coxme" packages [30,31] in RStudio [32].

Results

	Total sample (n = 78)
Age , mean (SD)	39.08 (13.45)
Sex , female, n (%)	56 (71.8)
Emergency department visits , n (%)	
only 1 (index event)	54 (69.2)
2 or more	24 (30.8)
Suicidality (CSSRS)	
Suicidal Ideation (SI, yes), n (%)	72 (90)
Intensity SI, mean (SD)	4.10 (1.03), range 1-5
Frequency SI, mean (SD)	2.67 (1.24), range 1-5
Duration SI, mean (SD)	3.19 (1.37), range 1-5
Controllability SI, mean (SD)	3.18 (1.47), range 0-5
Previous Suicidal attempts (SA, yes), n (%)	63 (80.7)

A total of 78 participants were included in the study, with a mean age of 39 years and most being female. According to the baseline suicidal behavior characteristics (CSSRS), 72

participants (90%) exhibited suicidal ideation with high-intensity, and 63 participants (80%) reported prior suicide attempts (Table 1). Across a one-year follow-up, 24 participants (30.8%) returned to ED services for suicidal behavior (i.e., suicidal ideation or attempt).

Table 1. Baseline sociodemographic characteristics of the total sample

Notes. SD = Standard deviation; CSSRS = Columbia Suicide Severity Rating Scale; SI = suicidal ideation; Intensity SI = severity of ideation, with (1) being the least severe and (5) being the most severe; Frequency SI = "How often have you had these thoughts?", ranging from (1) less than once a week to (5) many times a day; Duration SI = "When you have those thoughts, how long do they last?" ranging from (1) fleeting/a few seconds or minutes to (5) more than 8 hours/persistent or continuous; Controllability SI = "Could/can you stop thinking about killing yourself or wanting to die if you want to?" ranging from (1) You can control the thoughts easily to (5) You cannot control the thoughts, or (0) You do not try to control the thoughts; SA = suicidal attempts.

Subsequently, the frequency of ED returns and DSP usability in participants during the follow-up period was explored. 2.768 observations on the usage frequency of the digital safety plan were collected. From the overall participants enrolled, 31 (40%) activated the DSP throughout the follow-up period.

Given the non-normal distribution and positive skew of these variables, we reported the median, interquartile range (IQR), and 90th percentile (P90). The median time to ED return within the one-year follow-up, post-index event, was 55 days, with a higher frequency observed within the first 60 days, followed by a more uniform distribution throughout the remaining year (Figure 2a; range = 1-359 days, IQR = 211 days, P90 = 301 days). Regarding overall DSP usage (excluding the initial app installation and collaborative safety plan configuration with the psychiatrist), the median usage occurred at 14 days (Figure 2b; range = 2-359 days, IQR = 201 days, P90 = 105 days). When examining the frequency of DSP configuration (i.e., personalizing the safety plan), the median usage was at 11 days, with a decreased frequency throughout the rest of the year (Figure 2c; range = 2-359 days, IQR = 28 days, P90 = 107 days). For the frequency of DSP activation (i.e., accessing the safety plan during crisis moments), the median usage was at 15 days, with a stable frequency in the first 90 days and a significantly reduced frequency in the remaining follow-up period (Figure 2d; range = 2-260 days, IQR = 67 days, P90 = 112 days). Overall, 90% of participants returned to the ED due to suicidal behavior within 300 days, while 90% of DSP configurations and activations occurred within the first 100 days of follow-up.

When examining the usage frequency of the DSP configuration, External coping strategies (23.30%), Professional ask for help (21.10%), and Warning signals (15%) were the most frequently accessed functions, followed by Personal contacts (12.10%) and Internal coping strategies (11.40%). Creating a safe environment (9.10%) and Reasons to live (8%) were utilized less often. When exploring the frequency of DSP activation, the most frequently activated sections were External coping strategies (22.90%), Warning signals (20.85%), Professional ask for help (19.48%), Internal coping strategies (12.30%) and Personal contacts (10.42%). Creating a safe environment (7.69%) and Reasons to live (6.32%) were less utilized. No significant differences were found between those who activated the digital safety plan and those who did not, according to age, sex, suicidal behavior characteristics or severity of suicidal ideation (all P -values $> .28$).

In general, while all safety plan function or sections were used, we observed a usage pattern that corresponded with the app's interface tab sequence. Specifically, the functions Creating a safe environment and Reasons to live, which were positioned at the end of the app's interface, were the least frequently used. This suggests that the arrangement of the functions influences the usability of the DSP configuration and activation.

