

Using Health Digital Technology for Suicide Prevention: A Systematic Review

Dutya Intan Larasati¹, Yuli Anggraini¹, Ahmad Wahyudi¹

Abstract-- Suicide is a serious public health problem and is currently a global concern. The World Health Organization (WHO) estimates that each year around one million people die from suicide which represents a global death rate of 16 people per 100,000 or one death every 40 seconds. Health digital technology services need to be developed, especially in countries that do not yet have an adequate mental health service system and adequate access. This study analyzed health digital technology for suicide prevention with a systematic review sight. A literature search was performed on databases from Scopus, Science Direct, PubMed, ProQuest, and Sage for the years 2015-2019. The keywords in the search are "suicide", "self injury", "prevention", "avoidance", "health technology", "digital technology", and "mHealth". Challenges in the industrial era 4.0 increase the interest of the global community to find technology-based solutions that focus on the idea of suicide and mental health. Digital technology that can be used is a self-help guide digital intervention, mobile health applications, online interactive applications that have been proven to reduce suicidal thoughts. This intervention can overcome barriers related to access to health services with the availability of health digital technology that can be accessed anywhere and anytime, thereby offering sustainable and scalable solutions. The use of health technology can be beneficial for suicide prevention programs as they are effective, efficient, inexpensive, and can reach many people.

Keywords—Suicide, Prevention, Health technology, Digital technology

I. INTRODUCTION

Suicide is a serious public health problem and is currently a global concern. The number of deaths due to suicide in the world is close to 800,000 cases a year. For every person that dies, there are 20 cases of attempted suicide [1]. In the past 45 years, suicides have increased by 60% worldwide. Suicide is the third leading cause of death among people aged 15-44 years worldwide. The World Health Organization (WHO) estimates that each year around one million people die from suicide which represents a global death rate of 16 people per 100,000 or one death every 40 seconds. It is predicted that by 2020 the death rate will increase to one every 20 seconds [2]. Suicides in Indonesia have a mortality rate of 0.71 / 100,000 population; with a population of 265 million in 2018, the estimated number of deaths due to suicide in Indonesia is around 1,800 per year. Deaths due to suicide occur at a young and productive age, 46% at the age of 25-49, and 75% at a productive age (15-64 years). The most common method of suicide is hanging by 60.9% [3].

The idea of suicide is a key element in the process of suicide which can gradually increase the frequency and intensity so it develops into an attempted suicide or suicide [4]. Many conventional health services are effective in helping eliminate suicidal thoughts, but many people do not seek help [1]. This is due to a lack of perceived needs, stigma, shame, trust in

¹ Faculty of Nursing, Universitas Airlangga, Surabaya, Indonesia.

Corresponding author:
Dutya Intan Larasati, S.Kep., Ns
Dutya.intan.larasati-2019@fkip.unair.ac.id

receiving professional help, fear of being hospitalized and negative experiences meeting mental health care professionals [5]. Interventions that focus on the idea of suicide are necessary even when such thoughts do not yet exist as suicide prevention efforts.

Today, people are becoming very familiar with the choices and uses of flexible and dynamic health services that remain relevant and useful. Internet services provide a way to reach people all over the world. Digital health technology, mobile health, and internet-based health service systems are innovations in the health sector that support the transformation of health and care and economic development in the industrial era 4.0 [6]. Challenges in the industrial era 4.0 increase the interest of the global community to find technology-based solutions that focus on the idea of suicide and mental health, especially in countries that do not yet have an adequate mental health service system and adequate access [7].

This research is important as an effort to support suicide prevention programs that can be easily accessed anywhere, anytime and by anyone who utilizes the advantages of digital technology and internet access to find health information. It is considered fast and responsive so that it can reduce the incidence of suicidal thoughts. Digital-based interventions are web-based programs or mobile applications that are designed to be used without professional guidance. This has proven to have the potential to prevent and reduce suicidal behavior and suicidal thoughts. Digital-based interventions provide fast, efficient, cost-effective therapeutic support and can be accessed anywhere. These interventions can overcome barriers related to access to traditional treatments, thereby offering sustainable and scalable solutions [8].

II. METHODS

- Data Sources

The present study is a systematic review using a randomized controlled trial method. A literature search was performed on databases from Scopus, Science Direct, PubMed, ProQuest, and Sage to identify articles published from 2015 to 2019. The keywords in the search are “suicide”, “self-injury”, “prevention”, “avoidance”, “health technology”, “digital technology”, and “mHealth”.

