Effectiveness of mobile health technologies in suicide prevention among depressed people: A systematic review and meta-analysis

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Abstract

There is increasing burden of depression and suicide related deaths worldwide. Many sufferers are not receiving treatment despite the availability of effective treatment. With the rapid growth of mobile devices usage, utilizing mobile intervention will help in health outcomes in suicide related behaviours. We evaluated the efficacy of mobile health interventions in suicide prevention and deaths using a systematic review. We searched PubMed, the Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, PsycINFO and Google Scholar for studies published from 2000 – 2017. We reviewed the reference lists of retrieved included trials. An updated search was re-run in December 2017. Out of 4,244 records, 38 full-text were assessed for eligibility. We included seven randomized controlled trial (RCT) studies with a total of 1,387 participants. Out of seven, only four studies reported outcomes of death. Risk of bias among domains was low-risk except for high performance bias. Our study favors mobile intervention in suicide prevention: risk ratio (RR) 0.67, 95% confidence interval (CI) 0.49 to 0.92, moderate quality of evidence. The number needed to treat for suicide prevention was 25, indicating that suicide reduction is moderately meaningful clinically. Healthcare providers may consider integrating mHealth into their practices for suicide prevention. The use of mHealth in suicide prevention is in its early days. This review
highlights the need to fill this gap. Studies included in this review, were few. Standards are lacking for quantifying the intervention value. Further research is necessary to demonstrate the influence of mHealth and its effectiveness of suicide prevention and death.

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Keywords: Mobile health, Suicide, Death
Effectiveness of mobile health technologies in suicide prevention among depressed people: A systematic review

**Background**

Depression ranks as the highest contributor to global disability. According to the World Health Organization (WHO), there was an estimate of more than 300 million people suffering from depression in 2015, an increase of 18.4% in 10 years (WHO, 2017). Globally, there were about 800,000 suicide related deaths, not accounting those attempted suicide (WHO, 2017). Both survivors and those left behind tend to experience suicide bereavement indirectly. Suicide knows no age boundary, but is preventable and treatable. Despite the availability of many effective treatments for suicidal-related behaviours, the majority of sufferers are not receiving any treatment (Bruffaerts, et al., 2011). Treatment rates worldwide show under-treatment of suicidal patients – less than half of them had received treatment even in countries with access to available psychotherapy (Bruffaerts, et al., 2011). Presence of treatment barriers identified included low perceived needs, attitudinal barriers such as wanting to handle problem on their own, and lack of awareness, as well as structural barriers such as of financial difficulties, and lack of resources in mental health services that widens the treatment gap (Bruffaerts, et al., 2011).
The expansion and advancement of mobile technologies in their application to health settings has made way to a new field of eHealth, known as mHealth (Mechael, Kaonga, & Batavia 2011). According to the WHO Global Observatory for eHealth (GOe) in 2005, mHealth was defined as a medical and public health practice supported by mobile devices, such as mobile phones, and patient monitoring (Mechael, et al., 2011). In short, mHealth is the mobile wireless technologies for public health (WHO, 2016). In 1992, Simon by IBM was deemed to be the first mobile phone, however public exposure of smartphones did not begin until 2001 with the Palm OS Treo, which offered full keyboard, wireless web, e-mail, calendar, and an ability to synchronize to computers (Terry, 2010).

When touch-screen user interfaces and advanced features of iPhone and Android smartphone were introduced in 2008, the ownership of mobile devices and its usage rose rapidly (Boulos, Wheeler, Tavares, & Jones, 2011; Yoo, 2013). Worldwide, nearly 5 billion mobile phone subscriptions, with over 85% of population are commercial wireless users (Mechael, et al., 2011). The penetration rate of mobile phone networks in low- and middle-income countries exceeded their other infrastructures such as paved roads and electricity (Mechael, et al., 2011).
Mobile intervention has been used to deliver psychosocial interventions out of the clinic setting, via telephone psychotherapy, videoconferencing and internet-based interventions (Depp, et al., 2010). Capitalizing on the rapid development of mobile technology usage will overcome the barriers to seeking health treatment and propagates the mobile health era. (Mechael, et al., 2011)

Existing systematic reviews of mHealth interventions focus on specific mobile technology functions for example text messaging, types of illness (e.g. asthma), chronic disease management and health behavioral change. (Cole-Lewis, & Kershaw, 2010; Free, et al., 2013; Marcano Belisario, Huckvale, Greenfield, Car, & Gunn, 2013). Despite studies assessing mobile health technologies on numerous health outcomes, evidence based support remains scare on suicide prevention.

The GOe reported that one of the barriers to mHealth implementation involves assessing the effectiveness of mHealth application (Mechael, et al., 2011). Therefore with the fast-growing field of mHealth, it is warranted to conduct a review of mobile health technology in suicide prevention. A systematic review and meta-analysis of randomized controlled trial studies will help to identify the effectiveness of mHealth interventions.

The aim of this review was to synthesize the potential role of mobile health
intervention on suicidal attempts and fatal outcomes based on all published randomized controlled trials using a systematic review and meta-analysis. The objective of this study was to evaluate the efficacy of mobile health technology interventions in the prevention of suicide attempts and deaths.

Methods

This was a systematic review and meta-analysis. The review and analysis was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Liberati, et al., 2009).

Protocol and registration

The review has been registered (CRD42017069275; 5 July 2017), and the review protocol has been published on the International prospective register of systematic reviews (PROSPERO) at

https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=69275

Selection criteria

We included individual and cluster randomized controlled trials (RCTs), which
were published from 2000 – 2017. We searched for studies published from the year 2000, since the concept of mobile health technologies existing prior to that time is limited (Terry, 2010). The inclusion criteria were all RCTs that included: male or female, aged 13 years and above, and with symptoms of depression or patients with depression. Studies utilizing mobile health technology delivered partly or entirely in prevention of suicide attempts and death will be included. We included studies if their interventions were compared to other comparators or control conditions or alternative methods used which were described. We did not restrict any studies based on publication languages. We excluded studies if participants were less than 13 years old or had dementia, psychosis or dissociative symptoms.

