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Technology-enhanced suicide prevention interventions: A systematic review

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Abstract

Objective: Suicide prevention is a high priority. Scalable and sustainable interventions for suicide prevention are needed to set the stage for population-level impact. This systematic review explores how technology-enhanced interventions target suicide risk and protective factors, using the Centers for Disease Control and Prevention (CDC, 2015) Risk and Protective Factors Ecological Model.

Methods: Information databases (PsycINFO, PubMed and CINAHL) were systematically searched and records including technology-enhanced interventions for suicide prevention ($n = 3764$) were reviewed. Records with varying technologies and diverse methodologies were integrated into the search.

Results: Review of the records resulted in the inclusion of 16 studies that utilized technology-enhanced interventions to address determinants of suicidal behaviour. This includes the use of standalone or, in most cases, adjunct technology-enhanced interventions for suicide prevention delivered by mobile phone application, text message, telephone, computer, web, CD-ROM and video.

Conclusion: Intervention effectiveness was variable, but several technology-enhanced interventions have demonstrated effectiveness in reducing suicidal ideation and mental health co-morbidities. Large-scale research and evaluation initiatives are needed to evaluate the costs and long-term population-level impact of these interventions.

Keywords

Phone, computer, web, video, suicide prevention

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In the USA, age-adjusted suicide rates increased 24% from 1999 through 2014.[1] Suicide is one of the 10 leading causes of death overall, and within every age group 10–64 years.[1] Every suicide is both an individual tragedy and a part of a public health crisis that imposes a great burden on society.[2] The burden of suicide reaches beyond the deaths themselves, extending to family, friends and colleagues of the individuals who have died by suicide.[3] It is estimated that between six and 32 survivors (e.g. close family and friends) are personally affected by suicide mortality in terms of increased mental health risk, and this may include increased risk of suicide for the bereaved.[4] Concomitantly, suicide results in financial burdens, costing society approximately US$44.6 billion per year in combined medical and work loss costs.[4]

Population-based strategies to reduce suicide risk are needed.[3] Scalable and cost-efficient (sustainable) approaches are particularly critical. Population-level impact depends both on *effectiveness* and *reach*. Technology-enhanced interventions are appealing due to their wide accessibility. The rapid growth of technology has positioned these interventions for large-scale evaluation of population-level reach and impact. Other advantages of technology-enhanced interventions are that they address access barriers, such as stigma (e.g. privately accessible), scheduling/transportation (e.g. accessible virtually anywhere, anytime) and cost.

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Purpose and theoretical framework

The purpose of this systematic review is to identify how technology-enhanced interventions address determinants of suicidal behaviour, using the CDC[5,6] Risk and Protective Factors Ecological Model (see Table 1). Risk factors directly and/or indirectly increase the likelihood of suicide; protective factors buffer individuals from suicidal thoughts and behaviour.[5,6] Because suicide is a multifaceted public health crisis involving interactions among individual, relational, community and societal factors, different contexts in which shared risk and protective factors exist must be analysed in suicide prevention efforts.[5–7]

Technology-enhanced was defined as the use of technology in delivering a suicide-prevention intervention. This included standalone or adjunct interventions delivered by mobile phone application, text message, telephone, computer, web, CD-ROM and video.

Method

Since preliminary literature searches yielded limited available technology-enhanced interventions for suicide prevention, articles with diverse methodologies and varying technology platforms were systematically and purposefully reviewed, to provide a balanced assessment and interpretation of current evidence. Appraisal and synthesis of data then permitted evaluation of the strength and quality of existing evidence.

The Whittemore and Knafl[8] integrative methodology and Cochrane Library key data item recommendations[9] were applied to systematically guide and enhance the rigor of this systematic review. After formulation of the research question (i.e. how do technology-enhanced interventions for suicide prevention address determinants of suicidal behaviour?), exploration of the current state of the science guided and provided boundaries for the systematic literature search. Both computerized database and reference list search strategies were employed to identify the maximum number of sources. A PhD student completed the literature searches, frequently discussing processes with the PhD senior mentor, with additional oversights and input from remaining doctorally prepared co-authors. No discrepancies arose and interpretations were congruent among co-authors.

Information databases PubMed, CINAHL and PsycINFO were systematically searched, from May 2015–July 2015. Original research and secondary analyses from academic journals were included. Reviews and reports were excluded. Articles not written in English were excluded. The consistent application of medical subject heading (MeSH) terms and keywords, and inclusion and exclusion criteria were utilized during the search. Systematic data reduction, data comparison, data appraisal, conclusion drawing and verification permitted a thorough interpretation, evaluation and synthesis of evidence. The mobile phone and computer-based searches are described, and combined searches are presented in Figure 1 using the modified Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram.[10]

Mobile phone databases search

MeSH terms *suicide*, *self-injurious behaviour* and *suicidal ideation* were individually searched with AND, in combination with the following MeSH terms and keywords searched with OR: *cell phones; mobile applications; technology; technology assessment, biomedical; intervention studies; mobile phones*; *mobile devices*; *smartphone*; *phone apps*; *application*; *platform*; *software*; *trial*; *intervention*; and *suicide prevention*. In PubMed, the similar articles feature was utilized; similarly, in CINAHL and PsycINFO the telemedicine, cellular phones, wireless communication, information technology, information systems, communication systems, messages, product design and cognitive behaviour therapy subject heading filters were leveraged. Because few mobile phone-specific articles were retrieved, references were hand-searched ($n = 48$); no additional articles were included.

Computer, web-based and video database search

MeSH terms *suicide, self-injurious behaviour* and *suicidal ideation* were individually searched with AND, in combination with the following MeSH terms searched with

Table 1. Suicide risk and protective factors.

	Risk factors	Protective factors
Individual	Family history of suicide and child maltreatment; previous suicide attempt(s); history of mental disorders and alcohol or substance abuse; feelings of hopelessness; impulsive or aggressive tendencies; religious beliefs endorsing suicide as a noble resolution to personal dilemma; social isolation; and physical illness.	Effective clinical care for mental, physical, and substance abuse disorders; support from medical and mental health care relationships; skills in problem solving, conflict resolution, and non-violent ways to handle disputes; and religious beliefs discouraging suicide and encouraging self-preservation.
Relational	Loss (relational, social, work, financial).	Family and community support and connectedness.
Community	Cultural beliefs that are accepting of suicide; local epidemics of suicide; barriers to accessing mental health treatment; and unwillingness to seek help because of stigma.	Easy access to a variety of clinical interventions and supports for help seeking; and cultural beliefs that discourage suicide.
Societal	Easy access to lethal methods.	Not discussed.

