A Systematic Review of the Evidence Supporting Mobile- and Internet-Based Psychological Interventions For Self-Harm

USMAN ARSHAD, MSc, FARHAT-UL-AIN, MSc, JESSICA GAUNTELLT, MSc, NUSRAT HUSAIN, MD, NASIM CHAUDHRY, MD and PETER JAMES TAYLOR, PhD

Objectives: Internet- and mobile phone-based psychological interventions have the potential to overcome many of the barriers associated with accessing traditional face-to-face therapy. Self-injurious thoughts and behaviors (STB) are prevalent global health problems that may benefit from Internet- and mobile-based interventions. We provide a systematic review and meta-analysis of studies evaluating mobile- and Internet-based interventions for STB, including nonsuicidal self-injury (NSSI).

Methods: Online databases (PsycINFO, Web of Science, Medline) were searched up to March 2019 for single-arm and controlled trials of Internet- or mobile-based interventions for STB. The potential for bias was assessed using the Cochrane risk of bias tool.

Results: Twenty-two eligible trials were identified. The research was limited by a lack of controlled designs and small samples. Evidence supports the acceptability of interventions. There is preliminary evidence that these interventions are associated with a decline in STB. A meta-analysis suggested a positive treatment effect on suicidal ideation when compared to treatment as usual, but not when trials with active controls were also considered.

Conclusions: Overall, Internet- and mobile-based interventions show promise and further controlled trials are warranted, focusing on behavioral outcomes (NSSI, suicidal behavior). This review was preregistered with PROSPERO (CRD42017074065).
Suicide is a serious global public health issue ranked among the leading causes of death in many countries (World Health Organisation, 2014). Self-injurious thoughts and behavior (STB) are associated with an increased risk of suicide (Grandclerc, De Labrouhe, Spodenkiewicz, Lachal, & Moro, 2016; Hawton, Bergen, et al., 2015; Ribeiro et al., 2016; Scott, Pilkonis, Hipwell, Keenan, & Stepp, 2015). Even where STB does not lead to suicide, it is associated with a reduced life span, and greater physical and mental health difficulties (Bergen et al., 2012; Goldman-Mellor et al., 2014; Hawton, Saunders, & O'Connor, 2012). STB encompasses self-injurious behaviors (SB), which can be divided into those behaviors with suicidal intent (i.e., suicide attempts) and nonsuicidal self-injury (NSSI), and self-injurious thoughts, which include suicidal ideation (Ribeiro et al., 2016; Silverman, Berman, Sanddal, O’Carroll, & Joiner, 2007).

There is evidence that psychological and social interventions can be effective in preventing STB (Hawton, Witt, et al., 2015; Hawton et al., 2017; Hetrick, Robinson, Spittal, & Carter, 2016; Turner, Austin, & Chapman, 2014). There is preliminary support for the efficacy of a number of psychological therapies for people who struggle with STB, including Cognitive Behavioral Therapy (CBT), Emotion-Regulation Group Therapy (ERGT), and Dialectical Behavioral Therapy (DBT; Hawton, Witt, et al., 2015; Hawton et al., 2017; Hetrick et al., 2016; Turner et al., 2014). However, these therapies are typically costly in terms of resources, the necessity of trained therapists, and the duration of therapy typically required. While there is also preliminary evidence for some brief psychological therapies for STB (Guthrie et al., 2001; Tapola, Lappalainen, & Wahlström, 2010), a limitation of the suicide prevention literature is that the majority of interventions rely on face-to-face contact (delivered at a group, family, community, or individual level). These interventions may therefore not be accessible for many individuals, due to geographical (e.g., living in rural setting with limited mental health resources, travel distance to appointments), social (e.g., barriers related to stigma), organizational (e.g., waiting times and service availability), or even financial reasons (e.g., in healthcare contexts where clients must pay for their treatment; Department of Health, 2017; Institute of Medicine, 2002; Leigh & Flatt, 2015; Poppleton & Gire, 2017). Approximately seventy-eight percent of suicides occur in low- and middle-income countries (World Health Organisation, 2018). These locations are therefore an important focus for STB and suicide prevention, but challenges related to access to treatment are also often exacerbated in these contexts. Challenges facing low- and middle-income countries include fewer available mental health practitioners relative to the population size and a lack of mental health services and staff in more rural areas (Rathod et al., 2017). Internet- or mobile-based interventions may be one avenue for overcoming these challenges (Lai, Maniam, Chan, & Ravindran, 2014; Leigh & Flatt, 2015; Poppleton & Gire, 2017). Stakeholders have identified improved access to treatment as a key benefit of Internet- or smart phone-mediated approaches to helping suicidal individuals (Ward-Ciesielski, Peros, Conigliaro, & Gilmore, 2018). Such interventions have the potential to be delivered remotely to provide an alternative way of helping those at risk of STB where access to face-to-face interventions is limited. The present review focuses on the evidence base for these interventions.

mHealth or mobile health, referring to health interventions that are delivered or supported via remote devices such as mobile phones, wearable technology, or personal digital assistants (PDAs), is increasingly being considered as a basis for mental health intervention (Bucci et al., 2015; Sort, 2017). Such interventions can be considered part of the broader body of Internet-based interventions, or eHealth (e.g., interventions delivered via Web sites and browser-based applications; Christensen, Batterham, & O’Dea, 2014). There is evidence that Web- and mobile-based interventions may be effective for common mental health difficulties including
depression and anxiety (Firth et al., 2017; Josephine, Josefine, Philipp, David, & Harald, 2017; Richards, Richardson, Timulak, & McElvaney, 2015; Stratton et al., 2017). A previous review of eHealth interventions for suicide prevention noted that they may be beneficial, but were likely to be more effective where specifically focused on suicide rather than related problems like depression (Christensen et al., 2014). A large number of mHealth interventions aimed at STB prevention have been developed (Larsen, Nicholas, & Christensen, 2016). However, research regarding the acceptability, feasibility, and efficacy of such interventions appears scarcer (Christensen et al., 2014; Melia et al., 2018; Perry, Werner-Seidler, Callear, & Christensen, 2016).

Despite the potential benefits of Internet- and mobile-based interventions for STB, there are also reasons for caution. The relationship between client and therapist appears to be a key factor in influencing the outcome of therapy (Blake, Larkin, & Taylor, 2019; Goldsmith, Lewis, Dunn, & Bentall, 2015; Michel, 2016). It has been suggested that Web- and mobile-based interventions may have a more limited capacity to facilitate a therapeutic relationship due to the lack of a face-to-face contact (Perle, Langsam, & Nierenberg, 2011). There is preliminary evidence that a positive working alliance (one aspect of the therapeutic relationship) can develop with computer-based interventions in individuals with mild-to-moderate mental health difficulties (Clarke et al., 2016). However, it remains unclear whether Web- or mobile-based interventions could provide an effective alternative in more complex contexts, including those at risk of STB. Clinicians have concerns about the use of such approaches with clients at risk of suicide, including the lack of a thorough assessment, and constraints on being able to respond to elevated risk (Gilmore & Ward-Ciesielski, 2017). A further potential issue is the reduced capacity for the collaborative development of understanding. Many therapeutic approaches rely on the development of a personalized understanding (or formulation) of a client’s difficulties, including how problems have developed and what has kept them going, which can guide the therapy (e.g., Tarrier & Johnson, 2016; Taylor, Gianfrancesco, & Fisher, 2019). The interaction with a therapist is key in guiding this development, and it may not be possible to replicate this process within mobile- or Web-based interventions. Consequently, questions can be raised about both the acceptability and efficacy of mobile- and Web-based interventions for individuals who struggle with STB.

Given the increasing number of studies evaluating mobile- and Web-based interventions for STB prevention, it is timely and important to evaluate the extant evidence regarding the acceptability, feasibility, and efficacy of mobile- and Web-based intervention for STB (including suicidal behavior) and suicidal ideation. The current review aimed to expand on previous reviews in this area by focusing specifically on interventions aimed at STB (rather than associated difficulties like depression), providing a synthesis of acceptability and feasibility results alongside efficacy, inclusion of a number of more recent trials in this area not covered by previous reviews, preregistration of the review protocol, and the use of meta-analysis incorporating a number of new trials. The aim of this study was to systematically review the current evidence for (1) the efficacy of Web- and mobile-based interventions in reducing STB and suicidal ideation in adults and young people at risk of STB; (2) the acceptability of these interventions, operationalized in terms of participant feedback on the experience of using the intervention (e.g., Proctor et al., 2011); and (3) the feasibility of these interventions, operationalized in terms of rates of engagement with the intervention (Proctor et al., 2011). We considered both active control interventions and treatment as usual. Regarding acceptability and feasibility, we recognize that these concepts can overlap with the “usability” of software (i.e., on a practical level how easy and intuitive the software is to use). For example, if software is difficult or confusing to use, participants are more likely to stop using it.
METHOD

Preregistration

A protocol for this review was preregistered with PROSPERO (CRD42017074065). The PRISMA reporting guidelines were adhered to in this review (Moher, Liberati, Tetzlaff, Altman, & The, 2009). Departures from protocol are listed in Appendix S1.