**Search methods for identification of studies**

We conducted comprehensive literature searches on the following databases for relevant publications: PubMed, the Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, PsycINFO and Google Scholar. K Sato (KS), librarian of St. Luke’s International University, assisted in the development of the search strategies. The database search strategies are described in Appendix 1. We performed the latest updated search on all specified databases in December 2017. We searched and reviewed
the reference lists of retrieved included trials for additional potential references.

**Data collection and analysis**

The study identification involved a two-step process. First, two reviewers CE Loo (CE) and BW Siy (BW) independently screened the titles and abstracts of all records retrieved as result of the search strategy, to identify potentially relevant studies for full review. Second, both reviewers independently determined if the full text of those studies which were considered relevant from the first screening, met the inclusion criteria, with assistance using Rayyan software (Ouzzani, Hammady, Fedorowicz, & Elmagarmid, 2016). Both CE and BW resolved disagreements through discussion. The third reviewer, O Takahashi (OT) was consulted, where agreements could not be reached. The number and reasons for all excluded studies were recorded.

**Data extraction, data item and management**

Both reviewers (CE and BW) independently extracted data from included studies using a standardized extraction form. Methodological details extracted were compared and discrepancies were discussed and resolved. If no agreement could be reached, the third reviewer (OT), was consulted. For articles containing insufficient information for
review, we contacted the relevant authors via-email to obtain the required study information. The following data items were extracted from the trials: author, study year, study design, country, number of participants, study population, details of intervention and control, outcomes and study duration. We entered data into the Review Manager software (Review Manager 5.3, 2014) and checked for accuracy.

Assessment of risk of bias in included studies

Both reviewers CE and BW independently assessed risk of bias for all included studies using The Cochrane Collaboration’s Risk of Bias Tool (Higgins, Altman, & Sterne, 2011). Any disagreements were resolved following consensus discussion, or by consultation with the third author (OT) if necessary. The risk of bias was assessed according to the following domains:

1. Random sequence generation
2. Allocation concealment
3. Blinding of participants and personnel
4. Blinding of outcome assessment
5. Incomplete outcome data
6. Selective reporting
7. Other bias.

For each individual study, the ‘risk of bias’ results for each domain are tabulated as low-risk, high-risk or unclear risk along with their descriptive justifications. The results are presented in a ‘risk of bias graph’ (Figure 2) and ‘risk of bias summary’ (Figure 3).

**Data analysis**

Characteristics of included studies were compared to determine the feasibility of performing a meta-analysis. For dichotomous data, we presented results as summary risk ratio with 95% confidence interval.

The impact between-study heterogeneity was identified by visual inspection of forest plots, a standard Chi square test with significance level of alpha = 0.1 and quantified by the $I^2$ statistics. We interpreted an $I^2$ statistics of 60% as indicating substantial levels of heterogeneity (Higgins, Altman, & Sterne, 2011).

We performed a subgroup analyses to investigate interactions between the high-risk and low-risk population towards outcome as outlined below. We undertook additional analyses to explore the influence of risk ratio (RR) and risk difference (RD) of treatment effect size. Publication biases were investigated using a funnel plot. The
funnel plot asymmetry was assessed visually.

**Data synthesis**

All statistical analyses were performed using the Review Manager software (RevMan version 5.3, 2014). Data on the outcomes i.e. attempted suicides and deaths were synthesized using pooled effect estimates risk ratio and 95% confidence intervals were calculated using fixed-effect model.

**Summary of findings’ table**

We assessed the quality of evidence using the GRADE approach on the main outcomes (Higgins, Altman, & Sterne, 2011). The GRADEpro GDT (GRADEpro Guideline Development Tool Software, 2015) was used to import data from Review Manager to present the findings in the ‘Summary of findings’ table.

**Subgroup analysis and investigation of heterogeneity**

We carried out the following subgroup analyses:

1. Risk of populations (high-risk vs low-risk of suicide) and types of interventions (internet delivered strategies vs telephone-based) – coincides with risk of
population analysis.

2. Study duration (studies of duration < 12 months versus ≥ 12 months).

3. Types of interventions (CBT intervention versus non-CBT intervention).

4. Study settings (studies conducted in high-income countries versus upper middle-income countries).

Sensitivity analysis

We carried out sensitivity analysis to explore any quality issues, which may have affected their interpretation and were judged using The Cochrane Collaboration’s Risk of Bias Tool (Higgins, Altman, & Sterne, 2011). We excluded those studies labeled as having high risk of selection bias for suicide rate outcome.

Additional analysis

Additional analyses were carried out to explore risk ratio (RR) vs risk difference (RD) in overall assessment of treatment effect on outcome.

Results

Study selection
Initial electronic searches run between July and September 2017 identified a total of 4,244 records. After excluding duplicates, the figure was reduced to 4,121 records. Upon screening of these records, 4,083 records were excluded after reviewing of titles and abstracts. This left 38 full text articles assessed for eligibility, where 31 articles were excluded due to various reasons. The most common reason for exclusion of articles (23 out of 31) was due to no relevant outcomes reported, followed by five articles were study protocols, two articles with multiple combined intervention types and one article, where participant recruitment was prior to the year 2000. Therefore, only seven independent studies were included for both qualitative synthesis and meta-analysis. See Figure 1 for the adapted PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow-chart of study selection.
Study characteristics

Study design and settings.