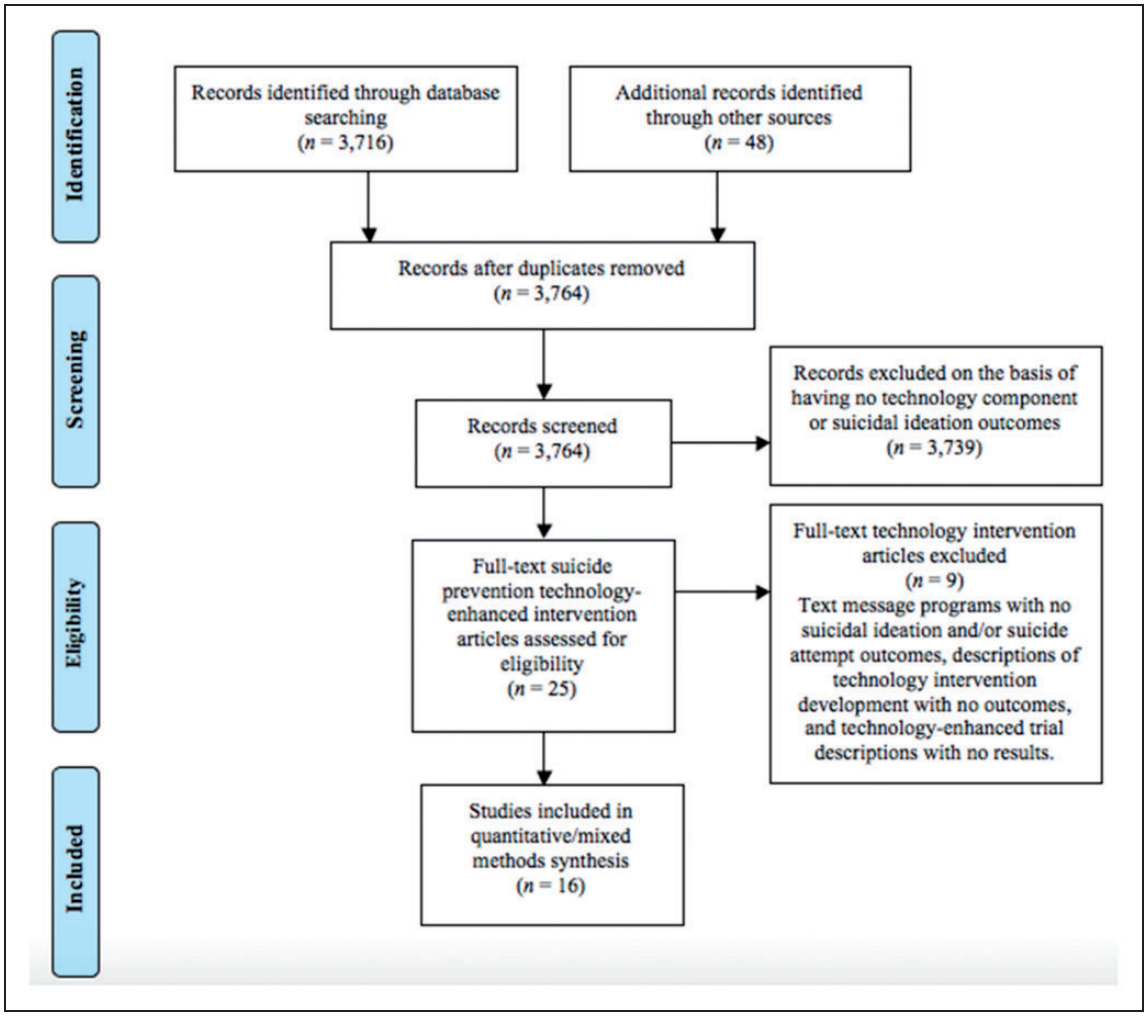

Figure 1. Modified Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram, outlining the systematic literature search.

OR: *intervention studies, programmes, programme evaluation, technology, computer-assisted instruction, computers, computer communication networks, local area networks, software, Internet, worldwide web, web browser, webcasts, information services* and *medical informatics*. In CINAHL and PsycINFO the intervention, prevention, treatment effectiveness evaluation, treatment outcomes, online therapy, computer assisted therapy, Internet assisted instruction, integrated services, symptoms, mental health, quality of life and health promotion subject heading filters were utilized.

Sixteen studies formed the sample for this systematic review and are detailed in Appendix I. Extracted study information was analysed according to the study purpose, theoretical framework, research setting, sample description and size, study design, technology platform, outcome variables, ecological risk and protective factors, results and level of evidence.

Results

Whereas study differences made combined syntheses complex, many commonalities were identified. Interventions targeted two of the four ecological levels, primarily providing prevention at the individual and community levels. Many programmes targeted the individual ecological level ($n = 10$) and shared coping strategies ($n = 7$), whereas two programmes had education outreach strategies, and one programme addressed risk factors. Similarly, community ecological level programmes ($n = 6$) leveraged similar technology platforms, utilizing telephone outreach ($n = 4$) and educational videos ($n = 2$). Further, most individual level interventions required Internet access ($n = 7$) while community level outreach required no Internet access. Across individual and community levels, coping strategies, educational content and supportive outreach were most frequently included.

Individual

Risk factors. Most interventions targeted protective factors, but one addressed risk factors.[11] The CD-ROM intervention addressed strategies to reduce dysfunctional attitudes, alcohol misuse and depression. All nine one-hour CD-ROM sessions were structured, providing guided cognitive

behavioural therapy (CBT). Therapists briefly assessed symptoms after each module. After controlling for confounding factors, no significant differences between CD-ROM- and therapist- delivered CBT on suicidal ideation were observed ($p = 0.43$). Suicidal ideation scores were relatively stable in both groups from baseline to 12-months (0.95 to 1.04 in the CD-ROM group; 0.99 to 0.82 in the CBT group).[11]

Coping protective factors. Most interventions targeted protective factors. The Virtual Hope Box (VHB), based on cognitive therapy (CT) and dialectical behaviour therapy (DBT), enabled veterans to identify and affirm personalized reasons for living.[12] The unguided VHB Smartphone application contained six primary sections designed to support, comfort, distract or relax using audio, video, pictures, games, mindfulness exercises, messages, inspirational quotes and coping statements. Participants managed suicidal thoughts, improved emotional regulation, increased distress tolerance and increased resiliency, which veterans reported were beneficial coping strategies.[12]

Similarly, coping strategies were incorporated into the Competent Adulthood Transition with Cognitive-behavioural, Humanistic and Interpersonal Training (CATCH-IT) programme.[13,14] Using a structured intervention website, adolescents completed guided weekly modules including behavioural activation, CBT, interpersonal psychotherapy (IPT) and community resiliency concepts; providing emotional mastery in peer, family and school domains. CATCH-IT significantly reduced depression ($p < 0.001$) and non-significantly reduced suicidal ideation ($p = 0.06$) from baseline to six months when combined with primary care provider (PCP) brief advice.[13] When combined with a PCP motivational interview, depression ($p < 0.001$) and hopelessness ($p = 0.04$) declined significantly from baseline to six months.[13] Depression and loneliness significantly decreased from baseline to one year ($p < 0.001$).[14]

