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A Systematic Review and Meta-Analysis on Mobile and Online Suicide Interventions

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Table of Content

Theoretical Background

Every 40 seconds, a person dies due to suicide, making it the 18th leading cause of death worldwide in 2016 (World Health Organization [WHO], 2019). In 2016 alone, 1363 people lost their lives to suicide in Austria. Although the numbers of suicide-related deaths decreased between 2000 and 2016 globally for all regions but the American continent, where a slight increase by 6% was found, countries' policymakers and their health care systems are in need for action and efficacious interventions for this public health issue (WHO, 2019).

Suicide can happen impulsively but is usually a process, which starts with suicidal ideation, which are thoughts that can arise of situations of crisis and disaster, overwhelming life problems, such as financial hardships, relationship problems, or physical or mental illnesses, such as cancer, addiction, or affective disorders (WHO, 2019). In case of the combination of internal and external factors, it can eventually lead up to a suicide attempt (Heeringen, 2001).

A suicide attempt "is a self-inflicted, potentially injurious behavior with a nonfatal outcome for which there is evidence (either implicit or explicit) of an intention to die" (Silverman et al., 2007, p. 272). An attempt can result in suicide, which "is the act of deliberately killing oneself" (WHO, 2019). Especially vulnerable to experiencing any form of suicidality are discriminated minority groups, such as refugees and indigenous people, or people with a different sexual orientation. Methods of suicide vary among countries, but firearms, self-poisoning and hanging are among the most used methods (WHO, 2019).

The occurrence of suicidality and related actions combined with the variety of suicide methods demonstrates the complexity of this issue and the need for a multi-level approach in reducing its prevalence. Ideally, in order to prevent suicides, interventions should target the emergence of suicidal ideation, before any suicidal actions and attempts take place (Heeringen, 2001; O'Connor & Nock, 2014).

Barriers to Effective Treatment

Although suicidal ideation is a common precursor of suicide attempts and potential suicides, all aspects of suicidality have to be targeted by specific and effective interventions. In research, this can be a difficult endeavor, because people experiencing suicidal ideation, which usually is the precedent of suicide attempts, will be excluded from clinical trials. A vicious circle emerges, in which treatment aspects, which could benefit not only the general, but especially the suicidal population, may get overlooked due to a lack of suicidal participants.

Wilks et al. (2016) found that over 90% of randomized controlled trials (RCTs) of online cognitive behavioral interventions excluded potential participants, who were suicidal. These exclusions happen despite the fact that suicidal people might be more likely to seek help online than in a personal, face-to-face setting (Wilks et al., 2018). The lack of including suicidal people in research trials could result in a treatment gap, which in turn might be linked to the low numbers of suicidal people receiving proper treatment. The lack of sufficient treatment in suicidal people was also shown by Bruffaerts et al . (2011), who find that in high-income countries, almost half of the people experiencing some form of suicidality do not receive treatment. In low-income countries, only 17% receive treatment. This difference appears to be mainly due to the low perception of needing help and wanting the handle one's problems by oneself. The barriers to treatment availability and attendance seem to affect low-income countries more than high-income countries (Bruffaerts et al., 2011), which is alarming given that 79% of all suicides in 2016 happened in middle- to low-income countries (WHO, 2019). Treatment approaches should, therefore, target these barriers, considering the differences in patients' socioeconomic backgrounds and the special challenges that come with it.

Cost Barrier

The cost barrier, referring to the personal effort, time, and money people invest in treatment, can keep many from receiving and accessing proper treatment (Mojtabai et al., 2011; Sareen et al., 2007). Therefore, one barrier influencing therapy attendance can be the cost of it (Bruffaerts et al., 2011). Full cost coverage of psychotherapy is not widely available around the world, and even Austria struggles with a sufficient provision of free therapy placements for all people in need (Kapusta et al., 2010). Especially for low- or no-income households, affording psychotherapy can become a hardship. Additionally, being unoccupied is associated with an increased risk of death by suicide (Agerbo, 2005). It is especially alarming that a population with an elevated risk of suicide due to their occupational situation is the least likely to be able to afford proper mental health care.

Geographical Location

Another constraint for treatment attendance may be the geographical location (Backhaus et al., 2012). Cities show a denser population of treating mental health care professionals (Wallace et al., 2006). Rural areas encounter the problem of fewer professionals, which can also pose a barrier in the sufficient provision of mental health care treatments (Thomas et al., 2009). Living in a remote area may force individuals who already struggle with daily life to travel far distances, which might make them even more uncomfortable or even be impossible, for instance, due to forms of anxiety such as social anxiety disorder. This increased hardship of geographical distance from a treatment facility can influence the treatment attendance of people coping with suicidal problems (Bruffaerts et al., 2011).

The scarcity of available personnel further poses the issue of maintaining the highest quality standards in treatment. Van Den Berg et al. (2004) show that responsible mental health care providers do not necessarily use the best empirically supported therapies, a situation, which

is even worse in rural areas (Wallace et al., 2006). Attending regular professional training courses to guarantee the highest, most recent standards of care also seems difficult considering geographical seclusion. A possible difference in treatment quality between densely and scarcely populated areas would point towards a lesser standard treatment for patients in rural areas. The potential lack of high-quality treatment among mental health care professionals in rural areas can therefore pose a barrier to treatment availability and attendance.

Internal Factors

Bruffaerts et al. (2011) further report that the wish to handle one's issues concerning suicidality oneself poses another barrier for adequate treatment. This wish can be linked to the fear of stigma and being prejudiced against. Even more, the need for seeking help is underestimated, which increases the likelihood of not receiving treatment. As a positive treatment outcome also requires a time commitment and the willingness to put in effort, which is not always feasible due to occupational and private circumstances, the personal investment can pose another obstacle in the efficacious reduction of suicidality.

Numerous approaches to battle suicide, suicide attempts, and suicidal ideation have been proposed and implemented, among them standard psychiatric care and psychotherapy. Comtois and Linehan (2006) show that among psychotherapy approaches, cognitive behavioral therapy (CBT), dialectical behavior therapy, and interpersonal psychotherapy are widely used and have been found to be effective in the field of suicide intervention and prevention. In their systematic review and meta-analysis, Tarrier et al. (2008) show the efficacy of CBT on suicidal behavior in adults in comparison to the control group. Other approaches are mindfulness-based cognitive therapy (MBCT) and problem-solving therapy,which may also effectively reduce suicidal ideation (Comtois & Linehan, 2006; Forkmann et al., 2014).

Delivery Modalities

To overcome the barriers of therapy cost, attendance, and availability, the renunciation from standard face-to-face treatments towards nontraditional approaches is being considered increasingly. Christensen et al. (2014) found that interventions directly targeting suicide-related outcomes may be more effective than interventions targeting other related outcomes. Therefore, the focus on interventions primarily targeting suicide-related outcomes is indicated.

Postcards, Letters, and Emails

Caring letters may be an effective medium to reach people struggling with suicidality (Comtois & Linehan, 2006; Motto, 1976). The intervention is based on sending a certain number of letters, expressing concern to the patients after hospital discharge (Luxton et al., 2013). This intervention was first done by Motto (1976), who successfully showed a reduction of completed suicides using a caring letter intervention that lasted two years. Postcards have also been shown to have some positive effects on suicidal behavior (Luxton et al., 2013).

Online Programs

The Internet has gained increased interest in delivering treatments for a variety of mental disorders (Andersson & Cuijpers, 2009), as it becomes more accessible to more people around the world (Aggarwal, 2012). Over 4 billion people were using online sources in 2019, which constitutes an increase of 5.3% in comparison to 2018 (International Telecommunication Union, 2019). Andersson and Cuijpers (2009) found that online programs can be effective for depression, alcohol abuse, and anxiety disorders. Regarding suicide-related interventions and preventions, online programs have been of increased interest to researchers (Kerkhof et al., 2013; van Spijker et al., 2014, 2018) and therefore pose a possible medium to deliver remote interventions. Especially the possibility of using elements of evidenced-based CBT in an online

setting shows promising results regarding suicide-related outcomes (De Jaegere et al., 2019; van Spijker et al., 2014).

Mobile Phones and Apps

Using a cell- or smartphone for treatment delivery in the context of mental health is a reasonable consequence of the modernized technical world. Over 4.5 billion people use a mobile phone (Statista Research Department, 2018) and can, therefore, gain access to a variety of resources. This, in turn, means that mental health interventions based on mobile- and smartphones could reach many more people than traditional face-to-face delivery and break through several of the barriers, influencing positive treatment outcome of suicidal ideation and behavior (De Beurs et al., 2015; Kerkhof & Mishara, 2013). This trend is reflected in apps being incorporated into the creation of mental health interventions increasingly (Ainsworth et al., 2013; Ben-Zeev et al., 2015; Goodwin et al., 2016). Telephone interventions targeting suicidal behavior have already found effective results (De Leo et al., 2002; Vaiva et al., 2006).

Online interventions, mobile interventions via phone contact and apps, as well as letters and postcards, have the potential to overcome the barrier of cost, geographical remoteness in treatment attendance and availability, seclusion, lack of anonymity, and varying quality standards in treatment between denser and less densely populated areas. Mobile and online interventions could even reach people who are not aware of the severity of their illness as interventions not performed by a healthcare professional themselves may be perceived as less acute and serious.

Goals of the Present Research

So far, previous systematic reviews found that there was not enough literature about online and mobile interventions targeting suicidal ideation, attempts, or completed suicides to draw valid conclusions about their efficacy (Milner et al., 2015; Witt et al., 2017). Further, their impact in varying populations remains unclear (Beautrais et al., 2010).

Because of the rapid developments in this field of research and no recent analysis on the whole corpus of possible online and mobile interventions, I conducted a systematic review and meta-analysis of the currently available literature. Besides assessing the current state of the interventions, the goal was to reduce the uncertainty about their efficacy and to search for convincing evidence to further invest in this line of research.

Methods

Literature Search

I conducted an exhaustive literature search including all available data up to September 2019 from databases relevant to the field of psychology (PsycInfo, Web of Science, PubMed, Cochrane Library, Scopus). Grey literature, which refers to not commercially published material like conference papers, thesis, or official reports was also included. Sources included the Blackdog Institute, the Grey Literature Report by The New York Academy of Medicine (greylit.org), Open Grey-System for Information on Grey Literature in Europe (opengrey.eu), clinicaltrials.gov by the National Library of Medicine (NLM), International Prospective Register of Systematic Reviews (PROSPERO), The Directory of Open Access Scholarly Resources (ROAD) by the ISSN International Centre (road.issn.org) and The Bielefeld Academic Search Engine (BASE, base-search.net).

Google Scholar was searched as an additional resource but returned about 200,000 results per search term, which is why the broad search strategy kept stringent for all other databases was constrained to only titles with the search strings of interest to gain meaningful results. I adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). I searched with ten different search strings referring to suicide and the type of intervention, maintaining a broad scope of potentially includable literature. The thesis was not preregistered on PROSPERO or any similar trial preregistration platform, because

it was an exploratory study and, apart from the search terms, the inclusion and exclusion criteria were modified along the search process.

The following search terms were used: "Suicide" AND "Online Intervention" OR "Online Prevention"; "Suicide" AND "E Intervention" OR "E Prevention" OR "Electronic Intervention" OR "Electronic Prevention"; "Suicide" AND "Mobile Intervention" OR "Mobile Prevention"; "Suicidal Ideation" AND "Online Intervention" OR "E- Intervention" OR "Mobile Intervention"; "Suicidal Behavior" AND "Online Intervention" OR "E- Intervention" OR "Mobile Intervention"; "Suicidal Intent" OR "Suicidal Attempt" OR "Suicidal Behavior" AND "Online Intervention" OR "E Intervention" OR "Mobile Intervention"; "Suicidal Intent" AND "Online Intervention"; "Suicidal Intent" AND "E Intervention"; "Suicidal Intent" AND "Mobile Intervention"; "Suicidal Attempt" AND "Online Intervention"; "Suicide Attempt" AND "E Intervention"; "Suicide Attempt" AND "Mobile Intervention"; "Suicidal Behavior" AND "Online Intervention"; "Suicidal Behavior" AND "E Intervention"; "Suicidal Behavior" AND "Mobile Intervention"; "Web - Based Suicide Prevention" OR "Web - Based Suicide Intervention"; "Web Based Suicide Prevention" OR "Web Based Suicide Intervention"; "Suicide" AND "Online Support", "Emotional First Aid" AND "Suicide" AND "Online"; "E-Therapy" AND "Suicide" OR "E Therapy" AND "Suicide" OR "e-Therapy" AND "Suicide" OR "e Therapy" AND "Suicide". Additional articles were identified through backward search and the reference lists of included articles.

Inclusion Criteria

Literature was included, if it met the following criteria: The primary outcome had to be suicide-related, and the study had to be an RCT. RCTs are considered the gold standard in conducting research, as this method aims to reduce the risk of bias the most (Castillo et al., 2012). In contrast, Yang et al. (2010) argue that the inclusion of only RCTs does not represent the

general population well as this study design imposes stringent criteria on the study population, for instance, excluding older participants, or people who have severe or comorbid diseases. Because this work intended to focus on a selective (clinical) population, which by its nature only represents a rather small part of the general population and specific aspects of suicidality, the exclusion of non-RCTs seemed necessary. Even more so because the goal of this thesis was to determine the efficacy of the interventions with the least possible bias. Further, interventions had to be delivered online or via mobile channels, which include any form of delivery on the Internet, via phone or similar devices, or postal mail.

Since this thesis was of exploratory character, the inclusion criteria were modified and adjusted according to the available literature. As the line between exclusively online, mobile and electronically, and mostly online was not as clear as assumed in the beginning, the strict inclusion criterion of the intervention exclusively taking place online was extended to literature presenting interventions which take place mostly online, mobile, or electronically. This means that the actual amount of time spent with the intervention must have exceeded the time spent in a face-to-face setting with a mental health professional. I demonstrate this criterion with an example: A study giving all-time access to an app while overseeing the progress with eight therapy sessions over the course of 16 weeks provided theoretically more exposure to the app than to the in-person setting, which is why this exemplary study would have been included. A further necessary criterion was that it had to be clearly distinguishable how much face-to-face interaction there was. Vague, non-quantifiable information was not deemed sufficient, and respective studies were therefore excluded. Face-to-face interaction at baseline and follow-up assessment was allowed, as trials with patients experiencing any form of suicidality require security measures, which may include face-to-face evaluations by a clinician.

During the search process, it was decided to include only samples from clinical populations into the study pool, as a clear distinction between a high-risk population, with clinical scores on the later defined outcomes and the general public, with average, non-clinically significant scores, was needed. The former was then classified as 'interventions', and the latter could be regarded as 'preventive approaches', which were not assessed in this thesis. Exceptions were made for samples from non-clinical populations reaching high, clinically relevant scores in the outcomes of interest.

For the final decision on which literature to include and subsequently perform analysis on, I decided on three target outcomes to group the interventions. These were suicidal ideation, suicide attempts and completed suicides. All studies not reporting on any of those three outcomes were excluded from qualitative and quantitative analysis.

I further decided to group the studies based on their used medium of intervention delivery. The categories were letters and postcards, emails, online programs, apps, telephone contact interventions, and a mixed category of all studies that could not be assigned to any of the previous categories as they reported a variety of delivery media mixed together.

To collect, organize, and store the literature, Zotero 5.080 (Roy Rosenzweig Center for History and New Media., 2016) was used.

Coding Process

For the coding process, a coding scheme was developed. It included bibliographical references such as the authors' names and the publication year. Sample characteristics were further extracted (overall sample size, the sample size of the intervention group and control group, the country of study conduct, the age of the sample and the sex ratio).

Regarding the research design, characteristics like sampling strategy, intervention and treatment description, primary outcomes, results, and methods of analysis were coded. Where

available, I also extracted the effects sizes and other statistical parameters indicating the

magnitude of the effect (mean, standard deviation, percentages). Problems that occurred during

the coding process were documented. The coding scheme can be found in Table A1 (provided in

the Appendix). As there was no double-coding, and no inter-rater-reliability was calculated. After

finishing the initial coding process, suicide risk was synthesized from the reported study

outcomes as a further outcome by combining the data for suicidal ideation and attempts. This

outcome was then investigated for the various delivering media. The synthesizing of outcomes

was done to increase the number of studies, which could be included in the analysis, and

therefore to increase its statistical power. No secondary outcomes were coded.

Study Quality

To be able to draw valid conclusions based on the included studies, an assessment of each

study's limitations and potential biases has to be performed. Higgins et al. (2011) argue that

study quality is an ill-defined concept, but overall refers to the appropriateness of a study's

design, its conduct, methods, and analysis in order to answer the research question. Study quality

was assessed using a seven-item rating scheme, consisting of six items from the Guidelines of

the International Society of Traumatic Stress Studies (ISTSS, Foa et al., 2000) and one item from

the Study Quality Assessment Tools for Controlled Intervention Studies by the National Heart,

Lung, and Blood Institute (National Heart, Lung, and Blood Institute [NHLBI], 2019). The items

regarded the adequacy of the randomization, whether the assessment was blinded, reasons and

analysis for dropout, whether a treatment protocol existed, whether adherence to the protocol

was checked, whether an intention to treat (ITT) analysis was performed, and if there was a large

enough sample size to provide a power of at least 80% to detect a clinically relevant difference in

the mean outcome between groups. A sum score was calculated ranging from 0 (*lowest quality*)

to 7 (*highest quality*). The Cochrane Collaboration advises against the use of a sum score to

evaluate the risk of bias, as quality scales often unjustifiably mix aspects about the study conduct with the quality of reporting (Higgins et al., 2011). They propose six domains in the Cochrane Collaboration risk of bias tool, which allows for answers regarding high risk, low risk, and unclear risk of bias. For demonstration within this master thesis and to explore a potential moderator effect in heterogeneous results, a sum score was computed. While I agree that quality scales can distort the actual risk of bias by assigning the same weight to differently important risk-of-bias items, this works' quality items were selected based on what was believed to provide a valid indicator of high-quality study standards. Therefore, the items were assumed to be of equal importance and a sum score was calculated to quantify the studies' quality and to examine potential moderating effects. It can also be noted that four out of six domains (selection bias, performance bias, attrition bias, and other biases) of the Cochrane Collaboration risk of bias tool were accounted for using the current quality assessment items. Only detection bias and reporting bias might not have been accounted for thoroughly enough. It can be argued though that detection bias in this line of studies is less important, because the interventions themselves took place mostly without any personal interaction. Therefore, it is unlikely that the assessor could have influenced the outcome of the intervention by knowing who was allocated to which condition. Even if the final assessment, in case of suicidal ideation, was done through an administered questionnaire like the Beck Scale for Suicide Ideation (BSSI, Beck et al., 1988) the outcome of weeks-long treatment could have been influenced marginally by the assessor. Reporting bias targets selective reporting, which was partly included in the quality assessment by taking a conservative approach and deducting a point if an information was not reported. Furthermore, most studies reported not significant results. As values of yes (*1*) or no (*0*) were assigned to the assessed quality items, it can be said that a distinction between mentioned and not mentioned or not clearly reported information was made and therefore a difference between

higher and lower quality was established, which is the essence of a quality assessment. An overview of the used items can be found in Table A2 (provided in the Appendix).

For the meta-analysis, Meta Essentials 1.5 (Suurmond et al., 2017) was used. This free tool was designed for Microsoft Excel and consists of a variety of workbooks for the synthesis of statistical parameters, like effect sizes, based on numerical input of the primary literature. Besides the meta-analytic computations, it allows for meta-regression (moderator analysis) and the investigation of publication bias, but cannot be used to compute meta-regressions with multiple indicators (van Rhee et al., 2015).