We included seven RCT studies with a total sample size of 1,387 participants in the meta-analysis as shown in Table 1. The studies were published from 2006 – 2017.
Based on the World Bank list of economies June 2017, this review included four studies conducted in high-income countries including: Australia, Germany, The Netherlands and France (The World Bank, 2017). Three studies were conducted in upper middle-income countries: one study from China, and two studies in Iran.

**Population.**

When comparing across the included studies, participants differed in terms of risk of suicide. Four studies (Mousavi, Zohreh, Maracy, Ebrahimi, & Sharbafchi, 2014; Mousavi Amini, Mahaki, & Bagherian-Sararoudi, 2016; Vaiva et al. 2006 and Wei et al. 2013) recruited patients who attempted suicide and presented to the emergency departments. In the Vaiva et al. (2006), study, the effect of telephone contact was compared with two groups of interventions (contact at one month and contact with three months) against a control group. Kordy et al. (2016), researched those patients diagnosed with recurrent major depressive disorder (MDD) according to the Structural Clinical Interview for DSM-IV with exclusion of those with acute suicide risk were recruited from six psychiatric departments in Germany. Hetrick et al. (2017) recruited high school students with suicidal ideation within a four-week recruitment period. However, the study did not mention how they were diagnosed. In the study of van
Spijker, van Straten, & Kerkhof, (2014), adults with mild to moderate suicidal thoughts defined as score between 1-26 on the Beck Scale for Suicide Ideation (BSS) and consultation of clinical expert, were recruited from websites, newspapers and Google Adwords advertising.

**Interventions.**

There were four studies i.e. Mousavi et al., 2014, Mousavi et al., 2016, Vaiva et al., 2006 and Wei et al., 2013, that used telephone contact as the mobile health intervention. Mobile phones were included in the SYSCALL intervention of Vaiva et al., (2006). In the study by Vaiva et al., (2006), telephone contacts were made either at one or three months by psychiatrists with at least five years of experience in managing suicide crises and patients were followed up for 13 months. Using a psychotherapeutic approach, based on empathy, reassurance, explanation and suggestion, the intervention aimed to enhance compliance to treatment and offer brief crisis intervention as needed. Both studies by Mousavi et al., (2014) and Mousavi et al., (2016), evaluated the effect of telephone contacts to evaluate patients’ condition, provide guidance on coping with harmful conditions and stress, and made the necessary referrals made to psychiatrist, psychologist or social worker if needed. For Mousavi et al., (2014), the intervention
included the Brief Intervention Control (BIC), and a psychiatric resident in the last year of training made the phone calls within a six-month period. For Mousavi, et al., (2016), eight calls were made within eight months by an assistant of psychiatry. In the Wei, et al., 2013 three-arm study, two intervention groups of cognitive therapy and telephone group were compared to the control group. In this review, the telephone intervention group was considered as a mHealth intervention, which professors carried out using 12 weekly telephone calls within a three months period providing psychological support based on empathy, reassurance, explanation and suggestion.

Hetrick, et al., (2017) and van Spijker, et al., (2014) used an internet-based cognitive behavioral therapy (CBT) in delivering mobile health intervention. In the Hetrick, et al., (2017) study, a 10-week internet-based CBT program consisting of eight modules were provided to participants. These modules focused on preventing suicidal thinking and behaviors. The impact on suicide attempts was evaluated by a specifically designed self-report questionnaire asking participant if they had made any suicide attempts since the last assessment and the number of attempts made. These assessments and follow-ups were conducted at 10 and 22-weeks post-intervention. For the van Spijker, et al. (2014) study, unguided self-help CBT was incorporated with components of dialectical behavioral therapy (DBT), problem solving therapy (PST), and
mindfulness based cognitive therapy (MBCT) to reduce the frequency and intensity of suicidal thoughts. Weekly assignments of a total of six modules were to be completed; each module consisted of a theory section, an assignment, ‘core exercises’, several ‘optional exercises and FAQs, and a function which enabled questions to be posted and answered in a general non-personal level. Follow-up measurement was at 12-weeks post-intervention.

In the Kordy et al., (2016) study, a three-arm design was conducted. There were two intervention groups. The first was the ‘supportive monitoring and depression management over the Internet’ (SUMMIT) and the second was the SUMMIT-person (included regular chats with experts). These two groups were compared to the control group using a 1:1:1 ratio. In this review, we only report on the SUMMIT intervention group that used a mobile health strategy, which enables participants to receive intense monitoring by e-mail or smartphone. Participants could signal of upcoming crises, receive assistance with personal crisis management and early intervention over 12 months. Suicidal attempts and deaths were reported as adverse events during the study.

**Control conditions.**

For the seven RCTs designed trials, the interventions were compared against numerous types of control conditions: treatment as usual (TAU) or control condition
(Hetrick, et al., 2017; Kordy, et al., 2016; Mousavi, et al., 2014; Vaiva, et al., 2006; Wei, et al., 2013), eight sessions of face-to-face meetings with a psychiatric assistant (Mousavi 2016), and a waitlist control group (van Spijker, et al., 2014). In the van Spijker et al., (2014) study, the control waitlist group was provided access to a website with information on suicidality, treatment, and links to mental health organization but it was unclear as to whether usual treatment was provided.

**Outcomes.**

Vaiva, et al., (2006) reported both suicide and its death rate as primary outcomes. Participants’ self-reported further suicide attempts and was recorded if it met the standardized definition and was assessed by blinded specially trained research psychologist via telephone during the 13 months’ follow up period. In the Hetrick et al., (2017) study, a trained research assistant reported suicide attempts as secondary outcomes using a specifically designed questionnaire asking whether they had attempted suicide and how many attempts were at baseline; data were gathered 10 weeks (post intervention) and 22 weeks (12 weeks follow-up).