Search Strategy

Electronic databases (PsycINFO, Web of Science, and MEDLINE) were searched for eligible studies. The original search, specified in the protocol, was conducted from the earliest date up to January 2019. The details of this search are available in Appendix S2. Based on reviewer feedback, we adjusted our search terms and repeated the search from earliest date available up to March 2019. For this revised search, the following subject terms and Boolean operators were used: (web OR online OR internet OR “mobile device” OR “cell* phone” OR “smartphone” OR “phone app” OR “mobile app” OR “cell* app” OR “tablet computer” OR iPad OR iPhone OR Samsung OR android OR “windows phone”) AND (self-harm” OR “self-injury” OR DSH OR NSSI OR “self-burn*” OR “self-mutilation” OR “self-cutting” OR suicide OR overdose) AND (therapy OR intervention OR treatment OR training). The asterisks indicate wildcard operators.

These online literature searches were supplemented by (1) checking for any additional potentially eligible papers cited by included articles; (2) contacting all corresponding authors of included articles inquiring whether they have any other studies (published or not) that might be eligible for the review; and (3) checking reference lists of relevant reviews (Christensen et al., 2014; Lai et al., 2014; Perry et al., 2016; Witt et al., 2017).

The data screening was done in two steps. Firstly, titles and abstracts were screened and studies not fulfilling the inclusion criteria were excluded. Where it was uncertain if studies met inclusion criteria, they were retained for the next stage of screening. Secondly, full-text articles were screened out on the basis of inclusion/exclusion criteria. Both stages of screening were completed in parallel by two independent reviewers (active researchers with masters or doctoral level qualifications in psychology) and discrepancies resolved through discussion.

Inclusion and Exclusion Criteria

Both published literature and gray literature were included. Trials were eligible for inclusion provided that they met the following criteria: (1) Intervention studies include single-arm trials, case series, and randomized controlled trials; (2) participants characterized by experiences of STB; (3) the intervention is an Internet- or mobile phone-delivered psychological intervention broadly focused on STB prevention. We excluded a number of studies where the intervention was directed more broadly at depression and the sample was not characterized by experiences of STB (e.g., Mewton & Andrews, 2015). This was important given evidence that interventions directed primarily at other difficulties where STB is a secondary outcome tend to be less effective (Christensen et al., 2014; Tarrier, Taylor, & Gooding, 2008). Developments in mHealth and eHealth focused on
assessment or screening for STB risk were also not included. Studies were excluded if (1) exclusively qualitative methodology was used (studies with mixed method were considered); (2) non-English studies were excluded, only if full-text English translation was not available.

**Potential for Bias**

We assessed potential for bias for each included study using the Cochrane Collaboration Risk of Bias tool (Higgins et al., 2011). Each study was rated as high, unclear, or low potential of bias with respect to the following: adequacy of the random sequence generation procedure, adequacy of allocation concealment, presence of participant and clinical personnel blinding, presence of outcome assessor blinding, presence of incomplete outcome data, presence of selective outcome reporting, and presence of any other bias. Potential for bias ratings were made independently by at least two reviewers (UA, F-UA, PJT; researchers with master’s or doctoral level qualifications in psychology). Discrepancies were resolved through discussion.

**Data Extraction**

Quantitative information was extracted independently by at least two reviewers (UA, F-UA, PJT) using a data extraction spreadsheet. Extracted information included study characteristics, study design, sample characteristics (for both intervention and control group), intervention characteristics, and results. Any disagreements were resolved after discussion among the team members. Study authors were contacted to provide additional information where data were missing or unclear. The primary outcomes were STB (including suicide attempts), feasibility, and acceptability. Acceptability was based upon participant reported experiences of using the intervention, specifically how helpful or useful the intervention was, or the perceived likelihood of using it again in the future. Feasibility was based upon intervention engagement or usage rates (e.g., number of times accessing a mobile phone app during the study period). Suicidal ideation was also included as a secondary outcome.

**Meta-Analysis**

Meta-analysis was undertaken where five or more trials were identified with data on a specific outcome (STBs, see protocol). Meta-analysis was only undertaken for RCTs due to the problems with aggregating effects from single-arm studies (Cuijpers, Weitz, Cristea, & Twisk, 2016). Following screening, there were only enough trials to undertake meta-analysis for suicidal ideation. Suicidal ideation was treated as a continuous scale representing severity or frequency of ideation. Hedge’s $g$ was used to represent these effect sizes. Due to the variety of different assessment tools used, the unstandardized mean difference could not be compared across studies. Endpoint data were used to compare trial arms but a sensitivity analysis looking at mean change score where available was also undertaken. The analyses focused on the time-point closest to end of treatment. For one trial, the 6-month follow-up data were used because following this point both arms of the trial received the mobile-based intervention preventing a comparison (Marasinghe, Edirippulige, Kavanagh, Smith, & Jiffry, 2012). Where data were unavailable, this was requested from authors. A random-effects model, using the DerSimonian and Laird (1986) inverse variance estimator, was adopted as heterogeneity in treatment model and outcome assessment was expected. Inconsistency was assessed via the $I^2$ statistic (Higgins & Thompson, 2002; Higgins, Thompson, Deeks, & Altman, 2003). Analyses were undertaken in STATA 14 (StataCorp, 2015).

**RESULTS**

**Study Characteristics**

This systematic review identified 22 eligible trials in total (see Figure 1 for flowchart of screening process), one of which was
unpublished trial data provided by the author (Eylem, 2019; Eylem, van Straten, Bhui, & Kerkhof, 2015). Study characteristics are summarized in Table 1. Twelve were randomized controlled trials (RCTs), nine were single-arm studies, and one used a cross-over counterbalanced controlled design. Twenty-one studies were from higher income countries including the USA, UK, China, Denmark, Australia, Sweden, Netherland, Japan, Belgium, and France. Only one study was from a middle or lower income country, namely Sri Lanka (Marasinghe et al., 2012).

**Sample and Intervention Characteristics**

The included trials comprised a total of $n = 2,016$ adults and adolescents. The majority of the studies included adult samples ($k = 16$). Seven interventions involved established psychological therapies including CBT, DBT, and individual emotion-regulation therapy, delivered via an Internet Web site (Bjureberg et al., 2018; Eylem, 2019; Hetrick et al., 2017; Robinson et al., 2016; van Spijker, van Straten, & Kerkhof, 2014; van Spijker et al., 2018; Wilks et al., 2018). Nine used mobile phone applications to deliver a toolbox of support including coping skills and strategies (often derived from approaches such as CBT and DBT) as well as signposting or crisis support (Bush et al., 2015, 2017; Kennard et al., 2018; Maama O’Brien, LeCloux, Ross, Gironda, & Wharff, 2016; O’Toole, Arendt, & Pedersen, 2019; Pauwels et al., 2017; Rizvi, Hughes, &

---

**Figure 1. Flowchart of literature screening.**
| Author(s)                        | Study year, Country | Study design | Sample characteristics                                                                 | Follow-up period | Intervention                                                                                     | Control | Measures of self-harm and suicidal ideation | Key results                                                                 |
|---------------------------------|---------------------|--------------|----------------------------------------------------------------------------------------|------------------|-----------------------------------------------------------------------------------------------|---------|---------------------------------------------|--------------------------------------------------------------------------------|
| Berrouiguet et al. (2014), France | Single arm          | $N = 18$ Adults with a suicide attempt history; Age $M = 37.9$ years, $SD = 8.6$; Female $N = 15$ (93%) | 2 months         | Text Messages. Personalized supportive text messages following discharge. Four messages were sent over 30 days, validating experiences and encouraging help-seeking if needed | NA      | Psychiatrists' report                      | Overall positive response from participants concerning acceptability of intervention |
| Bjureberg et al. (2018), Sweden  | Single arm          | $N = 25$ Adolescents aged 13 to 17 years meeting criteria for NSSI disorder; Age $M = 15.7$ years, $SD = 1.3$; Female $N = 19$ (76%) | 6 months         | Internet Web site. Eleven module individual emotion-regulation therapy. Includes individualized crisis plan. Also parent version with nine modules. Delivered over 12 weeks | N/A     | Deliberate self-harm inventory (Bjärehed & Lundh, 2008) | Significant reduction in NSSI frequency (pretreatment to 6 months of follow-up, $d = 1.36$, 95% CI: 1.12, 1.63) Good average completion rates of intervention by adolescents ($M = 9.7$ modules completed out of 11) |