- Study selection

The feasibility of the study was assessed using the PICOT framework. The inclusion criteria were (i) people with suicidal thoughts (ii) people at risk of suicide (iii) people who have committed suicide and self-injury (iv) types of study: randomized controlled trials (RCTs) and pilot RCT (v) type of intervention: digital health technology for suicide prevention (vi) main outcome: reduce suicidal thoughts and suicidal behavior.

- Data Extraction

The following information was extracted from 15 articles: information about demographics and study participants, research designs, sample sizes, interventions, controls, pre-post-intervention results, country and year of publication for each study.

- Quality Assessment

The systematic review method was based on the PRISMA checklist (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to strengthen reporting. PRISMA is not an assessment instrument but is used to criticize published systematic review and measure its quality. (Figure 1)

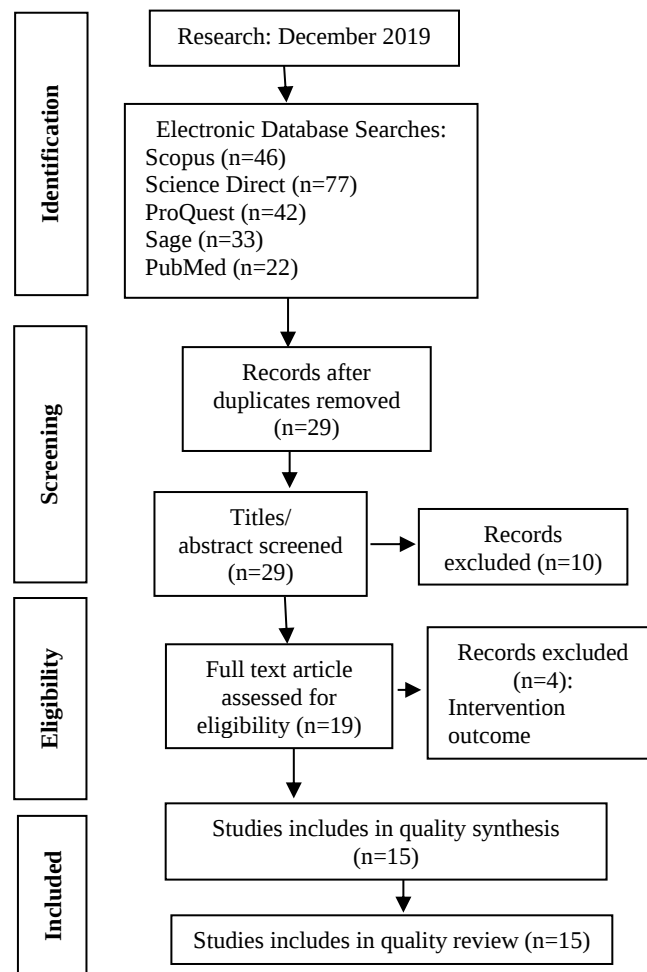


Figure 1---Flow diagram of the study selection process [9]

III. RESULTS

- General factors and type of studies

The total number of articles in this systematic review is 15 with respondents and interventions that meet the inclusion criteria. The areas in this study are communities, hospitals and online forums (Table 1). It shows that the type of health-related digital technology that is widely used is self-help guides digital interventions (40%), online interaction applications (26.6%) and mobile health applications (33.3%). The study was conducted mostly on adult participants aged over 18 years (86.6%). The type of study used is a randomized controlled trial (100%).

Table 1. General characteristics of selected studies (n=15)

Category	N	%
Year of journal research		
2015	2	13.3
2016	3	20
2017	3	20
2018	4	26.6
2019	3	20
Type of Health Digital Technology		
Online interaction application	4	26.6
Self-help guides digital intervention	6	40
Mobile health application	5	33.3
Participants' Ages		

≤ 18 years old	2	13.3
≥ 18 years old	13	86.6
Type of Study		
RCT	15	100

* RCT: Randomized Controlled Trial

- Type of Health Digital Technology

Digital-based interventions are web-based programs or mobile applications designed to be used without professional guidance. This has proven to have the potential to prevent and reduce suicidal behavior. Digital-based interventions provide fast, efficient, cost-effective therapeutic support and can be accessed anywhere. These interventions can overcome barriers related to access to traditional treatments, thereby offering sustainable and scalable solutions [8]. Several studies have been carried out to identify the use of digital technology in suicide prevention, for example, the use of digital intervention self-help guides, mobile health applications, and online interactive applications.