Both Kordy et al., (2016) and van Spijker et al., (2014) reported suicide attempts or deaths that occurred during the trials as part of their safety procedure adverse events. Mousavi, et al., (2014) and Mousavi et al., (2016) reported suicide attempts as primary
outcomes. An interviewer used a follow-up questionnaire during each assessment. For Wei, et al., (2013), suicide attempts as one of the outcomes were assessed during the 3rd, 6th and 12th months. Further information on each of included studies is summarized in the Characteristics of included studies (Table 1).
<table>
<thead>
<tr>
<th>Study, Year</th>
<th>Study Design</th>
<th>Country</th>
<th>N Intervention</th>
<th>N Control</th>
<th>Population</th>
<th>Intervention</th>
<th>Control</th>
<th>Outcomes</th>
<th>Study Duration</th>
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<tr>
<td>Hetrick, 2017</td>
<td>RCT</td>
<td>Australia</td>
<td>26</td>
<td>24</td>
<td>High school students aged 13-19 years old, from 18 schools in North West Melbourne catchment area from August 2013 - December 2016, who engaged with a well-being staff</td>
<td>REFRAME-IT: Consisting 8 modules of internet-based CBT program, delivered over 10-weeks period. Participants also receive Treatment As Usual</td>
<td>Participants were allocated to Treatment As Usual (TAU): contact with school well-being staff, additional outside mental</td>
<td>Suicide attempts: using specifically designed questionnaire asking whether suicide attempts were made and amount of</td>
<td>22 weeks</td>
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<td>member, experience any level of suicidal ideation within 4 weeks.</td>
<td>(TAU).</td>
<td>health service provision including usual treatment by psychologists, psychiatrists, counsellors, GP support, social work and integrated youth mental health attempts made.</td>
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<td>Assessment conducted at baseline, 10 weeks (post-intervention and 22 weeks (12 weeks follow-up) at schools by a trained research assistant.</td>
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<td>Kordy, 2016</td>
<td>RCT</td>
<td>Germany</td>
<td>75</td>
<td>78</td>
<td>Patients aged 18-65 years old, who had met DSM-IV criteria with at least 3 depressive episodes were recruited at 6 psychiatric departments in Germany from June 2010 - March 2013.</td>
<td>SUMMIT (Supportive Monitoring and Depression Management over the Internet): Internet self-guided emotion coping program. Participants were encouraged to access services and medications.</td>
<td>Participants allocated to TAU: usual psychiatry care, pharmacotherapy, and psychotherapy as necessary.</td>
<td>Suicide attempts and deaths: Safety reporting as re-hospitalisation following a suicide attempt.</td>
<td>24 months.</td>
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<td>Mousavi, RCT 2014</td>
<td>Iran</td>
<td>69</td>
<td>70</td>
<td>Recruited patients from emergency services at Noor Hospital, Iran who attempted suicide by intoxication from 2010-2011.</td>
<td>Brief Intervention Control (BIC): Seven follow-up telephone contacts, lasting half hour, at 2nd, 3rd, 4th, 5th and 6th week.</td>
<td>Participants allocated to TAU.</td>
<td>Suicide attempts: Follow-up validated questionnaire by interviewer during each assessment via 6 months.</td>
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<tr>
<td>Study</td>
<td>Design</td>
<td>Country</td>
<td>n1</td>
<td>n2</td>
<td>Intervention</td>
<td>Follow-up</td>
<td>Main Outcomes</td>
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<td>Mousavi, 2016</td>
<td>RCT</td>
<td>Iran</td>
<td>25</td>
<td>22</td>
<td>Recruited patients from emergency services Noor Hospital, Iran who attempted suicide by poisoning from</td>
<td>Eight phone call sessions by assistant of psychiatry at 2nd, 4th, 2nd, 3rd, 4th, 5th and 8 week,</td>
<td>Eight face to face meeting sessions of 20 mins each, by assistant of psychiatry, at</td>
<td>Suicide attempts and deaths: follow-up forms by interviewer during</td>
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**EFFECTIVENESS OF MOBILE HEALTH**

<table>
<thead>
<tr>
<th>van Spijker, 2014</th>
<th>RCT</th>
<th>The Netherlands</th>
<th>116</th>
<th>120</th>
<th>Recruited from online websites e.g. <a href="http://www.113Online.nl">www.113Online.nl</a>, newspapers and Google Adwords advertising from</th>
<th>Unguided self-help intervention based on Cognitive Behavioural Therapy (CBT), components of Dialectical</th>
<th>Participants were allocated to a waitlist control condition: Given access to website where suicide attempts and deaths: scores on BSS and/or BDI, considered under safety procedure</th>
<th>6 weeks</th>
<th>2nd week, 4th week, 2nd, 3rd, 4th, 5th and 8th months.</th>
<th>2nd week, 4th week, 2nd, 3rd, 4th, 5th and 8th months.</th>
<th>assessment.</th>
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<td>January - May 2014. Participants aged 20 years and above, with suicide attempts at least 2 times.</td>
<td>months.</td>
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<td>October 2009 - November 2010.</td>
<td>Adults aged 18 and above with mild to moderate suicide thoughts (score 1-26 on Beck Scale for Suicide Ideation (BSS), Beck Depression Inventory (BDI) &lt;40.</td>
<td>Behavioural Therapy (DBT), Problem Solving Therapy (PST) and Mindfulness Based Cognitive Therapy (MBCT). Consisting six modules ideally completed weekly.</td>
<td>information on suicidality is provided and login code for intervention is provided after 6 weeks.</td>
<td>events of study.</td>
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<td>Vaiva, 2006</td>
<td>RCT</td>
<td>France</td>
<td>293</td>
<td>312</td>
<td>Recruited from 13 emergency departments in northern France who attempted suicide by self-poisoning. Participants aged 18-65 years old.</td>
<td>SYSCALL: systematic telephone contacting at end of 1st month, or end of 3rd month, made by psychiatrist of at least 5 years of experience managing suicidal crises.</td>
<td>Participants allocated to control condition.</td>
<td>Suicide attempts: self-reported by participants and assessed by trained research psychologist via telephone and recorded if met standardised definition at 13 months' follow-up.</td>
<td>13 months</td>
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<td>Wei, 2013</td>
<td>RCT</td>
<td>China</td>
<td>80</td>
<td>77</td>
<td>Recruited from emergency departments of four general hospitals in Shenyang, China, who were referred to hospitals by a clinical research assistant to check records on suicide attempts and deaths.</td>
<td>Telephone intervention: consisting 12 weekly calls, each lasting 20-40 mins, by Participants allocated to control condition.</td>
<td>Suicide attempts: assessed at baseline, 3-, 6- and 12-months by telephone</td>
<td>12 months</td>
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attempted suicide from June 2007- January 2008. Participants aged > 15 years old. professors within a 3-months period. using questionnaire.
Risk of bias in included studies

