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Effectiveness of school-based preventive programs in suicidal thoughts and behaviors: A meta-analysis

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ABSTRACT

Background: Suicidal thoughts and behaviors (STBs) among adolescents have hardly decreased despite preventative efforts. School-based prevention programs could have a great reach, yet suicide prevention is not an easy topic to address. To increase acceptability of school-based suicide prevention, it is important to evaluate whether programs that target known risk factors of STBs, such as depression, could be equally effective.
Methods: We conducted a systematic literature search in major electronic databases. Outcomes were suicidal ideation and behaviors. Multivariate random effects meta-regression-analyses were conducted.
Results: Eleven primary studies met the inclusion criteria, totalling 23,230 participants. The post-test effect size was small for both suicidal ideation ($g = 0.15$) and suicidal behaviors ($g = 0.30$). Meta-regression indicated that targeting known risk factors of STBs was not a significant modifier of effect size for ideation, indicating equal effectiveness. However, it was significant modifier of effect for behaviors, but only one intervention targeted know risk factors. Effects at follow-up (3–12 months) were also significant but small for both outcomes.
Limitations: Substantial heterogeneity between studies was noted. Only few and small sample size studies could be included that targeted known risk factors of STBs. Therefore, these results should be interpreted with caution.
Conclusions: School-based prevention of STBs shows some promise within three months post-test assessments, and potentially also have effects that are sustained over time. More studies are needed to make conclusions regarding school-based interventions that target risk factors of STBs.

1. Introduction

Death by suicide is globally the second leading cause of death among adolescents (World Health Organization, 2018). Suicide rates in the USA in the age group 15–24 years old have been increasing since 2007 (Centers for Disease Control and Prevention, 2018) and a similar trend can be noted in the UK, whereas in most European countries suicide rates remain relatively stable over the years despite policy and prevention efforts (Eurostat, 2018). This shows there is an obvious need for effective preventive interventions in these age groups.

Suicidal thoughts and behaviors (STBs) comprise suicidal ideation, suicidal behaviors, and death by suicide (Nock et al., 2008). Suicidal ideation (SI) refers to thoughts of engaging in behavior with an intent to end one's life, while suicidal behaviors (SB) refer to engaging in self-injurious behavior in which there is at least some intent to die (Nock et al., 2008). Both of these STBs generally occur for the first time during adolescence (Esposito-Smythers et al., 2014). Even though suicidal thoughts and ideation often start in early adolescence, they generally remain covert for quite some time (Runeson et al., 1996), because adolescents are not likely to seek help for issues related to mental health in fear for stigma and stemming from low levels of mental health literacy (Parslow and Jorm, 2002). Crucially, STBs have an inverse relationship

Abbreviations: STBs, suicidal thoughts and behaviors; SI, suicidal ideation; SB, suicidal behaviors.

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with help-seeking (Burns and Patton, 2000; Carlton and Deane, 2000). All in all, a pro-active method of early detection is warranted for this age group. As such, active preventive strategies at schools, where the vast majority of adolescents can be reached, seem more promising than a passive approach in which adolescents seek help themselves. Indeed, a systematic review showed that schools are a suitable avenue for suicide prevention in young populations (Gould et al., 2003).

Several systematic reviews have been conducted to examine the effectiveness of school-based or educational preventive strategies for suicidal thoughts and behaviors (Cooper et al., 2011; Cusimano and Sameem, 2011; Kalafat, 2003; Katz et al., 2013; Miller et al., 2009; Robinson et al., 2018, 2013). Those studies revealed that universal and selective (target populations with increased risk factors) prevention programs can improve knowledge about STBs and promote an attitudinal change towards STBs. Furthermore, programs aimed at screening for suicidal behavior (i.e. identifying those adolescents that score higher on suicidal thoughts and behaviors), gatekeepers' training (increasing knowledge on STBs), and indicated programs (target populations with elevated symptoms) aimed at reducing suicidal behavior in adolescents with elevated suicidal complaints show the most promising results according to these reviews. Previous reviews have furthermore concluded that combining several strategies could increase efficacy (Katz et al., 2013).