(continued)
| Author(s) year, Country | Study design | Sample characteristics | Follow-up period | Intervention | Control | Measures of self-harm and suicidal ideation | Key results |
|------------------------|-------------|------------------------|------------------|--------------|---------|------------------------------------------|-------------|
| Bush et al. (2015), USA | Cross-over trial | N = 18 Adult veterans diagnosed with posttraumatic stress disorder, depression, bipolar disorder, borderline personality disorder or mood disorder, deemed at high risk of SB; Age M = 41.4 years, SD = 8.6; Female N = 10 (56%) | 8 weeks | Mobile Phone Application. Suicide prevention application providing a virtual “hope box,” signposting, and coping skills. Used over 6–8 weeks | NA | NA | Overall positive response from participants concerning acceptability of intervention |
| Bush et al. (2017), USA | RCT | Adult veterans with recent suicidal ideation; Treatment group: N = 58; Age M = 46.5 years, SD = 13.8; Female N = 22 (38%); Control group: N = 60; Age M = 48.7 years, SD = 14.3; Female N = 15 (25%) | 12 weeks | Mobile Phone Application. Suicide prevention application providing a virtual “hope box,” signposting, and coping skills. Used over 12 weeks | Treatment as usual supplemented with printed material about coping with suicidal feelings | First five-items of the Beck Scale for Suicidal Ideation (BSS; Beck, Kovacs, & Weissman, 1979) | No significant differences (p > .05) in treatment groups for suicidal ideation at any follow-up point |
| Author(s)          | Study year, Country | Study design | Sample characteristics                                                                 | Follow-up period | Intervention                                                                 | Control | Measures of self-harm and suicidal ideation | Key results                                                                 |
|-------------------|--------------------|--------------|----------------------------------------------------------------------------------------|------------------|-----------------------------------------------------------------------------|---------|---------------------------------------------|--------------------------------------------------------------------------------|
| Chen et al.       | (2010), China      | Single-arm   | N = 15 Adults presenting at hospital due to a suicide attempt; 60% aged < 35 years; Female N = 12 (80%) | 4 weeks          | Text messages. Supportive text messages delivered to mobile phone or smartphone delivered over 4 weeks encouraging help-seeking | NA      | NA                                         | The majority of participants (80%) were positive about the value of the text messages and wished to continue to receive them |
| Eylem et al.      | (2019), Netherlands | RCT          | N = 18 Turkish adults living in the Netherlands with suicidal ideation; Age M = 33.5, SD = 8.4; Female N = 13 (72%) | 3 months         | Internet Web site. Eight online modules drawing on CBT and DBT principles, Delivered across 6 weeks | Waiting list | BSS                                         | NA                                                                            |
| Author(s) year, Country | Study design | Sample characteristics | Follow-up period | Intervention | Control | Measures of self-harm and suicidal ideation | Key results |
|------------------------|-------------|------------------------|------------------|-------------|---------|---------------------------------------------|-------------|
| Franklin et al. (2016), USA | RCT         | Adults with two or more episodes of self-cutting in past month; Sample 1: \( N = 114 \); Age \( M = 23.0 \) years, \( SD = 5.5 \); Female \( N = 92 \) (81%); Sample 2: \( N = 131 \); Age \( M = 22.9 \) years, \( SD = 5.0 \); Female \( N = 97 \) (74%); Sample 3: \( N = 163 \); Age \( M = 24.5 \) years, \( SD = 6.6 \); Female \( N = 96 \) (59%) | 2 months | Mobile Phone/Computer Application. Therapeutic Evaluative Conditioning (TEC). Game-like intervention based on behavioral conditioning pairing self-harm related stimuli with aversive stimuli. Used over 1 month | Nonactive control version of TEC | The Self-Injurious Thoughts and Behaviors Interview (SITBI; Nock, Holmberg, Photos, & Michel, 2007) | Fewer NSSI episodes in treatment group at 1 month (Sample 1: \( M = 9.33, SE = 2.08 \); Sample 2: \( M = 22.25, SE = 4.71 \); Sample 3: \( M = 6.84, SE = 1.37 \)) compared to control (Sample 1: \( M = 21.52, SE = 5.34 \); Sample 2: \( M = 23.19, SE = 6.24 \); Sample 3: \( M = 6.71, SE = 1.98 \)). Difference significant \( (p < .05) \) in two of the three samples. Treatment effects not maintained at 2 month follow-up |
| Author(s) | Study year, Country | Study design | Sample characteristics | Follow-up period | Intervention | Control | Measures of self-harm and suicidal ideation | Key results |
|-----------|---------------------|--------------|------------------------|------------------|-------------|---------|-----------------------------------|-------------|
| Hetrick et al. (2016), Australia | RCT | N = 50 High school students in contact with well-being staff members with suicidal ideation in past 4 weeks; Age $M = 14.7$ years, $SD = 1.4$; Female $N = 41$ (82%) | 22 weeks | Internet Web site. CBT-based intervention delivered across eight modules over 10 weeks, focused on suicidal thinking and behavior | Treatment as usual | Suicidal Ideation Questionnaire (Reynolds, 1987); Nonvalidated measure of suicidal behavior | Decrease in suicidal ideation from baseline to week 10 greater in treatment group ($M$ change $= -37.3, SD = 39.1$) compared to control ($M$ change $= -31.6, SD = 42.8$), but difference not significant ($p = 0.59$). Also no significant treatment effect at 22 weeks |
| Hooley et al. (2018), USA | RCT | N = 144 Adults with two or more episodes of NSSI in the past month; Age $M = 25.63$ years, $SD = 5.83$; Female $N = 123$ (85%) | 16 weeks | Internet Web site. Autobiographical Self-Enhancement Training (ASET). Involves writing exercises focused on identifying and focusing on positive personal characteristics. Delivered over 4 weeks | Expressive writing; Journaling | SITBI | No significant differences ($p > .05$) between groups for the number of NSSI episodes at end of treatment, 1 month or 2 month follow-up |

(continued)
| Author(s) year, Country | Study design | Sample characteristics | Follow-up period | Intervention | Control | Measures of self-harm and suicidal ideation | Key results |
|------------------------|-------------|------------------------|------------------|-------------|---------|---------------------------------|-------------|
| Kennard et al. (2018), USA | RCT         | N = 66 Adolescents hospitalized due to suicidal ideation or suicide attempt; Age M = 15.1 years, SD = 1.5; Female N = 59 (89%) | 24 weeks        | Face-to-face therapy supplemented with mobile phone application. The mobile phone application delivers CBT- and DBT-informed skills training and safety planning interventions | Treatment as usual | Suicidal Ideation Questionnaire-Junior version (SIQ-J; Reynolds, 1987); Columbia Suicide Severity Rating Scale (CSSRS: Posner et al., 2011) | No significant association (p > .05) between app use frequency and changes over time in suicidal ideation or behavior |
| Kodama et al. (2016), Japan | Single arm | N = 30 psychiatric outpatients; Age M = 38.4 years, SD = 11.4; Female N = 15 (50%) | 6 months | Text messages, Supportive text messages delivered to mobile phone or smartphone delivered over 6 months | NA | Psychiatrists’ report | Significant effect of time (p < .05) whereby proportion who reported SB decline from 28% to 7% Significant effect of time (p < .05) whereby intensity of suicidal ideation declined from M = 2.00, SD = 1.18, to M = 0.83, SD = 1.00 |

(continued)
| Author(s) year, Country       | Study design | Sample characteristics                                                                 | Follow-up period | Intervention                                                                 | Control          | Measures of self-harm and suicidal ideation | Key results                                                                 |
|------------------------------|--------------|----------------------------------------------------------------------------------------|------------------|------------------------------------------------------------------------------|------------------|--------------------------------------------|-----------------------------------------------------------------------------|
| Marasinghe et al. (2012), Sri Lanka | RCT          | N = 68 Patients admitted to hospital after attempting self-harm, and displaying significant suicidal intent; Intervention group: Age $M = 34.0$, $SD = 14.0–17.0$; Female $N = 17$ (50%) Control group: Age $M = 29.0–31.0$, $SD = 16.0–17.0$; Female $N = 17$ (50%) | 6 and 12 months | Text messages. Text message reminders concerning coping skills, use of support and signposting. These follow face-to-face and telephone intervention. Delivered over 12 months | Wait-list/usual care | BSS | Significant time by group effect ($p < .05$) whereby suicidal ideation declined more over 12 months for the treatment group |
| McManama O’Brien et al. (2016), USA | Single arm   | N = 20 Adolescent mental health outpatients; Age $M = 15.7$ years, $SD = 1.6$; Female $N = 16$ (80%) | NR               | Mobile Phone Application. Suicide prevention application providing signposting, and coping skills. Modules are also available to help support parents | NA               | NA | Overall positive response from participants concerning acceptability of intervention |