Coping strategies were integrated into an Internet intervention incorporating CBT, DBT, problem-solving therapy (PST) and mindfulness-based cognitive therapy (MBCT).[15,16] An intervention website displayed unguided content, with one new module opening weekly for six weeks. Adults selectively reviewed strategies to improve controlled thinking, regulate emotions, identify automatic thoughts, enhance thinking patterns and promote thought challenging abilities. Participants experienced significant improvement in suicidal thoughts ($p = 0.04$) and worry ($p = 0.01$), when compared to control subjects.[16] Individuals with a previous suicide attempt had greater improvement than controls ($p < 0.05$), with no differences among those who never attempted suicide.[16] The mean incremental cost-effectiveness ratio was US$37,985; willingness to pay for a favourable treatment response was high.[15]

Coping strategies were incorporated into another CBT-based Internet programme, including behavioural assessment, activity planning, daily structure life review, positive memory activation, cognitive restructuring and social competence to prevent relapse.[17] Adults received guided website-facilitated therapist contact and personalized feedback on structured assignments. Participants improved significantly on depression, anxiety and hopelessness ($p < 0.001$), and self-esteem and negative automatic thoughts ($p < 0.01$); in-person CBT controls showed similar significant improvement. Suicidal ideation did not decrease significantly in the online group ($p = 0.24$), but did in the in-person group ($p < 0.05$). At three months, within-group effect sizes were more favourable for the online versus in-person group on depression ($d = 2.0$ online; $d = 1.04$ in-person), anxiety ($d = 1.13$ online; $d = 0.55$ in-person), hopelessness ($d = 1.14$ online; $d = 0.65$ in-person) and negative automatic thoughts ($d = 1.59$ online; $d = 0.52$ in-person).[17]

Likewise, coping strategies were applied in the Brief Mobile Treatment (BMT) intervention.[18] Adults received supportive phone calls, access to audio phone messages, and generic weekly text messages up to 26 weeks, to reinforce psychotherapy principles. Immediate-BMT participants received texted reminders about meditation, problem solving, spiritual/philosophical ideas, importance of social support, avoiding alcohol and drugs, and SMS message or help-line use during crises. Delayed-BMT participants received texted reminders after six months. With regard to suicidal ideation, depression and social support, Condition × Time was significant for baseline vs six months but not for baseline vs 12 months.[18]

Educational protective factors. Two interventions provided educational feedback. The unguided Electronic Bridge to Mental Health Services (eBridge) programme, using the health belief theoretical model and motivational interviewing principles, connected counsellors and college students through an intervention website.[19] During specified hours, students connected with counsellors in real-time chat sessions. Private messages were also sent through the website. Participants selectively reviewed personalized feedback and education on emotional distress and alcohol use. At two months, readiness to talk to family ($p = 0.007$), friends ($p = 0.010$) and to see a mental health professional ($p = 0.001$) was significantly higher than controls. The eBridge group perceived significantly less public ($p = 0.040$) and personal ($p = 0.004$) stigma when compared to controls. Additionally, significantly more eBridge participants met with a mental health professional relative to controls ($p = 0.002$).[19]

Similarly, participants received education through an individual-specific, interactive multimedia computer programme (IMCP), guided by health behaviour and patient activation theory.[20] Adults were taught to recognize depression symptoms and were prompted to discuss suicidal ideation with their PCP. Educational content was tailored, based on participants' Patient Health Questionnaire-9 (PHQ-9) score. No significant differences were found in suicide discussion between treatment groups among those with minimal depressive symptoms

($p = 0.32$). However, the IMCP arm had significantly more suicide discussion than controls among those with moderate or higher depressive symptoms ($p = 0.03$).[20]

Community

Combined risk and protective factors. Programmes targeted community factors through telephone outreach. The first of these programmes extended organizational reach by providing three months of contact with adults post-suicide attempt.[21] A weekly telephone call included psychological support, empathy, reassurance, active listening and collaborative problem solving. There were no significant differences in rates of suicide re-attempts among those assigned to telephone care, in-person CT, or the control condition ($p = 0.08$). Rates of suicidal ideation among the three conditions did not differ significantly at baseline, three, six or 12 months ($p = 0.43$, 0.72, 0.75, 0.67, respectively), nor did conditions differ significantly in depression ($p = 0.57$, 0.89, 0.49, 0.99, respectively) or quality of life ($p = 0.25$, 0.43, 0.62, 0.71, respectively).[21]

Post-suicide attempt telephone outreach was also provided at one week, one month and at three, six, nine and 12 months.[22] The first call included a programme introduction and interview. Follow-up calls inquired about significant changes, while re-assessing suicide risk. With elevated risk, a crisis conversation and urgent emergency department visit followed. Suicide re-attempts were delayed significantly in adults receiving telephone care, compared to the one-year baseline period and concurrent treatment as usual (TAU) population ($p < 0.0005$); similarly, suicide re-attempt rates declined significantly, compared to baseline and TAU ($p = 0.0005$).[22]

Likewise, the Brief Interventional Contact (BIC) programme involved telephone outreach after suicide attempt, at two and four weeks, and at two, three, four, five and six months.[23] Calls provided risk assessment, education about the importance of follow-up, and included coping strategies. Compared to TAU, frequency of suicidal thoughts decreased significantly ($p = 0.007$) while hope increased significantly ($p = 0.001$) for the telephone group. There were no significant differences in suicide re-attempt rates between telephone and TAU groups ($p = 0.18$).[23]

In a similar BIC approach, suicide attempters received telephone outreach at one, two, four, seven and 11 weeks, and four, six, 12 and 18 months.[24] Calls provided education about suicide, distress, risk and protective factors, and alternatives to suicidal behaviours. If adults displayed distress, an in-person crisis visit and referral followed. At the 18-month follow-up, significantly more TAU adults died by suicide than BIC adults ($p < 0.001$).[24]

Educational protective factors. Community outreach was also achieved using videos describing suicide survivors' stories.[25] In regions with high rates of suicide by self-burning, survivors provided education on self-burning complications, and alternative coping strategies. Videos were shown in community areas, health centres, village councils, video clubs and high schools. Compared to baseline, intervention city self-burning and all-mechanism suicide rates non-significantly decreased 57% ($p = 0.07$) and 19% ($p = 0.1$), respectively. Comparatively, reference city self-burning rates non-significantly decreased 27% ($p = 0.48$), while all-mechanism suicide rates non-significantly increased 24% ($p = 0.07$). During the three-year intervention period, however, mean suicide rates between the intervention ($M = 14.3$ to 6.2) and reference city ($M = 14.9$ to 10.9) differed significantly ($p < 0.0001$).[25]

Similarly, the school-based Signs of Suicide (SOS) video programme increased suicide and depression awareness, and encouraged help-seeking.[26] The video provided dramatizations, interaction strategies and interviews with people impacted by suicide; discussion guides facilitated meaningful video-related conversations. Adolescents were taught to recognize signs of suicide and depression in themselves and others. Adolescents were approximately 40% less likely to report a suicide attempt in the three months following the intervention, compared to the control ($p < 0.05$). Further, there were significant increases in knowledge and adaptive attitudes toward suicide and depression ($p < 0.05$).[26]

Study quality

In addition to assigning levels of evidence (Appendix I), study quality and bias were further evaluated using funnel plots. Cohen's *d* effect sizes and standard error for depression and suicidal ideation outcomes are presented in Figures 2 and 3. The magnitude of the intervention effect (i.e. Cohen's *d*) was plotted against the standard error, which provides a measure of precision of Cohen's *d* as an estimate of the actual population value.