- Self-Help Guides Digital Intervention

From the 15 articles, 6 use self-help guidelines, digital interventions as an effort to eliminate as well as a knowledge module on self-spending. The self-help guide consists of five applications namely ibobbly mobile health, self-help web-based programs, self-help interventions, frame IT intervening, self-guide digital interventions. Two articles discuss self-help interventions. All interventions have positive results. Better than the application of the devil that can reduce tolerance of mental health, improve depression but cannot approve the idea of self-change or impulsiveness [10].

- Mobile Health Applications

From the 15 articles, 5 use mobile health applications as an effort to prevent suicide. Mobile health applications help automatically detect negative behavior, bad emotions and suicide-related thoughts through a smartphone application. Mobile health applications consist of 5 applications, namely online daily diary treatment, combining mobile-health (mHealth) and artificial intelligence (AI), brief mobile applications, sensor network systems, online and mobile apps. The success rate of the intervention was all positive.

- Online Interaction Applications

From the 15 articles, 4 use online interaction application as an effort to prevent suicide. The online interaction application presents interactive mental health services both via the web and smartphone, and it is useful as an online-based health support system so it can reach many users without using conventional methods. The online interaction application has four functions, mobile text messaging, online support system, smartphone app, and app-assisted treatment. Intervention outcomes show positive results.

IV. DISCUSSION

Digital health technology, mobile health, and internet-based health service systems are innovations in the health sector that support the transformation of health and care and economic development in the industrial era 4.0 [6]. Digital-based interventions are web-based programs or mobile applications designed to be used without professional guidance. This has proven to have the potential to prevent and reduce suicidal behavior and suicidal thoughts. There are three digital-based technologies used in the research analyzed for suicide prevention, namely digital intervention self-help guides (40%), mobile health applications (33.3%), and online interaction applications (26.6%).

Self-help guides digital intervention to provide services for users to independently assess themselves and their emotions and has a knowledge module on suicide prevention. Self-help guides consist of five applications. First, Ibobbly mobile health is an online program with a content module and self-assessment which is carried out in continuously.

Participants can track their progress through a personalized dashboard about their functions and state of mind, including suicide. As a result, this intervention is effective in reducing symptoms of mental health disorders, showing a reduction in the level of depression but not in suicide or impulsive ideas [10]. Second, the self-help web-based program is a program for suicide prevention consisting of 4 modules containing theory, weekly assignments, exercises, and optional exercises that combine relevant information and skills. Also, there is a get-help feature for access to health service referral and monitoring information. The results of this intervention show a reduction in suicidal thoughts after the intervention [12]. Third, self-help intervention is a self-assessment and training module that serves to detect general thoughts, recognize general and negative thought patterns, suicide crises, manage intense emotions that begin with psychoeducation. The average intervention is 30 minutes per day. The results of this intervention are the intention to treat showed a significantly stronger decrease in suicidal ideation in the intervention group [4][22]. Fourth, the IT-frame intervention contains a CBT module on involvement and identification of problems, emotional recognition, and pressure tolerance, identification of negative thoughts, seeking help, scheduling relaxation techniques, problem-solving and cognitive reconstruction. The result of this intervention is to reduce suicidal thoughts and increase cognitive behavior [15]. Fifth, self-guide digital intervention is a self-assessment of the idea of suicide, suicide plans, suicide attempts and depression. After knowing the results, it can develop strategies for suicide prevention interventions. The result demonstrates the effectiveness of self-guided digital interventions for suicide prevention and reinforces the importance of including direct suicide prevention content within digital interventions [8].

Mobile health applications help automatically detect negative behavior, bad emotions and suicide-related thoughts through a smartphone application. Mobile health applications consist of 5 applications. First, the online daily diary treatment, an online daily journal proposed for the prevention of suicidal thoughts which can be accessed in any software. The result of this intervention can reduce self-criticism and increase positive self-esteem [16]. Second, combining mobile-health (mHealth) and artificial intelligence (AI) is a smartphone application with an EMA protocol that can monitor the patient's condition such as sleep quality, wanting to live or die, questions about emotional status. Also, the application will record a diurnal activity that is related to sleep quality using a smartphone sensor. The result is a system capable of identifying changes in mobility patterns that can be used to determine changes in behavior and mental health recurrence so it can be used for early suicide prevention measures[14]. Third, the brief mobile application is maintenance that can be accessed using a smartphone device with an internet connection. This application contains self-assessment, emotional conditions, and behavior recorded for one month. The results indicated that the brief mobile application reductions in NSSI self-cutting and overall [17]. Fourth, the sensor network system is useful to detect and respond early through the suicide corresponding sensor system installed at two locations of Han-River bridges where suicide occurs frequently. After analyzing the pilot system's performance of the past year, the conclusion was that attaching the detecting sensor to the top of the rail is very effective [19]. Fifth, the online and mobile app is a health service provider that is on a smartphone. The results show significantly greater improvement in suicidal thoughts and suicidal ideation in the intervention groups [21].