(continued)
| Author(s)          | Study design | Sample characteristics                                                                 | Follow-up period | Intervention                                                                                           | Control         | Measures of self-harm and suicidal ideation | Key results                                                                 |
|-------------------|--------------|----------------------------------------------------------------------------------------|------------------|--------------------------------------------------------------------------------------------------------|-----------------|-------------------------------------------|-----------------------------------------------------------------------------|
| O'Toole et al.    | RCT          | Adult psychiatric outpatients with current suicidal ideation. Treatment group: N = 60; Age M = 28.1 years, SD = 9.2; Female N = 24 (40%) Control group: N = 69; Age M = 29.3 years, SD = 9.7; Female N = 30 (44%) | 4 months        | Mobile phone application. Application includes psychoeducation, self-assessment, and safety planning components as well as library of self-help exercises | Treatment as usual (including psychotherapy) | NA                         | The majority of participants made use of the app (83%) but ratings regarding the role of the app in overall treatment were neutral |
| Pauwels et al.    | Single arm   | N = 21 adults with some degree of suicidal ideation; Age M = 30.0 years; Female N = 16 (76%) | 1 week          | Mobile Phone Application. Series of components to help during a suicidal crisis including coping strategies (based upon CBT principles), safety and crisis planning, support in accessing social network. Delivered over 1 week | NA              | BSS                        | Mixed evidence of acceptability. Seventy percent of participants indicated they would use the app in daily life but 20% also said it did not help with suicidal thoughts |
| Author(s) year, Country | Study design | Sample characteristics | Follow-up period | Intervention | Control | Measures of self-harm and suicidal ideation | Key results |
|------------------------|--------------|------------------------|------------------|--------------|---------|------------------------------------------|-------------|
| Rizvi et al. (2016), USA | Single arm | N = 16 Adults diagnosed with borderline personality disorder with a recent history of repeated NSSI and/or suicide attempt; Age M = 27.5 years, SD = 7.1; Female N = 12 (75%) | 9 months | Mobile Phone Application. DBT skills training and coaching delivered across four modules. Taking place alongside face-to-face therapy. App available for 9 months | NA | STTBI | App usage was significantly associated (p < .05) with a decline in NSSI, explaining 26% of within-person variance in NSSI. App usage was not significantly (p > .05) associated with changes in suicide attempts. |
| Robinson et al. (2016), Australia | Single arm | N = 34 High school students in contact with well-being staff members with suicidal ideation in past month; Age M = 15.6 years; Female N = 28 (88%) | 8 weeks | Internet Web site. CBT-based intervention delivered across eight modules focused on suicidal thinking and behavior (same intervention used by Hetrick et al., 2017) | NA | SIQ-J for year 8 and 9 students and the Adult Suicidal Ideation Questionnaire for older students (Osman et al., 1999) | There was a significant reduction (p < .05) in suicidal ideation from baseline to posttreatment, \( d = 0.66, p < .01 \) |
| Author(s) year, Country | Study design | Sample characteristics | Follow-up period | Intervention | Control | Measures of self-harm and suicidal ideation | Key results |
|-------------------------|-------------|------------------------|-----------------|--------------|---------|------------------------------------------|-------------|
| Stallard et al. (2018), UK | Single arm | $N = 44$ Young people aged 12 to 17 years with a history of self-harm; Age $M = 16.0$ years, $SD = 1.4$; Female $N = 40$ (91%) | 12 weeks | Mobile Phone Application. Toolbox of strategies derived from CBT and DBT principles. Delivered over 12 weeks | NA | Nonvalidated self-report measure of self-harm | The number of participants reporting SB in the past 4 weeks declined from 79% at baseline to 67% posttreatment, No significant time by group effect, $p = .30$ |
| Tighe et al. (2017), Australia | RCT | $N = 61$ Adults with moderate or greater depression and suicidal thoughts in last 2 week; Age $M = 26.3$ years, $SD = 8.1$; Female $n = 39$ (64%) | 6 weeks | Mobile Phone Application. Suicide prevention skills training intervention including mindfulness, self-soothing and acceptance-based techniques alongside emergency contact signposting, delivered across three modules over 6 weeks | Wait-list/usual care | The depressive symptom inventory-suicidality subscale (Metalsky & Joiner, 1997) | (continued) |
| Author(s) year, Country | Study design | Sample characteristics | Follow-up period | Intervention | Control | Measures of self-harm and suicidal ideation | Key results |
|-------------------------|--------------|------------------------|------------------|-------------|---------|------------------------------------------|-------------|
| van Spijker et al. (2014), Netherlands | RCT | N = 236 Adults with mild to moderate suicidal ideation; Age M = 40.93 years, SD = 13.7; Female N = 156 (66%) | 6 weeks | Internet Web site. Unguided self-help intervention primarily based upon CBT principles, but also including elements of DBT, problem-solving therapy, and mindfulness-based cognitive therapy. Delivered across six modules over 6 weeks | Access to Web site providing information on suicide | BSS | A significant time by group effect whereby there was greater improvement in suicidal ideation in the treatment group (M change = 4.47, SD = 8.72) compared to the control group (M change = 2.30, SD = 6.57), p < .05 |
| van Spijker et al. (2018), Australia | RCT | N = 418 Adults currently experiencing suicidal thoughts; Intervention group N = 207; Age M = 39.5 years, SD = 11.9; Female N = 160 (77%) Control group N = 211; Age M = 41.7 years, SD = 11.9; Female N = 163 (77%) | 12 months | Internet Web site. Six online modules drawing on CBT and DBT principles, Delivered across 6 weeks | Online 6-week “living” programme, focused on general health and well-being | Suicidal Ideation subscale of the CSSRS | No significant (p = .23) difference in treatment groups for the severity of suicidal ideation at posttreatment, or at six and 12 months follow-up |
| Author(s) year, Country | Study design | Sample characteristics | Follow-up period | Intervention | Control | Measures of self-harm and suicidal ideation | Key results |
|-------------------------|--------------|-----------------------|------------------|--------------|---------|---------------------------------------------|-------------|
| Wilks et al. (2018), USA | RCT          | Adults with suicidal ideation, high emotion dysregulation and a history of heavy episodic drinking | Intervention group $N = 30$; Age $M = 38.0$ years, $SD = 11.3$; Female $N = 20$ (67%); Control group $N = 29$; Age $M = 37.4$ years, $SD = 10.1$; Female $N = 21$ (72%) | 4 months | Internet delivered. Internet-delivered DBT skills training. Delivered over 8 weeks | Waiting list | BSS | No significant Time by group effect on suicidal ideation ($p = .22$) |

BSS, Beck Scale of Suicidal Ideation; CBT, Cognitive Behavioral Therapy; CI, Confidence Intervals; DBT, Dialectical Behavior Therapy; NA, Not Applicable; NR, Not Reported; NSSI, Nonsuicidal Self-Injury; RCT, Randomized Controlled Trial; SB, Self-injurious Behavior; SITBI, Self-Injurious Thoughts and Behaviors Interview; TEC, Evaluative Conditioning.
Three interventions involved supportive text messages (Berrouiguet, Gravey, Le Galudec, Alavi, & Walter, 2014; Chen, Mishara, & Liu, 2010; Kodama et al., 2016). One intervention involved the use of audio and text messages relating to coping skills and strategies, which followed on from face-to-face support (Marasinghe et al., 2012). Another intervention employed an aversive behavioral conditioning-based intervention (Therapeutic Evaluative Conditioning; TEC), delivered via mobile application, whereby NSSI-related stimuli were paired with aversive stimuli (Franklin et al., 2016). Lastly, one intervention involved Autobiographical Self-Enhancement Training (ASET) whereby participants undertook a written (or typed) exercise that helped them identify and focus on positive personal attributes (Hooley, Fox, Wang, & Kwashie, 2018). Kennard et al. (2018) combined a mobile application with novel face-to-face therapy, and we therefore focus on outcomes linked specifically to application use.

**Potential for Bias**

A summary of the potential for bias assessment is displayed in Table 2. Nine studies used single-arm or pre–post designs and so were not rated for items related to sequence generation or allocation concealment since participants were not allocated to treatment groups. However, the results of such studies should be interpreted with caution since improvements cannot be attributed to the treatment itself, and may reflect other factors. There were a number of areas of recurring high potential for bias across studies. The potential for detection bias was high for 13 studies, where research staff undertaking assessments were not masked. Also, because it is usually not possible to mask participants to the fact they are receiving therapy, all included studies were rated high for performance bias except two that used active control interventions. Twelve studies were also judged at high potential for selective reporting bias, largely due to the lack of preregistration of trial protocols. However, the potential for attrition bias was generally low across studies. Other sources of bias were identified for eleven trials related to nonvalidated measurement tools or small sample size. In summary, the research appears at a preliminary stage and improvements in design (great use of RCT designs, use of allocation concealment, and masking), sample size, and preregistration would be beneficial.

**Self-Injurious Behaviors Not Otherwise Specified**

Two trials (Kodama et al., 2016; Stallard et al., 2018) investigated the effect of the therapeutic interventions on SB, where suicidal intent was not specified. In psychiatric outpatients, a supportive text messaging service was associated with a significant effect of time characterized by decline in the frequency of SB (from $N = 8$, 27.6%, to $N = 2$, 6.9%, $p = .03$) over 6 months. For young people with a history of STB using a mobile therapy app, the number who reported any recent SB declined from 78.8% to 66.7%, and of those who reported SB, 68.2% reported the frequency had reduced. However, the small scale of these trials ($n = 30–44$) and lack of a control group means these results remain preliminary.