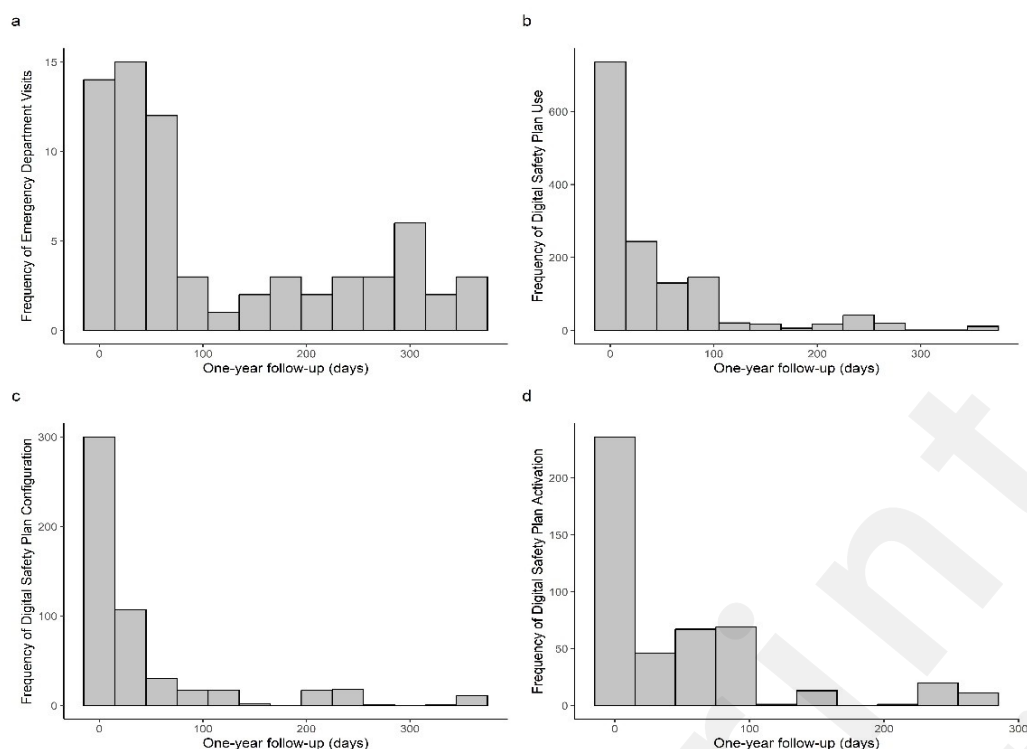


Figure 2. Frequency of emergency department returns due to suicidal behavior (a). Frequency of total digital safety plan usage (b), configuration (c), and activation (d) during follow-up.

Association between DSP use and subsequent emergency department visits

Participants who activated the DSP had a lower frequency of ED visits compared to those who did not activate the plan (16.6% vs. 29.1%; $\chi^2 = 37.48$, $P > .001$). Subsequent analyses examined the predictive utility of DSP activation for ED visits over a one-year follow-up period. Using the "coxme" function, we identified the best-fitting model with participant ID and days of safety plan use as random effects. Receiver operating characteristic (ROC) analysis demonstrated good discriminatory capacity of the model (AUC = .82) in predicting ED visits for suicidal behavior based on DSP activation (Figure 3).

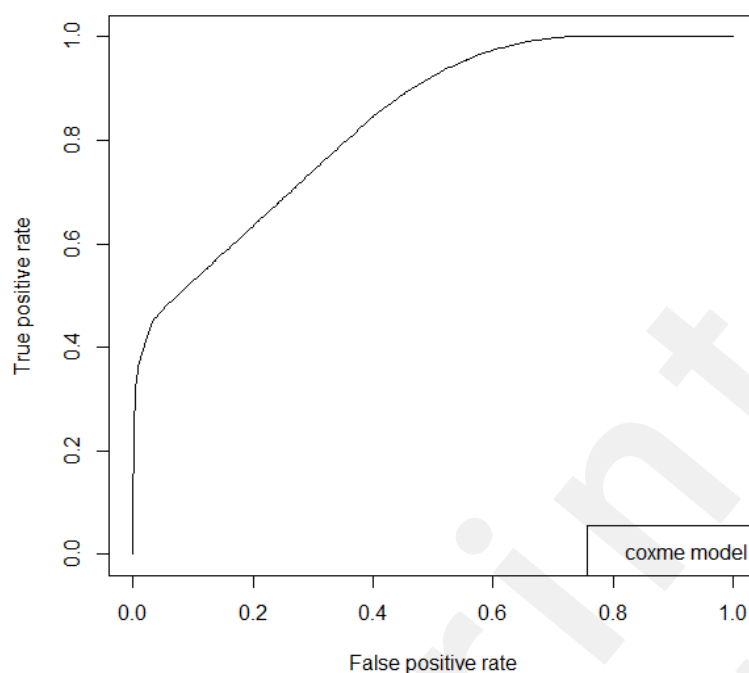


Figure 3. ROC curve for survival model

A Cox proportional hazards model, adjusted for participant demographics, revealed a significant association between DSP activation and a reduced likelihood of subsequent ED visits. Participants who activated the safety plan had a 50% lower likelihood of returning to the ED for suicidal behavior (i.e., suicidal ideation or attempt) compared to those who did not (Figure 4). Furthermore, male participants and those aged 30 and above showed a reduced likelihood of returning for subsequent ED visits (Table 2). These results suggest that engaging in the digital safety plan, and consequently accessing pre-configured suicide-related coping strategies within the app, may enable individuals to effectively manage suicidal thoughts and prevent escalation during a suicidal crisis, potentially diminishing the frequency of ED readmissions. Additionally, sex and age are important clinical considerations in predicting ED readmissions for suicidality.