For analysis, the studies were grouped by their primary outcome (suicidal ideation, suicide attempts, completed suicides) and by their intervention-delivering medium (letters/postcards, online programs, intervention mix, apps, telephone contact).

Effect size computations for the three primary outcomes utilized all provided data, whether presented on a continuous scale or as a categorical variable. As results obtained from different studies using different scales or instruments, for instance, the BSSI (Beck et al., 1988) or the Suicidal Behavior Questionnaire (informally published by Linehan, 1981), cannot be combined meaningfully, standardized mean differences were computed for continuous data. For suicidal ideation, the effect size d with 95% CIs were calculated, using the group means, the sample sizes of each group and the pooled within-groups standard deviation, see Equations 1 and 2 (Borenstein et al., 2009).

$$d = \frac{\overline{Y_1} - \overline{Y_2}}{S_{pooled}} \qquad\qquad (1)$$

$$S_{pooled} = \sqrt{\frac{(n_1-1)S_1^2 + (n_2-1)S_2^2}{n_1+n_2-2}} \qquad\qquad (2)$$

A *d* of 0.2, 0.5, and 0.8 can be interpreted as small, medium, and large effect sizes respectively (Cohen, 1988), with a positive value indicating an improvement and a negative value meaning a deterioration for the intervention group.

For the categorical outcomes, suicide attempts and completed suicide odds ratios (*OR*), which are the ratios of two odds, were computed with 95% CIs (Borenstein et al., 2009). Regarding the interpretation of the *OR*, which can take values between 0 and infinity, the equivalent of a small *d* of 0.2, would be an *OR* of 1.68 (or inverted 0.60), a medium *d* of 0.5 is equal to an *OR* of 3.47 (or inverted 0.29) and a large *d* of 0.8 resembles an *OR* of 6.71 (or inverted 0.15) (H. Chen et al., 2010). An *OR* of 1 indicates no difference between the intervention and control group; a value above 1 indicates the improvement, and a value below 1 indicates the deterioration of the intervention group. Where necessary, the *OR* was converted to *d* for analysis using Equations 3 and 4 (Borenstein et al., 2009)

$$d = logOR \times \frac{\sqrt{3}}{\pi} \qquad\qquad (3)$$

$$SE_d^2 = SE_d^2 logOR \times \frac{\sqrt{3}}{\pi^2} \qquad\qquad (4)$$

To maintain the correct interpretation for the specific measures, the inverse value of the *OR* was taken and then converted to a *d*, as negative *d* values mean a deterioration for the intervention group. A low *OR,* on the other hand, does not mean a deterioration for the intervention group but becomes translated into one, if no inverse value is computed.

Random Effects Model

A Random Effects Model assumes that the studies do not share the same effect size and it estimates the distribution of these effect sizes around a mean. This variance of the true effects stems from the assumption that there are differences in samples due to, for example, age or health of the participants, differences in intervention intensity, or even the researcher team. A

fixed effect model, in contrast, assumes that all studies share the same underlying true effect size and that any observed variation is due to sampling error (Borenstein et al., 2009). Because other meta-analyses (Lai et al., 2014; Witt et al., 2017) reported inconsistent effect sizes and because of the heterogeneity between the studies' interventions, a random effects model was used, except for when only two studies were included in the meta-analysis.

Heterogeneity Analysis

Heterogeneity in effect sizes means variation in the true effect sizes. Within the context of meta-analysis, the observed variation of effect sizes consists of heterogeneity and sampling error. To quantify the observed heterogeneity, which is not due to chance or sampling error, several indices exist. (Borenstein et al., 2009).

I^2 was a parameter referring to the proportion of observed variance posing a real difference in effect sizes, therefore representing a relative scale for the observed variance. It can range from 0 to 100% and is independent of the number of included studies as well as the metric of the effect size being used (Borenstein et al., 2009). Some point of reference for the value of I^2 was provided by Higgins (2003). They propose an I^2 up to 25% translates into small heterogeneity, I^2 up to 50% translates into a medium amount of heterogeneity and an I^2 over 75% resembles a large amount of heterogeneity. An I^2 of 90% would, therefore, represent a large amount of heterogeneity, which does not mean that the effects are distributed over a wide range, but that most of the observed variance is real (Borenstein et al., 2009). They further argue that these values can be classified as benchmarks for clinical trials but would most likely be different in a different field of research or trial designs.

If the heterogeneity could be attributed to a covariate moderating the influence of the outcome, moderator analysis should be performed. Within this thesis, two potential moderators,

previous suicide attempts, as suggested by the literature (House et al., 1999; Suominen et al., 2004; van Spijker et al., 2014), and study quality were examined.

An indicator, as to how much of the true variance can be explained by the examined covariate, the R^2 index is used, which has a range from 0 to 1 or 0 to100%. Borenstein et al. (2009) define it as the ratio of true variance to total true variance. It is an intuitive measure and widely accepted across researchers. Borenstein et al. (2009) further mention that a sufficient amount of studies (approximately ten) reporting on moderator data should be included in a meta-regression. Nevertheless, this is argued to be a rule of thumb and fewer studies, for demonstration purposes, especially within this master thesis were being used, as not all studies reported sufficient data for the moderator analysis.

Sensitivity Analysis

Sensitivity analysis can be used to examine the robustness of the findings regarding the computations and syntheses having been made. Borenstein et al. (2009) describe four approaches to a sensitivity analysis. The first is to check whether the included data may impact the results differently based on their inclusion, in comparison if other data had been included. Therefore, studies can be excluded at random to check if this exclusion impacts the previously obtained results. This can be the case if studies produce divergent results in comparison to all other included studies or identify as outliers.

The second approach is to test the robustness of the used statistical methods and to vary them to check if the obtained results are influenced differently by different analysis methods. The third approach deals with missing data and if results would differ when applying a different analysis to them. The fourth approach is linked to the third, by focusing on the imputation of missing data and if results would differ when other imputations would have been made.

For this thesis, the first approach was used by excluding all studies of low quality, meaning a score lower than four in the quality rating.

Correction for Measurement Error

When multiple tests are performed, the likelihood of rejecting the null hypothesis, when it is true (type I error) increases. Instead of performing a Bonferroni correction, which controls for an accumulation of type I error by using the family-wise error rate, it was intended to use the Benjamini-Hochberg correction (Benjamini & Hochberg, 1995), which controls for the false discovery rate. It refers to the proportion of hypotheses that can be expected to have been falsely rejected. In comparison to correcting for the family-wise error rate, an increase in power is likely (Benjamini & Hochberg, 1995). However, the results of the meta-regressions were not significant and therefore, no correction was performed after all.

Publication Bias

Publication bias means the tendency for literature with significant results or larger effect sizes to be published more often than literature reporting not significant results or smaller effect sizes (Borenstein et al., 2009). This bias of the available literature influences research on all levels but has a special impact on systematic reviews and meta-analyses, as they rely on the available published literature for meaningful inferences. This bias can distort the relationship between variables and the outcome and yield wrong results, especially if the sample size is small (Hedges, 1984). Dickersin and Min (1993) and Dickersin et al. (1992) showed that not significant results were up to 86% less likely to be published and underwent longer waiting periods in the publication process. On the level of meta-analysis, Rothstein (2006, as cited in Borenstein et al., 2009, p. 279) found that out of 95 meta-analytic reviews, more than 20% did not include any grey literature in their work. To address this issue, a thorough literature review of all sources and channels is vital. Also, a funnel plot was used to graphically estimate if any

asymmetry in the distribution of effect sizes is present. The trim-and-fill method by Duval and

Tweedie (2000) was used to impute missing data to reach symmetry around the (adjusted) effect

size (Borenstein et al., 2009). Both procedures are available in Meta Essentials 1.5. (Suurmond et

al., 2017) for Microsoft Excel.

<div align="center">**Results**</div>

Literature Search

The literature search returned 45,457 results through search in the databases mentioned

above and an additional 3,080 results through the grey literature and Google Scholar search.

I screened the titles of the available literature before importing it to the Zotero library due

to capacity issues, which is why I modified the PRISMA flow chart (Fig. 1) by removing the

number of records screened, as it would have disrupted the flow of the chart. Therefore, the total

number of records identified through database searching is followed by the total number of

records after duplicates have been removed, which also included title screening and led up to

8777 remaining articles. After looking at the abstracts, 99 articles remained for full-text reading.

Out of those, 73 did not meet the inclusion criteria. Therefore, 26 were included in the qualitative

and 22 in the quantitative synthesis. Figure 1 shows the results of my search.

Figure 1.

PRISMA flow chart of the literature search
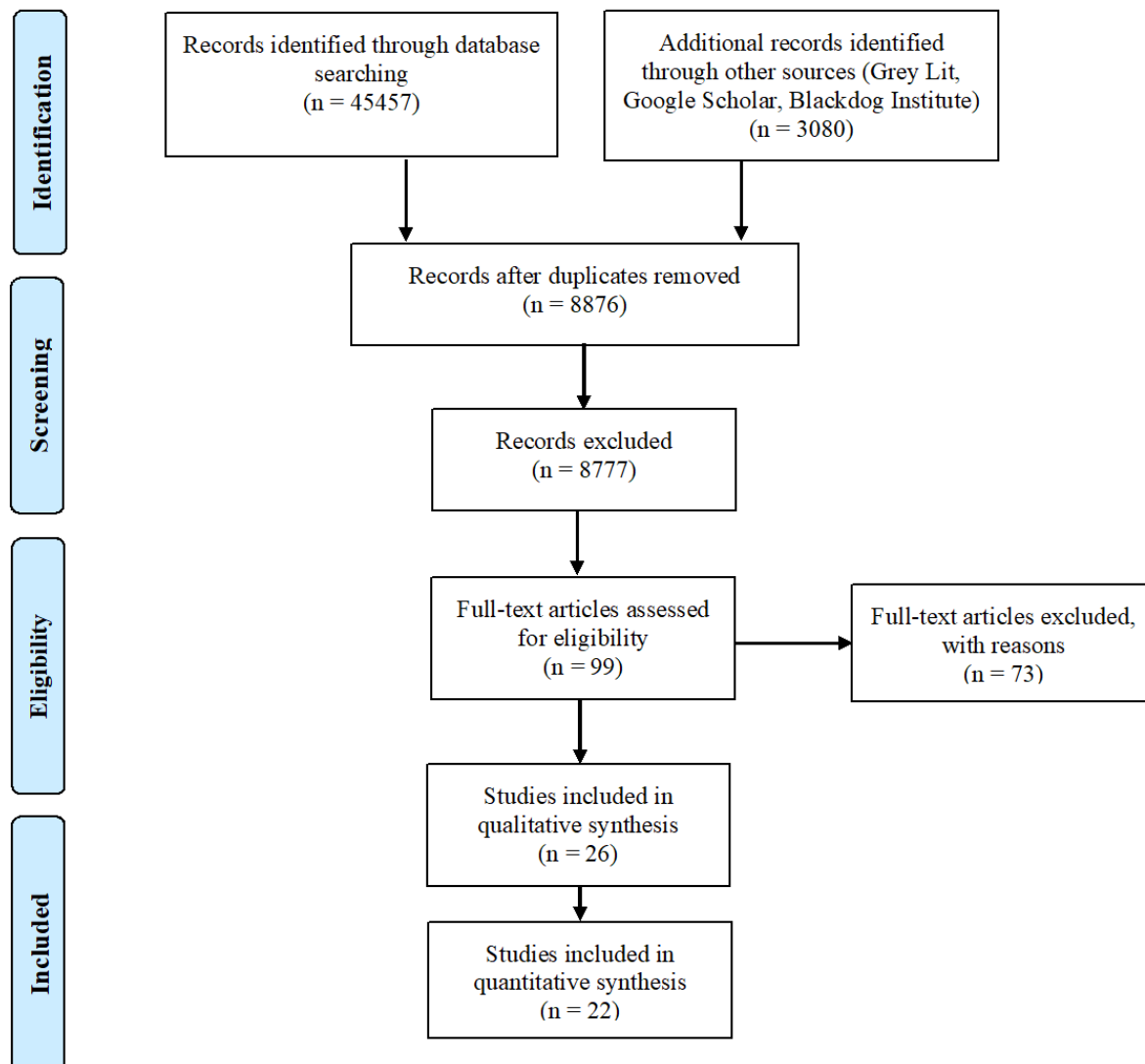
Study Characteristics

Six of the studies were conducted in the United States of America (Bush et al., 2017;

Kasckow et al., 2016; Kennard et al., 2018; Luxton et al., 2019; Motto & Bostrom, 2001; Wilks

et al., 2018), four in Australia (Carter et al., 2005; Robinson et al., 2012; Tighe et al., 2017; van

Spijker et al., 2018), two in the United Kingdom (E. Evans et al., 2005; M. O. Evans et al.,

1999), France (Mouaffak et al., 2015; Vaiva et al., 2006) and the Netherlands (van Spijker et al.,

2014, 2015), and one in Iran (Hassanian-Moghaddam et al., 2011), New Zealand (Beautrais et

al., 2010), Belgium (De Jaegere et al., 2019), Denmark (O'Toole et al., 2019), Taiwan (W.-J.

Chen et al., 2013), Switzerland (Gysin-Maillart et al., 2016), French Polynesia (Amadéo et al.,

2015), Sweden (Cedereke et al., 2002) and Sri Lanka (Marasinghe, 2012). One study recruited

participants from the USA, Canada, Europe, Asia, and South America without any further

specification (Franklin et al., 2016).

All studies included a total of 10,867 participants, not counting two studies (E. Evans et

al., 2005; van Spijker et al., 2015), which reported partial follow-up data based on the same or

parts of the same sample as already reported in the original studies. The smallest study included

51 participants (Kasckow et al., 2016), and the largest included 2,300 participants (Hassanian-

Moghaddam et al., 2011). Six studies (Beautrais et al., 2010; Carter et al., 2005; E. Evans et al.,

2005; M. O. Evans et al., 1999; Hassanian-Moghaddam et al., 2011; Motto & Bostrom, 2001;

Robinson et al., 2012) used letters, postcards, or crisis cards as intervention, out of which five

(Beautrais et al., 2010; Carter et al., 2005; E. Evans et al., 2005; M. O. Evans et al., 1999;

Hassanian-Moghaddam et al., 2011; Robinson et al., 2012) aimed to reduce suicide-related

behavior like self-harm or self-poisoning. One study aimed to reduce suicide rates (Motto &

Bostrom, 2001).

One study (Luxton et al., 2019) used emails to reduce suicidal ideation, suicide attempts,

and completed suicides. Five studies (De Jaegere et al., 2019; van Spijker et al., 2014, 2015,

2018; Wilks et al., 2018) used online programs to reduce suicidal ideations, of which one (Wilks

et al., 2018) also examined heavy drinking as primary outcome besides suicidal ideations.

Seven studies (W.-J. Chen et al., 2013; Gysin-Maillart et al., 2016; Kasckow et al., 2016;

Kennard et al., 2018; Marasinghe, 2012; Mouaffak et al., 2015; O'Toole et al., 2019) addressed

suicidal ideation and attempts through a combination of modalities like resource cards and

postcards, phone calls, letters, apps, audio-, and text-messages.

Three studies concerned themselves with reducing suicidal ideation via apps (Bush et al., 2017; Franklin et al., 2016; Tighe et al., 2017). Amadeo et al. (2015), Cedereke et al. (2002), and Vaiva et al. (2006) reached out to their participants via phone calls to reduce suicidal ideation, suicide attempts, and completed suicides.

The mean age of all included participants was 34.17 years ($SD = 8.29$) with 59.18% being women. Robinson et al. (2012) and Kennard et al. (2018) were the only studies focusing on adolescent participants. All studies but Kasckow et al. (2016) excluded schizophrenic participants. An overview of the study characteristics grouped by delivering medium can be found in Table 1.

Table 1.
Overview of The Study Characteristics Grouped by Delivering Medium

Study	Treatment Intention	Sample	Quality*
Postcards/Letters/Crisis cards			
Carter et al. (2005)	Reduce deliberate self-poisoning	772 participants (68% women) from Australia, mean age n.r.	5
Hassanian-Moghaddam et al. (2011)	Reduce deliberate self-poisoning	2300 participants (66.4% women) from Iran, mean age 24.13	3
Robinson et al. (2012)	Reduce suicide-related behavior	165 participants (62.6% women) from Australia, mean age 18.6	4
M. O. Evans et al. (1999)	Reduce deliberate self -harm, completed suicides	827 participants (55.4% women) from the UK, mean age 33.35	3
E. Evans et al. (2005)	Reduce deliberate self -harm, completed suicides	827 participants (55.4% women) from the UK, mean age 33.35	0
Beautrais et al. (2010)	Reduce deliberate self- harm	327 participants (66.4% women) from New Zealand, mean age 33.85	5
Motto & Bostrom (2001)	Reduce suicide rates (completed suicides)	843 participants, (56% women) from the U.S.A., mean age 33.6	0
Emails			

Study	Treatment Intention	Sample	Quality*
Luxton et al. (2019) (excluded from quant. Analysis)	Reduce suicidal ideation, attempts, completed suicides	1318 participants, (24% women) from the U.S.A., mean age 33.1	2
Online Programs (Modules)			
van Spijker et al. (2014)	Reduce suicidal thoughts	236 participants, (66.1% women) from Netherlands, mean age 40.93	7
van Spijker et al. (2015) (excluded from quant. analysis)	Reduce suicidal thoughts	116 participants, (65.5% women) from Netherlands, mean age 40.5	6
van Spijker et al. (2018)	Reduce suicidal thoughts	418 participants, (77.3% women) from Australia, mean age 40.63	7
De Jaegere et al. (2019)	Reduce suicidal thoughts	724 participants, (59.4% women) from Belgium, mean age 35.7	5
Wilks et al. (2018)	Reduce suicidal ideation & heavy drinking	59 participants, (69.6% women) from the U.S.A., mean age 38	4
Intervention Mix (content specified below study authors)			
Mouaffak et al. (2015) (resource card, phone calls, letters, outreach to treating practitioner)	Reduce suicide attempts	320 participants, (73.9% women) from France., mean age 38.8	3
O'Toole et al. (2019) (face-to-face sessions + app)	Reduce suicidal ideation	129 participants, (42.0 % women) from Denmark, mean age 28.7	4
Gysin-Maillart et al. (2016) (face-to-face sessions + letters)	Reduce suicide attempts	120 participants, (55.0 % women) from Switzerland, mean age 37.85	6
Kennard et al. (2018) (face-to-face sessions + app)	Reduce suicidal ideation and attempts	66 participants, (89.2 % women) from the U.S.A., mean age 15.1.	7
W.-J. Chen et al. (2013) (case management + 1 postcard, excluded from quant. analysis)	Reduce suicide attempts	761 participants, (68.0% women) from Taiwan, mean age 39.9	2

Study	Treatment Intention	Sample	Quality*
Kasckow et al. (2016) (face-to-face sessions, phone calls, Health Buddy System (= telephone device for symptom assessment and communication, support)	Reduce suicidal ideation	51 participants, (5.5 % women) from the U.S.A, mean age 51.1	2
Marasinghe et al. (2012) (face-to face-sessions, 10 phone calls, 5 min audio messages, text - message reminders)	Reduce suicidal ideation	68 participants, (50.0 % women) from Sri Lanka, mean age 29.5	2
Apps			
Tighe et al. (2017)	Reduce suicidal thoughts	61 participants, (64.0% women) from Australia, mean age 26.23	5
Bush et al. (2017)	Reduce suicidal ideation	118 participants, (31.5% women) from the U.S.A, mean age 47.59	3
Franklin et al. (2016) *(excluded from quant. analysis)*	Reduce suicidal ideation	163 participants, (58.9 % women) from USA, Canada, Europe, Asia, South America, mean age 24.52	2
Telephone Contact			
Vaiva et al. (2006)	Reduce deliberate self- poisoning, completed suicides	605 participants, (74.5% women) from France, mean age 36	4
Amadéo et al. (2015)	Reduce suicide attempts and completed suicides	200 participants, (64.2 % women) from French Polynesia, mean age 32.24	4
Cedereke et al. (2002)	Reduce suicidal ideation, suicide attempts, completed suicides	216 participants, (66.0 % women) from Sweden, mean age 41	4

Note: n.r. = not reported,

*Quality rating: 0 = lowest, 7= highest

Control Group Interventions

The control conditions consisted of either a waitlist control (De Jaegere et al., 2019; Tighe et al., 2017; van Spijker et al., 2014, 2015; Wilks et al., 2018), an attention control (van Spijker et al., 2018), treatment as usual (TAU) plus waitlist control (Marasinghe et al., 2012), TAU plus psychoeducative materials (Bush et al., 2017), TAU plus control app (Franklin et al., 2016), TAU plus initial safety interview (Gysin-Maillart et al., 2016; Robinson et al., 2012), or TAU plus reminding letters (Mouaffak et al., 2015).