**Nonsuicidal Self-Injury**

Four trials (Bjureberg et al., 2018; Franklin et al., 2016; Hooley et al., 2018; Rizvi et al., 2016) investigated the effect of therapeutic interventions on NSSI with mixed findings. Two trials (Bjureberg et al., 2018; Rizvi et al., 2016) reported significant effects of time characterized by reductions in NSSI for individuals using a DBT-informed mobile app (frequency of app use associated with declines in NSSI over 3 months) or online emotion-regulation therapy (e.g., 69% reduction in NSSI frequency over 6 months, $d = 1.36$, 95% CI: 1.12, 1.63). However, the absence of a control group means these effects cannot be attributed to the interventions.
| Study                         | Random sequence generation | Allocation concealment | Reporting bias | Other bias | Performance bias | Detection bias | Attrition bias |
|------------------------------|-----------------------------|------------------------|----------------|------------|-----------------|----------------|----------------|
| Berrouiguet et al. (2014)    | NA                          | NA                     | High           | High       | High             | High           | Low            |
| Bjureberg et al. (2018)      | NA                          | NA                     | Low            | High       | High             | High           | Low            |
| Bush et al. (2015)           | Unclear                     | Unclear                | High           | High       | High             | High           | Low            |
| Bush et al. (2017)           | Low                         | Unclear                | High           | Low        | High             | High           | Low            |
| Chen et al. (2010)           | NA                          | NA                     | High           | High       | High             | High           | Low            |
| Eylem (2019)                 | Low                         | Low                    | Low            | High       | High             | Low            | Unclear        |
| Franklin et al. (2016)       | Low                         | Unclear                | High           | Low        | Low              | Low            | High           |
| Hetrick et al. (2016)        | Low                         | Low                    | Low            | Low        | High             | Low            | High           |
| Hooley et al. (2018)         | Low                         | Low                    | High           | Low        | Low              | Low            | Low            |
| Kennard et al. (2018)        | Low                         | Unclear                | Low            | Low        | High             | Low            | Low            |
| Kodama et al. (2016)         | NA                          | NA                     | High           | High       | High             | High           | Low            |
| Marasinghe et al. (2012)     | Unclear                     | Unclear                | High           | Low        | High             | Low            | Low            |
| McManama O’Brien et al. (2016)| NA                         | NA                     | High           | High       | High             | High           | Low            |
| O’Toole et al. (2019)        | Unclear                     | Low                    | High           | Low        | High             | High           | High           |
| Pauwels et al. (2017)        | NA                          | NA                     | High           | High       | High             | High           | High           |
| Rizvi et al. (2016)          | NA                          | NA                     | High           | High       | High             | High           | Low            |
| Robinson et al. (2016)       | NA                          | NA                     | Low            | High       | High             | High           | Low            |
| Stallard et al. (2018)       | NA                          | NA                     | Low            | High       | High             | High           | High           |
| Tighe et al. (2017)          | Low                         | Unclear                | Low            | Low        | High             | High           | Low            |
| van Spijker et al. (2014)    | Low                         | Low                    | Low            | High       | Low              | Low            | Low            |
| van Spijker et al. (2018)    | Low                         | Low                    | Low            | Low        | High             | Low            | High           |
| Wilks et al. (2018)          | Low                         | Unclear                | Low            | High       | Low              | Low            | Low            |

NA, not applicable.
Franklin et al. (2016) studied a behavioral conditioning-based intervention delivered via a mobile phone application with mixed findings across three studies. In two of the three studies, those in the active treatment reported fewer NSSI episodes during the treatment month than those in the control condition (Incident Rate Ratio for treatment group = 0.72–0.88). However, none of these treatment effects were maintained during the follow-up month. Hooley et al. (2018) found no evidence of a beneficial treatment effect on NSSI compared to active control conditions (g = 0.14, 0.07), though all groups experienced a decline in NSSI episode count.

**Suicide Attempt**

Three RCTs investigating the effect of the therapeutic intervention on suicidal behavior did not identify any significant treatment effects, but power was likely adversely affected by the low base rate of such behavior (Hetrick et al., 2017; Hooley et al., 2018; van Spijker et al., 2018). van Spijker et al. (2018) reported small treatment effects following online therapy (d = 0.11, 0.15; calculated from marginal means). A trend toward reductions in suicidal behavior was, however, noted by Hetrick et al. (2017), with no suicide attempts at either 10 weeks or 22 weeks of follow-up in the intervention group compared to three and two participants attempting suicide in the control group. A fourth study by Franklin et al. (2016) also reported fewer participants engaging in suicidal behavior in the active treatment group compared to the control group in two of their studies (study 1: 5 vs. 4 individuals; study 2: 4 vs. 8 individuals; study 3: 3 vs. 5 individuals). In two further studies, the use of a therapeutic mobile app was not associated with a decline in the risk of suicide attempts (Kennard et al., 2018; Rizvi et al., 2016).

**Suicidal Ideation**

Eleven RCTs (14 samples) included suicidal ideation as an outcome. In one trial (Kennard et al., 2018), the effect of a mobile application could not be separated from a novel face-to-face intervention within the treatment group comparisons, so these data were not included in the meta-analyses. Endpoints ranged from 4 weeks to 6 months. Only two trials reported significant treatment effects (differences between treatment arms; Marasinghe et al., 2012; van Spijker et al., 2014). A random-effects meta-analysis, focusing on the endpoint closest to posttreatment, indicated a nonsignificant effect of treatment upon suicidal ideation, k = 13, g = −0.12 (95% CI: −0.29, 0.05), I² = 47%, with a moderate degree of inconsistency (see Figure 2). It is notable that treatment effects were often less favorable in those studies where control tasks or treatments other than TAU were used. When focusing only on trials with TAU as a comparator, there was a significant beneficial treatment effect, k = 8, g = −0.26 (95% CI: −0.48, −0.03), I² = 35%, with moderate inconsistency apparent (see Figure 2). The meta-analysis was also repeated with three trials (all with TAU as a comparator) where mean change data were available, g = −0.26 (95% CI: −0.48, −0.05), I² = 0%, leading to a significant effect of treatment on suicidal ideation. A final meta-analysis focused on outcomes at 3–6 months of follow-up (k = 5), but did not identify a beneficial effect on suicidal ideation, g = −0.18 (95% CI: −0.49, 0.12), I² = 37%.

The results emerging from single-arm studies of mobile- or Internet-based intervention were largely favorable. Four single-arm studies all reported a decline in suicidal ideation following the intervention. This was apparent for CBT-based online intervention aimed at students with recent suicidal ideation (d = 0.66; Robinson et al., 2016), text messaging interventions aimed at psychiatric outpatients (Kodama et al., 2016), and a DBT-based mobile intervention aimed at adults diagnosed with borderline personality disorder (30% of sessions with the app were associated with a decline in urges to SB; Rizvi et al., 2016). Kennard et al. (2018) did not find a significant relationship between app use and changes in ideation. A further mobile
phone app for adults with suicidal ideation did not lead to a reduction in ideation, though the study was likely under-powered (N = 21) given the 1-week follow-up period (Pauwels et al., 2017).

Acceptability

Self-reported acceptability was good where assessed (k = 13). For text message-based services, participants in three studies found the interventions to be helpful (80%–93%), and a good way to stay in touch with services (93%; Berrouiguet et al., 2014; Chen et al., 2010; Kodama et al., 2016). However, in one of these studies participants were more divided around whether the service benefited their psychological health, and suicidal thoughts or behavior (40%–60% felt the service was helpful in these areas; Berrouiguet et al., 2014). For mobile phone apps, participants typically found these helpful or were satisfied with the content (e.g., 84%–89%; Bush et al., 2015, 2017; McManama O’Brien et al., 2016), and would consider using the apps again (e.g., 60%–80%; Pauwels et al., 2017; Stallard et al., 2018). In one study, helpfulness ratings were more ambivalent (M rating = 2.46 of 5) but higher when participants were specifically asked if the app would be helpful for SB (M rating = 3.23 of 5; Rizvi et al., 2016). In two other studies, the majority of participants also felt the apps would help with STB (60%–80%; Pauwels et al., 2017; Stallard et al., 2018).

Internet-delivered CBT and DBT approaches were largely seen as helpful (91% of participants; Robinson et al., 2015) or rated useful across two studies (M usefulness rating = 3.91 of 5; Wilks et al., 2018). Overall satisfaction was only moderate for one Internet-delivered emotion regulation therapy (M rating = 17.8 of 32; Bjureberg et al., 2018). Hooley et al. (2018) also reported relatively low acceptability ratings for their online

Figure 2. Forest plot of treatment effects on suicidal ideation, subdivided by control group (active or nonactive).
therapeutic writing task, with low ratings for how much participants understood the task and planned to continue using it (average scores below 3, indicative of disagreement).

Feasibility

With regard to engagement rates, most interventions reported good rates of initial engagement but often rates of completion, or continued use of the intervention were more limited (reported by $k = 11$). Hetrick et al. (2016) reported that, on average, participants commenced five of eight modules, with only eight of the 26 participants completing all eight modules. Rates of initial engagement with therapy Web sites were high (88%–92% starting the intervention; van Spijker et al., 2018, 2014) but fewer accessed at least three of the six modules (44%–56%). Wilks et al. (2018) identified a declining trend in engagement, but note that technical problems may have been a contributing factor. Similarly for mobile phone apps while good rates of initial engagement were noted by three studies (e.g., 71%–83% using the app at least once; Franklin et al., 2016; Kennard et al., 2018; O'Toole et al., 2019), a trend toward a decline in use was also identified in one (Franklin et al., 2016). For example, Bush et al. (2015) report that 88% using app over 2 weeks versus 59% over 6 weeks. Completion rates for other mobile apps (85%; Tighe et al., 2017) and Web sites (average completion rate of 9.7 of 11 modules; Bjureberg et al., 2018) were good. Hooley et al. (2018) also reported good engagement (mean completion of 21.31 sessions of a possible 28), but engagement was incentivized. Importantly, while a decline in usage might indicate problems with feasibility, this may also reflect other processes such as participants no longer needing the support of the intervention due to recovery.

DISCUSSION

The aim of this review was to evaluate the efficacy and acceptability of mobile- and Internet-based interventions for STB. Twenty-two studies covering mobile phone applications, text-based services, and Web site-based interventions with a focus on STB prevention were identified. The current review extends the literature by focusing specifically on interventions where a primary aim is STB prevention (as opposed to interventions primarily directed at related difficulties like depression). This is important since intervention effects on STB prevention may be better when this is the primary focus (Christensen et al., 2014; Tarrier et al., 2008). The majority of identified studies ($k = 17$) were not included in the last review on this topic (Witt et al., 2017). Results suggest that evidence for the efficacy of Internet- and mobile-based interventions for STB remains limited. Evidence of possible reductions in SB largely derives from single-arm, noncontrolled studies. Evidence of a beneficial effect on suicidal ideation was apparent compared with treatment as usual but not when active controls were also considered. However, two of three trials with active control conditions featured more atypical interventions (Franklin et al., 2016; Hooley et al., 2018), so this may have also explained the differing results. Findings were mixed regarding NSSI, but there was preliminary support for DBT-based applications. Evidence for more focused behavioral or autobiographical interventions (Franklin et al., 2016; Hooley et al., 2018) with regard to NSSI and suicidal ideation is currently lacking. There is currently no clear indication that therapies based on a particular modality (e.g., text messages, Internet, or mobile apps) are more effective.