For assessment of depression (Figure 2), most studies scattered in the middle of the plot indicating less precise study effects (i.e. estimates of Cohen's *d*), likely due to the small sample sizes.

For assessment of suicidal ideation (Figure 3), only four studies used comparable measures, therefore, interpretation of the funnel plot was not attempted.

Discussion

Several technology-enhanced suicide prevention interventions have been developed, and preliminary evaluations have been completed. These interventions provide strategies to reduce risk factors, increase protective factors and improve knowledge.

In studies with in-person treatment controls, CD-ROM and Internet groups appeared to experience somewhat less improvement in suicidal ideation when compared to in-person CBT counterparts.[11,17] However, technology-aided approaches performed comparably in other studies and with reference to secondary measures. For example, suicidal ideation and suicide re-attempt rates were similar among telephone care and in-person CT groups.[21] Moreover, technology-enhanced approaches have

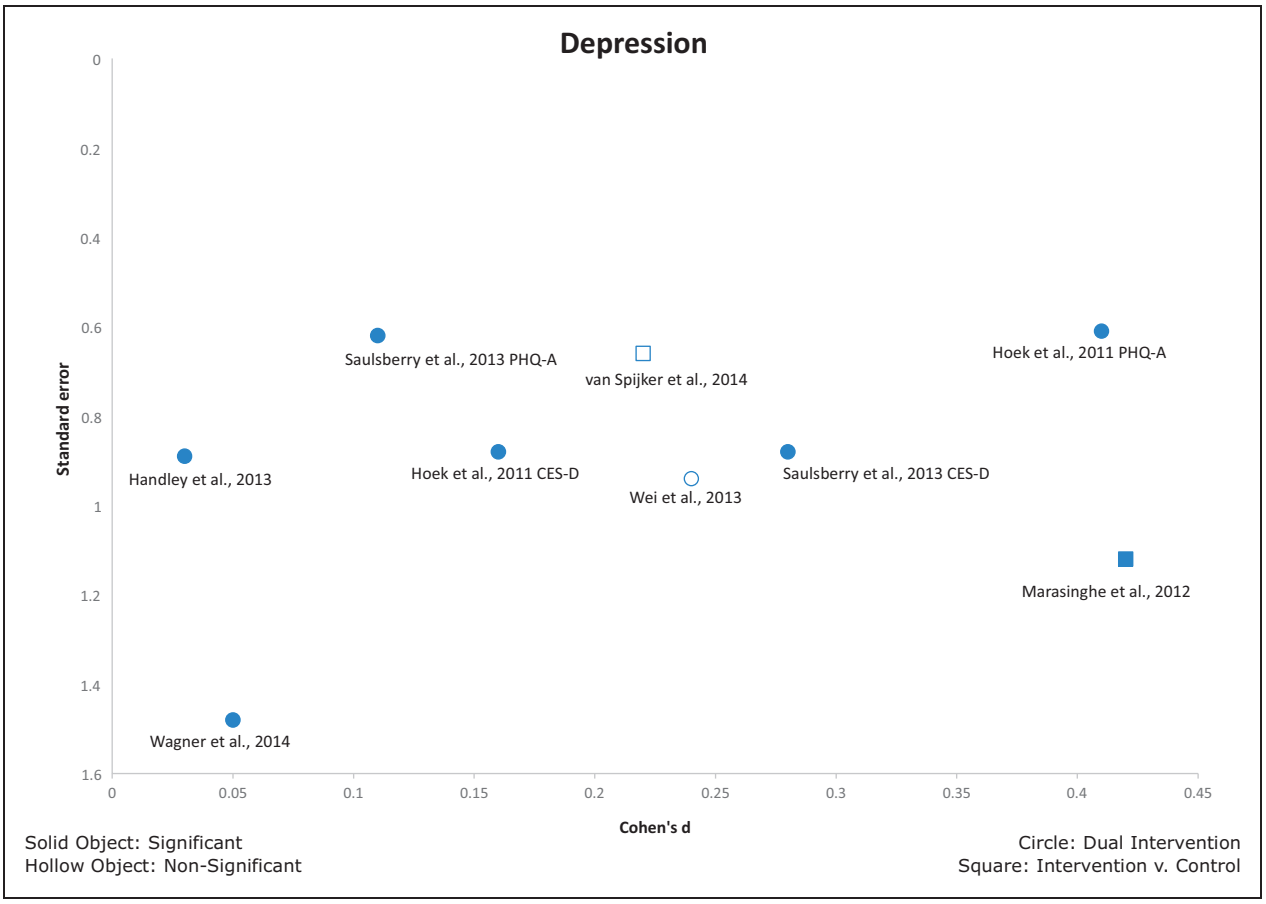

Figure 2. Depression funnel plot. Magnitude of the intervention effect (*x*-axis); precision of Cohen's *d* as an estimate of the population value (*y*-axis). Solid objects represent statistical significance, whereas hollow objects are non-significant. Circles represent intervention vs intervention groups and squares represent intervention vs control groups.

performed favourably on other indices such as depressed mood, anxiety, hopelessness and negative automatic thoughts.[17] Studies also have shown that, compared to usual care, adding telephone management reduced suicidal thoughts,[23] suicide re-attempts[22] and suicide mortality.[24]

Findings were mixed in studies targeting risk and protective factors; participants in Internet, text and telephone programmes experienced significant or near significant reductions in suicidal ideation,[13,14,16,18,23] whereas CD-ROM and Internet groups experienced non-significant reductions.[11,17] Similarly, telephone-care groups experienced significant improvement in suicide re-attempts compared to TAU,[22,24] while other telephone groups were similar to TAU and treatment controls in terms of suicide re-attempts.[21,23]

Studies providing education had variability, with video interventions reducing suicidal ideation,[25,26] but not the online programme.[19] While suicide outcomes were mixed, technology groups receiving education improved on secondary measures (i.e. stigma, adaptive attitudes, suicide discussions, help seeking).[19,20,26]

Taken together, technology-enhanced interventions appear to yield improvement in symptoms and risk, including notable improvement in secondary measures. Because technology-enhanced outreach improved symptoms and reduced risk, the likelihood of attaining population-level impact is highly potentiated, given the need for sustainable and scalable suicide prevention initiatives, which technology-enhanced outreach uniquely provides. Impact potential is heightened by improving these somewhat less effective technology-enhanced interventions, attaining the effect sizes achieved in face-to-face interventions to the extent possible, and making these much more affordable technology-enhanced interventions available to the majority of the at-risk population that has computer, Internet and cell phone availability.

Because most individuals have access to technology, many interventions targeted the individual level. Technology increases access to individuals, given frequent personal barriers to care, including stigma.[2] Further, with many individual-specific risk and protective factors,[5] individual level prevention is important to target and can be tailored via technology.[12,17,19,20] Identifying optimal strategies to enhance intervention uptake will better position technology interventions for population-level impact. Uptake is important given the opportunity for tailorable technology to reach at-risk individuals. This potential is maximized with further exploration of and correctly developed technologies that are highly scalable and sustainable.