Risk of bias for included studies is summarized below in Figure 2 and Figure 3.

Figure 2. 'Risk of bias' graph displays review authors' judgments about each risk of bias item presented as percentages across all included studies.
Figure 3. 'Risk of bias' summary is presented in a table format displaying review authors' judgments about each risk of bias item for each included study.

**Effects of interventions**

**Suicide attempts.**

Data was pooled using a fixed effect model, with a low heterogeneity, $I^2=1\%$.

(Figure 4) There was a statistically significant difference for reduction of suicide
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attempts using intervention compared to no intervention in the control group: (risk ratio (RR) 0.67, 95% confidence interval (CI) 0.49 to 0.92; seven RCTs of total 1,387 participants). Vaiva, et al., (2006) has the highest weightage in the analysis, 69.8% among the studies.

Figure 4. Forest plot of comparison: Mobile health interventions versus control, outcome: Risk ratio (RR) for suicide attempts.

Deaths.

Four studies (Kordy, et al., 2016; Mousavi, et al., 2016; van Spijker, et al., 2014; Vaiva, et al., 2006) reported fatal outcomes due to suicide. Meta-analysis for the outcome was performed using a fixed effect model with heterogeneity $I^2 = 0\%$. (Figure 5) No statistical difference was seen for death outcome in either the intervention or
control groups: (RR 0.43 95% CI 0.06 to 2.81). Both Kordy, et al., (2016) and van Spijker, et al., (2014) have zero-cell counts. RevMan automatically checked for problematic zero counts which may have yielded a computational error, and added a fixed value (typically 0.5) to all cells of the study result tables where it occurred (Higgins, Altman, & Sterne, 2011).

![Forest plot of comparison: Mobile health interventions versus control, outcome: Risk ratio (RR) for deaths.](image)

**Subgroup analyses**

Subgroup analyses were performed for the outcomes of suicide attempts for high-risk and low-risk populations as shown in Figure 6. Four studies (Mousavi, et al., 2014; Mousavi, et al., 2016; Vaiva, et al., 2006; Wei, et al., 2013) in which suicide attempters were recruited into the trials were categorized for high-risk subgroup
analysis. Suicide attempters have a high tendency of re-attempt suicides or completing suicide. These studies utilized mobile health technology via telephone contact.

Three low-risk population studies (Hetrick, et al., 2017; Kordy, et al., 2016; van Spijker, et al., 2014) were categorized as low-risk subgroup. There was no statistical significant difference in subgroup interaction test ($p$-value=0.45). Using fixed effect model with heterogeneity, $I^2 = 1\%$, the $p$-value=0.45 shows that the intervention is effective in reducing suicide attempts for both low- and high-risk population.

We posit that mHealth intervention was effective irrespective of low- or high-risk populations. However, we noted that the power of this subgroup analysis is low due to a small number of studies therefore the results should be considered with caution.
Figure 6. Forest plot of comparison: Mobile health interventions versus control, outcome: Suicide attempts comparing low and high-risk population.

We performed subgroup analyses on suicide attempts for the study duration < 12 months, and ≥ 12 months as shown in Figure 7. Four studies (Hetrick et al., 2017; Mousavi et al., 2014; Mousavi et al., 2016; van Spijker et al., 2014) had less than 12 months duration of follow-up. Three studies (Kordy et al., 2016; Vaiva et al., 2006; Wei et al., 2013) had more than 12 months duration of follow-up. Using a fixed effect model with heterogeneity, $I^2 = 1\%$, the subgroup interaction test result shows there was no
statistically significant difference of $p$-value =0.1; that intervention is overall effective for all studies.

<table>
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<tr>
<th>Study or Subgroup</th>
<th>Intervention</th>
<th>Total</th>
<th>Control</th>
<th>Risk Ratio</th>
<th>Risk of Bias</th>
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<td></td>
<td>Events</td>
<td>Total</td>
<td>Events</td>
<td>M-H Freq, 95 CI</td>
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<tr>
<td>Hetrick 2017</td>
<td>0</td>
<td>28</td>
<td>5</td>
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<tr>
<td>Massey 2014</td>
<td>17</td>
<td>69</td>
<td>4</td>
<td>0.29 (0.53, 1.21)</td>
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<tr>
<td>Massey 2016</td>
<td>1</td>
<td>25</td>
<td>2</td>
<td>0.44 (0.04, 4.53)</td>
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<tr>
<td>van Spijker 2014</td>
<td>236</td>
<td>236</td>
<td>0.35 (0.05, 3.23)</td>
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<td></td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>6</strong></td>
<td><strong>10</strong></td>
<td><strong>206</strong></td>
<td><strong>6.35 (0.45, 8.63)</strong></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: $Q^2 = 1.03$, $I^2 = 0$%

Test for overall effect: $Z = 2.59 (p = 0.002)$

1.2 Subgroup analyses on CBT intervention versus non-CBT intervention were performed using fixed effect model with heterogeneity, $I^2 = 1$% as shown as Figure 8.