Kasckow et al. (2016) and Chen et al. (2013) offered their control group intensive case monitoring or -management and Motto and Bostrom (2001) had no contact at all with the control group, as needed information was obtained from official governmental records.

TAU was the most widely used treatment for the control group (Amadéo et al., 2015; Beautrais et al., 2010; Carter et al., 2005; Cedereke, 2002; Evans et al., 1999; Hassanian-Moghaddam et al., 2011; Kennard et al., 2018; Luxton et al., 2019; O'Toole et al., 2019; Vaiva et al., 2006), but only a few studies specified the content of TAU. Table 2 shows the components of TAU used in each study.

Table 2
TAU Components of Each Study

Components of TAU	Study
Psychiatric assessment followed by a hospitalization, an outpatient follow-up, or no further care	Amadéo et al., 2015; E. Evans et al., 2005; Gysin-Maillart et al., 2016; Kennard et al., 2018
Crisis assessment, a referral to inpatient community based mental health services	Beautrais et al., 2010
No special care at all	Hassanian-Moghaddam et al., 2011
Medical care, evaluation of suicide risk and a treatment plan	Mouaffak et al., 2015
Psychotherapy treatment specifically for suicide-related purposes	O'Toole et al., 2019
Any form of treatment the person was receiving at the time (support from school counsellor, a general practitioner, private psychiatrist, or psychologist)	Robinson et al., 2012; Vaiva et al., 2006

Components of TAU	Study
Weekly assessments using BSS (Beck et al., 1979) and Personal Health Questionnaire 9 (PHQ9; Kroenke et al., 2001)	Kasckow et al., 2016
No mention of TAU components	Bush et al., 2017; Carter et al., 2005; Cedereke et al., 2002; W.-J. Chen et al., 2013; De Jaegere et al., 2019; M. O. Evans et al., 1999; Franklin et al., 2016; Luxton et al., 2019; Marasinghe et al., 2012; Motto & Bostrom, 2001; Tighe et al., 2017; van Spijker et al., 2014, 2015, 2018; Wilks et al., 2018

Study Quality

For the evaluation of the study quality, a total of seven items from the guidelines of the ISTSS and the NHLBI were used, resulting in a range of 0 to 7 obtainable points. Table provides details about the studies' quality scores. Seven studies scored below four and 15 studies scored four or above. Five studies reached a score of five, six studies reached a score of four, four studies reached a score of three, five studies reached a score of two and two studies reached a score of 0. Only four studies (Kennard et al., 2018; van Spijker et al., 2014, 2015, 2018) reached a score of six or higher.

Grouped by the intervention delivering medium, the studies ranking the highest on the overall quality score were using online programs ($M = 5.8$), followed by telephone contacts ($M = 4.0$), a mix of interventions ($M = 3.71$), apps ($M = 3.33$), and letters/postcards ($M = 2.86$). The mean overall quality score was 3.81, and the median was 4.

Suicidal Ideation

Suicidal Ideation and Letters/Postcards

Two studies reported on suicidal ideation in the context of letters or postcards (Hassanian-Moghaddam et al., 2011; Robinson et al., 2012). Assuming a fixed effect model, an *OR* of 0.59 (95% CI [0.19,1.83]), with a significant two-tailed *p*-value < 0.001 was calculated.

The observed heterogeneity I^2 was 48.35%. No moderator analysis was performed due to a lack

of studies. The forest and funnel plot can be seen in Figure A1 (provided in the Appendix).

Suicidal Ideation and Emails

Luxton et al. (2019) were the only ones attempting to reduce suicidal ideation through

emails in a veteran sample. The intervention group (N = 652) received 13 emails over two years

in addition to TAU, while the control group (N = 666) received no caring emails. The Rudd

Suicide Ideation Scale (RSIS, Rudd, 1989) was used to determine the presence and intensity of

suicidal thoughts and prior suicide attempts. At baseline assessment, the intervention group

reported a mean score of 21.82 (*SD* = 8.67) and at follow-up a mean of 16.84 (*SD* = 8.63). The

control group received a mean baseline score of 22.39 (*SD* = 9.05) and a mean score of 17.39

(*SD* = 8.67) at the follow-up assessment (*B* = 0.00, *b* = -0.02, 95% CI [-1.8, 1.76]). *d* was 0.064.

Suicidal Ideation and Online Programs

Five studies reported on the reduction of suicidal ideation through online programs (De

Jaegere et al., 2019; van Spijker et al., 2014, 2015, 2018; Wilks et al., 2018) of which van Spijker

et al. (2015) is a partial follow-up of the study conducted in 2014. It reports on the outcome of a

three month follow-up after the initial posttest of the study in 2014. Using the BSSI (Beck et al.,

1988), the authors reported a maintained reduction in suicidal ideation changing from a mean of

10.7 (*SD* = 9.2) at posttest to a mean of *10.3* (*SD* = 9.8) at follow-up (*d* = 0.49, 95% CI [0.3,

0.68]). No data on the control group was reported.

Assuming a random effects model, the meta-analytic computations for the remaining four

studies resulted in a *d* of 0.26, which resembles a small effect (Cohen, 1988) with a 95% CI

[0.03;0.48] and a significant two-tailed *p*-value < 0.001. An I^2 of 36.85% indicates a small

observed heterogeneity (Higgins, 2003). Three out of the four studies reported data on the first

moderator previous attempted suicides, resulting in an R^2 of 6.87% (*B* = 0.00029, 95% CI

[0.00;0.00], p = 0.786). Regarding the second potential moderator, study quality, all four studies were included resulting in an R^2 of 71.36% (B = -0.09389, 95 % CI [-0.26, 0.07], p = 0.066). The funnel plot showed no signs of a skewed study distribution or missing studies. The forest and funnel plot can be seen in Figure A2 (provided in the Appendix).

Suicidal Ideation and the Intervention Mix

Five studies reported on the reduction of suicidal ideation through an abundance of online or mobile interventions combined (Kasckow et al., 2016; Kennard et al., 2018; Marasinghe, 2012; O'Toole et al., 2019; Wilks et al., 2018). Despite Wilks et al. (2018) having already been included in the analysis of online programs in the reduction of suicidal ideation, they were also included in this analysis as they supplemented their intervention with emails and text messages for reminding their patients to use the online program. Assuming a random effects model, the computations reported a d of 0.21, 95% CI [-0.43, 0.84], which resembles a very small effect and a not significant two-tailed p-value of 0.366. An I^2 of 80.12% indicated a large observed heterogeneity (Higgins, 2003). No moderator analysis for the first moderator was performed due to a lack of studies. The second potential moderator study quality was based on data from all five studies and led to an R^2 of 17.34% of observed true variance (B = -0.10438, 95% CI [-0.51, 0.30], p = 0.478). The funnel plot indicated no missing studies or skewed distribution. The forest and funnel plot can be seen in Figure A3 (provided in the Appendix).

Suicidal Ideation and Apps

Three studies reported on the effect of apps on suicidal ideation (Bush et al., 2017; Franklin et al., 2016; Tighe et al., 2017), although Franklin et al. (2016) had to be excluded from quantitative analysis due to a non-comparable measure of suicidal ideation. Assuming a fixed effect model, the computations resulted in a d of 0.01, 95% CI [-1.89, 1.91], and a two-tailed p-value of 0.948. Due to the lack of studies and because the observed heterogeneity (I^2) was

0.00%, no moderator analysis was performed. The forest and funnel plot can be seen in Figure

A4 (provided in the Appendix).

Franklin et al (2016) conducted three studies, of which the third study was relevant to this

thesis, as it aimed at the reduction of suicide-related outcomes such as suicidal ideation and

behavior in suicidal individuals (N = 163). The app content for the intervention group was based

on the principle of increasing aversion to suicide-related stimuli and decrease aversion to the

self. The control group (N = 85) used a control app, which showed suicide-unrelated stimuli.

Suicidal ideation was measured in days, during which suicidal ideation was experienced.

Suicidal behaviors were measured as the number of nonfatal instances and analyzed over all

three studies, due to the low frequency of the behaviors. Because the samples of the first and

second study were not suicide focused, the results were disregarded for my analysis. Concerning

suicidal ideation, the intervention group reported a mean of 12.29 days (SD = 12.60) and the

control group a mean of 8.84 (SD= 10.36) days of suicidal thoughts. d was 0.3,95 % CI [-0.01,

0.61].

Suicidal Ideation and Telephone Contact

There was only one study using repeated telephone contacts to reduce suicidal ideation

by encouraging their patients to seek or continue professional treatment. Cedereke et al. (2002)

randomized their patients to an intervention group (N = 107) receiving a baseline assessment,

phone calls at four and eight months and a final assessment at 12 months post suicide attempt.

The control group (N = 109) received only the baseline and follow-up assessment and no phone

calls. The BSSI (Beck et al., 1974) was used for the self-rating of suicidal intentions. The mean

scores at the one-month baseline assessment were 7.9 (SD = 8.4) for the intervention group and

5.0 (SD = 6.8) for the control group ($p < 0.10$). There were 57 previous suicide attempts (54%) in

the intervention group and 56 (51%) in the control group. For measuring the change in the SSI,

standardized residual scores were used. As treated analysis showed that the suicidal ideation of

the intervention group lowered to a mean of 5.8 ($SD = 7.8$) ($p < 0.05$) and the control group

improved to a mean of 4.0 ($SD = 6.2$, $p < 0.05$). Overall, no significant difference was found

between the two groups ($d = 0.26$, 95% CI [-0.05, 0.56], $p = 0.10$).

Suicide Attempts

Suicide Attempts and Letters/Postcards

Six studies reported on reducing suicide attempts by using letters or postcards as

interventions (Beautrais et al., 2010; Carter et al., 2005; E. Evans et al., 2005; M. O. Evans et al.,

1999; Hassanian-Moghaddam et al., 2011; Robinson et al., 2012). Evans et al. (2005) reported on

the 12-months follow-up of the original crisis card study from 1999. They sent a crisis card

offering the telephone number of a crisis support team. The control group ($n = 410$) received no

information on the card. 21.6% of the intervention group had a repeat episode of self-harm in

comparison with the control group, in which 18.8% made an attempt. ($OR = 1.19$, 95% CI [0.85-

1.67]). The previous history of self-harm was used as a moderator of interest but showed no

group differences between the intervention- and control group ($\chi^2 = 2.37$, $p = 0.12$).

Concerning the remaining five studies, which were included in the meta-analytic

computations, a random effects model was assumed leading to an OR of 0.88,95% CI [0.58,

1.32], $p = 0.367$). An observed heterogeneity of 45.89% was found. Therefore, a moderator

analysis was performed using previous suicide attempts and study quality. Four out of five

studies reported data on previous suicide attempts with a not significant p-value of $p = 0.277$ and

an explained heterogeneity of $R^2 = 42.75$% ($B = 0.00$, 95% CI [0.00, 0.00]). The second

moderator was reported by all studies and resulted in a not significant p-value of $p = 0.918$ and a

small amount of explained observed heterogeneity of 0.39 % ($B = 0.02$, 95%[CI -0.51, 0.54]).

The funnel plot indicated no missing studies or skewed distribution. The forest and funnel plot

can be seen in Figure A5 (provided in the Appendix).

Suicide Attempts and Intervention Mix

Four studies reported on the reduction of suicidal ideation through a combination of

online or mobile modalities (W.-J. Chen et al., 2013; Gysin-Maillart et al., 2016; Kennard et al.,

2018; Mouaffak et al., 2015). Chen et al (2013) aimed at reducing suicide reattempts by sending

a crisis card after three months of case management sessions, which were individually tailored to

the patients based on their progress during crisis management support. The intervention group (N

= 373) received crisis management sessions and a crisis card and the control group (N =388)

received crisis management alone. They investigated whether there was a group difference in the

days until a suicide reattempt occurred. An ITT analysis showed no effect in favor of the

intervention (*Hazard Ratio* [*HR*] = 0.84; 95% CI [0.56, 1.29]). Including only compliant patients

who were originally assigned to either one of the two groups and received the treatment

according to plan (per protocol) showed a beneficial effect in favor of the intervention (*HR* =

0.39; 95% CI [0.21, 0.72]). The authors further report that on a per-protocol basis, 29.78% of the

participants of the intervention group, who received the full case management (N = 356), did not

read the crisis postcard. Out of those, 50% had a history of previous suicide attempts. In contrast,

34.4% of the participants of the intervention group, who received the full case management and

read the crisis postcard, had a history of previous suicide attempts (p = 0.01). As Chen et al.

(2013) used a non-comparable measure of the efficacy of their intervention, they were excluded

from the meta-analytic computations.

The remaining three studies aimed at reducing suicide attempts with a resource card,

phone calls, letters, an outreach to the treating practitioner (Mouaffak et al., 2015), face to face

sessions and letters (Gysin-Maillart et al., 2016) and face to face sessions and an app (Kennard et

al., 2018). Assuming a random effects model, an *OR* of 0.44 (95% CI [0.03, 6.45]), with a not

significant two-tailed *p*-value of 0.188 was calculated. The observed heterogeneity was 71.58%.

Due to a lack of studies, no meta-regression using the first potential moderator was performed.

All three studies were included in the second moderator analysis resulting in a not significant p-

value of *p* = 0.345 and a medium amount of explained observed heterogeneity (B = 0.34, 95%

CI[-1.89, 1.21], R^2 = 47.12%). The funnel plot showed one missing study. The forest and funnel

plot can be seen in Figure A6 (provided in the Appendix).

Suicide Attempts and Telephone Contact

Three studies reported reduced suicide attempts through telephone contacts (Amadéo et

al., 2015; Cedereke et al., 2002; Vaiva et al., 2006). Assuming a random effects model, an *OR* of

0.99 (95% CI [0.52, 1.90]) with a not significant two-tailed *p*-value of 0.961 was computed. The

observed heterogeneity I^2 was 0.00%, which is why no further moderator analysis was

performed. The funnel plot indicated no missing studies or skewed distribution. The forest and

funnel plot can be seen in Figure A7 (provided in the Appendix).

Suicide Risk

Suicide Risk and Letters/Postcards

Suicide risk was calculated based on the datasets of suicidal ideation and attempt. All

studies of these two formerly separated outcomes were combined under a random effects model

assumption leading to two meta-analytic computations, using letters and postcards and a

combination of interventions to reduce suicide risk.

Seven datasets from five different studies, using letters or postcards as interventions

(Beautrais et al., 2010; Carter et al., 2005; M. O. Evans et al., 1999; Hassanian-Moghaddam et

al., 2011; Robinson et al., 2012), were included in the analysis (*OR* = 0.80, 95% CI [0.59, 1.10],

p = 0.085). The observed heterogeneity was 65.78%. Four studies reported data about the first

moderator (previous suicide attempts), resulting in a not significant p-value of 0.201 and an explained observed true variance of 50.48% ($B = 0.00$, 95% CI [0.00, 0.00]). For the second moderator study quality, seven values were used resulting in an observed explained true variance of 9.96% ($B = 0.11$, 95% CI [-0.29, 0.51[, $p = 0.504$). The funnel plot indicated no missing studies, but one study in an outlying position of the funnel plot. The forest and funnel plot can be seen in Figure A8 (provided in the Appendix).

Suicide Risk and Intervention Mix

Eight datasets from seven studies (Gysin-Maillart et al., 2016; Kasckow et al., 2016; Kennard et al., 2018; Marasinghe, 2012; Mouaffak et al., 2015; O'Toole et al., 2019; Wilks et al., 2018), which used a variety of interventions (see Table 1).were included in the analysis. Assuming a random effects model, the meta-analytic computations resulted in a d of 0.33 (95% CI [-0.12,0.78]) and a not significant two-tailed p-value of 0.079. An I^2 of 84.73% was reported. Five studies reported data about the first moderator (previous suicide attempts), resulting in a not significant p-value of 0.208 and an explained observed true variance of 36.32% ($B = 0.01726$, 95% CI [-0.02, 0.06]). For the second moderator, study quality, eight values were used resulting in an observed explained true variance of 1.55% ($B = 0.03250$, 95% CI [-0.23, 0.29], $p = 0.766$).The funnel plot showed one missing study and signs of skewed study distribution as two studies lie outside the funnel plot. The forest and funnel plot can be seen in Figure A9 (provided in the Appendix).

Completed Suicides for all Media

Six studies reported data on interventions against completed suicides (Amadéo et al., 2015; Cedereke et al., 2002; M. O. Evans et al., 1999; Luxton et al., 2019; Motto & Bostrom, 2001; Vaiva et al., 2006). Assuming a random effects model, an OR of 0.53 (95% CI [0.29, 0.95]) and a significant two-tailed p-value of 0.005 was computed. Because of an observed

heterogeneity of I^2= 0% no moderator analysis was performed. The funnel plot indicated no missing studies or any signs of skewed distribution. The forest and funnel plot can be seen in Figure A10 (provided in the Appendix). An overview of the individual and meta-analytic effect sizes grouped by outcome and medium before the sensitivity analysis can be found in Table A3 (provided in the Appendix).

Sensitivity Analysis

A sensitivity analysis was performed for each one of the outcomes (suicidal ideation, suicide attempts, suicide risk, completed suicides) contrasting high-quality with low-quality studies. For this reason, all studies included in the meta-analyses scoring lower than four ($N = 7$) on the used quality rating scheme, were excluded from the analysis. Overall, eleven studies scored lower than four on the quality rating but reduced to the studies originally included in the meta-analyses seven were excluded. Out of the original seven studies using letters and postcards as intervention, three reached a minimum score of four (Beautrais et al., 2010; Carter et al., 2005; Robinson et al., 2012). One study, which used emails to reduce suicidal ideation (Luxton et al., 2019) was excluded due to a score of two. Within the category of online programs all original five studies scored higher than four (De Jaegere et al., 2019; van Spijker et al., 2014, 2015, 2018; Wilks et al., 2018). Out of the original seven studies using a mix of interventions, four scored a four or higher (Gysin-Maillart et al., 2016, Kennard et al. 2018, O'Toole et al. 2019, Wilks et al., 2018). Within the category of studies using apps as intervention, one of three studies reached the minimum score (Tighe et al., 2017). Out of all the three original studies using telephone contact interventions (Amadéo et al., 2015; Cedereke et al., 2002; Vaiva et al., 2006) all reached a minimum score of four.