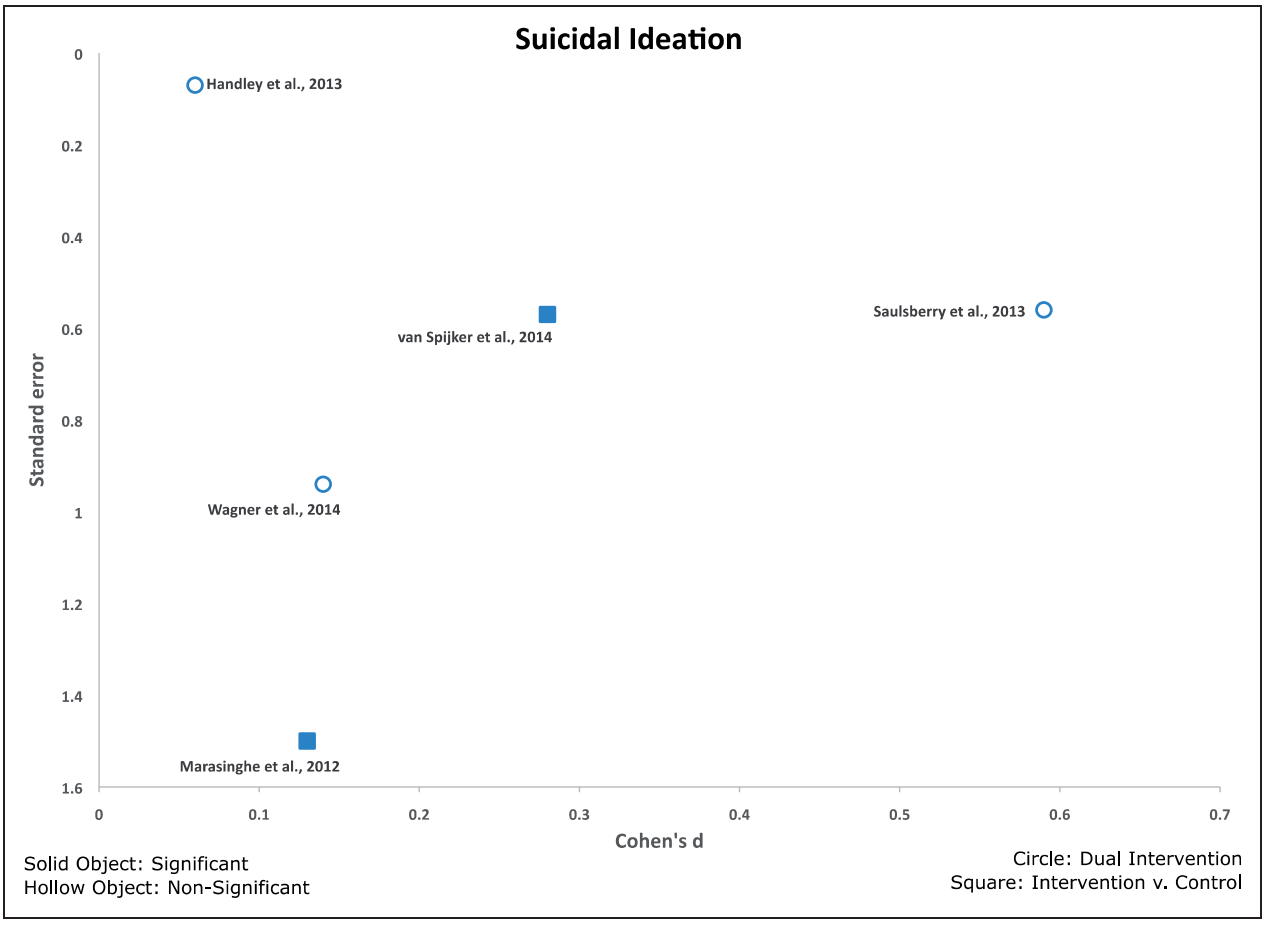

Figure 3. Suicidal ideation funnel plot. Magnitude of the intervention effect (*x*-axis); precision of Cohen's *d* as an estimate of the population value (*y*-axis). Solid objects represent statistical significance, whereas hollow objects are non-significant. Circles represent intervention vs intervention groups and squares represent intervention vs control groups.

Community level interventions were less prevalent, but are equally important.[3,6] When community members recognize the signs of suicidal ideation in themselves and others, adaptive attitudes and knowledge increase, while suicide mortality decreases.[25,26] Community perspectives especially relate to scalability and sustainability, as interventions have greater capacity to reach large audiences and increase penetration via community-based dissemination and outreach. Community strategies increase availability of resources and improve accessibility to education and support.[21–26] Community outreach is especially sustainable given the low cost of video and telephone outreach, becoming increasingly scalable as individuals seek help and confide in others, allowing healthcare providers to deliver technology-enhanced services.

Technology-enhanced suicide prevention interventions warrant additional exploration. This is a relatively new area of suicide prevention, and despite exhaustive searches, limited evidence is available. While studies included randomized controlled trial (RCT) designs,[13,16–21,23,24] secondarily analysed an RCT,[11,15] or performed longitudinal RCT follow-up evaluations,[14] modest sample sizes,[13,14,17–19,23] and attrition and/or low engagement[11,15,16,19] were additional limitations. Further, only three studies[11,17,21] directly compared a technology-enhanced treatment group to a simultaneous face-to-face treatment group, but these comparisons are important.

Additional study replications using more rigorous designs with larger samples may address present limitations and clarify existing variances in programme efficacy. Including concurrent comparative face-to-face treatment groups may further clarify conflicting outcomes. Future research must explore the effectiveness of technology-enhanced interventions in large-scale initiatives, while concurrently assessing the reach and use of technology-enhanced intervention components, and learning strategies to improve reach and encourage sustained use. Sustainability and scalability is important, and additional evaluations allow programme improvement and expansion. This ensures effective interventions are positioned for maximum impact because they possess population-level penetration potential.

Conclusion

Technology-enhanced programmes have demonstrated effectiveness in reducing suicidal ideation and

co-morbidities. With the existence of efficacious scalable and sustainable suicide prevention interventions, there is opportunity to study population-level impact and strategies to enhance effectiveness and reach. Scalable and sustainable interventions in the field of suicide prevention are critical to reducing suicide mortality in the USA, which is currently a top-10 leading cause of death.