The online interaction application presents interactive mental health services both via the web and smartphone, and it is useful as an online-based health support system because it can reach many users without employing conventional methods. It has four applications. First, the mobile text messaging with a system called Intervention Suicide Intervention Assisted by Messages (SIAM) which utilizes short message service (SMS) to connect participants to support services using SMS contacts that aim to reduce repeated episodes of self-injury, trips to the ER, and finally reduce suicide deaths. MHealth interventions that utilize mobile text messaging are effective for suicide prevention [11]. Second, an online support system called ACROSSnet is an interactive website that helps users get access to information, resources, peer support, guidance through expert chat forums, e-mail and teleconferences, as well as the latest information on all aspects of suicide prevention

and intervention. The result is the development of community support for suicide prevention based on an online support system [13]. Third, the smartphone app is an application-based service to provide direct access to a set of coping skills that they have identified helped during a suicide crisis and to enable them to access immediate assistance if necessary. The result, the scores on satisfaction with content demonstrated that changes needed to be made to Crisis Care before its development into a fully functioning app [18]. Fourth, App-Assisted Treatment is an application designed to provide psychoeducation about suicidal thoughts and ways to handle situations and reactions related to it. The results showed that the group receiving TAU in combination with access to the mobile application experienced a smaller decrease in self-reported suicide risk immediately following treatment [20].

Digital-based interventions provide fast, efficient, cost-effective therapeutic support and can be accessed anywhere. These interventions can overcome barriers related to access to traditional treatments, thereby offering sustainable and scalable solutions [8].

V. CONCLUSION

Health technology can be useful for suicide prevention programs as they are effective, efficient, inexpensive, and can reach many people. The health digital technology that can be used contains self-help guides digital intervention, mobile health applications, online interaction applications that have been proven to reduce suicidal thoughts. This intervention can overcome barriers related to access to health services with the availability of health digital technology that can be accessed anywhere and anytime, thereby offering sustainable and scalable solutions.

CONFLICT OF INTEREST

No conflicts of interest have been declared.

ACKNOWLEDGMENT

The authors of this study would like to thank the Faculty of Nursing and also Master's in Nursing Study Program, for providing the opportunity to present this study.

REFERENCES

- [1] Y. Finkelstein *et al.*, "Risk of Suicide Following Deliberate Self-poisoning," vol. 72, no. 6, pp. 570–575, 2015, doi: 10.1001/jamapsychiatry.2014.3188.
- [2] WHO, "Suicide rates (per 100 000 population)." 2019.
- [3] KEMENKES RI, "infodatin-Situasi-dan-Pencegahan-Bunuh-Diri.pdf." 2019.
- [4] E. De Jaegere *et al.*, "Behaviour Research and Therapy The online treatment of suicidal ideation : A randomised controlled trial of an unguided web-based intervention," *Behav. Res. Ther.*, vol. 119, no. September 2018, p. 103406, 2019, doi: 10.1016/j.brat.2019.05.003.
- [5] M. A. Hom, I. H. Stanley, and T. E. J. Jr, "Clinical Psychology Review Evaluating factors and interventions that influence help-seeking and mental health service utilization among suicidal individuals : A review of the literature," *Clin. Psychol. Rev.*, vol. 40, pp. 28–39, 2015, doi: 10.1016/j.cpr.2015.05.006.
- [6] C. Chute and T. French, "Introducing Care 4 . 0 : An Integrated Care Paradigm Built on Industry 4 . 0 Capabilities," 2019.
- [7] J. Han, M. Torok, N. Gale, Q. J. J. Wong, and A. Werner-seidler, "Use of Web Conferencing Technology for Conducting Online Focus Groups Among Young People With Lived Experience of Suicidal Thoughts : Mixed Methods Research Corresponding Author :," vol. 6, pp. 1–10, 2017, doi: 10.2196/14191.
- [8] M. Torok *et al.*, "Articles Suicide prevention using self-guided digital interventions : a systematic review and meta-analysis of randomised controlled trials," *Lancet*, vol. 7500, no. 19, pp. 1–12, 2019, doi: 10.1016/S2589-7500(19)30199-2.
- [9] A. Liberati *et al.*, "The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration," *J. Clin. Epidemiol.*, vol. 62, no. 10, pp. e1–