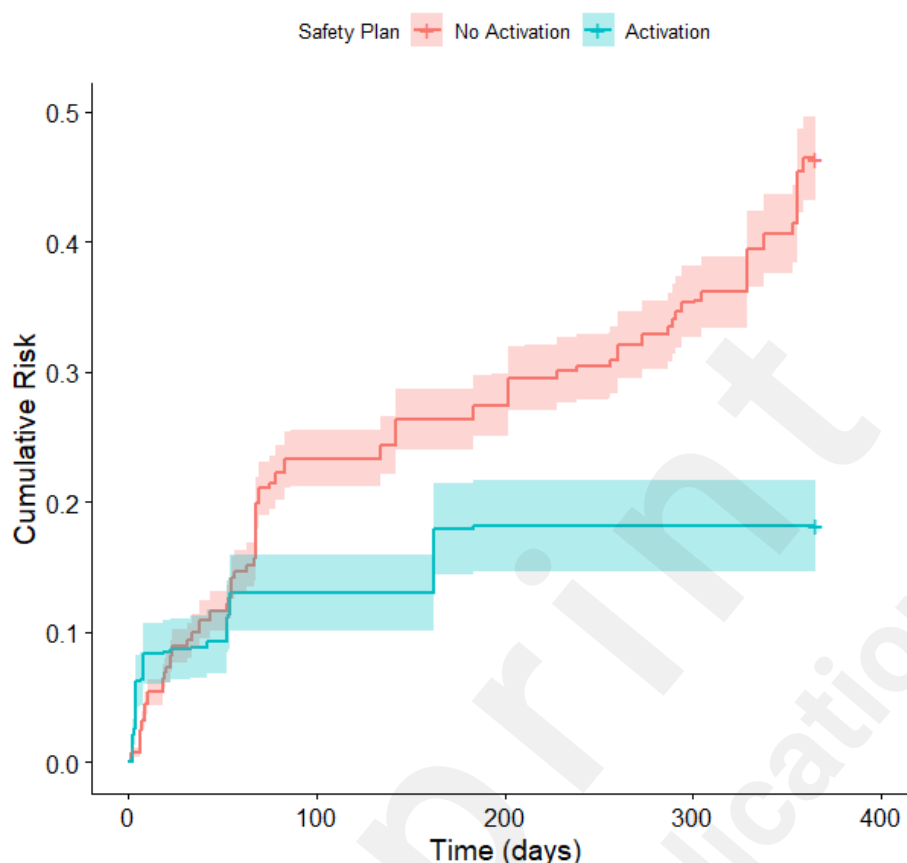


Figure 4. Cumulative risk of emergency department visits for suicidal behavior based on digital safety plan activation

Table 2. Association between digital safety plan activation and emergency department visits

Predictors	B (SE)	HR (95% CI)	P-value
Safety Plan Activation (ref:			
No)	-.68 (.19)	.50 (.34-.73)	< .001
Yes			
Sex (ref: female)			
Male	-.53 (.26)	.58 (.34-.97)	.03
Age (ref: 18-29 years)			
30-49 years	-.71 (.26)	.49 (.29-.81)	.006
50 and over	-2.01 (.32)	.13 (.07-.25)	< .001

Note. HR = hazards ratio; CI = confidence interval.

Discussion

Principal results

Prior studies have established the relevance of safety plan use in preventing or managing suicidal crises. However, to date, the effectiveness of a mobile DSP in

reducing ED visits for suicidal behavior has not been evaluated. This study found that participants who chose to activate a DSP showed a 50% reduction in the likelihood of subsequent suicide-related ED visits, compared to those who did not activate the DSP.

Additionally, male participants and those aged 30 and older were less likely to return to emergency services for suicidal behavior during the one-year follow-up after an index event, when compared to female and younger participants. Generally, men are less inclined to seek assistance for suicide-related issues, even though they employ more hazardous methods and exhibit elevated fatal-suicide rates worldwide [3] including in European countries [33]. Nonetheless, there was no observed association between DSP activation and participants' sex, age, or severity of suicidal ideation.

Our analysis also revealed that 30.8% of participants returned to the ED due to suicidal behavior following the index event, predominantly within the first 60 days. The initial three-months post-discharge represent a period of heightened risk for re-attempt, thus highlighting the relevance of prevention and follow-up during this phase [6]. Similarly, the highest frequency of DSP activation was concentrated within the first weeks, with a median of 15 days. Consequently, DSP usage was brief and closely associated with the index event. Prior research has indicated that the usability of DSP is sporadic and concentrated in the early follow-up weeks [25]. Safety plans are designed for use during suicidal crises [12], and therefore, it is expected that users will only utilize them when deemed necessary, and during the onset of suicidal thoughts.

The most activated sections of DSP were "warning signs", "external coping strategies", and "professional contacts". In contrast, less utilized sections included "reasons to live", "safe environments", "personal contacts", and "internal coping strategies". This suggests a potential preference for seeking external support during a suicidal behavior, such as contacting professionals, rather than relying solely on internal resources. This observation is consistent with findings that social support serves as a protective factor against suicidal behavior [34], particularly for individuals with a history of suicide attempts [35]. It is also possible that during periods of intense or severe suicidal ideation, internal coping strategies become more difficult to activate and manage

independently, while external suicide-related coping becomes more readily accessible [36]. Additionally, the design and interface of DSP app may impact which features are prioritized by users. For example, the interface's tab order, with 'warning signs' positioned first and 'reasons to live' last, may impact usability. Future research should further explore the usability of the app and which sections are most useful to users. Some of these improvements could include in-app digital scales on satisfaction with app use and the perceived effectiveness of the functions included in the DSP.