Suicidal Ideation and Letters/Postcards

Results showed that one out of two studies using letters and postcards to reduce suicidal ideation reached a minimum score of four in the quality rating. Robinson et al. (2012) found an *OR* of 0.97 (95% CI [0.47,1.99]), with a not significant two-tailed *p*-value of 0.923. No sensitivity analysis was performed.

Suicidal Ideation and Online Programs

As all original studies using online programs to reduce suicidal ideation could be included in the sensitivity analysis, no change in values was found.

Suicidal Ideation and Intervention Mix

Results showed that three out of the five studies using a mix of interventions to reduce suicidal ideation reached a score of four or more in the quality rating (Kennard et al., 2018; O'Toole et al., 2019; Wilks et al., 2018). A Cohen *d* of 0.00 (95% CI [-1.12, 1.12]) and a two-tailed *p*-value of 0.995 was calculated. An I^2 of 73.20% was found, but no moderator analysis performed due to the lack of reported data. The funnel plot showed no imputed studies. The forest and funnel plot can be seen in Figure A11 (provided in the Appendix).

Suicidal Ideation and Apps

Out of the original three studies reporting on the reduction of suicidal ideation using apps, one study (Tighe et al., 2017) reached a score of four or higher. Tighe et al.(2017) found a *d* of 0.00 (95% CI [-0.51, 0.51], *p* = 0.2962). No sensitivity analysis was performed.

Suicidal Ideation and Telephone Contacts

As only one study used telephone contacts to reduce suicidal ideation (Cedereke et al., 2002) no meta-analysis or subsequent sensitivity analysis was performed.

Suicide Attempts and Letters/Postcards

Out of five studies using letters and postcards to reduce suicide attempts, three could be included in the sensitivity analysis (Beautrais et al., 2010; Carter et al., 2005; Robinson et al., 2012). Meta-analytic computations led to an *OR* of 0.88 (95% [CI 0.52, 1.49]) and a not significant two-sided *p*-value of 0.283. I^2 was 0.00%; therefore no further moderator analysis was performed. Publication bias showed no imputed studies. The forest and funnel plot can be seen in Figure A12 (provided in the Appendix).

Suicide Attempts and Intervention Mix

Two out of three studies reporting on the reduction of suicide attempts through a mix of mobile and online interventions reached a minimum score of 4 on the quality rating (Gysin-Maillart et al., 2016; Kennard et al., 2018). Results based on a fixed effect model showed an *OR* of 0.26 (95% CI [0.00,143.79]) and a significant two-tailed *p*-value of 0.007. I^2 was 38.57%. No moderator analysis was performed due to a lack of studies. Publication bias showed no imputed studies. The forest and funnel plot can be seen in Figure A13 (provided in the Appendix).

Suicidal Attempts and Telephone Contacts

As all three original studies using telephone contacts to reduce suicide attempts reached a score of 4 or higher in the quality rating, no sensitivity analysis was performed, and the values do not deviate from the previous calculations.

Suicide Risk and Letters/Postcards

Out of seven datasets on letters or postcards trying to reduce suicidal ideation and suicide attempts, four could be included in the sensitivity analysis (Beautrais et al., 2010; Carter et al., 2005; Robinson et al., 2012). Robinson et al. (2012) examined both suicidal ideation and suicide attempts, which is why two different datasets by the same authors were included in this analysis. Results showed an *OR* of 0.89 (95% CI [0.66, 1.20]) with a two-sided *p*-value of 0.213. I^2 was

0.00%, which is why no further moderator analysis was performed. Publication bias showed no imputed studies. The forest and funnel plot can be seen in Figure A14 (provided in the Appendix).

Suicide Risk and Intervention Mix

Out of eight originally included datasets reducing suicidal ideation and suicide attempts with a mix of online and mobile interventions, five could be included in the sensitivity analysis (Gysin-Maillart et al., 2016; Kennard et al., 2018; O'Toole et al., 2019; Wilks et al., 2018). Kennard et al. (2018) reported on both outcomes, suicidal ideation and suicide attempts, which is why two different datasets by the same authors were included in this analysis. Results showed a *d* of 0.34 (95% CI [-0.40, 1.09]) and a two-sided *p*-value of 0.197. I^2 was 88.17%. All studies reported data on the moderator previous suicide attempts, resulting in an R^2 of 50.99% and a *p*-value of 0.166 (B = 0.02048, 95% CI [-0.03, 0.07]). Regarding the second potential moderator, study quality, all five datasets were included resulting in an explained observed true variance (R^2) of 9.54% and a *p*-value of 0.601 (B = 0.12186, 95% CI [-0.52, 0.77]). The funnel plot of the publication bias analysis showed no missing studies, but two lay outside of the funnel plot. The forest and funnel plot can be seen in Figure A15 (provided in the Appendix).

Completed Suicides for all Media

Out of six studies originally included in the meta-analysis on completed suicides, which included all online and mobile interventions regardless of its medium, three were included in the sensitivity analysis (Amadéo et al., 2015; Cedereke et al., 2002; Vaiva et al., 2006). An *OR* of 0.48 (95% CI [0.07, 3.37]) and a not significant two-tailed *p*-value of 0.103 was reported. I^2 was 0.00%; therefore no moderator analysis was performed. Publication bias showed no imputed studies but could not be calculated meaningfully due to a lack of studies. The forest and funnel plot can be seen in Figure A16 (provided in the Appendix).

Discussion

Summary Findings

In this master thesis, a systematic review and meta-analyses were conducted to examine the efficacy of online and mobile suicide interventions. Twenty-six studies met the inclusion criteria, out of which 22 were included in the quantitative synthesis, by grouping them in categories of delivering medium and outcome. Overall, results showed a significant, albeit small reduction of suicidal ideation using online programs. Other interventions using letters and postcards, apps, or telephone contacts were found to have no significant effect on the examined outcomes or were significant but inconclusive due to a lack of included studies (suicide attempts using a mix of interventions). In sum, moderator analysis was either not possible or its results not significant. The statistical power for these analyses was overall only low.

Sensitivity Analysis

Because of medium to low overall study quality, a sensitivity analysis was performed, excluding all studies scoring lower than four in the quality rating. Even though study quality did not significantly moderate the results of the meta-analyses, it was of interest, whether the found effects could withstand the exclusion of questionable studies, which could potentially have distorted the effects.

After exclusion of one low-quality study targeting suicidal ideation through letters and postcards, the results changed from a significant reduction in suicidal ideation by 41% for the intervention group to a not significant difference of 3% in favor of the intervention group. This result indicates that the significant effect may have been primarily caused by the low-quality study, although these findings should be interpreted carefully due to an insufficient amount of included studies.

Because no low-quality studies were included in the category of online programs, the significant small effect remained stable, indicating that the intervention group had a true reduction in experiencing suicidal ideation in comparison to the control group. The small observed heterogeneity could not be significantly explained by previous suicide attempts or study quality, which could be due to a lack of included studies or other factors playing a more important moderating role.

After excluding all low-quality studies concerning the reduction of suicidal ideation through an intervention mix, the not significant small effect changed to no effect, indicating that the intervention was not efficacious. The reasons for the large observed heterogeneity remain unclear but could partially be due to the lack of data reported by the studies. The exclusion of low-quality studies using apps and telephone contacts to reduce suicidal ideation resulted in no difference between the intervention and control group, suggesting that the interventions were not efficacious. The same holds for interventions using letters and postcards, as well as telephone contacts to reduce suicide attempts. After the exclusion of low-quality studies, the intervention mix category could significantly reduce the odds of a suicide attempt by 76% in comparison to the control group. However, this finding has to be interpreted with great caution due to wide confidence intervals as a result of the low number of included studies.

After the exclusion of low-quality studies reporting on all interventions reducing the number of completed suicides, the significant effect became not significant, but the odds for the intervention group to complete a suicide decreased further to 52% less than for the control group. Although this result could point towards underpowered studies, which could have influenced the effect size, the effectiveness of the interventions cannot be ruled out.

Interventions on suicide risk had no significant effect overall. After exclusion of the low-quality studies using letters and postcards, the odds of suicide risk for the intervention group

slightly increased, but still represent lower odds than for the intervention group, although not significantly. Studies using an intervention mix had a not significant small effect on the reduction of suicide risk, which could possibly become significant, with more included studies.

Moderator Analysis

Even though the moderators previous suicide attempts and study quality did not moderate the interventions' effects significantly, results regarding the amount of explained true variance (R^2) can be discussed. It is worth mentioning that study quality would have explained almost a large amount of observed true variance for the online program interventions. Past suicide attempts would have explained a medium amount of observed true variance for interventions using postcards and letters to reduce suicide attempts. Suicide risk, although not significantly, seems to be partially moderated by previous suicide attempts. Half of the observed heterogeneity of interventions using postcards and letters was not significantly moderated by previous suicide attempts. Despite the results being not significant, these findings are in line with other literature suggesting that suicidal behavior like past suicide attempts can moderate treatment effects (van Spijker et al., 2014) and can also be an indicator of future suicide (Suominen et al., 2004).

Publication Bias

Two funnel plots regarding the intervention mix against suicide attempts and suicide risk prior to sensitivity analysis showed one missing study as indicated by the Trim and Fill method by Duval and Tweedie (2000). This means that publication bias could be present. In the case of suicide attempts, where an *OR* was calculated, Sterne et al. (2011) advise against the use of the Trim and Fill method and reference toward other tests, to avoid statistical problems arising from the standard error of the log odds ratio being linked to the size of the *OR*. However, these tests should only be performed when including more than 10 studies (Sterne et al., 2011), which was not the case as only three were included. Due to this lack of studies and the method used to

assess publication bias, the interpretation is with caution. The adjusted combined effect size based on the imputed study was not used considering these limitations. Sterne et al. (2011) further mention other explanations that could have led to the detected asymmetry. However, it would be of interest how more studies would have influenced the confidence intervals of the significant, but not interpretable, result of the intervention mix category against suicide attempts. After the sensitivity analysis no missing and only outlaying studies were found, which again has to be interpreted carefully due to the low number of studies included. The same holds true for the imputed study regarding the intervention mix and suicide risk. Here, it should also be noted that the combination of the two outcomes suicidal ideation and suicide attempt could have caused heterogeneity, in which case the publication bias analysis is not indicated, as it assumes homogeneity for the study domain (Hak et al., 2016).

On the primary study level, the excluded low-quality studies did not tend to report more significant results, than the high-quality studies. Out of eleven excluded studies, only three reported significant results for the examined outcomes, which indicates no reporting bias regarding significance levels based on study-quality.

Overall, the results obtained from the funnel plots should be evaluated with great caution, as in all cases a smaller number than ten studies were included in the analyses. Considering that the majority of the studies report not significant results regarding the relevant outcomes, the chances of a reporting bias and therefore publication bias decrease further. However, these results can be used to draw attention to the problem of publication bias and subsequently, selection bias.

Efficacy of Intervention Media

Although there were not enough studies for each category and outcome, patterns of most widely used media targeting specific outcomes could be identified.

Online programs reported exclusively on suicidal ideation, but there were no programs targeting suicide attempts or completed suicides. This may be because suicidal ideation can be a predecessor of suicide attempts and subsequent suicide, and online programs could affect early onwards. Whether they would also significantly reduce suicide attempts and completed suicides remains unclear.

Letters and postcards were used to target suicidal ideation, suicide attempts, and completed suicides. This medium seems to be an all-round talent as it constitutes an affordable intervention, which can be made available to people in remote areas and without further gadgets like a computer.

Luxton et al. (2019) were the only ones attempting to reduce suicidal ideation through emails. The intervention showed no effect on suicidal ideation; however, due to a lack of studies, no final conclusions can be drawn. Overall, the paucity of studies using emails to reduce suicide-related outcomes leaves the questions of efficacy unanswered. Nevertheless, it would be of interest if such interventions could reduce suicide attempts or completed suicides, especially because suicidal ideation can be a precursor of suicide attempts.

An intervention mix was used to target all three outcomes of interest. A combination of interventions seems to favorably affect suicide attempts, possibly because several modalities combined can reach more people, which might be a positive indicator of multidimensional intervention approaches. The mix of interventions showed no effect on suicidal ideation, which is an interesting finding considering the formation process of suicidal behavior, of which suicidal ideation can be a part of. It has to be mentioned that only one primary study found a significant

effect of their intervention. The large effect of Marasinghe et al. (2012) can either be seen as an incentive for further research in this direction or interpreted as a result of a low-quality study.

Intervention apps were only used to target suicidal ideation. They are easy to incorporate into daily life as already many people use their (smart)phones daily, which in turn could theoretically increase treatment adherence and improve the chances of a positive effect. Nevertheless, no effect was found. This lack of effect could be due to the paucity of studies included. Also, as no app focused on suicide attempts or completed suicides, the demand for more high-quality studies is evident, before apps can be written off entirely as a possible intervention medium.

There was only one study reducing suicidal ideation through telephone contacts. This medium represents a more accessible tool to reach people without appropriate smart devices or online access and resembles a potential therapy setting more closely than the other media, as it involves verbal interaction with a professional. Even though no significant effect was found, more studies must be analyzed to draw valid conclusions and assess the potential positive effects of such interventions on suicidal ideation. Telephone contact interventions could not effectively reduce suicide attempts. This lack of efficacy may be due to the small number of studies included, the inefficacy of the interventions themselves or the possibility that suicidal people are less susceptible to interventions via telephone due to the severity of their condition.

To reduce the number of completed suicides, studies used telephone interventions, emails, short letters, and crisis cards. Despite the variety of interventions, aggregating them resulted in a positive effect on completed suicides, at least before the exclusion of low-quality studies. The not significant finding could be due to underpowered studies, given the prevalence of the outcome, which could result in a distortion of the effect size. The low number of included studies could have influenced the results further. Additionally, two studies did not design their

interventions specifically for suicides, which could have reduced its efficacy regarding the outcome of suicides. Also, on the primary study level, five out of six studies did not find significant effects of the interventions on completed suicides. Therefore, the significant reduction of suicides on a meta-analytic level before the sensitivity analysis is surprising, yet it appears that combining all different interventions may be more effective than one intervention alone. These findings fuel the conversation about more high-quality studies to draw a firmer conclusion of the effects of online and mobile interventions on completed suicides.

Overall it appears that suicidal ideation was the most widely targeted outcome, and postcards and letters next to the intervention mix the most widely used media. There is a lack of studies focusing on suicide attempts and completed suicides.

Other Influencing Factors

Study Quality

The overall moderate to low study quality can be attributed to the loose reporting of information and the failure to report details such as having used a study protocol or if the adherence to the study protocol was checked. Positively it stands out that almost all studies reported on randomization and if it was conducted adequately and independently from involved staff. It almost seems as if many authors let the reader assume details, like the blinding process of research staff and participants or the assumed power, with which they wanted to detect an effect. Time pressure of publishing and being too engaged in one's manuscript could be explanations for the absence of precise and comprehensible reporting.

A high-quality study should report its methods and express its results stringently and understandably, without leaving any room for assumptions. Van Spijker et al. (2014, 2018) are good examples for excellently reporting a high-quality study.

Treatment as Usual

TAU was a widely used control condition, despite many studies not specifying which components TAU consisted of. The fact that many studies could not report any significant findings raised not only the question about the efficacy of the intervention but also, whether TAU was helpful by itself. Because the exact components of TAU were not always discussed, it cannot be determined exactly, what contributed to both groups' improvement. TAU usually consisted of the standard care, specific to a country's health care policy in the case of attempted suicide. However, because standards in care vary among countries, it is even more difficult to determine the effect of TAU. It can only be concluded that TAU possibly had an influence on the outcome and that researchers need to do a better job at identifying the potentially beneficial components of TAU and precisely distinguishing them from the intervention and its effects.

Adherence to Treatment and Dropout Rates

All 26 studies qualitatively evaluated, report dropout rates and issues with adherence to treatment. Even though most studies had an average dropout rate at the post-intervention, all studies reported having had high attrition rates during follow-up months, especially if they follow-up period exceeded 12 months. Even in shorter follow-up intervals, adherence to treatment was lacking. Franklin et al. (2016) reported that 64% of the intervention group did not open the TEC app once during the follow-up period. Although the ITT analysis is generally considered to provide the highest level of evidence and avoid bias through attrition, it could have potentially underestimated treatment effects. This may have been the case in the study of Chen et al. (2013), where the ITT analysis included a large number of participants, who verifiably did not even read the crisis postcard. As dropout rates and treatment adherence appear to be a big issue, irrespective of the analyzing method, the focus should be enlarged on how to motivate people to adhere to the interventions to avoid having to include non-compliant participants on an ITT basis

in the first place. Therefore, possible reasons for dropout have to be identified first. Weiner (2013) reports that dissatisfaction with treatment intervention, the failure to experience improvement, external responsibilities, which lead to a lack of time, or the inability to cope with feelings elicited by the intervention can be reasons for dropping out. These reasons may have also applied to the participants within the mentioned studies, possibly even stronger due to the population being vulnerable to begin with. Concerning the time commitment as possible detaining factor from treatment, it is noticeable that interventions like postcards or letters, which did not require any active work by the participant, have comparable dropout rates to work-intensive interventions like the CBT based online programs. Therefore, this justification seems rather unlikely. Targeting the above-mentioned aspects and engaging the patients with more follow-ups and reminders in shorter intervals from the beginning may also increase the odds of treatment adherence, but it also highlights the issue of monetary resources. Despite all efforts, in the end, it is also up to the patients to be compliant and to exhibit sufficient self-motivation and self-responsibility to make use of the interventions accordingly.

Target Population

Overall, online programs, apps, telephone contacts, and the intervention mix were designed for owners of Internet-accessible or electronic devices. These portable interventions provide access to people even in remote areas or without access to mental health services, but at the same time exclude people without access to such devices or with physical disabilities, for instance, persons unable to operate a keyboard.

Within my review, not only electronic and online interventions were searched for but also mobile interventions, referring to the literal meaning of the word, to try to account for all the people not having access to online or electronic devices. Especially for older people who might not own a smartphone or computer with online access or have an email account, most of the

interventions mentioned above become redundant. The overall studies' mean sample age is 34 years, reflecting a gap between adults and seniors. It is also misrepresentative of the general population, as it grows older every year due to an increased life expectancy and a lower old-age mortality rate (Shah et al., 2016). The older population moreover tends to experience an increase in suicide-related behavior (Bertolote & De Leo, 2012; Shah et al., 2016), which causes the highest suicide rates among this age group in most countries of the world. (WHO, 2019). In Austria alone, the suicide rates for the age group of 55 to 75years old people are more than double the suicide rates of the age cohort of 25 to 34 years old people.

Interestingly, none of the identified interventions were aiming at older adults, but entirely at young to middle-aged adults. This finding shows a clear gap of much-needed research. Applying the existing interventions to an older sample could be tested, but as this age group is facing special challenges increasing suicide-related risk factors (Conejero et al., 2018) it remains to be seen, whether the same effects would be found. Also, the media of delivery remain a potential issue for older or handicapped cohorts, drawing attention to less technical media like postcards, letters, or telephone contact interventions.

Incorporation of Findings in Current Research

Overall, one main effect was found significantly reducing suicidal ideation through online programs. The effects on suicidal ideation through online programs are congruent with Witt et al. (2017), who also found some evidence for the reduction of suicidal ideation. Regarding suicide attempts, my inconclusive findings are congruent with those of Witt et al. (2017), who also could not reach a final conclusion and completed suicides they did not assess. Milner et al. (2015) assessed the efficacy of brief contact interventions like postcards, crisis cards, letters, and telephone contacts on suicide attempts and suicides and could not find any significant reduction. This result is in line with our findings regarding these forms of delivery on

suicide attempts and completed suicides, especially as the included interventions were also using postcards, letters, and telephone contacts as well as emails. Without the exclusion of low-quality studies, the results of Milner et al. (2015) contrast our findings of a significant reduction of the odds of dying of suicide. They also reached a comparable *OR*, but with a medium heterogeneity, which we did not find.