Declaration of conflicting interests

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Appendix I: Literature Table

Authors and year	Summarized study aim	Theory therapies	.Research setting	Sample description and size (*n*)	Study design	Intervention and technology platform	Primary outcomes	CDC risk and protective factors ecological level addressed	Results	Oxford Center for Evidence-Based Medicine levels of evidence
Ahmadi and Ytterstad,[15] 2007	Describe a community-based programme for preventing deliberate self-burning. Assess changes in self-burning and all mechanism suicide attempt rates.	Bandura's social learning theory.	Gilangharb, Iran (intervention city); Sarpolzahab, Iran (reference city).	Gilangharb $n = 70,000$. Sarpolzahab $n = 89,000$. Young women and socio-economically deprived groups were targeted.	Quasi-experimental. 12-month historical control followed by 3-year intervention period, with data on suicide attempt patients collected prospectively.	Videos showing survivor stories provided education on complications of self-burning, and strategies for alternative problem-solving and coping.	Changes in self-burning suicide attempt rates and changes in all mechanism suicide attempt rates.	Community: educational and coping protective factors increased awareness of and provided alternatives to self-burning.	Gilangharb self-burning and all mechanism suicide rates decreased 57% and 19%, respectively. Sarpolzahab self-burning rates decreased 27% and all mechanism suicide rates increased 24%. In the intervention period, mean suicide rates between cities differed ($p < 0.001$).	2b
Aseltine and DeMartino,[26] 2004	Assess the short-term impact of SOS on suicidal behaviour, seeking help, and knowledge and attitudes toward depression and suicide.	Curriculum to raise awareness of suicide/depression, and a brief screen for depression/suicide behaviours.	3 US public high schools in Hartford, CT and 2 schools in Columbus, GA. $n = 2100$ students were represented.	Hartford, CT ($n = 1435$): Hispanic ~59%; Black ~20%; Female 53%. Columbus, GA ($n = 665$): White ~39%; Black ~37%; Male 52%.	Experimental design with randomized treatment and control groups and posttest-only data collection.	A video provided dramatizations, interaction strategies, and interviews with people impacted by suicide; discussion guides led conversations.	Suicide attempts, ideation, knowledge and attitudes toward depression and suicide, help-seeking behaviours.	Community: education to increase awareness of depression and suicide, while encouraging help seeking.	Adolescents ~40% less likely to report a suicide attempt in the 3-months following intervention, compared to controls ($p < 0.05$). There were increases in knowledge and adaptive attitudes toward suicide and depression ($p < 0.05$).	2c
Bush et al.,[12] 2015.	Determine if a Smartphone app containing elements of a CHB, CT, and DBT can be developed. Determine if the VHB is as usable, acceptable, convenient, and useful as a CHB.	Clinical utility of CT, DBT, and the CHB described.	US participants from a regional Veteran Administration (VA) behavioral health clinic.	$n = 18$ high-risk-of-self-harm veterans. White $n = 14$; mean age 41.4 years; female $n = 10$.	Proof-of-concept evaluation of the prototype VHB, using a crossover, counter-balanced design. Participants tested the CHB and VHB consecutively, with order of use randomized to a defined outcome of equal cell sizes.	A smartphone app designed to support, comfort, distract, or relax, by using audio, video, pictures, games, mindfulness exercises, inspirational quotes, and coping statements.	Frequency, purpose, ease of use; goal achievement; function, reaction, impression, suggestions to improve, likelihood to use again, and error.	Individual: develop coping strategies and personalized reasons for living, increase distress tolerance and improve emotional regulation.	Participants reported managing suicidal thoughts, improving emotional regulation, increasing distress tolerance, and increasing resiliency, which veterans reported was beneficial coping strategies.	4
Cebria et al.,[22] 2013	Determine the effectiveness of telephone management in delaying and reducing the percentage of suicide	Sample's elevated suicide risk described. Previous telephone research cited.	Intervention: CSPT in Sabadell, Spain $n = 400,000$. Control: CST in Terrassaa, Spain $n = 220,000$.	Intervention ED $n = 296$ telephone management; mean age 41.92 years; female 63.6%. Control ED $n = 218$ TAU;	Multicentre, case-control, population-based design. Compare changes in suicide reattempt rates between baseline	Telephone outreach provided at 1 week, 1 month, at 3-, 6-, 9-, and 12- months. Crisis calls and ED referral as needed.	Days between first suicide attempt and repetition of suicidal behaviour; percentage suicide re-attempts.	Community: Combined risk and protective factors; calls inquired about significant changes and provided	Suicide reattempts were delayed in adults receiving telephone care, compared to the 1-year baseline period and concurrent TAU population ($p < 0.0005$); suicide	3b