The findings of this study have important clinical and practical implications. The observed association between DSP activation and reduced ED readmission for suicidal behavior underscores the potential of DSPs in secondary suicide prevention. Integrating such tools into routine post-suicide attempt care could provide an accessible, scalable, and potentially cost-effective intervention to mitigate future crises. Moreover, DSP offer an ecologically valid approach by enabling real-time usage monitoring and empowering individuals with digital tools and suicide-related coping strategies to manage future suicidal crises [25].

Digital mental health interventions have the potential to leverage technology to increase user engagement in suicide prevention and ensure continuity of treatment between emergency/hospital services and outpatient care [37]. Furthermore, digital interventions could be cost-effective, given their promising cost-benefit in suicide prevention within the framework of current mental health interventions, which could argue for increased public health policy investment in digital strategies [38,39]. In particular, DSPs for suicide prevention present a compelling alternative to traditional methods, offering enhanced usability and reduced access barriers. These plans can integrate multimedia elements, such as personal photos, prerecorded messages, relaxation videos, and links to health resources [20]. Their immediate availability, customizable nature, and dynamic functionality, which allows for real-time updates, further distinguish them [27].

However, despite these advantages, the practical usability of DSP outside clinical environments remains under-explored. Enhancing accessibility and monitoring utilization are crucial for understanding their preventive impact. Research indicates that many individuals seeking suicide-related support are

unfamiliar with safety plans or lack them in their treatments [18]. Furthermore, depressive moods and perceived lack of collaborative planning with clinicians may hinder their effective use [19]. Future studies should prioritize the sustainability of these tools, focusing on identifying usage barriers and implementing user-driven improvements through rigorous follow-up. Integrating specialized telephone follow-ups could also provide timely support and reinforce user engagement by offering guidance on coping strategies [15].

Limitations

First, the generalizability of our findings is limited by the small sample size, which was largely composed of women and did not include adolescents. Second, we lacked detailed data on the usage time of each DSP functions and its perceived utility. This data could provide valuable insights into which specific functions, or their combinations, are associated with the reduction of suicidal ideation and ED visits. Third, we did not collect information on participants who did not use or activate the DSP. Understanding the reasons why some individuals did not engage in its use (e.g., due to perceived lack of need, usefulness, or technological barriers) would be valuable. Fourth, the absence of a control group limited our ability to directly compare the efficacy of digital versus traditional safety plan in suicide prevention. Finally, the data on the features of suicidal behavior were based on baseline and self-reported measures. Future research could enhance this by incorporating real-time, in-app monitoring of suicidal ideation (e.g., intensity and duration) and correlating it with DSP utilization.

Conclusions

To our knowledge, this study is the first to demonstrate that activating a DSP can reduce the likelihood of repeat suicide-related ED visits by 50%. While these results do not directly demonstrate a decrease in suicidal behavior among participants, the reduction in ED visits following an index suicidal event suggests that individuals may find supportive elements to manage a crisis by readily accessing suicide-related coping strategies through the activation of DSP. This suggests that DSP may offer a valuable resource, as a complement to interventions delivered in the ED. Future research should investigate the

dynamics of DSP use among participants, focusing on which functions (i.e., tabs) are most utilized and their specific association with reduced suicidal behavior and ED visits.

Acknowledgments

This research was supported by CIBER -Consortio Centro de Investigación Biomédica en Red- (CB/07/09/0025), the Instituto de Salud Carlos III with the support of the European Regional Development Fund (ISCIII PI23/00614; PMP24/00026), by Fundació La Marató de TV3 (202226-31) and by CaixaResearch Health 2023 LCF/PR/HR23/52430033.

Conflicts of Interest

EBG designed the MEmind application. The rest of authors declare no financial or non-financial competing interests.

Data availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Author contributions

M.L.B. Managed the data acquisition, drafted and edited the manuscript; C.S Analyzed the data and drafted the initial manuscript. M.E. Drafted and edited the manuscript; A.P-S. Supported the statistical analysis, edited and reviewed the manuscript. A.M.G-B Contributed to manuscript writing and data interpretation. A.A-R. Supported the statistical analysis and edited the

manuscript. P.C. Edited and reviewed the manuscript. V.P.S. Edited and reviewed the manuscript; E.G.B. Designed the study, managed the project and obtained funding, edited and reviewed the manuscript. All authors reviewed and approved the final version of the manuscript.