This review further builds on previous work by synthesizing the data concerning acceptability and feasibility. The acceptability of interventions was largely supported. Questions tended to center broadly on how accessible and helpful interventions appeared to participants. More in-depth exploration of issues that might be particular to Internet- or mobile-based intervention, such as the ability to develop a therapeutic alliance or feeling facilitated in better understanding one’s SB risk and engaging in problem solving around
this, would be beneficial. Regarding feasibility, there was evidence that engagement or usage of interventions may decline with time, but this may be due to several reasons and further examination of this is warranted. Technological problems and issues with the usability of apps or Web sites (e.g., nonintuitive interfaces) represent a further factor that may affect acceptability and feasibility. Distinguishing between these issues is likely to be difficult in practice. Careful initial pilot testing of software for technical issues prior to fuller evaluation is likely to be beneficial. Moreover, the use of more detailed qualitative interviews may help to disentangle issues with usability of the technology from issues related to the acceptability or feasibility of the intervention content.

While there is evidence regarding the potential benefits of Internet- and mobile-based interventions for mental health difficulties (Firth et al., 2017; Josephine et al., 2017; Richards et al., 2015; Stratton et al., 2017), the benefits for interventions focused specifically on STB prevention are less established. The majority of identified studies concerned CBT- and DBT-informed interventions (both Internet and mobile application based), and there is preliminary evidence that these are acceptable and can be potentially helpful in reducing suicidal thinking. An important next step is to further develop this evidence base by undertaking larger-scale RCTs of these existing interventions. These RCTs should consider outcomes related to SB (NSSI and suicide attempts) in addition to suicidal ideation. As the majority of identified studies concerned adults, further trials of interventions aimed at adolescents and young people at risk of STB would also be beneficial.

A broader issue relates to how such interventions compare to face-to-face psychological interventions, and whether there are any gains or losses in efficacy. None of the included trials compared interventions to active face-to-face counterparts. However, noninferiority trials for problems such as depression and posttraumatic stress disorder suggest similar treatment effects are possible (Acerno et al., 2017; Ly et al., 2015). Further noninferiority trials would be beneficial, but these are difficult to conduct as expected differences might be small and result in large sample size requirements. It is important to explore whether Internet- or mobile-based interventions work best as an adjunct to face-to-face intervention, or can be beneficial as stand-alone interventions. We would hypothesize that Internet- or mobile-mediated interventions for SB work best when they facilitate a working alliance with a real-world therapist, but overcome barriers to access (e.g., stigma, distance, cost); however, further research is needed to test this possibility. SB is a highly heterogeneous problem, which can have a wider range of underlying functions and triggers (Hawton et al., 2012; Taylor et al., 2018). This may pose further challenges to Internet- or mobile-based interventions if they are not able to tailor their approach to the needs of a particular client. However, developments in machine learning raise the possibility of more “intelligent” therapy application (Kelly et al., 2012). Machine learning could involve software using data inputted by the user to “learn” over time the optimal times or situations to introduce particular interventions. This would mean that the treatment package or options that individuals receive could be personally tailored to their particular difficulties, potentially leading to more effective interventions. It remains to be established whether machine learning could approximate the idiosyncratic formulation-driven treatment that can be offered within face-to-face talking therapies (e.g., Tarrier & Johnson, 2016).

The current review was limited by excluding non-English language papers, which may have meant otherwise relevant research was not included. Similarly, the small number of included studies prevented us from applying approaches such as subgroup analysis or meta-regression to better understand the possible causes of heterogeneity in effects. We combined effects from several different types of intervention (mobile apps, therapy Web site, text message service), and this is likely one factor contributing to
heterogeneity in meta-analyses. Likewise, the small number of studies precluded tests of publication bias, which may be a factor biasing findings.

Internet- and mobile-based interventions have the potential to help individuals at risk of STB, but further trials are needed to confirm their efficacy. When considering Internet- and mobile-based interventions together, a larger number of RCTs have been undertaken concerning problems like depression and anxiety (Firth et al., 2017; Josephine et al., 2017; Richards et al., 2015; Stratton et al., 2017). The comparative smaller number of RCTs that focus on STB may be the result of the often greater risk and complexity associated with STB. The results of this review indicate that it is possible to develop mobile- and Internet-based interventions for STB that are acceptable and potentially helpful in reducing suicidal ideation. We encourage future trials to focus on existing interventions that have already shown promise but require further evaluation in larger samples using controlled designs. In developing and evaluating Internet- and mobile-based interventions, greater interdisciplinary collaboration would be valuable. For example, collaboration between computer scientists, software engineers, clinicians, and mental health researchers may help improve the acceptability and usability of such interventions, and help support the development of interventions drawing on machine learning principles. Likewise, involving those with lived experience of STB in intervention development is important in ensuring interventions feel acceptable and useful to the individuals they have been designed to help.

REFERENCES

ACIERNO, R., KNAPP, R., TUERR, P., GILMORE, A. K., LEJUEZ, C., RUGGIERO, K., ET AL. (2017). A non-inferiority trial of prolonged exposure for posttraumatic stress disorder: In person versus home-based telehealth. *Behaviour Research and Therapy, 89*, 57–65. https://doi.org/10.1016/j.brat.2016.11.009

BECK, A. T., KOVACS, M., & WEISSMAN, A. (1979). Assessment of suicidal intention: The Scale for Suicide Ideation. *Journal of Consulting and Clinical Psychology, 47*, 343–352. https://doi.org/10.1037/0022-006X.47.2.343

BERGEN, H., HAWTON, K., WATERS, K., NESS, J., COOPER, J., STEEG, S., ET AL. (2012). Premature death after self-harm: A multicentre cohort study. *The Lancet, 380*, 1568–1574. https://doi.org/10.1016/S0140-6736(12)61141-6

BERROUGUE, S., GRAVEY, M., LE GALUDEC, M., ALAVI, Z., & WALTER, M. (2014). Postacute crisis text messaging outreach for suicide prevention: A pilot study. *Psychiatry research, 217*, 154–157. https://doi.org/10.1016/j.psychres.2014.02.034

BJUREBERG, J., SAHLIN, H., HEDMANN-LAGERLOF, E., GRATZ, K. L., TULL, M. T., JOKINEN, J., ET AL. (2018). Extending research on Emotion Regulation Individual Therapy for Adolescents (ERITA) with nonsuicidal self-injury disorder: Open pilot trial and mediation analysis of a novel online version. *BMC Psychiatry, 18*, 326. https://doi.org/10.1186/s12888-018-1885-6

BLAKE, A., LARKIN, A., & TAYLOR, P. J. (2019). The relationship with the therapist. In P. J. Taylor, O. Gianfrancesco, & N. Fisher (Eds.), *Personal experiences of psychological therapy for psychosis and related experiences* (pp. 166–184). Abingdon, UK: Routledge. https://doi.org/10.4324/9781315108665

BUCCI, S., BARROWCLough, C., AINSWORTH, J., MORRIS, B., BERRY, K., MACHIN, M., ET AL. (2015). Using mobile technology to deliver a cognitive behaviour therapy-informed intervention in early psychosis (Actissist): Study protocol for a randomised controlled trial. *Trials, 16*, 404. https://doi.org/10.1186/s13063-015-0943-3

BUSH, N. E., DOBSCHA, S. K., CRUMPION, R., DENNESSON, L. M., HOFFMAN, J. E., CRAIN, A., ET AL. (2015). A Virtual Hope Box smartphone app as an accessory to therapy: Proof-of-concept in a clinical sample of veterans. *Suicide and Life-Threatening Behavior, 45*, 1–9. https://doi.org/10.1111/sltb.12103
BUSH, N. E., SMOLENSKI, D. J., DENNISON, L. M., WILLIAMS, H. B., THOMAS, E. K., & DOBSCHA, M. D. (2017). A virtual hope box: Randomized controlled trial of a smartphone app for emotional regulation and coping with distress. *Psychiatric Services, 68*, 330–336. https://doi.org/10.1176/appi.ps.201600283

CHEN, H., MISHARA, B. L., & LIU, X. X. (2010). A pilot study of mobile telephone message interventions with suicide attempters in China. *Crisis*, 31, 109–112. https://doi.org/10.1027/0227-5910/a000117

CHRISTENSEN, H., BATTERHAM, P. J., & O’DEA, B. (2014). E-health interventions for suicide prevention. *International Journal of Environmental Research and Public Health, 11*, 8193–8212. https://doi.org/10.3390/ijerph110801193

CLARKE, J., PROUDFOOT, J., WHITTON, A., BIRCH, M.-R., BOYD, M., PARKER, G., ET AL. (2016). Therapeutic alliance with a fully automated mobile phone and web-based intervention: Secondary analysis of a randomized controlled trial. *JMIR Mental Health, 3*, e10. https://doi.org/10.2196/mental.4656

CUIPERS, P., WEITZ, E., CRISTEA, I. A., & TWISK, J. (2016). Pre-post effect sizes should be avoided in meta-analyses. *Epidemiology and Psychiatric Sciences, 26*, 364–368. https://doi.org/10.1017/S2045796016000809

Department of Health. (2017). Preventing suicide in England: Third progress report of the cross-government outcomes strategy to save lives. Department of Health. Retrieved from https://www.gov.uk.gov/ukgovernment/publications/suicide-prevention-third-annual-report

DERSIMONIAN, R., & LAIRD, N. (1986). Meta-analysis in clinical trials. *Controlled Clinical Trials, 7*, 177–188. https://doi.org/10.1016/0197-2456(86)90046-2

EYLEM, O. (2019). Unpublished trial data.