Limitations and Future Research

Limitations of this current work are most of all, the lack of a second coder. Despite a thorough literature search and coding process, the possibility of missed studies and biased coding decisions remains, which could lower reliability. Therefore, my results need replication before being able to utilize them.

It can be criticized that interventions including face-to-face therapy sessions should not have been included in the study corpus, as it is difficult to distinguish its effects from those of the actual intervention. I argue that my approach was exploratory, and the findings of suitable studies were too scarce to impose stringent exclusion criteria.

Within my meta-analytic computations, only two moderators, which could not account for the observed variance, were included. This decision was partly due to suggestions of other literature and the restrictions of Meta Essentials, which only allows for the inclusion of one moderator. Consequently, other less exploratory studies should include more moderators, using a different program.

It can further be criticized that despite the grey literature search, no actual grey literature met the inclusion criteria and was therefore not included in my study corpus. Even though some researchers like Weisz et al. (1995) argue that peer-reviewed and therefore published literature fulfills higher quality standards, this lack of unpublished material could have introduced bias into my work. The increased high-quality standards of peer-reviewed articles argued by Weisz et al.

(1995) do not hold considering the low quality of the studies included in this thesis. To conform with Borenstein et al. (2009), who argue that even peer-reviewed studies may be of different quality, biased and unreliable, the lack of unpublished material could have introduced bias into my work and it is a limitation worth mentioning. It also highlights the importance of high-quality grey literature and the need for more available literature for future meta-analyses.

Future research should focus on the construction and implementation of interventions focusing on the older population and keeping in mind the special challenges this cohort faces. Additionally, more continuous monitoring appears to be necessary to reduce dropout- and attrition rates and the use of several interventions tailored to the specific population.

As CBT based online programs had the largest impact on suicidal ideation, it is reasonable to continue research in this direction, but the extension of these interventions on to less technical media such as postcards or letters is necessary. This would include people without access to such devices or less technically gifted people, who are still in need of remote interventions. Future research could also include the secondary outcomes to check for additional treatment effects.

Overall it can be concluded that further, especially high-quality research in the direction of evidence-based approaches like CBT through media like online programs or letters, and postcards is needed. Combining multiple media to ensure comprehensive care is further advisable based on our findings.

In order to reach more conclusive results, a higher number of studies is needed with larger sample sizes and enough power to detect the effects of interest. Continuing to work on these topics to find meaningful results, only makes sense, if researchers heed taking a more conscious, high-quality approach in conducting their studies. Furthermore, researchers will have to show more conscientiousness and precision with reporting detailed results and drafting the

manuscript. Lacking reports on the items I included in my quality rating, which were basic, is not acceptable for peer-reviewed and published papers and raises even more concern beyond the low- quality studies themselves. Nevertheless, this exploratory work provides some insight into the status quo regarding online and mobile treatments for suicide interventions and hopes to serve as a basis for further research.

Conclusion

This work extended the evidence for the efficacy of online and mobile interventions regarding suicidal ideation and suicide attempts using online programs and an intervention mix. Albeit not significant, there was a reduction of completed suicides, which gives reason for the hope that future studies using larger sample sizes will find a significant effect, especially if higher quality standards in the study's conduct are considered. Innovations in this sector are expected, considering the recency of the entire online and mobile intervention field targeting suicidality. This research should focus on online programs and on using a combination of different media within one intervention, based on approaches like CBT or MBCT. Likely, these treatments will not be able to substitute face-to-face interaction with a mental health professional and function as a standalone treatment.

Nevertheless, it provides a low-cost option for people unable to afford immediate care and allows bypassing a shortage of therapy placements until treatment is available. It further allows people to receive some treatment even in the most remote areas and countries, which are not able to provide advanced mental health care to their citizens. The variety of available media could give the chance to satisfy the preferences of all age groups, which future research has to focus on more intensely. Most of all, online and mobile suicide interventions allow people of different backgrounds to receive some of the necessary care and emphasizes the persistent importance and need for better and overarching mental health care around the world.

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Figures

Tables

Appendix

Coding Scheme

Table A1
Coding Scheme

Coding Scheme	
Bibliographic Reference	Study ID
	Authors
	Year
Sample Descriptors	Representative Analysis N Size total
	N Intervention Group (IG)
	N Intervention IG 2
	N Control Group (CG)
Patients' Background	Original Intent for Treatment
	Sample Home Country
	Mean Age IG
	Mean Age IG 2
	Mean Age CG
Sex Ratio male vs female in %	male vs. female %: IG
	male vs female %: IG2
	male vs. female %: CG
Research Design	Sampling Procedure
	IG 1 Treatment Description
	IG 2 Treatment Description
	Duration of Treatments in Months
	Number of Contacts/Calls
	CG Treatment Description
	Primary Outcome
	Methods used for Checking Primary Outcome
	Intention to Treat Analysis?
Effect Sizes	Measure of Primary Outcome
	Effect Size Used
	Results Primary Outcome IG:
	Results Primary Outcome CG:
	Results Primary Outcome IG: Per Protocol
	Results Primary Outcome CG: Per Protocol
	Results Primary Outcome IG :CG follow-up 12 months
	Primary Outcome significant?
	Results Other outcome IG:
	Results Other outcome CG:
	Other outcome significant?
Problems/Comments	

Quality Rating

Table A2
Quality Rating

Study	Random-ization[a]	Blinding of Assessment[b]	Drop-out[c]	Treatment Protocol Adherence[d]	ITT[e]	Treatment Protocol[f]	Sample Size & Power[g]	Sum Score (0–7)
Carter et al. (2005)	yes	yes	yes	no	yes	n.r.	yes	5
Hassanian-Moghaddam et al. (2011)	yes	n.r.	yes	no	no	n.r.	yes	3
Robinson et al. (2012)	yes	yes	yes	no	n.r.	n.r.	yes	4
M. O. Evans et al. (1999)	yes	n.r.	no	no	yes	n.r.	yes	3
E. Evans et al. (2005)	n.r.	n.r.	no	no	n.r.	n.r.	n.r.	0
Beautrais et al. (2010)	yes	yes	yes	no	yes	n.r.	yes	5
Motto & Bostrom (2001)	n.r.	n.r.	no	no	n.r.	n.r.	n.r.	0
Luxton et al. (2019)	yes	no	no	no	yes	n.r.	no	2
van Spijker et al. (2014)	yes	yes	yes	yes	yes	yes	yes	7
van Spijker et al. (2015)	yes	yes	no	yes	yes	yes	yes	6
van Spijker et al. (2018)	yes	yes	yes	yes	yes	yes	yes	7
De Jaegere et al. (2019)	yes	n.r.	yes	n.r.	yes	yes	yes	5
Wilks et al. (2018)	yes	n.r.	yes	n.r.	yes	yes	no	4

Study	Randomization[a]	Blinding of Assessment[b]	Drop-out[c]	Treatment Protocol Adherence[d]	ITT[e]	Treatment Protocol[f]	Sample Size & Power[g]	Sum Score (0–7)
Mouaffak et al. (2015)	yes	n.r.	yes	n.r.	yes	n.r.	n.r.	3
O'Toole et al. (2019)	yes	no	yes	n.r.	yes	yes	no	4
Gysin-Maillart et al. (2016)	yes	n.r.	yes	yes	yes	yes	yes	6
Kennard et al. (2018)	yes	yes	yes	yes	yes	yes	yes	7
W.-J. Chen et al. (2013)	yes	n.r.	no	n.r.	yes	n.r.	no	2
Kasckow et al. (2016)	n.r.	n.r.	yes	n.r.	n.r.	yes	n.r.	2
Marasinghe et al. (2012)	n.r.	yes	no	n.r.	yes	n.r.	no	2
Tighe et al. (2017)	yes	no	yes	no	yes	yes	yes	5
Bush et al. (2017)	yes	no	no	n.r.	yes	n.r.	yes	3
Franklin et al. (2016)	yes	n.r.	no	n.r.	yes	n.r.	n.r.	2
Vaiva et al. (2006)	yes	yes	yes	n.r.	yes	n.r.	no	4
Amadéo et al. (2015)	yes	n.r.	yes	n.r.	yes	yes	n.r.	4
Cedereke et al. (2002)	yes	yes	yes	n.r.	yes	n.r.	n.r.	4

Note: n.r. = not reported

[a] Was randomization conducted adequately and independently from researchers & therapists (using computer software)?

[b] Was the assessment blinded?

[c] Did the studies report reasons for dropout or analysis on differences between dropouts &
completers?

[d] Was adherence to treatment manual/protocol ensured with adequate measures or checked
empirically?

[e] Was an ITT analysis conducted and reported?

f Did a treatment protocol exist?

[g] Did the authors report that the sample size was large enough to detect a difference in the mean
outcome between groups with > 80% power?

Effect Sizes Prior to Sensitivity Analyses

Table A3

Individual and Meta-Analytic Effect Sizes Before the Sensitivity Analyses

Authors (year)	Outcome/Medium	Effect size	Overall effect size
Hassanian-Moghaddam et al. (2011)	Suicidal ideation/ Letters/Postcards	$OR = 0.57$ [0.48, 0.68]	$OR = 0.59$ [0.19, 1.83], $p < 0.001$
Robinson et al. (2012)		$OR = 0.97$ [0.47, 1.99]	
De Jaegere et al. (2019)	Suicidal ideation/ Online Programs	$d = 0.34$ [0.19, 0.49]	$d = 0.26$ [0.03, 0.48], $p < 0.001$
van Spijker et al. (2014)		$d = 0.28$ [0.02, 0.54]	
van Spijker et al. (2018)		$d = 0.09$ [-0.10, 0.28]	
Wilks et al. (2018)		$d = 0.49$ [-0.09, 1.07]	
Kasckow et al. (2016)	Suicidal ideation/ Intervention Mix	$d = 0.08$ [-0.64, 0.8]	$d = 0.21$ [-0.43, 0.84], $p = 0.366$
Kennard et al. (2018)		$d = 0.03$ [-0.46, 0.52]	
Marasinghe et al. (2012)		$d = 0.91$ [0.40, 1.42]	
O'Toole et al. (2019)		$d = -0.41$ [-0.76, -0.05]	
Wilks et al. (2018)		$d = 0.49$ [-0.09, 1.07]	
Bush et al. (2017)	Suicidal ideation / Apps	$d = 0.01$ [-0.35, 0.38]	$d = 0.01$ [-1.89, 1.91], $p = 0.948$

Authors (year)	Outcome/Medium	Effect size	Overall effect size
Tighe et al. (2017)		d=0.00 [-0.51, 0.51]	
Beautrais et al. (2010)	Suicide attempts/ letters /postcards	OR= 0.99 [0.60, 1.62]	OR = 0.88 [0.58, 1.32], p =0.367
Carter et al. (2005)		OR = 0.77[0.52, 1.13]	
Hassanian-Moghaddam et al. (2011)		OR = 0.57 [0.36, 0.89]	
Evans et al. (1999)		OR= 1.18 [0.81, 1.71]	
Robinson et al. (2012)		OR = 1.46 [0.44, 4.83]	
Gysin- Maillart et al. (2016)	Suicide attempts/ Intervention Mix	OR = 0.12 [0.02, 0.57]	OR = 0.44 [0.03,6.45], p = 0.188
Kennard et al. (2018)		OR = 0.43 [0.12, 1.51]	
Mouaffak et al. (2015)		OR = 1.04 [0.54, 1.99]	
Amadeo et al. (2015)	Suicide attempts/ Telephone contact	OR = 1.37 [0.70, 2.69]	OR=0.99 [0.52, 1.90], p =0.961
Cedereke et al. (2002)		OR = 0.94 [0.43, 2.07]	
Vaiva et al. (2006)		OR = 0.84 [0.50, 1.41]	
Beautrais et al. (2010)	Suicide risk/ Letters/Postcards	OR = 0.99 [0.60, 1.62]	OR= 0.80 [0.59, 1.10], p =0.085

Authors (year)	Outcome/Medium	Effect size	Overall effect size
Carter et al. (2005)		$OR = 0.77$ [0.52, 1.13]	
Evans et al. (1999)		$OR = 1.18$ [0.81, 1.71]	
Hassanian-Moghaddam et al. (2011)		$OR = 0.57$ [0.48, 0.68]	
Hassanian-Moghaddam et al. (2011)		$OR = 0.57$ [0.36, 0.89]	
Robinson et al. (2012)		$OR = 0.97$ [0.47, 1.99]	
Robinson et al. (2012)		$OR = 1.46$ [0.44, 4.83]	
Gysin- Maillart et al. (2016)	Suicide risk/ Intervention Mix	$d = 1.17$ [0.74, 1.16]	$d = 0.33$, [-0.12, 0.78], $p = 0.079$
Kasckow et al. (2016)		$d = 0.08$ [-0.64, 0.80]	
Kennard et al. (2018)		$d = 0.03$ [-0.46, 0.52]	
Kennard et al. (2018)		$d = 0.47$ [-0.05, 0.99]	
Marasinghe et al. (2012)		$d = 0.91$ [0.40, 1.42]	
Mouaffak et al. (2015)		$d = -0.02$ [-0.25, 0.20]	
O'Toole et al. (2019)		$d = -0.41$ [-0.76, -0.05]	
Wilks et al. (2018)		$d = 0.49$ [-0.09, 1.07]	

Authors (year)	Outcome/Medium	Effect size	Overall effect size
Amadeo et al. (2015)		*OR* = 0.22 [0.01, 4.69]	*OR* = 0.53 [0.29, 0.95], *p* =0.005
Cedereke et al. (2002)		*OR* = 1.02 [0.06, 16.76]	
Evans et al. (1999)	Completed Suicides/ all media	*OR* = 1.97 [0.18, 21.90]	
Luxton et al. (2019)		*OR* = 0.44 [0.11, 1.70]	
(Motto & Bostrom, 2001)		*OR* = 0.46 [0.14, 1.49]	
Vaiva et al. (2006)		*OR* = 0.42 [0.02, 8.9]	

Abbreviations and Definitions

Table A4

List of Abbreviations and Definitions

BSSI	Beck Scale for Suicide Ideation
CBT	Cognitive behavioral therapy
CI	Confidence Interval
HR	Hazard Ratio
ISTSS	International Society of Traumatic Stress Studies
ITT	Intention to Treat
M	Mean
MBCT	Mindfulness based cognitive therapy
NHLBI	National Heart, Lung, and Blood Institute
OR	Odds Ratio
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomized controlled trial
SD	Standard Deviation
TAU	Treatment as Usual
WHO	World Health Organization