References

1. World Health Organization. *Suicide worldwide in 2019: global health estimates*. Geneva: World Health Organization; 2021. Accessed September 25, 2024. License: CC BY-NC-SA 3.0 IGO.
2. World Health Organization. Preventing suicide: a global imperative. Geneva: World Health Organization; 2014. Accessed September 25, 2024.
3. Knapik D, Padmanathan P, Newton-Howes G, Chan LF, Kapur N. Suicide and self-harm. *Lancet*. 2022;399(10338):1903-1916. doi:10.1016/S0140-6736(22)00173-8
4. Plataforma Nacional para el Estudio y la Prevención del Suicidio. *The National Statistics Institute releases suicide mortality data for 2023 in Spain: the crude mortality rate stands at 8.5 per 100,000 inhabitants*. Plataforma Nacional para el Estudio y la Prevención del Suicidio; 17 de diciembre de 2024. Recuperado de: <https://www.plataformanacionalsuicidio.es/news/the-national-statistics-institute-releases-suicide-mortality-data-for-2023-in-spain-the-crude-mortality-rate-stands-at-85-per-100000-inhabitants>.
5. Zalsman G, Hawton K, Wasserman D, et al. Suicide prevention strategies revisited: 10-year systematic review. *Lancet Psychiatry*. 2016;3(7):646-659. doi:10.1016/S2215-0366(16)30030-X
6. Chung DT, Ryan CJ, Hadzi-Pavlovic D, Singh SP, Stanton C, Large MM. Suicide Rates After Discharge From Psychiatric Facilities: A Systematic Review and Meta-analysis. *JAMA Psychiatry*. 2017;74(7):694-702. doi:10.1001/jamapsychiatry.2017.1044
7. de la Torre-Luque A, Pemau A, Ayad-Ahmed W, et al. Risk of suicide attempt repetition after an index attempt: A systematic review and meta-analysis. *Gen Hosp Psychiatry*. 2023;81:51-56. doi:10.1016/j.genhosppsych.2023.01.007
8. Witt KG, Hetrick SE, Rajaram G, et al. Interventions for self-harm in children and adolescents. *Cochrane Database Syst Rev*.

- 2021;3(3):CD013667. Published 2021 Mar 7.
doi:10.1002/14651858.CD013667.pub2
9. Gega L, Jankovic D, Saramago P, et al. Digital interventions in mental health: evidence syntheses and economic modelling. *Health Technol Assess.* 2022;26(1):1-182. doi:10.3310/RCTI6942
 10. Doupnik SK, Rudd B, Schmutte T, et al. Association of Suicide Prevention Interventions With Subsequent Suicide Attempts, Linkage to Follow-up Care, and Depression Symptoms for Acute Care Settings: A Systematic Review and Meta-analysis. *JAMA Psychiatry.* 2020;77(10):1021-1030. doi:10.1001/jamapsychiatry.2020.1586
 11. Ferguson M, Rhodes K, Loughhead M, McIntyre H, Procter N. The Effectiveness of the Safety Planning Intervention for Adults Experiencing Suicide-Related Distress: A Systematic Review. *Arch Suicide Res.* 2022;26(3):1022-1045. doi:10.1080/13811118.2021.1915217
 12. Stanley B, Brown GK. Safety planning intervention: a brief intervention to mitigate suicide risk. *Cogn Behav Pract.* 2012;19(2):256-264. doi:10.1016/j.cbpra.2011.01.001
 13. Doupnik SK, Rudd B, Schmutte T, et al. Association of Suicide Prevention Interventions With Subsequent Suicide Attempts, Linkage to Follow-up Care, and Depression Symptoms for Acute Care Settings: A Systematic Review and Meta-analysis. *JAMA Psychiatry.* 2020;77(10):1021-1030. doi:10.1001/jamapsychiatry.2020.1586
 14. Nuij C, van Ballegooijen W, de Beurs D, et al. Safety planning-type interventions for suicide prevention: meta-analysis. *Br J Psychiatry.* 2021;219(2):419-426. doi:10.1192/bjp.2021.50
 15. Stanley B, Brown GK, Brenner LA, et al. Comparison of the Safety Planning Intervention With Follow-up vs Usual Care of Suicidal Patients Treated in the Emergency Department. *JAMA Psychiatry.* 2018;75(9):894-900. doi:10.1001/jamapsychiatry.2018.1776
 16. Palmer VJ. The Participatory Zeitgeist in Health Care: It is Time for a Science of Participation. *J Particip Med.* 2020;12(1):e15101. Published 2020 Jan 10. doi:10.2196/15101
 17. Ko W, Jeong H, Yim HW, Lee SY. Collaborative care interventions to reduce suicidal behavior among patients with depression or at risk of suicide in primary-care settings: A systematic review and meta-analysis. *J Affect Disord.* 2025;374:141-149. doi:10.1016/j.jad.2025.01.012
 18. Rainbow C, Tatnell R, Blashki G, Melvin GA. Safety plan use and suicide-related coping in a sample of Australian online help-seekers. *J Affect Disord.* 2024;356:492-498. doi:10.1016/j.jad.2024.04.053
 19. Kayman DJ, Goldstein MF, Dixon L, Goodman M. Perspectives of Suicidal Veterans on Safety Planning: Findings From a Pilot Study. *Crisis.* 2015;36(5):371-383. doi:10.1027/0227-5910/a000348
 20. Jiménez-Muñoz L, Peñuelas-Calvo I, Díaz-Oliván I, Gutiérrez-Rojas L, Baca-