- e34, 2009, doi: 10.1016/j.jclinepi.2009.06.006.
- [10] J. Tighe, F. Shand, R. Ridani, A. MacKinnon, N. De La Mata, and H. Christensen, "Ibobbly mobile health intervention for suicide prevention in Australian Indigenous youth: A pilot randomised controlled trial," *BMJ Open*, vol. 7, no. 1, pp. 1–10, 2017, doi: 10.1136/bmjopen-2016-013518.
- [11] S. Berrouguet *et al.*, "Toward mhealth brief contact interventions in suicide prevention: Case series from the suicide intervention assisted by messages (SIAM) randomized controlled trial," *JMIR mHealth uHealth*, vol. 6, no. 1, 2018, doi: 10.2196/mhealth.7780.
- [12] B. A. J. Van Spijker *et al.*, "Effectiveness of a web-based self-help program for suicidal thinking in an australian community sample: Randomized controlled trial," *J. Med. Internet Res.*, vol. 20, no. 2, pp. 1–12, 2018, doi: 10.2196/jmir.8595.
- [13] D. L. Penn *et al.*, "Development of ACROSSnet: An online support system for rural and remote community suicide prevention workers in Queensland, Australia," *Health Informatics J.*, vol. 11, no. 4, pp. 275–293, 2005, doi: 10.1177/1460458205058755.
- [14] S. Berrouguet, M. L. Barrigón, J. L. Castroman, P. Courtet, A. Artés-Rodríguez, and E. Baca-García, "Combining mobile-health (mHealth) and artificial intelligence (AI) methods to avoid suicide attempts: The Smartercrises study protocol," *BMC Psychiatry*, vol. 19, no. 1, pp. 1–9, 2019, doi: 10.1186/s12888-019-2260-y.
- [15] S. E. Hetrick *et al.*, "Internet-based cognitive behavioural therapy for young people with suicide-related behaviour (Reframe-IT): a randomised controlled trial," vol. 20, no. 3, 2017.
- [16] J. M. Hooley, K. R. Fox, S. B. Wang, and A. N. D. Kwashie, "Novel online daily diary interventions for nonsuicidal self-injury : a randomized controlled trial," pp. 1–11, 2018.
- [17] J. C. Franklin *et al.*, "A Brief Mobile App Reduces Nonsuicidal and Suicidal Self-Injury : Evidence From Three Randomized Controlled Trials," vol. 84, no. 6, pp. 544–557, 2016.
- [18] K. H. M. O. Brien, M. Lecloux, A. R. Licsw, C. G. Ba, and E. A. Wharff, "Archives of Suicide Research A Pilot Study of the Acceptability and Usability of a Smartphone Application Intervention for Suicidal Adolescents and Their Parents A Pilot Study of the Acceptability and Usability of a Smartphone Application Intervention for Suicidal Adolescents and Their Parents," vol. 1118, no. May, 2016, doi: 10.1080/13811118.2016.1182094.
- [19] J. Lee, C. Lee, and N. Park, "Application of sensor network system to prevent suicide from the bridge," *Multimed. Tools Appl.*, pp. 14557–14568, 2016, doi: 10.1007/s11042-015-3134-z.
- [20] M. S. O. Toole, M. B. Arendt, and C. M. Pedersen, "Author note US," *Behav. Ther.*, p. #pagerange#, 2018, doi: 10.1016/j.beth.2018.07.007.
- [21] K. Witt *et al.*, "Effectiveness of online and mobile telephone applications (‘ apps ’) for the self- management of suicidal ideation and self- harm : a systematic review and meta- analysis," 2017, doi: 10.1186/s12888-017-1458-0.
- [22] B. A. J. Van Spijker, A. Van Straten, and A. J. F. M. Kerkhof, "Effectiveness of Online Self-Help for Suicidal Thoughts : Results of a Randomised Controlled Trial," vol. 9, no. 2, 2014, doi: 10.1371/journal.pone.0090118.