EYLEM, O., VAN STRATEN, A., BHUI, K., & KERKHOF, J. F. M. (2015). Protocol: Reducing suicidal ideation among Turkish migrants in the Netherlands and in the UK: Effectiveness of an online intervention. *International Review of Psychiatry, 27*, 72–81. https://doi.org/10.3109/09540261.2014.996121

FIRTH, J., TORYOUS, J., NICHOLAS, J., CARNEY, R., ROSENBAUM, S., & SARRIS, J. (2017). Can smartphone mental health interventions reduce symptoms of anxiety? A meta-analysis of randomized controlled trials. *Journal of Affective Disorders, 218*, 15–22. https://doi.org/10.1016/j.jad.2017.04.046

FRANKLIN, J. C., FOX, K. R., FRANKLIN, C. R., KLEIMAN, E. M., RIBEIRO, J. D., JAROSZEWSKI, A. C., ET AL. (2016). A brief mobile app reduces nonsuicidal and suicidal self-injury: Evidence from three randomized controlled trials. *Journal of Consulting and Clinical Psychology, 84*, 544–557. https://doi.org/10.1037/ccp0000093

GILMORE, A. K., & WARD-GIESIELSKI, E. F. (2017). Perceived risks and use of psychotherapy via telemedicine for patients at risk for suicide. *Journal of Telemedicine and Telecare, 25*, 59–63. https://doi.org/10.1177/1357663317735539

GOLDMAN-MELLOR, S. J., CASPI, A., HARRINGTON, H., HOGAN, S., NADARAJA, S., POULTON, R., ET AL. (2014). Suicide attempt in young people: A signal for long-term health care and social needs. *JAMA Psychiatry, 71*, 119–127. https://doi.org/10.1001/jamapsychiatry.2013.2803

GOLDSMITH, L. P., LEWIS, S. W., DUNN, G., & BENTALI, R. P. (2015). Psychological treatments for early psychosis can be beneficial or harmful, depending on the therapeutic alliance: An instrumental variable analysis. *Psychological Medicine, 45*, 2365–2373. https://doi.org/10.1017/S003329171500332X

GRANDCLERC, S., DE LABROUCHE, D., SPODENKIEWICZ, M., LACHAL, J., & MORO, M.-R. (2016). Relations between nonsuicidal self-injury and suicidal behavior in adolescence: A systematic review. *PLoS ONE, 11*, e0153760. https://doi.org/10.1371/journal.pone.0153760

GUTHRIE, E., PATTON, G. C., KAPUR, N., MACKWAY-JONES, K., CHEW-GRAHAM, C., MOOREY, J., ET AL. (2001). Randomised controlled trial of brief psychological intervention after deliberate self-poisoning. *BMJ, 323*, 135. https://doi.org/10.1136/bmj.323.7305.135

HAWTON, K., BERGEN, H., COOPER, J., TURNBULL, P., WATERS, K., NESS, J., ET AL. (2015). Suicide following self-harm: Findings from the Multicentre Study of self-harm in England, 2000–2012. *Journal of Affective Disorders, 175*, 147–151. https://doi.org/10.1016/j.jad.2014.12.062

HAWTON, K., SAUNDERS, K. E. A., & O’CONNOR, R. C. (2012). Self-harm and suicide in adolescents. *The Lancet, 379*, 2373–2382. https://doi.org/10.1016/S0140-6736(12)60322-5

HAWTON, K., WITT, K. G., TAYLOR SALISBURY, T. L., ARENSMAN, E., GUNNELL, D., HAZELL, P., ET AL. (2017). Psychosocial interventions for self-harm in adults. *Cochrane Database of Systematic Reviews, 3*, CD012189. https://doi.org/10.1002/14651858.CD012189

HAWTON, K., WITT, K. G., TAYLOR SALISBURY, T. L., ARENSMAN, E., GUNNELL, D., TOWNSEND, E., ET AL. (2015). Interventions for self-harm in children and adolescents. *Cochrane Database of Systematic Reviews, 12*, CD012013. https://doi.org/10.1002/14651858.CD012013

HETRICK, S. E., ROBINSON, J., SPIFFAL, M. J., & CARTER, G. (2016). Effective psychological and psychosocial approaches to reduce repetition of self-harm: A systematic review, meta-analysis and meta-regression. *British Medical Journal Open,*
HETTRICK, S. E., YUEN, H. P., BAILEY, E., COX, G. R., TEMPER, K., RICE, S. M., ET AL. (2017). Internet-based cognitive behavioural therapy for young people with suicide-related behaviour (Reframe-IT): A randomised controlled trial. Evidence Based Mental Health, 20, 76–82. https://doi.org/10.1136/eb-2017-102719

HIGGINS, J. P. T., ALTMAN, D. G., GOTzsche, P. C., JUNI, P., MOHER, D., OXMAN, A. D., ET AL. (2011). The Cochrane Collaboration’s tool for assessing risk of bias in randomised trials. BMJ, 343, d5928. https://doi.org/10.1136/bmj.d5928

HIGGINS, J. P. T., & THOMPSON, S. G. (2002). Quantifying heterogeneity in a meta-analysis. Statistics in Medicine, 21, 1539–1558. https://doi.org/10.1002/sim.1186

HIGGINS, J. P. T., THOMPSON, S. G., DEEKS, J. J., & ALTMAN, D. G. (2003). Measuring inconsistency in meta-analyses. BMJ, 327, 557. https://doi.org/10.1136/bmj.327.7414.557

HOOLEY, J. M., FOX, K. R., WANG, S. B., & Kwashe, A. N. D. (2018). Novel online daily diary interventions for nonsuicidal self-injury: A randomized controlled trial. BMC Psychiatry, 18, 264. https://doi.org/10.1186/s12888-018-1840-6

Institute of Medicine. (2002). Reducing suicide: A national imperative. Washington, DC: The National Academies Press.

JOSEPHINE, K., JOSEFINE, L., PHILIPP, D., DAVID, E., & HARALD, B. (2017). Internet- and mobile-based depression interventions for people diagnosed with depression: A systematic review and meta-analysis. Journal of Affective Disorders, 229, 28–40. https://doi.org/10.1016/j.jad.2017.07.021

KELLY, J., GOODING, P., PRATT, D., AINSWORTH, J., WELFORD, M., & TARIFF, N. (2012). Intelligent real-time therapy: Harnessing the power of machine learning to optimise the delivery of momentary cognitive-behavioural interventions. Journal of Mental Health, 21, 404–414. https://doi.org/10.3109/09638237.2011.638001

KENNARD, B. D., GOLSTEIN, T., FOXWELL, A. A., McMAKIN, D. L., WOLFE, K., BIERNESSER, C., ET AL. (2018). As safe as possible (ASAP): A brief app-supported inpatient intervention to prevent postdischarge suicidal behavior in hospitalized, suicidal adolescents. American Journal of Psychiatry, 175, 864–872. https://doi.org/10.1176/appi.ajp.2018.17101151

KODAMA, T., SYOJII, H., TAKAKI, S., FUMOTO, H., ISHIKAWA, S., FUKUTAKE, M., ET AL. (2016). Text messaging for psychiatric outpatients: Effect on help-seeking and self-harming behaviors. Journal of Psychosocial Nursing and Mental Health Services, 54, 31–37. https://doi.org/10.3928/02793695-20160121-01

LAI, M. H., MANIAM, T., CHAN, L. F., & RAVINDRAN, A. V. (2014). Caught in the web: A review of web-based suicide prevention. Journal of Medical Internet Research, 16, e30. https://doi.org/10.2196/jmir.2973

LARSEN, M. E., NICHOLAS, J., & CHRISTENSEN, H. (2014). A systematic assessment of smartphone tools for suicide prevention. PLoS ONE, 11, e0152285. https://doi.org/10.1371/journal.pone.0152285

LEIGHTON, S., & FLATT, S. (2015). App-based psychological interventions: Friend or foe? Evidence Based Mental Health, 18, 97. https://doi.org/10.1136/eb-2015-102203

LY, K. H., TOPOOCO, N., CEDERLUND, H., WALLIN, A., BERGSTROM, J., MOLANDER, O., ET AL. (2015). Smartphone-supported versus full behavioural activation for depression: A randomised controlled trial. PLoS ONE, 10, e0126559. https://doi.org/10.1371/journal.pone.0126559

MARASINGHE, R. B., EDIRIPULIGE, S., KAVANAGH, D., SMITH, A., & JEFFY, M. T. (2012). Effect of mobile phone-based psychotherapy in suicide prevention: A randomised controlled trial in Sri Lanka. Journal of Telemedicine and Telecare, 18, 151–155. https://doi.org/10.1258/jtt.2012.SFT107