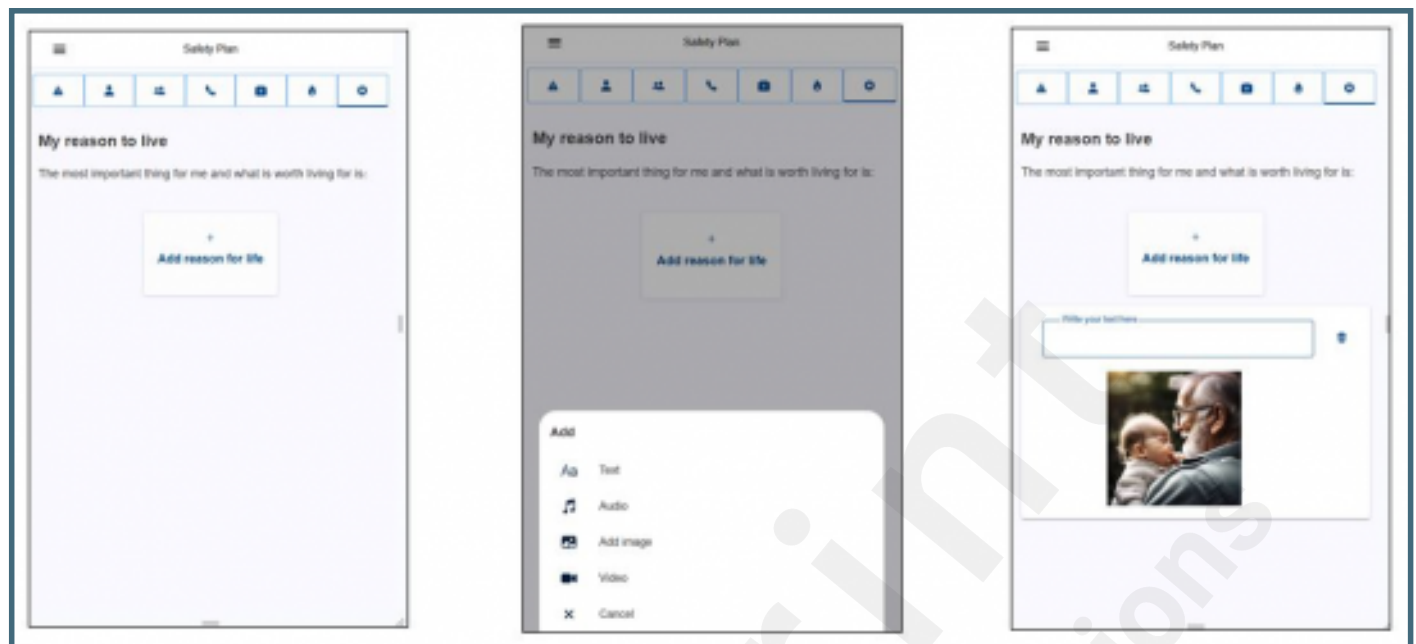
- García E, Porras-Segovia A. Suicide Prevention in Your Pocket: A Systematic Review of Ecological Momentary Interventions for the Management of Suicidal Thoughts and Behaviors. *Harv Rev Psychiatry*. 2022;30(2):85-99. doi:10.1097/HRP.0000000000000331
21. Berrouiguet S, Courtet P, Larsen ME, Walter M, Vaiva G. Suicide prevention: Towards integrative, innovative and individualized brief contact interventions. *Eur Psychiatry*. 2018;47:25-26. doi:10.1016/j.eurpsy.2017.09.006
 22. Barrigón ML, Porras-Segovia A, Courtet P, et al. Smartphone-based Ecological Momentary Intervention for secondary prevention of suicidal thoughts and behaviour: protocol for the SmartCrisis V.2.0 randomised clinical trial. *BMJ Open*. 2022;12(9):e051807. Published 2022 Sep 20. doi:10.1136/bmjopen-2021-051807
 23. Melvin GA, Gresham D, Beaton S, et al. Evaluating the Feasibility and Effectiveness of an Australian Safety Planning Smartphone Application: A Pilot Study Within a Tertiary Mental Health Service. *Suicide Life Threat Behav*. 2019;49(3):846-858. doi:10.1111/sltb.12490
 24. Dimeff LA, Jobes DA, Koerner K, et al. Using a Tablet-Based App to Deliver Evidence-Based Practices for Suicidal Patients in the Emergency Department: Pilot Randomized Controlled Trial. *JMIR Ment Health*. 2021;8(3):e23022. Published 2021 Mar 1. doi:10.2196/23022
 25. Rainbow C, Tatnell R, Blashki G, Fuller-Tyszkiewicz M, Melvin GA. Digital safety plan effectiveness and use: Findings from a three-month longitudinal study. *Psychiatry Res*. 2024;333:115748. doi:10.1016/j.psychres.2024.115748
 26. Barrigón ML, Berrouiguet S, Carballo JJ, et al. User profiles of an electronic mental health tool for ecological momentary assessment: MEmind. *Int J Methods Psychiatr Res*. 2017;26(1). doi:10.1002/mpr.1554
 27. Porras-Segovia A, De Granda-Beltrán AM, Gallardo C, et al. Smartphone-based safety plan for suicidal crisis: The SmartCrisis 2.0 pilot study. *J Psychiatr Res*. 2024;169:284-291. doi:10.1016/j.jpsychires.2023.11.039
 28. Al-Halabí S, Sáiz PA, Burón P, et al. Validation of a Spanish version of the Columbia-Suicide Severity Rating Scale (C-SSRS). Validación de la versión en español de la Columbia-Suicide Severity Rating Scale (Escala Columbia para Evaluar el Riesgo de Suicidio). *Rev Psiquiatr Salud Ment*. 2016;9(3):134-142. doi:10.1016/j.rpsm.2016.02.002
 29. Posner K, Brown GK, Stanley B, et al. The Columbia-Suicide Severity Rating Scale: initial validity and internal consistency findings from three multisite studies with adolescents and adults. *Am J Psychiatry*. 2011;168(12):1266-1277. doi:10.1176/appi.ajp.2011.10111704
 30. Therneau TM. A Package for Survival Analysis in R. Accessed October 05, 2024. <https://CRAN.R-project.org/package=survival>
 31. Therneau TM. coxme: Mixed Effects Cox Models. R package version 2.2-22.