Forest and Funnel Plots

Figure A1

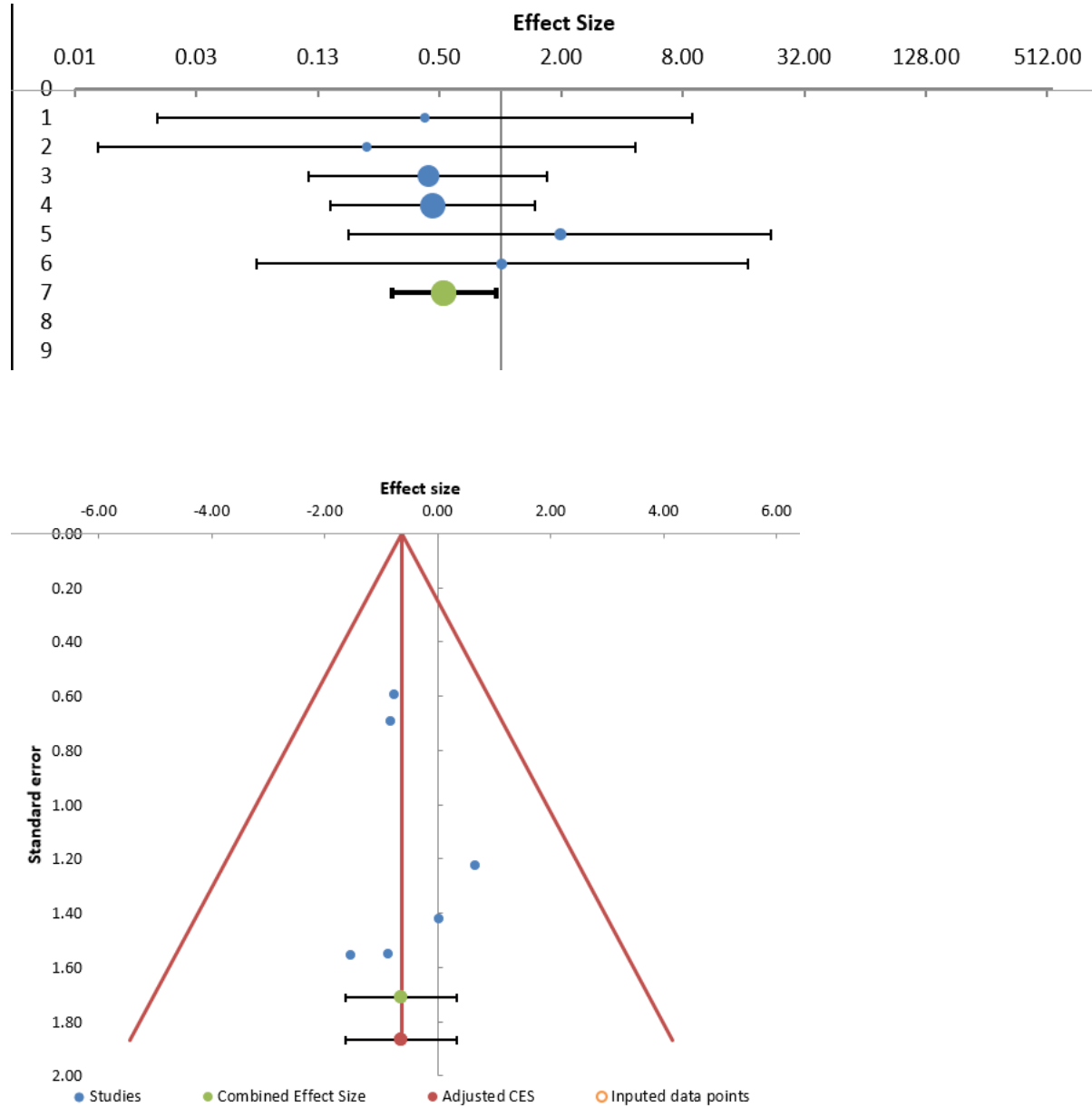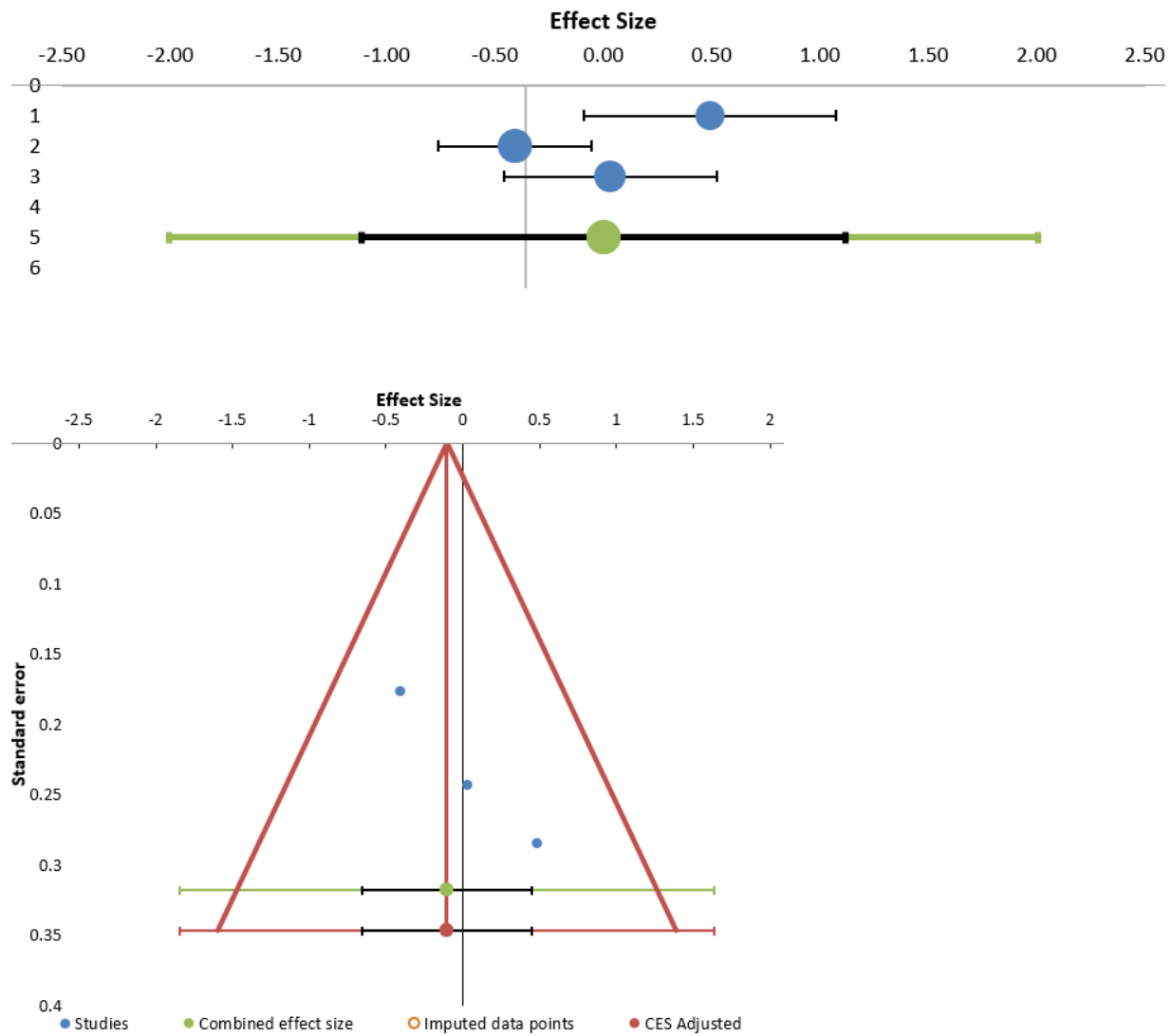*Forest and Funnel Plots of Interventions Using Letters and Postcards Against Suicidal Ideation*
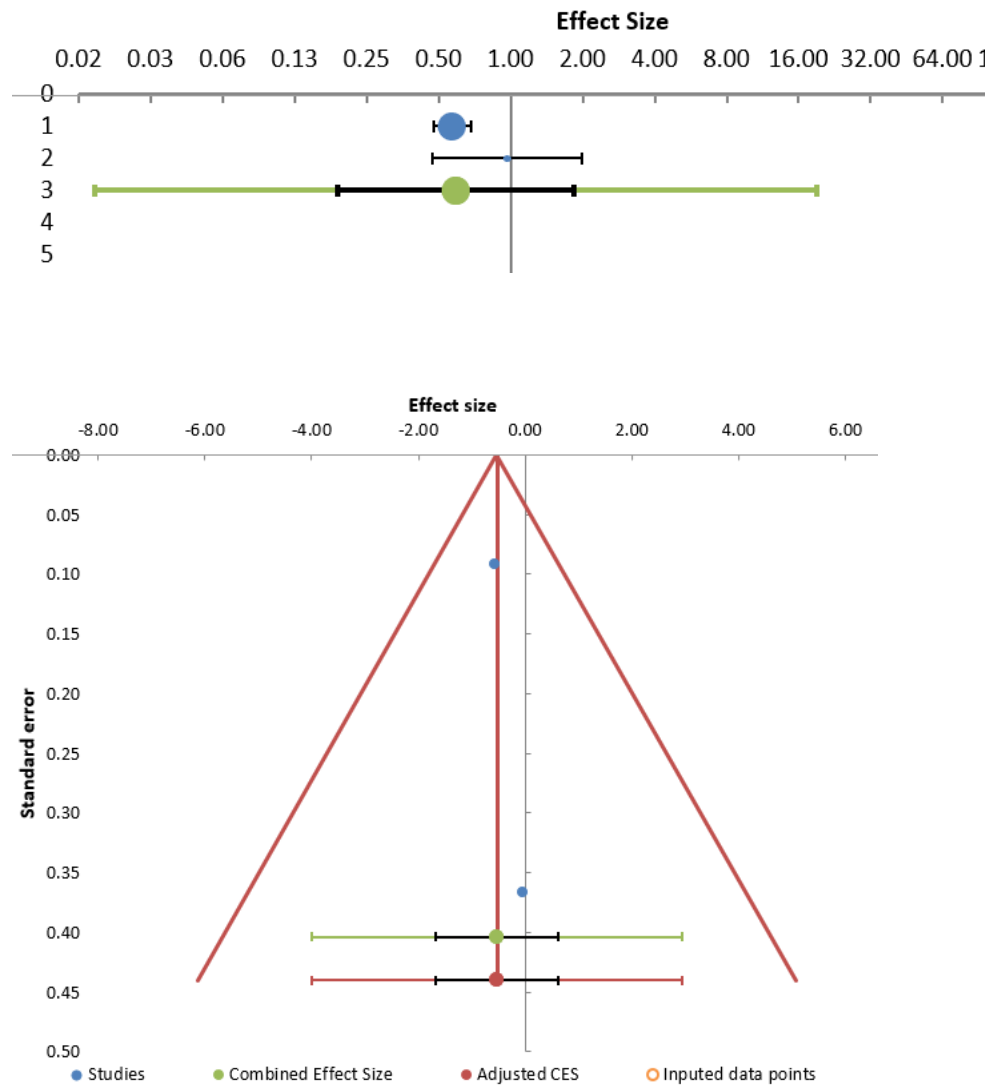
Figure A2

Forest and Funnel Plots of Interventions Using Online Programs Against Suicidal Ideation
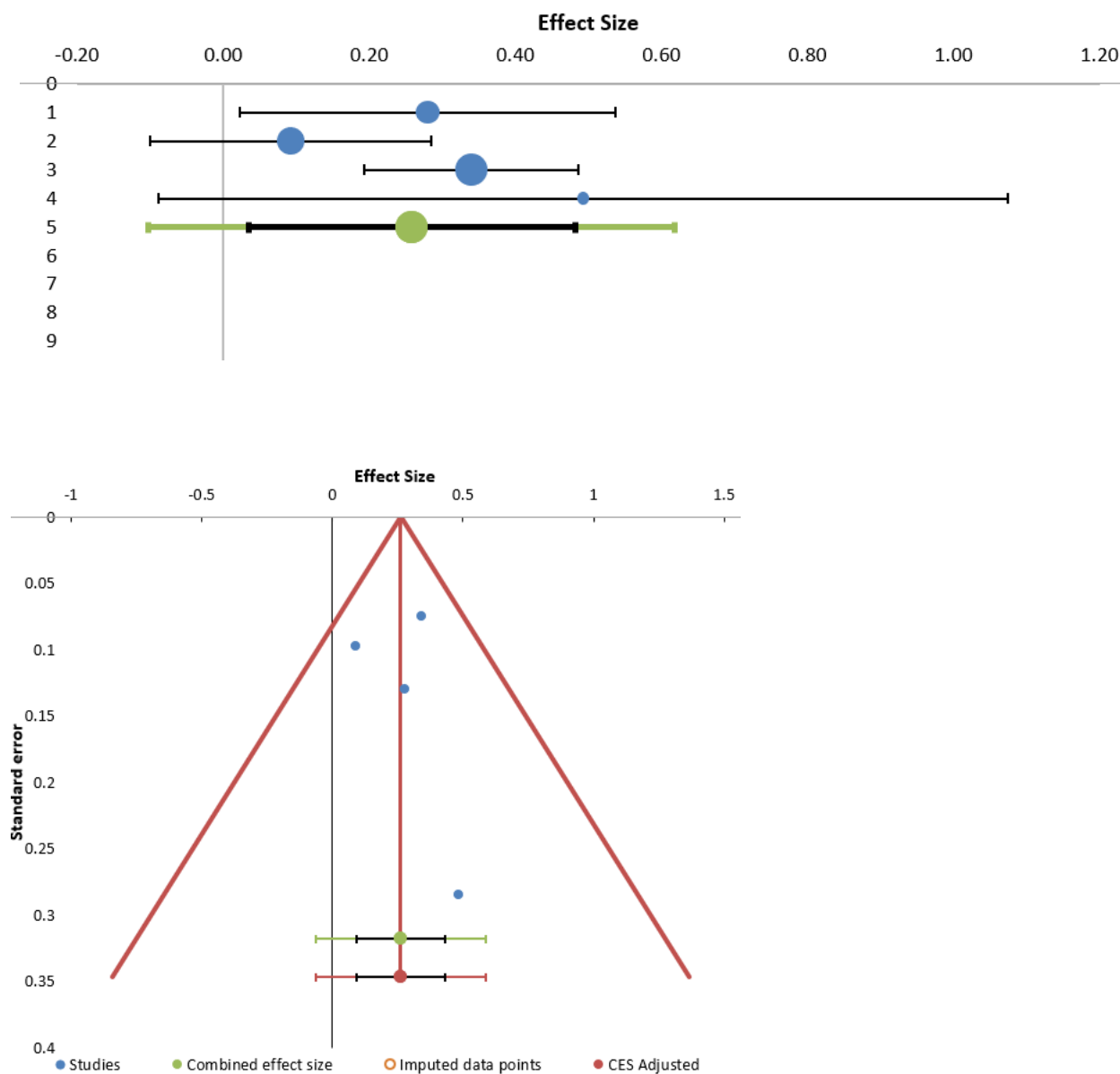
Figure A3

Forest and Funnel Plots of Interventions Using Online Programs Against Suicidal Ideation
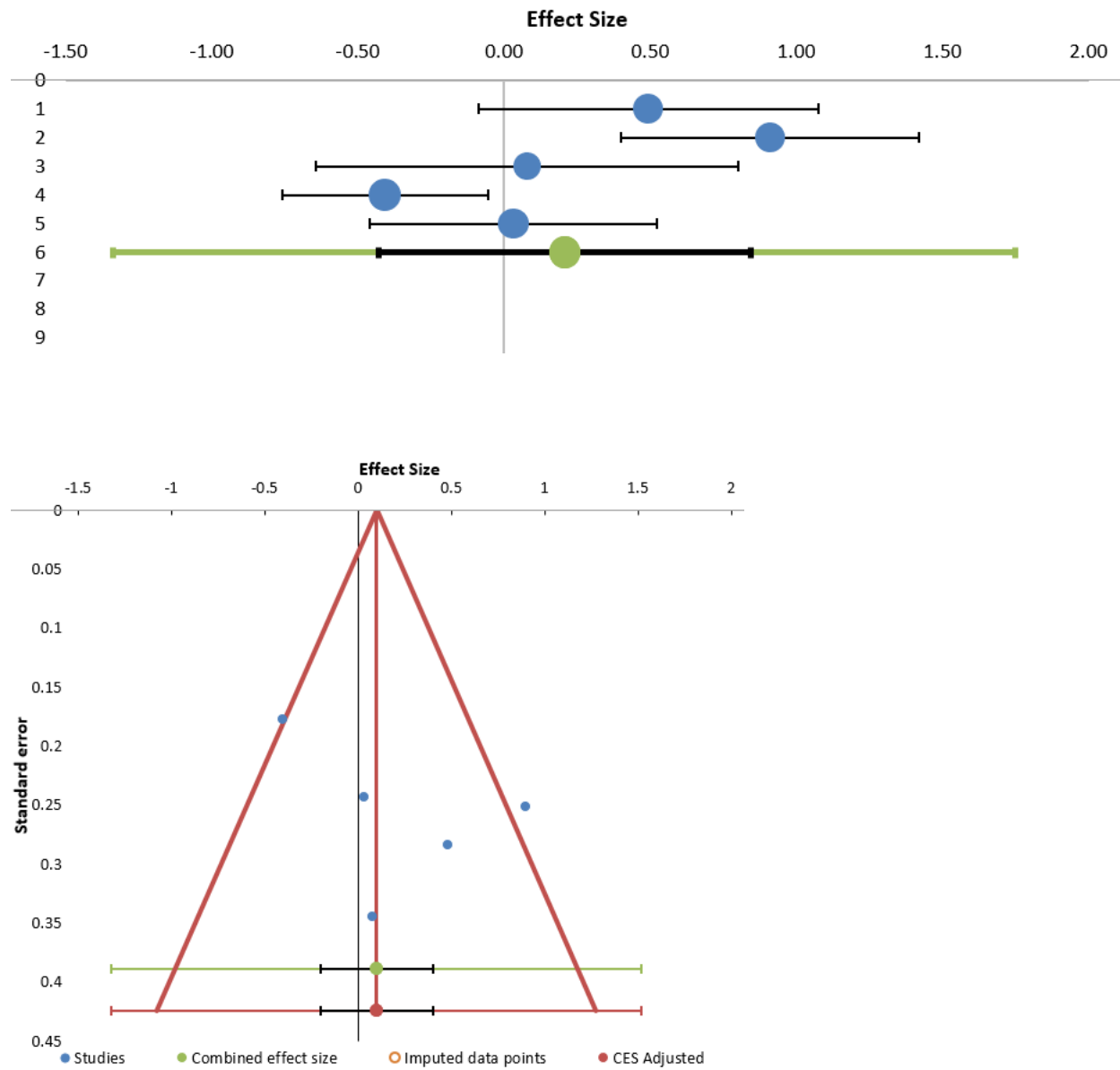
Figure A4

Forest and Funnel Plots of Interventions Using Apps Against Suicidal Ideation
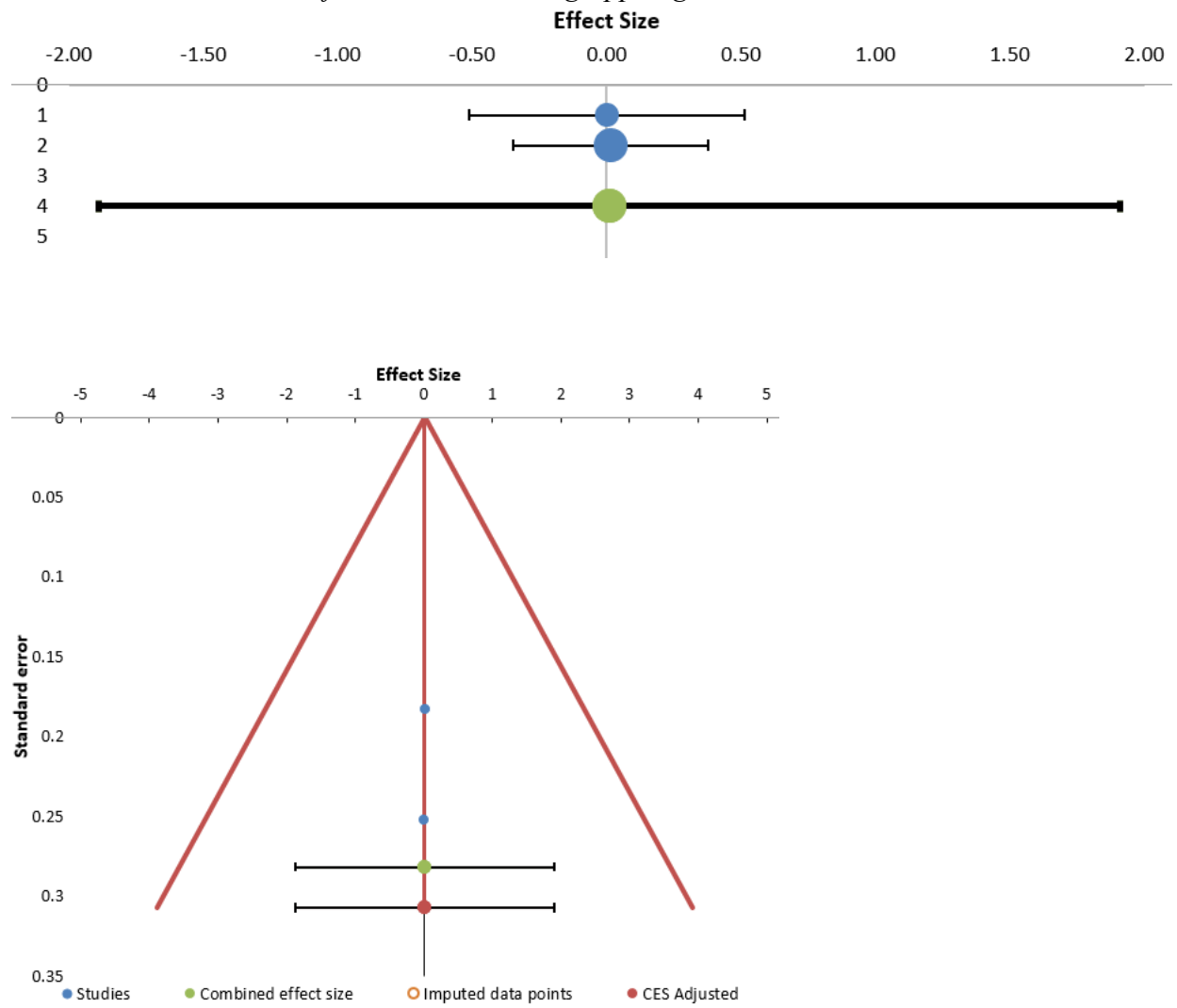
Figure A5