VI. APPENDIX

Table 2. Summary of selected studies

Author	Design	Sample	Intervention	Results
Berrouguet <i>et al.</i> , 2018 [11]	RCTs	471 244 patients aged 18 years or older	mHealth: mobile text messaging	1. SIAM interventions function to maintain contact with patients after discharge from the emergency room and prevent repetitive suicidal behavior 2. mHealth interventions that utilize mobile text messaging are effective for suicide prevention
Tighe <i>et al.</i> , 2017 [10]	RCTs	260 61 native Australians aged 18-35 years	Ibobbly mobile health	1. Shows a reduction in the level of depression but does not show a reduction in suicide or impulsive ideas 2. Effective for reducing symptoms of mental health disorders
Van Spijker <i>et al.</i> , 2018 [12]	RCTs	418 adults aged 18 to 65	Web-Based Self-Help Program	Demonstrates reduced suicidal thoughts after the intervention

Author	Design	Sample	Intervention	Results
Penn <i>et al.</i> , 2015 [13]	RCTs	325 people in Queensland Australia aged 18 years or older	online support system: ACROSSnet	The development of community support for suicide prevention based on an online support system
Berrouguet <i>et al.</i> , 2019 [14]	RCTs	210 patients aged 18 years or older	Combining mobile-health (mHealth) and artificial intelligence (AI)	The system can identify changes in mobility patterns that can be used to determine changes in behavior and mental health recurrence so that it can be used for early suicide prevention measures
De Jaegere <i>et al.</i> , 2019 [4]	A two-arm RCT	total of 724 participants aged 18 years or older	Online self-help intervention	1. The intention to treat analysis showed a significantly stronger decrease in suicidal ideation in the intervention group 2. For all secondary outcome measures i.e., suicidal ideation attributes, depressive symptoms, hopelessness, worrying, and anxiety, a significantly greater reduction was found at post-test in the intervention
Hetrick <i>et al.</i> , 2017 [15]	A parallel RCT	50 participants aged 13-18 years old	The Reframe-IT intervention	1. Suicidal ideation (SIQ) scores, Self-reported depression severity (RADS), Clinician reported depression severity (CDRS-R), Anxiety severity (MASC), Negative problem orientation (NPOQ) decreased to a greater extent in the intervention group 2. Cognitive-behavioral skills (CBTSQ), specifically behavioral skills (CBTSQ-BA), cognitive skills (CBTSQ-CR) increased to a greater extent in the intervention group were significant.
Van Spijker <i>et al.</i> , 2015 [12]	RCTs	The 236 participants aged at least 18 years old	self-help intervention	1. The results show significantly greater improvement in suicidal thoughts in the intervention 2. The post hoc exploratory subgroup analysis examining treatment effects according to the history of attempted suicide revealed a significantly greater improvement in the intervention group
Hooley <i>et al.</i> , 2018 [16]	RCTs	144 Participant aged 18-45 years old	Online daily diary treatment	Primary outcomes were NSSI episodes and self-criticism. We also examined the effects of treatment on depression, desire to discontinue NSSI, the likelihood of future NSSI, days of active suicide ideation, and days of suicide plans.
Franklin <i>et al.</i> , 2016 [17]	RCTs	Participants were 114 individuals in psychopathology forum aged 18 years or older	Brief Mobile Application	Results indicated brief mobile application reductions in self-cutting and overall NSSI
Kimberly, H., 2016 [18]	Pilot RCT	The sample included a total of 20 adolescent parents aged 13-18 years old	Smartphone Application	Scores on satisfaction with content demonstrated that changes needed to be made to Crisis Care before its development into a fully functioning app
Julak <i>et al.</i> , 2016 [19]	Cohort RCTs	221 participants aged 18 years or older	Sensor Network system	After analyzing the pilot system's performance of the past year, the conclusion was that attaching the detecting sensor to the top of the rail is very effective.
O'Toole <i>et al.</i> , 2018 [20]	RCTs	129 participants aged between 18 and 65 years old	App-Assisted Treatment	Results showed that the group receiving TAU in combination with access to the mobile application experienced a smaller

Author	Design	Sample	Intervention	Results
Michelle Torok et al., 2019 [8]	RCTs	842 participants aged 18 years or older	self-guided digital interventions	decrease in self-reported suicide risk immediately following treatment The result demonstrates the effectiveness of self-guided digital interventions for suicide prevention and reinforces the importance of including direct suicide prevention content within digital interventions.
Witt et al., 2017 [21]	RCTs	325 participants aged 18 years or older	Online and mobile app	The results show significantly greater improvement in suicidal thoughts and suicidal ideation in the intervention groups