- Accessed October 05, 2024. <https://CRAN.R-project.org/package=coxme>
32. R Core Team. *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing; 2017. <http://www.R-project.org/>
 33. Eurostat. Suicide - causes of death statistics. Eurostat. Updated September 20, 2023. Accessed from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Suicide_statistics_-_causes_of_death.
 34. Kleiman EM, Liu RT. Social support as a protective factor in suicide: findings from two nationally representative samples. *J Affect Disord*. 2013;150(2):540-545. doi:10.1016/j.jad.2013.01.033
 35. Coppersmith DDL, Kleiman EM, Glenn CR, Millner AJ, Nock MK. The dynamics of social support among suicide attempters: A smartphone-based daily diary study. *Behav Res Ther*. 2019;120:103348. doi:10.1016/j.brat.2018.11.016
 36. Stanley B, Green KL, Ghahramanlou-Holloway M, Brenner LA, Brown GK. The construct and measurement of suicide-related coping. *Psychiatry Res*. 2017;258:189-193. doi:10.1016/j.psychres.2017.08.008
 37. Park SY, Nicksic Sigmon C, Boeldt D. A Framework for the Implementation of Digital Mental Health Interventions: The Importance of Feasibility and Acceptability Research. *Cureus*. 2022;14(9):e29329. Published 2022 Sep 19. doi:10.7759/cureus.29329
 38. Torok M, Han J, Baker S, et al. Suicide prevention using self-guided digital interventions: a systematic review and meta-analysis of randomised controlled trials. *Lancet Digit Health*. 2020;2(1):e25-e36. doi:10.1016/S2589-7500(19)30199-2
 39. Morrish N, Stallard P, Whittle K, et al. Cost-effectiveness of adding a smartphone app (BlueIce) to the mental health care of adolescents who repeatedly self-harm. *Psychiatry Res*. 2024;342:116186. doi:10.1016/j.psychres.2024.116186