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Authors and year	Summarized study aim	Theory therapies	.Research setting	Sample description and size (*n*)	Study design	Intervention and technology platform	Primary outcomes	CDC risk and protective factors ecological level addressed	Results	Oxford Center for Evidence-Based Medicine levels of evidence
	re-attempts in patients post-suicide attempt.			mean age 40.73 years; female 70.5%.	and intervention year; compare changes between control and intervention populations.			ongoing risk assessment.	reattempt rates declined, compared to the baseline year and TAU population ($p = 0.0005$).	
Fleischmann et al.,[24] 2008	Determine whether a brief intervention and telephone contact is effective in reducing suicide mortality among suicide attempters in low- and middle- income countries.	Rationale for combining information, education, and practical advice provided.	Campinas, Brazil; Chennai, India; Colombo, Sri Lanka; Karaj, Islamic Republic of Iran; and, Yuncheng, China.	$n = 1867$ adults were randomized to TAU plus BIC ($n = 922$) or TAU ($n = 945$). BIC mean age 23 years; female 59.4%. TAU mean age 23 years; female 57.4%.	Multisite randomized controlled trial. Clinicians did not know allocation sequence. Subjects blinded to their treatment group. Overall, 91% completed the study.	Telephone outreach at 1-, 2-, 4-, 7- and 11- weeks, and 4- 6- 12- and 18- months. During crises, an in-person visit and ED referral occurred.	Suicide mortality (death by suicide).	Community: combined risk and protective factors. Education on suicide, distress, risk and protective factors, and alternatives to suicide.	At 18-month follow-up, more TAU adults died by suicide than BIC adults (2.2% versus 0.2%, respectively; $p < 0.001$).	1b
Handley et al.,[11] 2013	Explore if CBT targeting depression and alcohol misuse is associated with significant reductions in suicide vulnerability at 12-months. Investigate treatment delivery differential effects.	Utility of CBT provided. Depression and alcohol misuse as risk factors described.	DAISI (Baker et al., 2010) and SHADE (Kay-Lambkin, Baker, Kelly, et al. 2011) RCTs combined; included adults with elevated suicide vulnerability at baseline.	$n = 303$ Australian's ($n = 195$ DAISI trial and $n = 108$ SHADE trial). CD-ROM arm $n = 37$. Therapist-delivered arm $n = 89$. Mean age 43.4 years.	Secondary analyses using integrated data from two RCTs. Retention rate was 59.7%; CD-ROM and PCT (control) groups had significantly higher attrition. Multiple imputation provided full data.	A CD-ROM programme provided guided CBT. CD-ROM sessions mirrored therapist-integrated treatment. Therapists briefly checked symptoms after each session.	Suicidal ideation, hopelessness, depression severity, and alcohol consumption.	Individual: Strategies to reduce dysfunctional attitudes, alcohol misuse, and depression (i.e., address risk factors for suicide).	No differences between CD-ROM- and therapist-delivered CBT on suicidal ideation were observed ($p = 0.43$). Suicidal ideation scores stable in both groups from baseline to 12-months (0.95 to 1.04 CD-ROM; 0.99 to 0.82 therapist-delivered).	2b
Hoek et al.,[13] 2011	Determine whether a MI is superior to BA in terms of clinical outcomes. Determine whether pre/post within group changes support intervention efficacy.	Behavioral activation, CBT, IPT, and a community resiliency concept model.	CATCH-IT was combined with PCP BA or a PCP MI. PCP contact occurred at 13 primary care sites across the USA.	Dual intervention; $n = 83$ adolescents randomized to: 1.) $n = 43$ MI plus CATCH-IT; 2.) $n = 40$ BA plus CATCH-IT. Mean age 17.47 years; female 56.6%. White 60%.	Phase 2 randomized clinical trial. Outcomes assessed using blinded phone assessments. At 6-months 23% had no data. Hierarchical linear modelling corrected missing data.	A structured intervention website to provide access to 14 total guided weekly modules.	Depression, self-harm ideation, and hopelessness.	Individual: Strategies to master emotions in peer, school and family domains, build coping skills, and increase resiliency.	CATCH-IT reduced depression ($p < 0.001$) and suicidal ideation ($p = 0.06$) from baseline to 6-months when combined with BA. When combined with a MI, depression ($p < 0.001$) and hopelessness ($p = 0.04$) declined from baseline to 6-months.	2b
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Authors and year	Summarized study aim	Theory therapies	.Research setting	Sample description and size (*n*)	Study design	Intervention and technology platform	Primary outcomes	CDC risk and protective factors ecological level addressed	Results	Oxford Center for Evidence-Based Medicine levels of evidence
King et al.,[19] 2015	Determine whether eBridge students would report greater readiness to consider mental health treatment and be more likely to link to treatment by 2-month follow-up, compared to control students.	Health belief theoretical model.	$n = 116$ screened positive for depression, suicide ideation, previous suicide attempt, and/or alcohol abuse. $n = 40$ excluded (i.e. already in treatment).	$n = 76$ US college students randomized to: (a) eBridge $n = 35$ (mean age 22.5 years; female 66%); (b) control $n = 41$ (mean age 23.3 years; female 51%).	Pilot randomized controlled trail. eBridge group completed 76% of follow-up evaluations, and controls completed 83% (follow-up differences $p = 0.44$).	An intervention site connected counsellors and students. During specified hours, students could connect with counsellors in real-time chat sessions. Private messages were sent through the website.	Depression and suicidal ideation (PHQ-9), alcohol use, perceived need for help, help-seeking, perceived stigma, readiness to access help.	Individual: participants selectively reviewed personalized feedback and education on emotional distress and alcohol use.	Readiness to talk to family ($p = 0.007$), friends ($p = 0.01$), and to see a mental health professional ($p = 0.001$) was higher in the eBridge group than controls. The eBridge group perceived less public ($p = 0.04$) and personal ($p = 0.004$) stigma, compared to controls. More eBridge participants met with a mental health professional ($p = 0.002$), than the control.	
Marasinghe et al.,[18] 2012	Test whether a Brief Mobile Treatment (BMT) intervention can improve outcomes relative to usual care among suicide attempters.	Limited resources for follow-up post-suicide attempt were described.	Sri Lankan adults ($n = 68$) were provided mobile phone based follow-up care, to reinforce psychotherapy principles.	Randomly allocated to: (a) I-BMT $n = 34$ (female 50%; mean age 32 years); (b) D-BMT $n = 34$ 6-month waitlist control arm (female 50%; mean age 30 years).	Randomized, single-blind clinical trail with 6-month waitlist control. At 6- and 12- months, a blinded independent assessor repeated study measures.	Supportive phone calls, continuous access to coping audio phone messages, and weekly SMS reminders about psychotherapy principles.	Suicidal ideation, self-harm, depression, social support, alcohol use, substance use.	Individual: meditation, problem solving, spiritual ideas, social support, avoiding alcohol/drugs, and SMS use during crises.	With regard to suicidal ideation, depression, and social support, Condition X Time was significant for baseline versus 6-months but was not significant for baseline versus 12-months.	2b
Mousavi et al.,[23] 2014	Evaluate the effect of telephone follow-up on suicide re-attempts.	Sample's elevated suicide risk described. Social and cultural factors considered.	Participants ($n = 139$) were recruited from Isfahan, Iran after a suicide attempt, and randomized to TAU or BIC.	TAU control: $n = 70$ or BIC intervention: $n = 69$. Female 63.4%. Age 15–25 years 56.9%, Age 26–35 years 28%, Age above 35 years 15.1%.	Randomized controlled clinical trial. Telephone interviewers followed a standard guide and used validated questionnaires.	Telephone outreach at 2- and 4- weeks, and at 2-, 3-, 4-, 5-, and 6- months. Emergency crisis numbers were also provided.	Suicidal ideation, hope, suicide re-attempt rates.	Community: Combined risk and protective factors; risk assessment, education about the importance of follow-up, and coping.	There were no differences in rates of suicide re-attempts between BIC and TAU groups ($p = 0.18$). However, frequency of suicidal thoughts decreased ($p = 0.007$), and hope increased ($p = 0.001$) for the BIC group, compared to the control.	1b
Saulsberry et al.,[14] 2013	Determine if symptoms would increase toward baseline levels at 1-year.	Behavioral activation, CBT, IPT, and a community resiliency concept model.	CATCH-IT was combined with PCP BA or a PCP MI. PCP contact occurred at 13	Dual intervention; $n = 83$ randomized: (a) $n = 43$ MI plus CATCH-IT; (b) $n = 40$ BA plus CATCH-IT.	1-Year follow-up study of the Hoek et al., 2011 randomized clinical trial cohort. Structured,	A structured intervention website to provide access to 14 total guided weekly modules.	Depression, suicidal ideation, hopelessness, and loneliness.	Individual: strategies to master emotions in peer, school and family domains, build	Declines in depressive symptoms were sustained from baseline to 1-year for BA and MI groups ($p < 0.001$). There was a decline in ratings of loneliness for BA	2b