Both Hetrick et al., (2017) and van Spijker et al., (2014) used more CBT-based intervention compared to the other studies. Statistically, there was no significant
difference $p$-value = 0.21 between either subgroup; intervention was effective in all studies.

![Figure 8. Forest plot of comparison: Mobile health interventions versus control, outcome: Suicide attempts comparing CBT and non-CBT interventions.]

Four studies were conducted in high-income countries which includes Hetrick et al., 2017, Kordy et al., 2016, Vaiva et al., 2006 and van Spijker et al., 2014 from Australia, Germany, France and The Netherlands respectively. Three studies (Mousavi et al., 2014; Mousavi et al., 2016; Wei et al., 2013) were conducted in upper-middle income countries: Iran and China. Interaction test using fixed effect model with...
heterogeneity $P = 1\%$ result yield $p$-value $= 0.12$, showing no statistical difference between the groups as shown in Figure 9.

Sensitivity analyses

We conducted sensitivity analyses to examine the effects of trials with high risk of selection bias towards suicide rate outcome as shown in Figure 10. Analysis using
fixed effect model with heterogeneity, $I^2 = 19\%$ shows a $p$-value = 0.03, indicating that excluding trials of high risk of selection bias (Mousavi et al., 2014; Mousavi et al., 2016) had statistical difference on the outcome of suicide rate.

![Forest plot of comparison: Mobile health interventions versus control, outcome: Risk ratio (RR) for suicide attempts (excluding trials at high risk of selection bias).](image)

**Figure 10.** Forest plot of comparison: Mobile health interventions versus control, outcome: Risk ratio (RR) for suicide attempts (excluding trials at high risk of selection bias).

**Additional analyses**

We conducted additional analyses to explore the pooled estimate effects of risk difference (RD) towards both suicide rate and death outcomes as shown in Figure 11 and Figure 12 respectively. For suicide attempts rate outcome, fixed effect model is used with heterogeneity $I^2 = 39\%$, and it showed a statistically significant result:

RD-0.04, 95% CI -0.07 to -0.01. However, the resulting number needed to treat (NNT)
25, was clinically moderately significant. For death outcomes, using a fixed effect model with heterogeneity $I^2 = 0\%$, showed no statistically significant results: RD 0.00. 95% CI - 0.01 to 0.01.

**Figure 11. Forest plot of comparison: Mobile health interventions versus control, outcome: Risk difference (RD) for suicide attempts.**
Publication bias

We performed a visual technique using a funnel plot to explore for possible publication biases. Based on the funnel plot of suicide attempt outcomes as shown in Figure 13, the distribution pattern of studies appears slightly skewed, showing that publication bias might be low. It may represent more publications of intervention groups being effective than those for control groups. However, due to the small number of studies in this review, other biases may confound this picture. Further statistical analysis was performed by a regression approach. Egger, Davey Smith, Schneider, & Minder (1997) proposed a test for asymmetry of the funnel plot. This is a test for the Y-intercept
at 0 from a linear regression of normalized effect estimate (estimate divided by its standard error) against precision (reciprocal of the standard error of the estimate).

The test yielded $p$-value = 0.121 (>0.05), indicating statistically insignificant result for publication bias, meaning the asymmetry of funnel plot is not due to publication bias but due to the small number of studies. However, this similar reason may confound this regression analysis, hence interpreting the presence of publication bias needs to be done with discretion.

Figure 13. Funnel plot of comparison: Mobile health interventions versus control, outcome: Risk ratio (RR) for suicide attempts.
Effects of interventions

The findings of effects of interventions is presented in ‘Summary of findings’ for the main comparison shown in Table 2.

Table 2. Summary of findings

Mobile health interventions compared to control for suicide prevention in depressed people

**Patient or population:** Suicide prevention in depressed people  
**Settings:** Australia, Germany, The Netherlands, France, China, Iran  
**Intervention:** Mobile health interventions  
**Comparison:** Control

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<th>Outcomes</th>
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<th>Relative effect (95% CI)</th>
<th>№ of participants (studies)</th>
<th>Certainty of the evidence (GRADE)</th>
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<tr>
<td>Risk ratio (RR) for suicide attempts</td>
<td>118 per 1,000 (58 to 109)</td>
<td>RR 0.67 (0.49 to 0.92)</td>
<td>1387 (7 RCTs)</td>
<td>✧✧✧◯ MODERATE a</td>
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<tr>
<td>Risk ratio (RR) for deaths</td>
<td>6 per 1,000 (0 to 16)</td>
<td>RR 0.43 (0.06 to 2.81)</td>
<td>1041 (4 RCTs)</td>
<td>✧✧◯◯ LOW b</td>
</tr>
</tbody>
</table>

*The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).
CI: Confidence interval; RR: Risk ratio

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. Detection bias was high risk of bias (-1).
b. Few number of events and confidence intervals crosses 1, the number of events is small (-2).