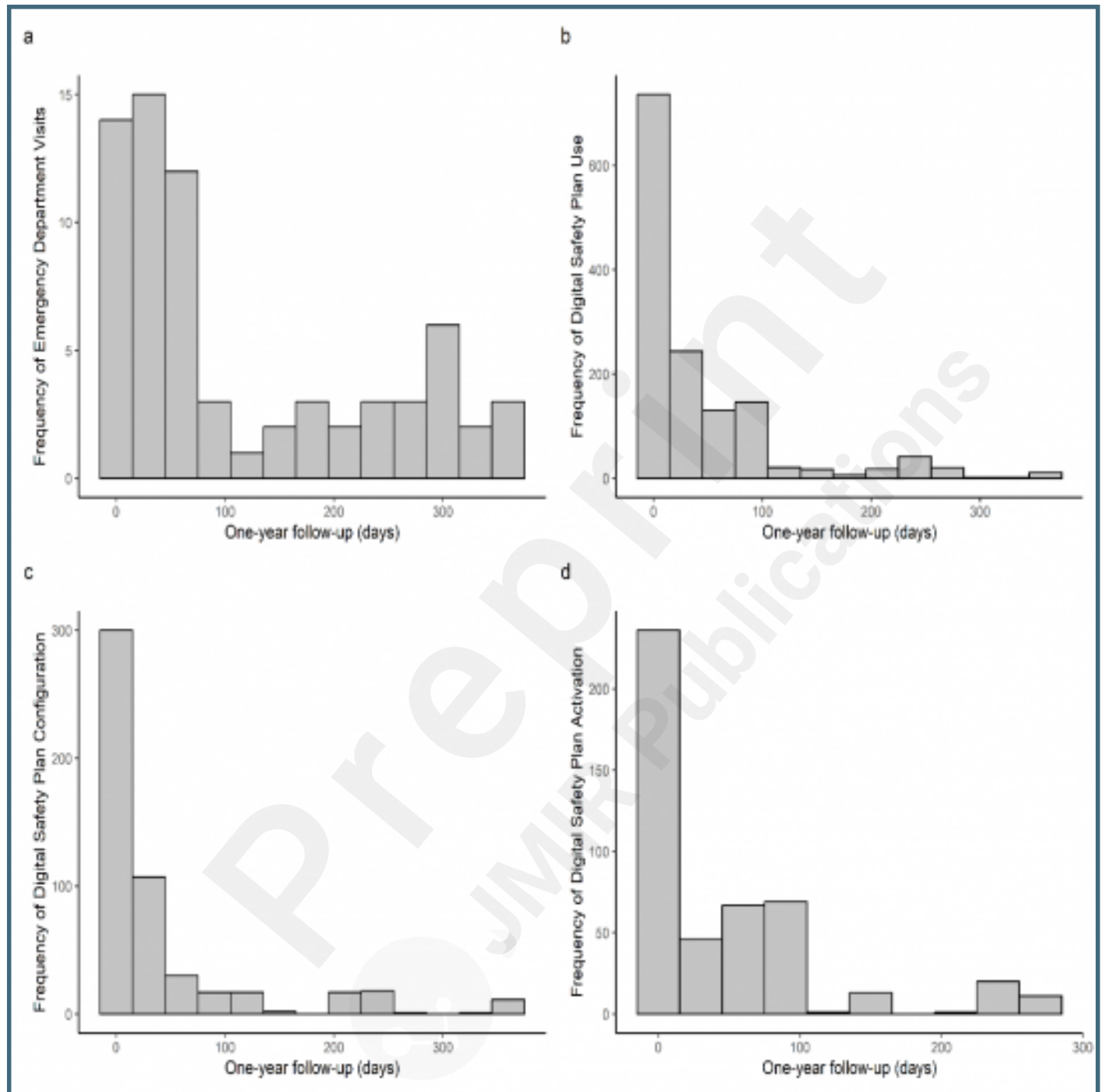
Supplementary Files

Figures

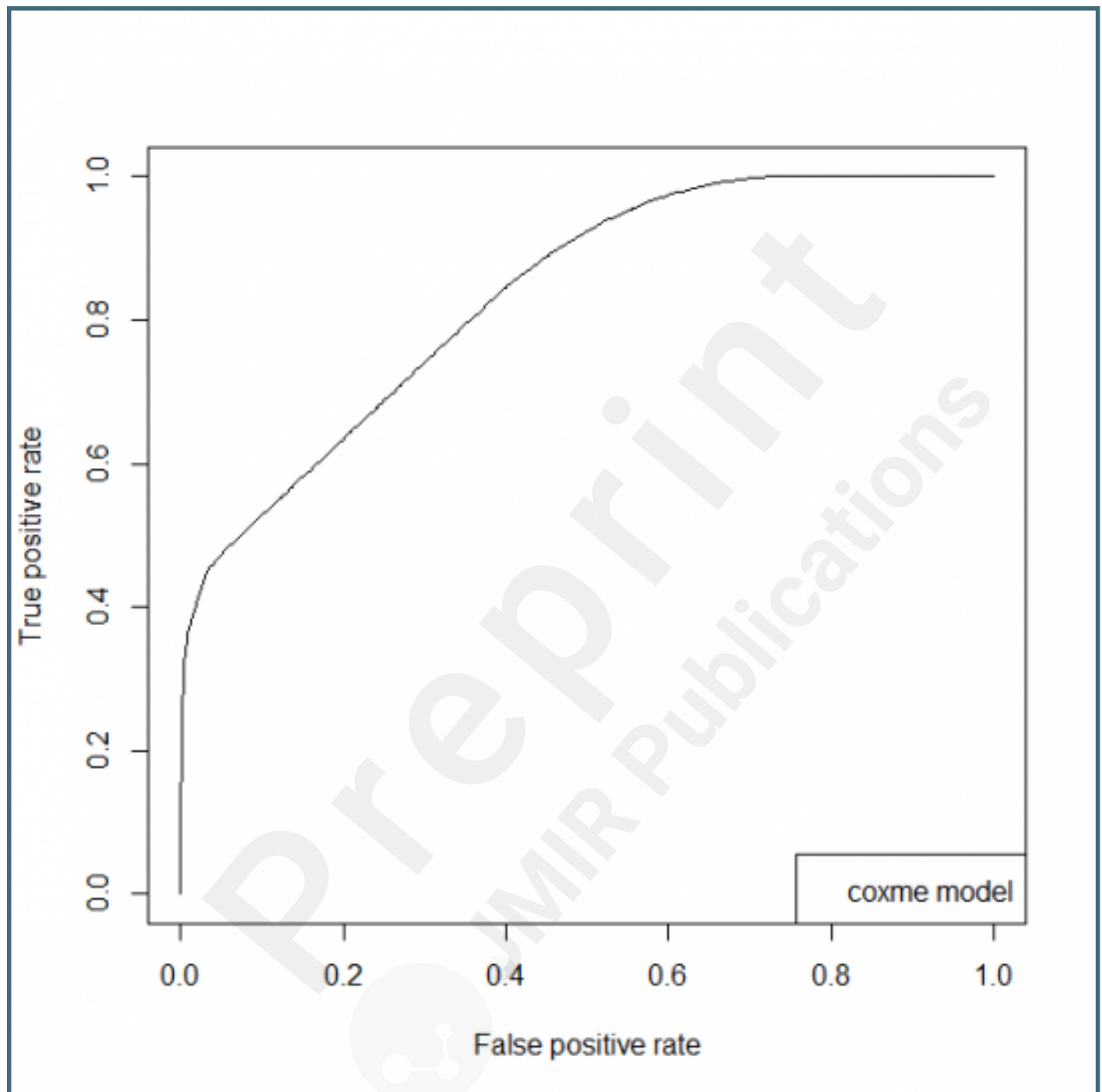
Example of MEmind app Safety Plan configuration.



Frequency of emergency department returns due to suicidal behavior (a). Frequency of total digital safety plan usage (b), configuration (c), and activation (d) during follow-up.



ROC curve for survival model.



Cumulative risk of emergency department visits for suicidal behavior based on safety plan activation.