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Authors and year	Summarized study aim	Theory therapies	.Research setting	Sample description and size (*n*)	Study design	Intervention and technology platform	Primary outcomes	CDC risk and protective factors ecological level addressed	Results	Oxford Center for Evidence-Based Medicine levels of evidence
	Determine if between-group differences would diminish by 1-year.		primary care sites across the USA.	Mean age 17.26 years; female 57%; White 61%.	blinded phone interviews used for follow-up assessments. Last observation carried forward corrected 30% missing data.			coping skills, and increase resiliency.	and MI groups at 1-year ($p < 0.001$).	
Shah et al.,[20] 2014	Determine if a targeted PSA, or an individually tailored IMCP programme, increases suicide discussion in patients with elevated risk for clinical depression, when compared to an attention control.	Health behaviour and patient activation theory.	Patients and PCPs recruited from US adult primary care sites in California. Data collected in the PCP office setting, before and after patients PCP visit.	$n = 867$ stratified by gender, race, site; randomized to: (a) IMCP $n = 286$; (b) PSA $n = 287$; (c) Attention control $n = 294$. One group difference at baseline; PSA arm had better mental health summary scores ($p = 0.01$).	Multicentre, stratified, parallel group, randomized controlled trial. PCPs blinded to patient's group assignment and study hypothesis, 6.3% excluded post-randomization.	A tablet computer in the PCP office provided tailored, individual-specific, interactive health messages. Messages related directly to participants' PHQ-9 score.	Depression, suicidal ideation, discussion of suicide with PCP, practice setting.	Individual: educational protective factors, increasing recognition of depression, encouraging discussion of suicidal thoughts with providers.	There were no differences in suicide discussion between IMCP and PSA groups in adults with minimal depressive symptoms, compared with the control ($p = 0.32$). With moderate or higher depressive symptoms, the IMCP arm had more suicide discussion than the control ($p = 0.03$).	1b
van Spijker et al.,[15] 2012	Evaluate the cost-effectiveness of an online, unguided, self-help intervention for reducing suicidal ideation.	CBT and parts of DBT, PST, and MBCT, were combined.	$n = 236$ Netherlands participants with suicidal ideation were recruited.	Participants were stratified for gender and randomized to the intervention ($n = 116$), or wait-list control ($n = 120$). Mean age 40.9 years; female 66.1%. Born in the Netherlands $n = 218$.	Cost-effectiveness analysis of the van Spijker, van Straten and Kerkhof (2010) RCT with parallel group 6-week waitlist control. 56% completed 3 modules, 21.6% completed all 6 modules, and 22.4% did not start the intervention.	An intervention website shared strategies to improve controlled thinking, regulate emotions, identify automatic thoughts, enhance thinking, and promote thought challenging.	Suicidal ideation, costs of uptake, out of pocket costs, production losses, direct and indirect costs, intervention and total costs.	Individual: coping strategies were integrated, and participants received a weekly motivational email to enhance protective factors.	There was a change in incremental effectiveness in the intervention group, compared with controls ($p = 0.01$). The mean incremental cost-effectiveness ratio was ~$37,985 for an additional treatment response. Willingness to pay for a favourable treatment response was high.	1b
Van Spijker et al.,[16] 2014	Test the effectiveness of unguided online self-help to reduce suicidal thoughts.	CBT and parts of DBT, PST, and MBCT, were combined.	$n = 236$ Netherlands participants with suicidal ideation were recruited.	Participants were stratified for gender and randomized to the intervention ($n = 116$), or wait-list control ($n = 120$). Mean	Randomized control trial with parallel group 6-week waitlist control. Attrition rates were 6.8% at T1, 10.6% at T2, 8.9% at T3; $n = 11$ had	An intervention website shared strategies to improve controlled thinking, regulate emotions, identify automatic thoughts, enhance	Suicidal ideation, depressive symptoms, anxiety, hopelessness, and worry.	Individual: coping strategies were integrated, and participants received a weekly motivational email to enhance protective factors.	The intervention group experienced improvement in suicidal thoughts ($p = 0.04$) and experienced less worry ($p = 0.01$), compared to controls. Individuals with a previous suicide attempt had greater	1b

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Authors and year	Summarized study aim	Theory therapies	.Research setting	Sample description and size (*n*)	Study design	Intervention and technology platform	Primary outcomes	CDC risk and protective factors ecological level addressed	Results	Oxford Center for Evidence-Based Medicine levels of evidence
				age 40.9 years; female 66.1%. Born in the Netherlands $n=218$.	missing values at T1 and T2, and were not included in the dropout analysis. Multiple imputation replaced missing values.	thinking patterns, and promote thought challenging.			improvement than controls ($p<0.05$), with no differences among those who never attempted suicide.	
Wagner et al.,[17] 2014	Compare treatment outcomes of an internet-based intervention with a face-to-face intervention for depression in a randomized non-inferiority trial.	Rationale for inclusion of therapist contact during treatment, and use of a guided online programme provided.	Zurich, Switzerland participants ($n=62$) randomly assigned to the therapist-supported internet CBT intervention or the face-to-face CBT intervention.	(a) Online CBT $n=32$. Mean age 37.3 years; female 78%. (b) In-person CBT $n=30$. Mean age 38.7 years; female 50%. No stratification; more women in the online versus in-person group ($p<0.05$).	Randomized controlled non-inferiority trial, The same treatment modules were provided in the same order and time frame. Length of therapist contact was equal. 22% of online participants failed to finish treatment; baseline observation carried forward corrected missing data.	Website-facilitated therapist contact. Behavioral assessment, activity planning, daily structure life review, positive memory activation, cognitive restructuring, and social competence also included.	Depression, suicidal ideation, anxiety, hopelessness, and negative automatic thoughts.	Individual: coping strategies were included; therapist contact and personalized feedback enhanced protective factors.	Participants improved on depression, anxiety, hopelessness ($p<0.001$), self-esteem and negative automatic thoughts ($p<0.01$); the in-person group showed similar improvement. Suicidal ideation did not decrease significantly in the online group ($p=0.24$), but did in the in-person group ($p<0.05$). At 3-months, within-group effect sizes were more favourable for the online versus in-person group.	2b
Wei et al.,[21] 2013	Describe the follow-up of patients who attempted suicide; determine whether the interventions would reduce suicide attempts.	Effective programmes from developed countries included, and tested in a Chinese population.	$n=239$ Patients from Shenyang China were randomized into one of three groups.	(a) In-Person CT $n=82$; (b) Telephone Intervention $n=80$; (c) Control $n=77$. Mean age 32.53 years; female 76.13%.	Randomized controlled trial. At 1-year, dropout attrition was 69.5% in the CT group, 55% in the telephone group, and 64.9% in controls.	A weekly telephone call included psychological support, empathy, reassurance, active listening, and collaborative problem solving.	Suicidal ideation, suicide re-attempt rates, depression, and quality of life.	Community: combined risk and protective factors, providing 3-months of supportive contact, and ongoing assessments.	No differences in suicide re-attempt rates among telephone care, CT, or control groups ($p=0.08$). Rates of suicidal ideation among conditions did not differ at baseline, 3-, 6- or 12-months ($p=0.43$, 0.72, 0.75, 0.67, respectively), nor did conditions differ in depression ($p=0.57$, 0.89, 0.49, 0.99, respectively) or quality of life ($p=0.25$, 0.43, 0.62, 0.71, respectively).	2b

BA: Brief Advice; CHB: Conventional Hope Box; CSPT: Corporacio Sanitaria Parc Tauli; CST: Consorci Sanitari de Terrassa; DAISI: Depression and Alcohol Integrated and Single-focused Interventions; D-BMT: Delayed-BMT; ED: emergency department; MI: Motivational Interview; PCT: Person-Centered Therapy; PSA: Public Service Announcement; I-BMT: Immediate-BMT; SHADE: Self-Help for Alcohol/other drug use and Depression.