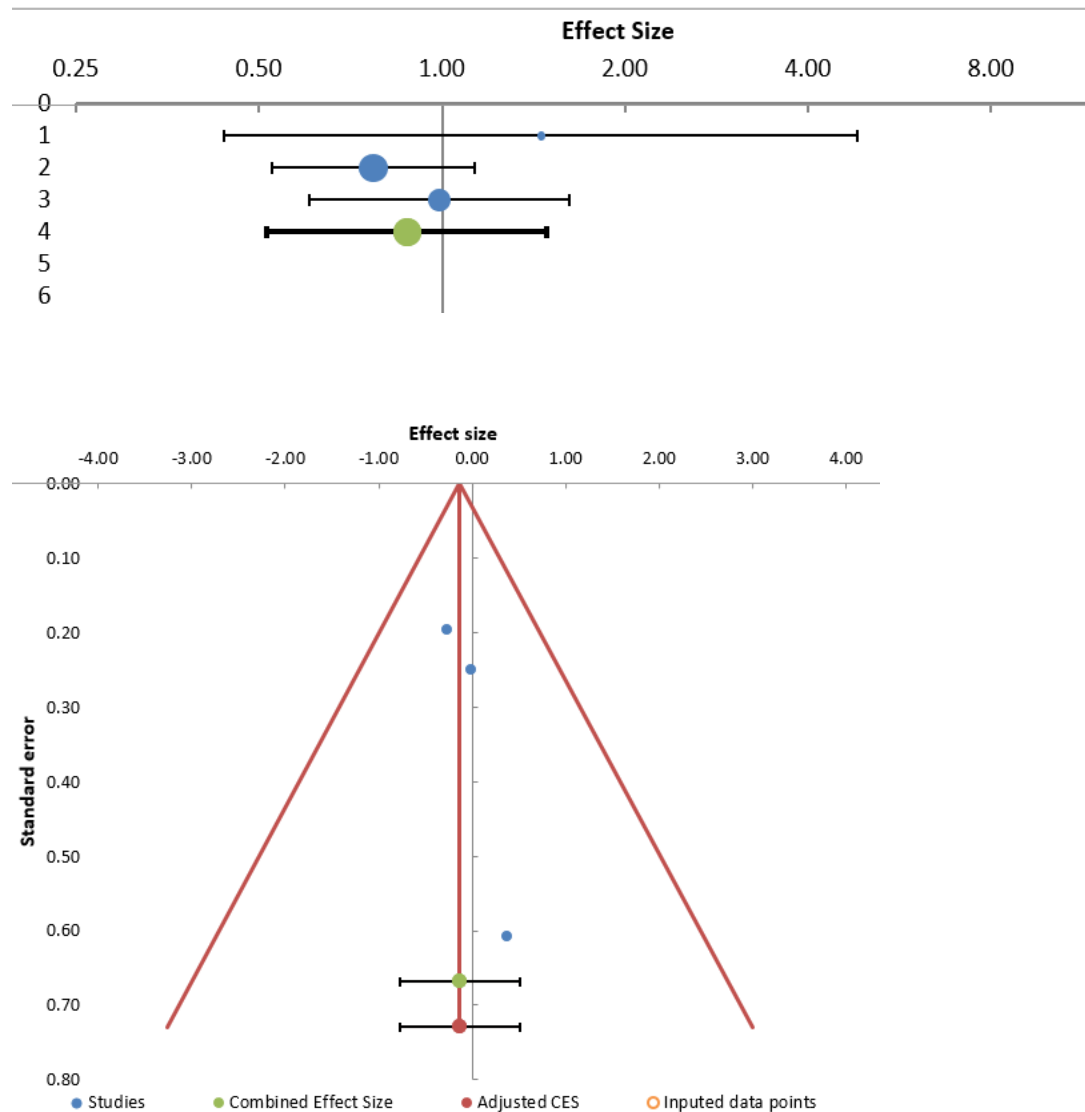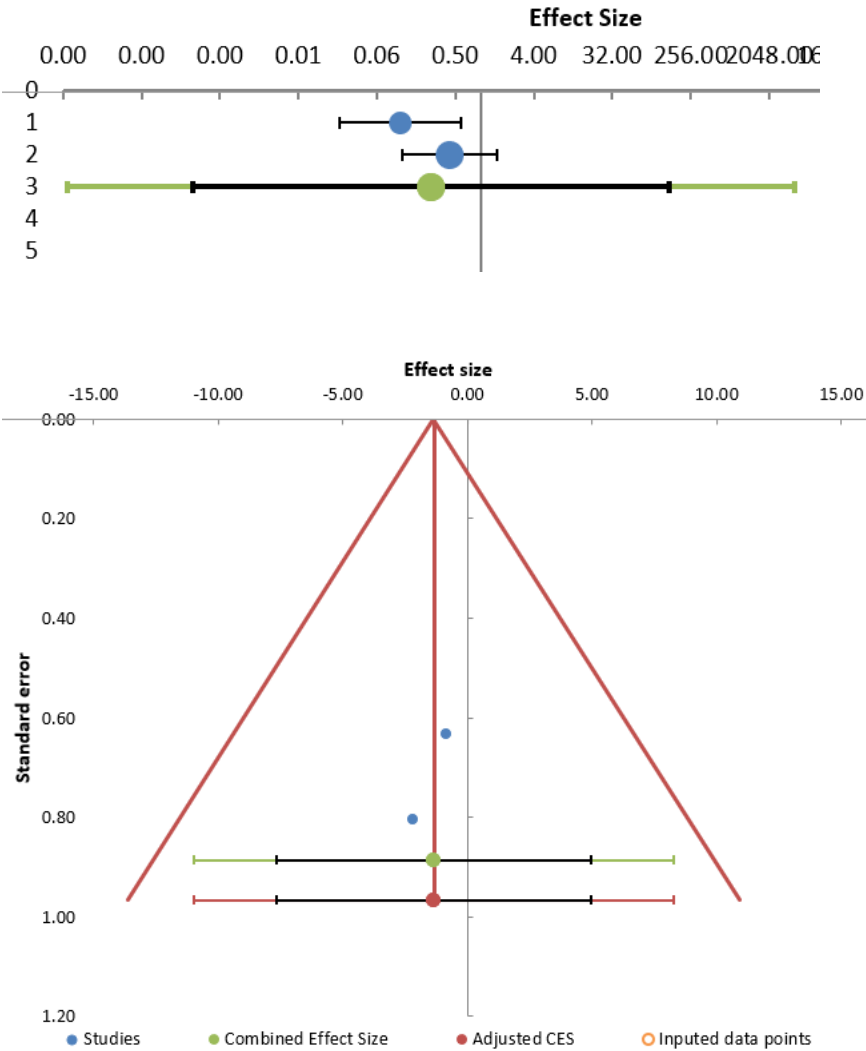*Forest and Funnel Plots of Interventions Using Letters and Postcards Against Suicide Attempts*
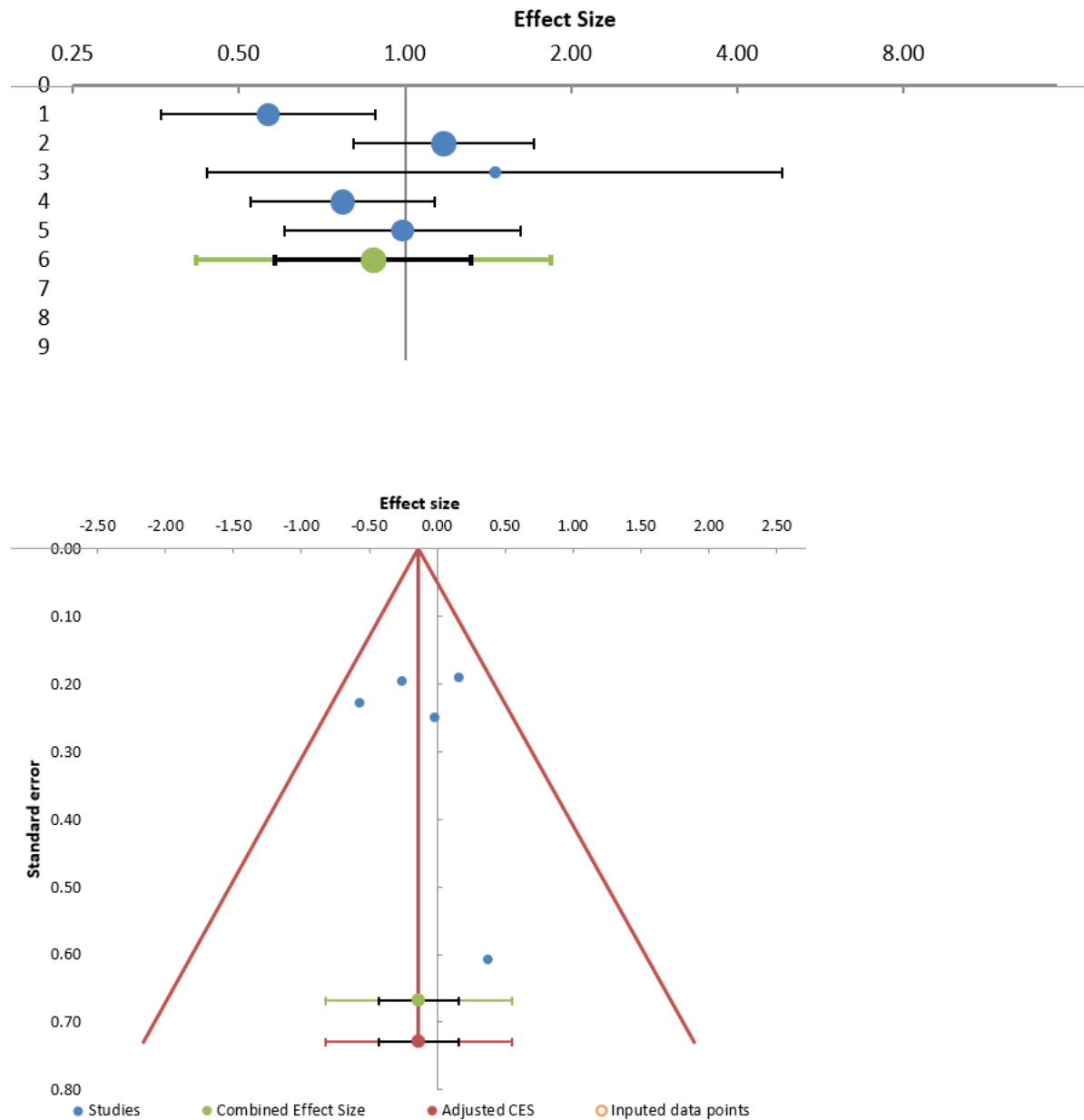
Figure A6

Forest and Funnel Plots of Interventions Using an Intervention mix Against Suicide Attempts
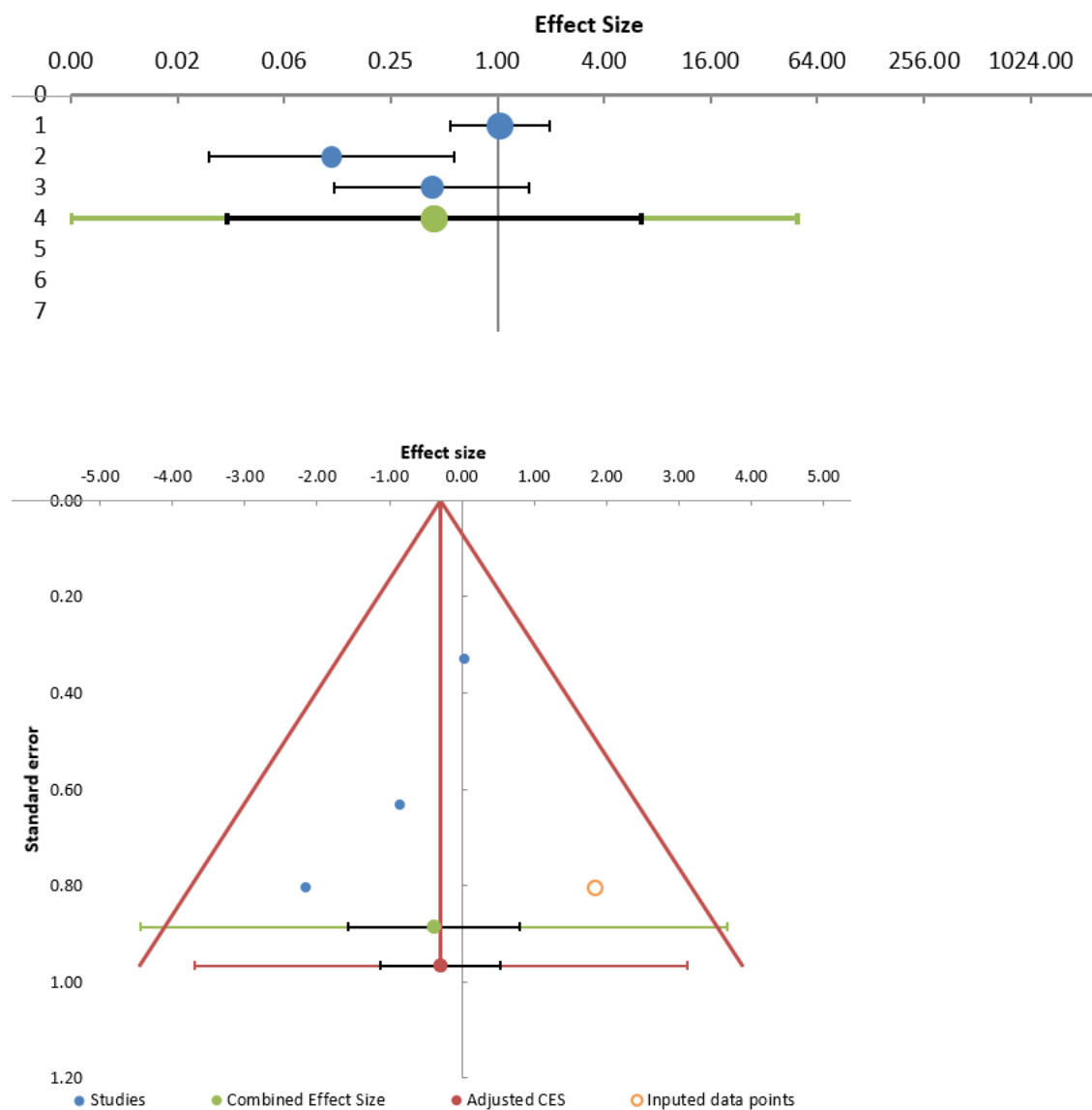
Figure A7

Forest and Funnel Plots of Interventions Using Telephone Contacts Against Suicide Attempts
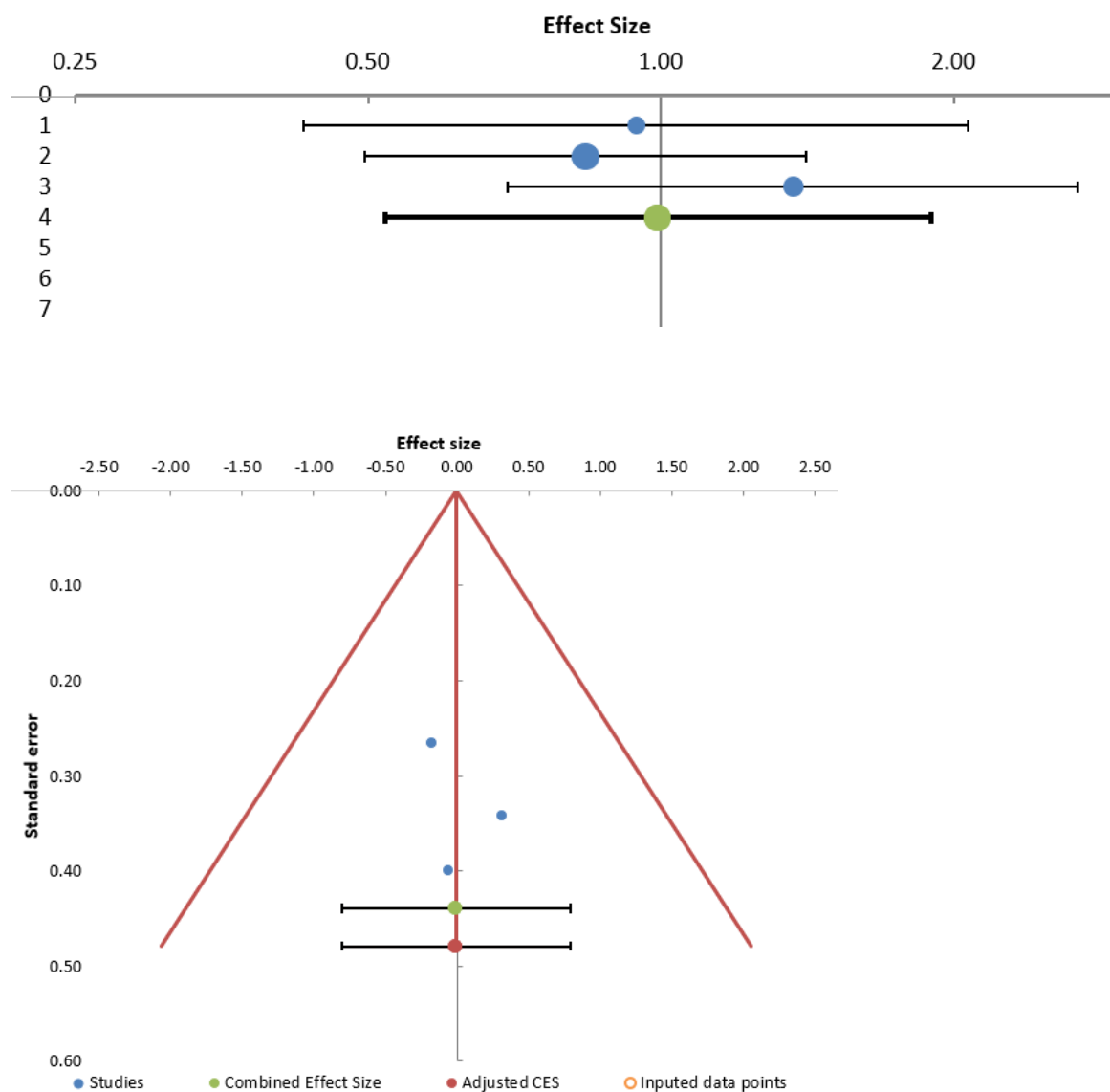
Figure A8

Forest and Funnel Plots of Interventions Using Letters and Postcards Against Suicide Risk
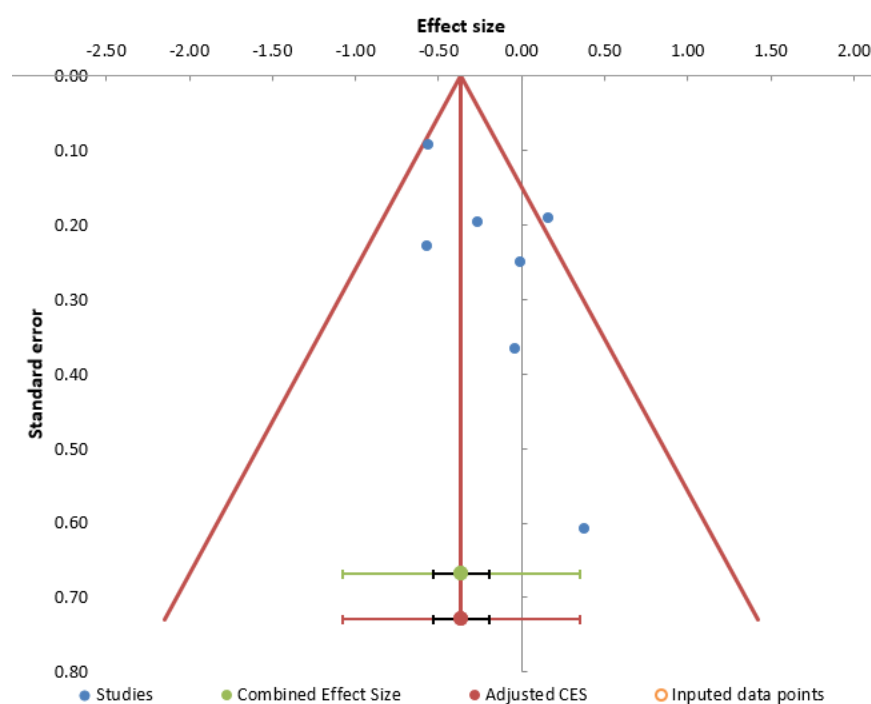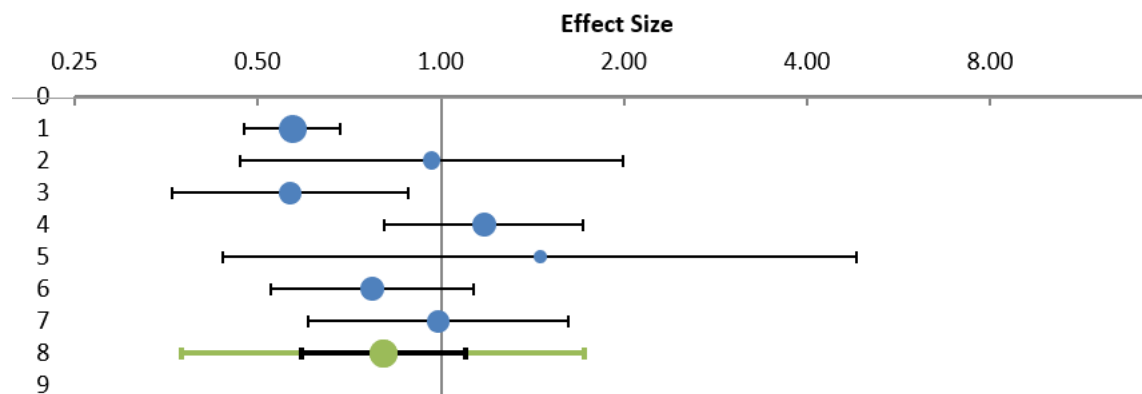
Figure A9