Discussion

Summary of main results

This systematic review and meta-analysis assessed the effectiveness of mobile technology interventions in the prevention of suicide attempts and fatal outcomes. A total of seven RCT studies were included in this review, which comprises data of 1,387 participants. Out of seven, only four studies reported outcomes of death. Overall, the available number of studies was small and most of the risk of bias domains were low-risk with exception of the presence of performance bias. The quality of evidence is
moderate for suicide rate due to detection bias. Death outcome was considered to be low quality of evidence, downgraded by two levels due to the few numbers of events and wide 95% CIs crossing the line of no effect. This synthesized review clearly demonstrates that mHealth intervention was beneficial in both low- and high-risk populations. These findings are useful for those who are reluctant to seek regular mental health services, as mHealth provides a platform of help and support. Results also did not differ among CBT and non-CBT interventions, high and upper-middle income countries, and study duration. We found statistical difference upon excluding high selection bias trials on suicide rate. This review summarizes a range of mobile health intervention used in the context of suicide prevention. Meta-analysis indicated that the number needed to treat (NNT) equals 25; this denotes that the interventions were clinically moderate for suicide attempt reduction effects.

**Strengths and limitations**

Comprehensive systematic literature searches were conducted to retrieve RCT articles and methodological quality was assessed thoroughly. Although, a variety of types of mHealth interventions were being considered, this review allowed us to gauge the strength of mHealth intervention across the spectrum of many populations included in this review. Additionally, many types of mHealth interventions were included and
differed across the population in this review. Variability in control conditions may have influenced the magnitude of treatment effects in the prevention of suicide. There is possibility of TAU differences across studies. True blinding of subjects and personnel was also difficult to achieve in mHealth intervention studies. Studies included for this review measured outcomes of suicide attempts by self-reporting. Four studies (Mousavi, et al., 2014; Mousavi, et al., 2016; Vaiva, et al., 2006; Wei et al., 2013) focused on suicide attempters. Out of that, three studies (Mousavi, et al., 2014; Mousavi, et al., 2016; Vaiva, et al., 2006) focused on intoxication and self-poisoning suicide attempters, selecting participants among patients attempting suicide in other ways could be done in the future. Vaiva, et al., (2006) reported that some attempted suicides occurred prior the start of intervention and that evaluation of interventions should began earlier to avoid larger number of suicides from occurring. Three studies (Hetrick, et al., 2017; Mousavi, et al., 2016; Wei, et al., 2013) were underpowered, and Hetrick, et al., (2017) and Wei, et al., (2013) had high drop-out rates, which is uncommon among suicide prevention trials. In addition, substantial drop-out rates indicated that attrition bias might be high. The study of van Spijker, et al., 2014 included a short-term follow up (<3 months). Both studies Mousavi et al., (2014) and Mousavi et al., (2016) had high selection bias, which affected the statistical outcome of the suicide rate.
Evaluation of mHealth technologies usage on suicide prevention and death is still in its early phase. Despite the variety of types of interventions, controls and outcomes of mHealth included in this review, the pooling and synthesizing of these studies enable us to gather information on a viable sample size number combined to appraise outcomes of published limited scopes such as suicide attempts and deaths. Heterogeneity across studies was explored to be very low for both outcomes in this study, enabling us to use a fixed effect model to demonstrate the pooled estimate effect of this study. The possibility of publication bias cannot be completely ruled out in this review, due to the small number of studies and its methodology qualities of studies included. This is the latest systematic review, which synthesized the evidence on RCT studies of mobile health use in the prevention of suicide attempts and death.

**Conclusions**

Mobile health technologies could be effectively employed as an adjunct in the treatment among depressed and suicidal patients. With the vast connectivity and coverage, mobile health enables mental health professionals to assist sufferers to reduce their suicidal tendency leading to avoidance of suicide and a fatal outcome. Furthermore, there is no loss in engaging mHealth technologies among mobile users. Moreover,
healthcare providers may consider integrating its practice of utilizing mHealth for suicide prevention as present studies show this reduction clinically is moderately meaningful. There were a small number of studies evaluating mobile health intervention in suicide prevention and death included in this study. We found a lack of evidence and standards in quantifying the intervention value of mobile health to prevent suicidal death. In low and middle-income countries, governments are interested in mHealth usage for strengthening health systems and reaching health-related Millennium Development Goals (MDGs) (WHO, 2011). Policy-makers should be made aware of the emerging mHealth field and expand its implementation along with its surveillance of usage. Further research is necessary to demonstrate the influence of mHealth and its effectiveness in prevention of suicide and death.

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Contributions of authors

C.E. Loo (CE) and B.W. Siy (BW) performed the study selection, data collection and
extraction. OT assisted CE with data analysis and synthesis. CE wrote the final draft of the review. All co-authors provided intellectual support for the review and approved the final version of manuscript for publication. CE was overall responsible for the design, development of search strategy, analysis and is the study guarantor.

**Declarations of interest**

The authors declare they have no conflict of interest. (None known)

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**Funding**

St. Luke’s International University, Tokyo, Japan
References

References marked with an asterisk indicate studies included in the meta-analysis.


doi:10.1002/14651858.CD010013.pub2 [doi]


phone call versus face-to-face follow-up on recurrent suicide attempts prevention in individuals with a history of multiple suicide attempts. *Advanced Biomedical Research, 5*, 184-9175.190990. eCollection 2016. doi:10.4103/2277-9175.190990