MCMANAMA O’BRIEN, K. H., LECLOUX, M., ROSS, A., GIRONDA, C., & WHARFF, E. A. (2016). A pilot study of the acceptability and usability of a smartphone application intervention for suicidal adolescents and their parents. Archives of Suicide Research, 21, 254–264. https://doi.org/10.1080/13811118.2016.1182094

MELLA, R., FRANCIS, K., HICKEY, E., BOGUE, J., DUGGAN, J., O’SULLIVAN, M., ET AL. (2018). A systematic review of mobile health technology interventions for suicide prevention. JMIR Research Protocols, 7, e28. https://doi.org/10.2196/resprot.8635

METALSKY, G. I., & JOINER, T. E. (1997). The hopelessness depression symptom questionnaire. Cognitive Therapy and Research, 21, 359–384. https://doi.org/10.1023/A:1021882717784

MELWTON, L., & ANDREWS, G. (2015). Cognitive behaviour therapy via the internet for depression: A useful strategy to reduce suicidal ideation. Journal of Affective Disorders, 170, 78–84. https://doi.org/10.1016/j.jad.2014.08.038

MICHEL, K. (2016). Therapeutic alliance and the therapist. In R. C. O’Connor, & J. Pirks (Eds.), The international handbook of suicide prevention (pp. 346–362). Chichester, UK: John Wiley & Sons. https://doi.org/10.1002/9781118903223

MOHER, D., LIBERATI, A., TETZLAFF, J., ALTMAN, D. G., & THE, P. G. (2009). Preferred reporting items for systematic reviews and meta-analyses:
The PRISMA statement. *PLoS Medicine*, 6, e1000097. https://doi.org/10.1371/journal.pmed.1000097

Nock, M. K., Holmberg, E. B., Photos, V. I., & Michels, B. D. (2007). Self-injurious thoughts and behaviors interview: Development, reliability, and validity in an adolescent sample. *Psychological Assessment*, 19, 309–317. https://doi.org/10.1037/1040-3590.19.3.309

Oman, A., Kopper, B. A., Linehan, M., Barros, F. X., Gutierrez, P. M., & Bagge, C. (1999). Validation of the Adult Suicidal Ideation Questionnaire and the reasons for living inventory in an adult psychiatric sample. *Psychological Assessment*, 11, 115–123. https://doi.org/10.1037/1040-3590.11.2.115

O’Toole, M. S., Arendt, M. B., & Pedersen, C. M. (2019). Testing an app-assisted treatment for suicide prevention in a randomized controlled trial: Effects on suicide risk and depression. *Behavior Therapy*, 50, 421–429. https://doi.org/10.1016/j.beth.2018.07.007

Pauwels, K., Aerts, S., Muizers, E., De Jaegere, E., Van Heeringen, K., & Portzky, G. (2017). BackUp: Development and evaluation of a smart-phone application for coping with suicidal crises. *PLoS ONE*, 12, e0178144. https://doi.org/10.1371/journal.pone.0178144

Perle, J. G., Langsam, L. C., & Nierenberg, B. (2011). Controversy clarified: An updated review of clinical psychology and tele-health. *Clinical Psychology Review*, 31, 1247–1258. https://doi.org/10.1016/j.cpr.2011.08.003

Perry, Y., Werner-Seidler, A., Callear, A. L., & Christensen, H. (2016). Web-based and mobile suicide prevention interventions for young people: A systematic review. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, 25, 73–79. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/27274742

Poppleton, A., & Gire, N. (2017). mHealth: Bridging the mental health gap in central and eastern Europe. *The Lancet Psychiatry*, 4, 743–744. https://doi.org/10.1016/S2215-0366(17)30359-0

Posner, K., Brown, G. K., Stanley, B., Brent, D. A., Yershova, K. V., Oquendo, M. A., et al. (2011). The Columbia-Suicide Severity Rating Scale: Initial validity and internal consistency findings from three multisite studies with adolescents and adults. *The American Journal of Psychiatry*, 168, 1266–1277. https://doi.org/10.1176/appi.ajp.2011.11111704

Proctor, E., Silmere, H., Raghavan, R., Holmmand, P., Aarons, G., Bunger, A., et al. (2011). Outcomes for implementation research: Conceptual distinctions, measurement challenges, and research agenda. *Administration and Policy in Mental Health and Mental Health Services*, 38, 65–76. https://doi.org/10.1007/s10488-010-0319-7

Rathod, S., Pinotti, N., Irfan, M., Gorczynski, P., Rathod, P., Gega, L., et al. (2017). Mental health service provision in low- and middle-income countries. *Health Services Insights*, 10, 1178632917694350. https://doi.org/10.1177/1178632917694350

Reynolds, W. M. (1987). *Suicidal Ideation Questionnaire (SIQ): Professional manual*. Odessa, FL: Psychological Assessment Resources.

Ribeiro, J. D., Franklin, J. C., Fox, K. R., Bentley, K. H., Kleiman, E. M., Chang, B. P., et al. (2016). Self-injurious thoughts and behaviors as risk factors for future suicide ideation, attempts, and death: A meta-analysis of longitudinal studies. *Psychological Medicine*, 46, 225–236. https://doi.org/10.1016/S0033-2917(15)001804

Richards, D., Richardson, T., Timulak, L., & McElwaney, J. (2015). The efficacy of internet-delivered treatment for generalized anxiety disorder: A systematic review and meta-analysis. *Internet Interventions*, 2, 272–282. https://doi.org/10.1016/j.invent.2015.07.003

Rizvi, S. L., Hughes, C. D., & Thomas, M. C. (2016). The DBT coach mobile application as an adjunct to treatment for suicidal and self-injuring individuals with borderline personality disorder: A preliminary evaluation and challenges to client utilization. *Psychological Services*, 13, 380–388. https://doi.org/10.1037/serv0000100

Robinson, J., Hetrick, S., Cox, G., Bessell, S., Yuen, H. P., Yung, A., et al. (2016). Can an internet-based intervention reduce suicidal ideation, depression and hopelessness among secondary school students: Results from a pilot study. *Early Intervention in Psychiatry*, 10, 28–35. https://doi.org/10.1111/eip.12137

Robinson, J., Hetrick, S., Cox, G., Bessell, S., Yung, A., & Pirkis, J. (2015). The safety and acceptability of delivering an online intervention to secondary students at risk of suicide: Findings from a pilot study. *Early Intervention in Psychiatry*, 9, 498–506. https://doi.org/10.1111/eip.12136

Scott, L. N., Pilkonis, P. A., Hipwell, A. E., Keenan, K., & Steepe, S. D. (2015). Non-suicidal self-injury and suicidal ideation as predictors of suicide attempts in adolescent girls: A multi-wave prospective study. *Comprehensive Psychiatry*, 58, 1–10. https://doi.org/10.1016/j.comppsych.2014.12.011

Silverman, M. M., Berman, A. L., Sandal, N. D., O’Carroll, P. W., & Joiner, T. E. (2007). Rebuilding the tower of Babel: A revised nomenclature for the study of suicide and suicidal behaviors Part 2: Suicide-related ideations, communications, and behaviors. *Suicide and Life-
Avoiding suicide: A systematic review and meta-analysis. *Canadian Journal of Psychiatry*, 59, 576–585. https://doi.org/10.1177/070674371405901103

van Spijker, B. A. J., van Straten, A., & Kerkhof, A. J. F. M. (2014). Effectiveness of online self-help for suicidal thoughts: Results of a randomised controlled trial. *PLoS ONE*, 9, e90118. https://doi.org/10.1371/journal.pone.090118

van Spijker, B. A., Werner-Seidler, A., Batterham, P. J., Mackinnon, A., Calear, A. L., Gosling, J. A., et al. (2018). Effectiveness of a web-based self-help program for suicidal thinking in an Australian community sample: Randomized controlled trial. *Journal of Medical Internet Research*, 20, e15. https://doi.org/10.2196/mir.8595

Ward-Ciesielski, E. F., Peros, O., Conigliaro, A., & Gilmore, A. K. (2018). Perceived benefits of psychotherapy via telemedicine based on suicide risk severity. *General Hospital Psychiatry*, 55, 100–101. https://doi.org/10.1016/j.genhosppsych.2018.09.002

Wilks, C. R., Lungu, A., Ang, S. Y., Matusumia, B., Yin, Q., & Linehan, M. M. (2018). A randomized controlled trial of an internet delivered dialectical behavior therapy skills training for suicidal and heavy episodic drinkers. *Journal of Affective Disorders*, 232, 219–228. https://doi.org/10.1016/j.jad.2018.02.053

Witt, K., Spittal, M., Carter, G., Pirks, J., Hetrick, S., Currier, D., et al. (2017). Effectiveness of online and mobile telephone applications (‘apps’) for the self-management of suicidal ideation and self-harm: A systematic review and meta-analysis. *BMC Psychiatry*, 17, 297–315. https://doi.org/10.1186/s12888-017-1458-0

World Health Organisation. (2014). *Preventing suicide: A global imperative*. Geneva, Switzerland: World Health Organization.

World Health Organisation. (2018). *Suicide*. Retrieved from http://www.who.int/news-room/fact-sheets/detail/suicide

Manuscript Received: February 12, 2019
Revision Accepted: May 8, 2019

**SUPPORTING INFORMATION**

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Departures from protocol.
Appendix S2. Original Search strategy.