Forest and Funnel Plots of Interventions Using an Intervention mix Against Suicide Risk
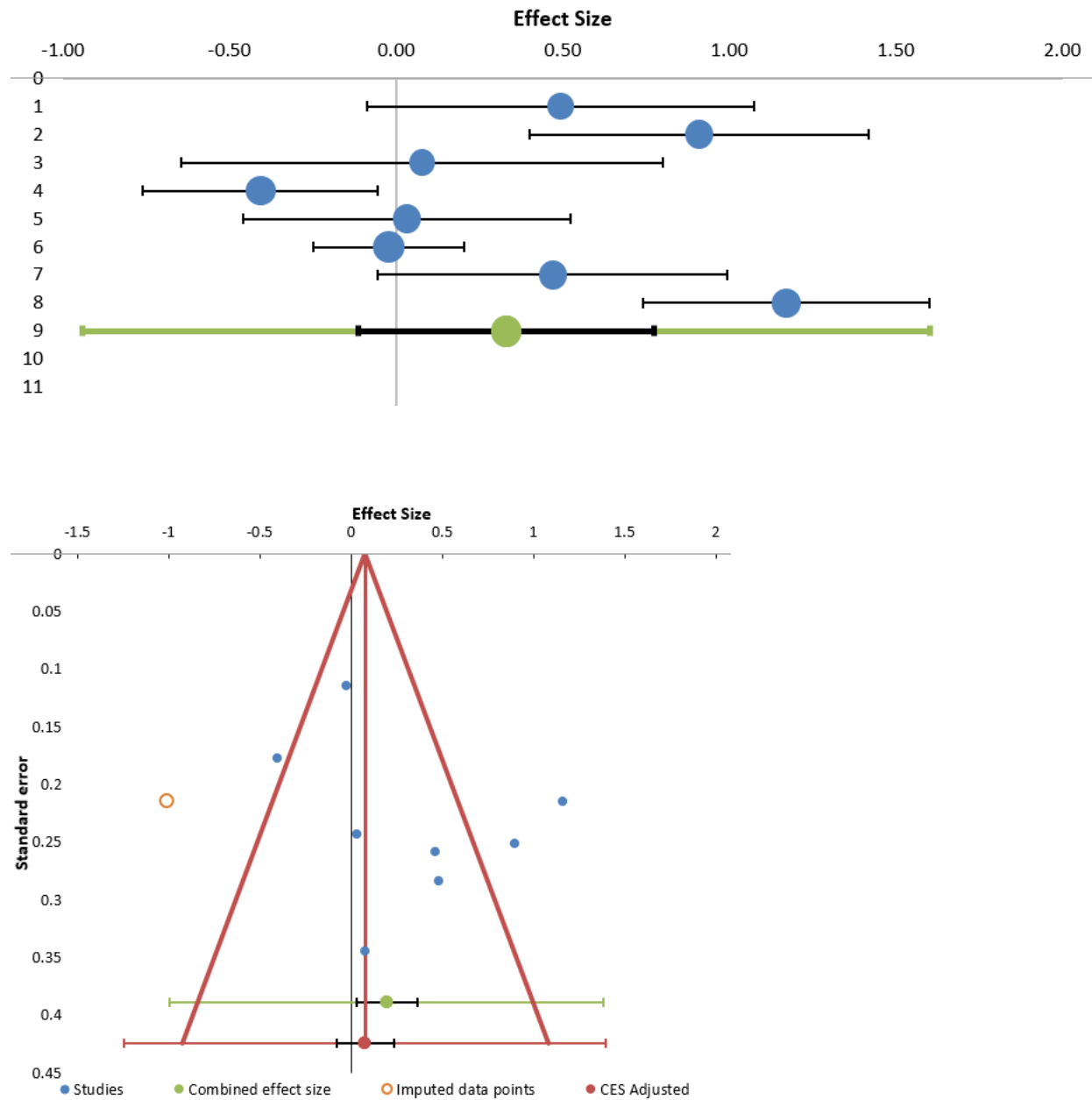
Figure A10

Forest and Funnel Plots of Interventions Using all Media Against Completed Suicides

Figure A11

Forest and Funnel Plots of Interventions Using an Intervention mix Against Suicidal Ideation After Sensitivity Analysis

Figure A12

Forest and Funnel Plots of Interventions Using Letters and Postcards Against Suicide Attempts
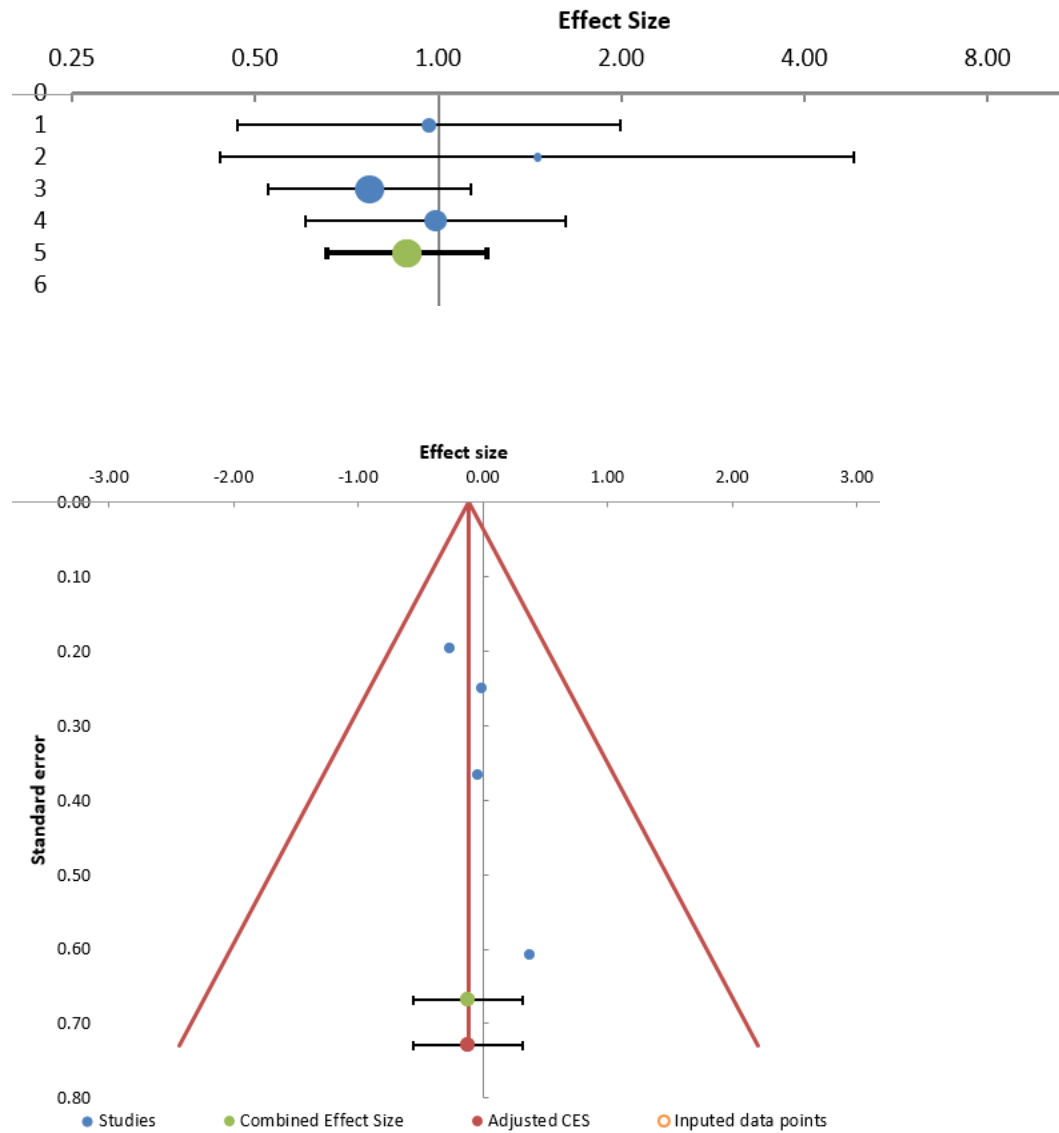
After Sensitivity Analysis

Figure A13

Forest and Funnel Plots of Interventions Using an Intervention mix Against Suicide Attempts After Sensitivity Analysis
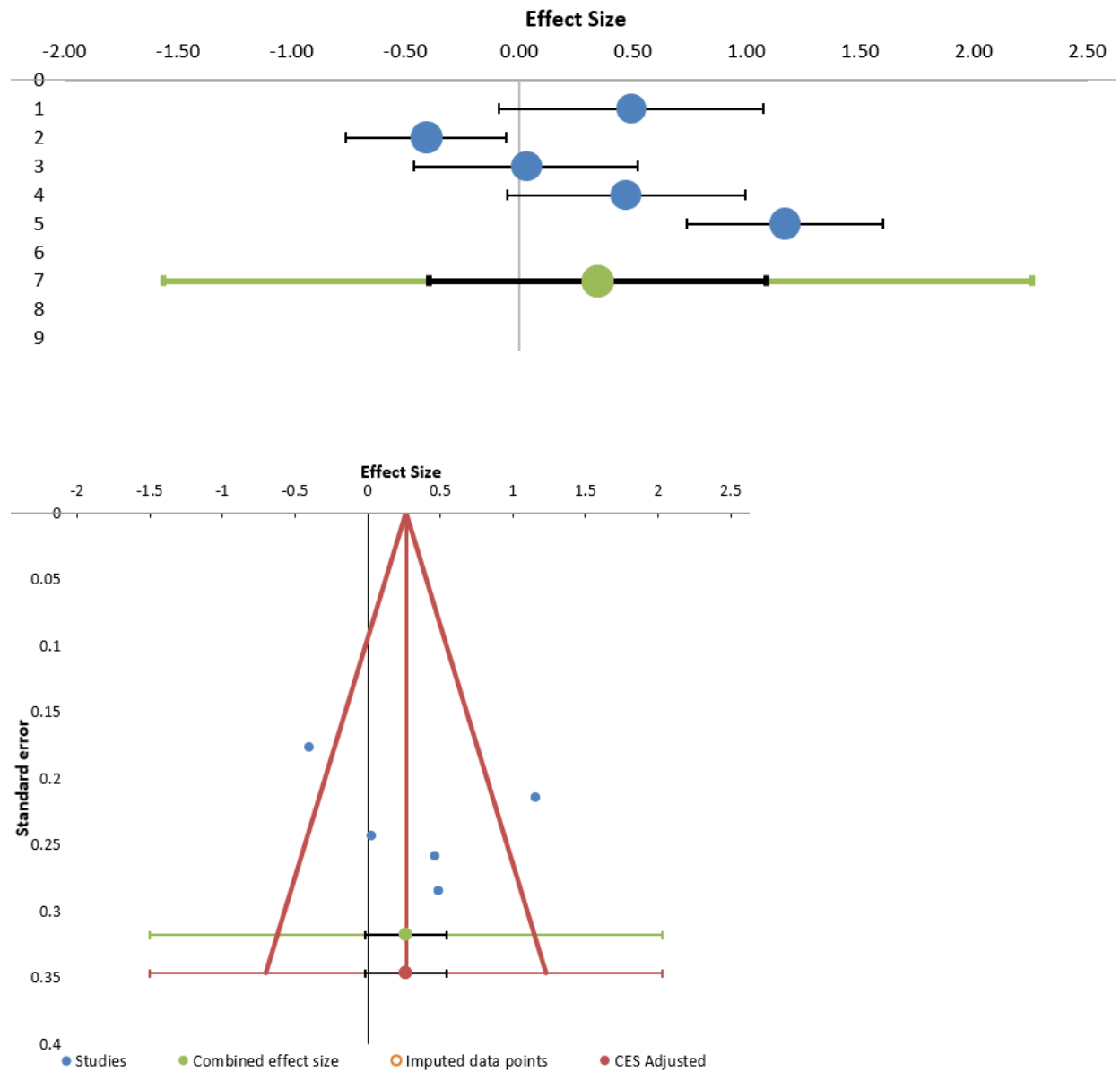
Figure A14

Forest and Funnel Plots of Interventions Using Letters and Postcards Against Suicide Risk After Sensitivity Analysis
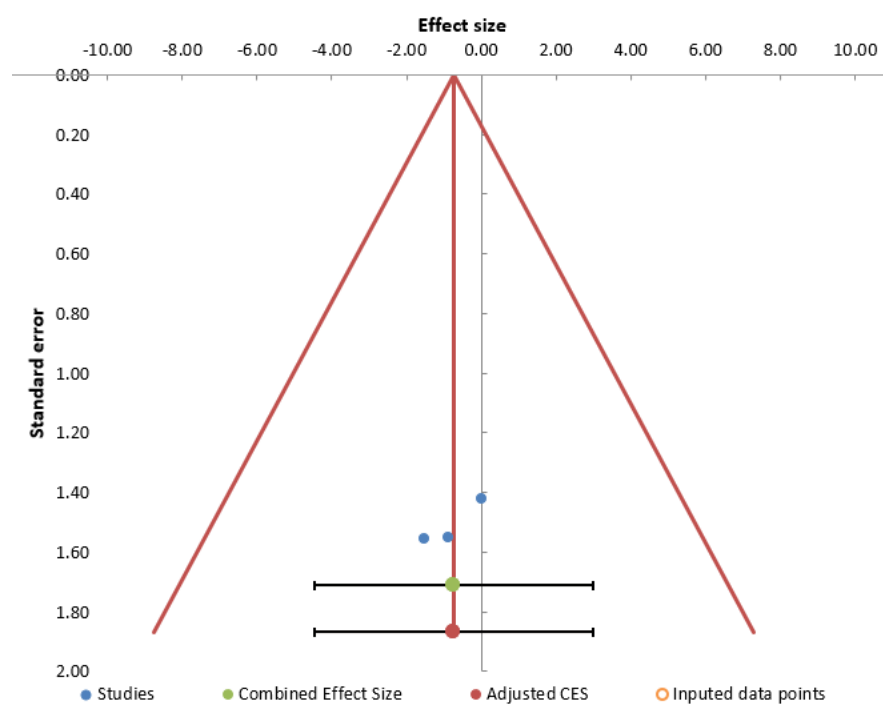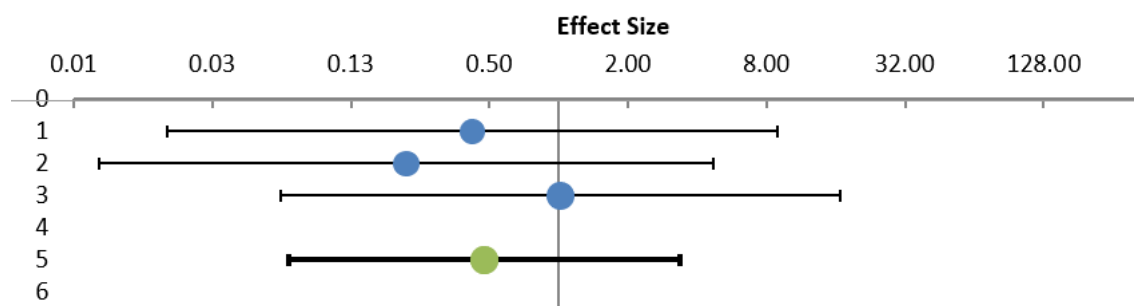
Figure A15

Forest and Funnel Plots of Interventions Using an Intervention mix Against Suicide Risk After Sensitivity Analysis

Figure A16

Forest and Funnel Plots of Interventions Using all Media Against Completed Suicides After Sensitivity Analysis

Abstract

Introduction. Suicide is the 18th leading cause of death worldwide, posing a serious global health issue. Effective interventions are available yet take place in majority in a face-to-face setting. Online and mobile suicide interventions, using media like letters and postcards, online programs, emails, phone contacts, or mobile telephone applications (apps), are a possible low-budget alternative to deliver interventions and able to reach patients even in remote locations. The goal of this thesis was to systematically review the available literature on online and mobile suicide interventions and to perform a meta-analysis to assess their efficacy. **Method.** Twenty-six studies were identified targeting three different outcomes (suicidal ideation, suicide attempts, completed suicides) for six categories of treatment modalities (letters/postcards, emails, online programs, intervention mix, apps, telephone contacts). **Results.** After the exclusion of low-quality studies, one small significant effect regarding online programs to reduce suicidal ideation remained ($d = 0.26$, 95% CI [0.03, 0.48]). Overall, high-quality studies did not find other significant effects and low-quality studies only slightly overestimated the interventions' efficacy. The assessed moderators (previous suicide attempts and study quality) did not significantly moderate the effects. **Discussion**. This work extends previous findings of the efficacy of online programs in reducing suicidal ideation. Future research needs to perform more high-quality studies, which also target older populations, starting by building on established efficacious interventions and media.

Keywords: online, mobile, suicide, intervention

Zusammenfassung

Einleitung. Suizid ist die 18-häufigste Todesursache weltweit und stellt folglich eine globale Gesundheitsbedrohung dar. Wirksame Interventionen werden immer noch vermehrt durch direkten Kontakt vermittelt. Online und mobil stattfindende Suizidinterventionen über Medien wie Briefe und Postkarten, Emails, online Programme, Apps oder Telefonkontakte stellen daher eine kostengünstige Alternative dar, welche Menschen sogar in ländlichen Regionen erreichen können. Das Ziel dieser Arbeit war die systematische Durchsicht der vorhandenen Literatur zu online und mobilen Suizidinterventionen und die Prüfung auf ihre Wirksamkeit mittels Meta-Analyse. **Methode.** Es konnten 26 Studien, die Suizidinterventionen über sechs verschiedene Medien (Briefe und Postkarten, Emails, online Programme, Interventionsmix, Apps oder Telefonkontakte) vermittelten identifiziert werden. **Ergebnisse.** Nach dem Ausschließen von Studien niedriger Qualität waren online Programme gegen suizidales Gedankengut die einzige Intervention mit signifikanten Ergebnissen ($d = 0.26$, 95% CI [0.03;0.48]). Studien niedriger Qualität überschätzen die Effektivität von Interventionen nur geringgradig und qualitativ hochwertige Studien fanden keine weiteren wirksamen Interventionen. Die Moderatoren (frühere Suizidversuche und Studienqualität) moderierten die Effektstärke nicht signifikant. **Diskussion.** Die Ergebnisse dieser Arbeit decken sich mit bisheriger Forschung zur Effektivität von online Programmen gegen suizidales Gedankengut. Zukünftige Forschungsarbeiten sollten mehr Wert auf höhere Qualität legen und die Interventionen sowie übermittelnde Medien allen Altersgruppen anpassen, aufbauend auf jenen Medien und Interventionen, deren Effizienz schon gezeigt wurde.

Schlüsselwörter: online, mobil, Suizid, Intervention