## EFFECTIVENESS OF MOBILE HEALTH

### Appendices

#### Appendix 1. Database search strategies

**PubMed**

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<td>((((((((mhealth) OR m-health) OR mobile health) OR ((mobile) OR techno*)) OR ehealth) OR e-health) OR electronic health) OR ICT) OR telemedicine) OR telehealth) OR computer*) OR ((&quot;hand held&quot;) OR handheld)) OR &quot;hand held&quot;) OR handheld) OR wireless) OR ((handphone*) OR &quot;hand phone*&quot;)) OR (((smartphone*) OR &quot;smart phone*&quot;)) OR tablet*[Text Word]) OR internet) OR ((telepsych*) OR &quot;tele-psych&quot;) OR &quot;Internet&quot;[Mesh]) OR &quot;Computers&quot;[Mesh]) OR (((&quot;Telemedicine&quot;[Mesh]) OR &quot;Cell Phones&quot;[Mesh]) OR &quot;Videoconferencing&quot;[Mesh]) OR &quot;Wireless Technology&quot;[Mesh]) OR &quot;Health Communication&quot;[Mesh]) OR &quot;Software&quot;[Mesh]) OR &quot;mass communication&quot;) OR mobile applications[MeSH Terms]) OR mobile) OR &quot;mobile application*&quot;) OR mobile phone</td>
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<td>Outcome</td>
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<td>((((randomized controlled trial [pt]) OR controlled clinical trial [pt]) OR randomized [tiab]) OR placebo [tiab]) OR drug therapy [sh]) OR randomly [tiab]) OR trial [tiab]) OR groups [tiab])) NOT ((animals [mh] NOT humans [mh]))</td>
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**EMBASE (Ovid) search strategy**

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<td>Intervene</td>
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<tr>
<td>Outcome</td>
<td>('self'/exp OR self) AND harming) OR (self AND harm:ti,ab) OR ('automutilation'/exp OR automutilation) OR ('suicidal behavior'/exp OR 'suicidal behavior') OR ('self'/exp AND injurious:ab,ti)</td>
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<td>Study Type</td>
<td>crossover procedure':de OR 'double-blind procedure':de OR 'randomized controlled trial':de</td>
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**PsycINFO (Ovid) search strategy**

| Population | DE "Major Depression" OR DE "Anaclitic Depression" OR DE "Dysthymic Disorder" OR DE "Endogenous Depression" OR DE "Late Life Depression" OR DE "Postpartum Depression" OR DE "Reactive Depression" OR DE "Recurrent Depression" OR DE "Treatment Resistant Depression" OR DE "Postpartum Depression" OR DE "Depression (Emotion)" OR DE "Treatment Resistant Depression" OR DE "Late Life Depression" OR DE "Recurrent Depression" OR DE "Reactive Depression" OR DE "Endogenous Depression" OR DE "Atypical Depression" OR DE "Spreading Depression" OR DE "Zungs Self Rating Depression Scale" OR DE "Long-term Depression (Neuronal)" OR DE "Beck Depression Inventory" OR DE "Bipolar Disorder" OR DE "Seasonal Affective Disorder" OR DE "Cyclothymic Personality" OR DE "Tricyclic Antidepressant Drugs" OR DE "Rumination (Cognitive Process)"

| Intervention | DE "Occupational Mobility" OR DE "Social Mobility" OR DE "Geographical Mobility" OR DE "Physical Mobility" OR DE "Mobility Aids" OR DE "Mobile Devices" OR DE "Cellular Phones" OR DE "Health Care Psychology" OR DE "Medical Psychology" OR DE "Health Disparities" OR DE "Health Literacy" OR DE "Health Care Utilization" OR DE "Health Personnel" OR DE "Allied Health Personnel" OR DE "Medical Personnel" OR DE "Mental Health Personnel" OR DE "Mental Health"
Inservice Training" OR DE "Community Mental Health Training" OR DE "Mental Health Inservice Training" OR DE "Physical Health Assessment" OR DE "Health Screening" OR DE "Mental Health Programs" OR DE "Crisis Intervention Services" OR DE "Deinstitutionalization" OR DE "Home Visiting Programs" OR DE "Hot Line Services" OR DE "Suicide Prevention Centers" OR DE "Mental Health Program Evaluation" OR DE "Holistic Health" OR DE "Health Knowledge" OR DE "Health Care Economics" OR DE "Allied Health Personnel" OR DE "Occupational Therapists" OR DE "Physical Therapists" OR DE "Psychiatric Aides" OR DE "Speech Therapists"

DE "Occupational Mobility" OR DE "Social Mobility" OR DE "Geographical Mobility" OR DE "Physical Mobility" OR DE "Technology Transfer" OR DE "Information Technology" OR DE "Mobility Aids" OR DE "Mobile Devices" OR DE "Technology" OR DE "Assistive Technology" OR DE "Health Care Psychology" OR DE "Health Disparities" OR DE "Health Literacy" OR DE "Health Care Utilization" OR DE "Health Personnel" OR DE "Innovation" OR DE "Mental Health Inservice Training" OR DE "Community Mental Health Training"

mobile health


mass communication

DE "Mobile Devices" OR DE "Cellular Phones" OR DE "Text Messaging" OR DE "Screen Time" OR DE "Occupational Mobility" OR DE "Social Mobility" OR DE "Geographical Mobility" OR DE "Physical Mobility" OR DE "Mobility Aids"

mobile

mhealth

"m health"

software


technolog*

DE "Telemedicine"
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internet

telepsychiatry

"tele psychiatry"

TI cell phone OR AB cell phone

TI cellphone OR AB cellphone

video conferenc*

videoconferenc*

(medical information) OR (DE "Information Systems")

TI health communication OR AB health communication
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### Study Type

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### CENTRAL on The Cochrane Library

#### Population

- depress*:ti,ab,kw in Trials (Word variations have been searched)

#### Intervention

- mobile health*:ti,ab,kw  (Word variations have been searched)
- mhealth*:ti,ab,kw or "m health":ti,ab,kw  (Word variations have been searched)
- mobile*:ti,ab,kw  (Word variations have been searched)
- technolo*:ti,ab,kw  (Word variations have been searched)
- ehealth*:ti,ab,kw or "e health":ti,ab,kw or electronic health:ti,ab,kw  (Word variations have been searched)
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