In view of the mostly narrative evidence, we still know too little about the effectiveness of school-based program in reducing STBs, as meta-analytic reviews are scarce. So far, only one meta-analytic review has been conducted that investigated the effect of suicide prevention in educational and other settings (Robinson et al., 2018). Robinson and colleagues found some evidence that preventive strategies could have an effect on suicidal ideation and self-harm. However, the effects on suicidal ideation seem to be only temporary since the small post-intervention effects were not sustained until follow-up with one possible exception: the effect on self-harm was still apparent at follow-up.

Previous reviews on effectiveness of school-based strategies for suicide prevention have so far solely focused on preventative strategies that are primarily aimed at reducing STBs (Cooper et al., 2011; Cusimano and Sameem, 2011; Kalafat, 2003; Katz et al., 2013; Miller et al., 2009; Robinson et al., 2018, 2013). However, co-called upstream preventive strategies, *interventions targeting factors that might influence the pathogenesis of STBs,* are also a potentially interesting strategy for suicide prevention which is gaining interest (Singer et al., 2019; Wyman, 2014; Christensen and Petrie, 2013). Notably, many emotional, behavioral and mental health problems arise during early adolescence and are known risk factors for the pathogenesis of STBs (Bridge et al., 2006). Moreover, school-based preventative strategies for these problems already exist. Studies have shown that universal programs that focus on increasing social and emotional skills positively affect adolescents' mental health in a sustainable manner (Durlak et al., 2011). As Wilcox and Wyman (2016) have noted, it is noteworthy to examine whether universal preventive programs for mental health could have a cross-over effect on STBs. Previous prevention studies have shown that many preventive programs can have such cross-over effects in suicide prevention (Hawkins et al., 2005; Kerr et al., 2014; Lynn et al., 2014; Reider and Sims, 2016; Wilcox et al., 2008). For example, an intervention to increase family functioning by strengthening communication and family support decreased suicidal ideation among adolescents (Lynn et al., 2014).

There are many factors involved in the onset of STBs, and these include depressed mood, anxiety, anger and aggressive/ disruptive behaviors (Esposito-Smythers et al., 2014). A rise of psychopathology or mental health problems is characteristic before a suicide attempt or suicide (Runeson et al., 1996). But also factors such as stigma, help-seeking behaviors, school connectedness and stress and coping have a profound impact on the pathogenesis, progression and maintenance of STBs (Batterham et al., 2013; Drum et al., 2009; Mirkovic et al., 2015). Prevention strategies not primarily aimed at suicide prevention could be more readily implemented in schools as these topics are less sensitive in nature, thus reducing common barriers experienced by schools. Engagement from both school administrators and teachers is essential for implementation of school prevention strategies (Granello and Zyromski, 2018; Jaycox et al., 2006). Teachers do agree that they play an important role in suicide prevention among adolescents (Hatton et al., 2017) and feel a responsibility towards their students in suicide prevention (Gould et al., 2003). Common barriers schools have mentioned are fearing opposition from parents due to the sensitive nature of the topic (Whitney et al., 2011). In addition, schools experience barriers regarding scheduling, such as missing classes and tracking down individual students (Girio-Herrera et al., 2019).

It could be speculated that preventive programs directed at the early manifestations of psychopathology (such as a depressed mood, increased anxiety and elevated levels of distress), stigma reduction, increased help-seeking or connectedness could be effective targets for effective suicide prevention. Therefore, the current review and meta-analysis will not be restricted to studies that aim to reduce suicidality, but will include all studies that have included STBs as an outcome measurement to explore potential effects of studies that target risk factors of STBs. As such, the current meta-analyses aims to review the literature to identify and analyze effectiveness of school-based preventive strategies on STBs. We hypothesize that, in accordance with previous reviews, school-based preventive programs show potential in reducing STBs among adolescents. Considering, STBs are often the result of complex interactions between behavioral, emotional and mental health problems, we expect that interventions not specifically aimed at reducing STBs could also show potential in reducing STBs, in particular preventive interventions directed at depression as a primary outcome and which may have beneficial secondary impacts on STBs. The reasoning here is that in the younger age groups depression and STBs often co-occur and are more intertwined than in older age groups. In addition, depression prevention might be regarded as more acceptable and less prone to stigma than prevention of depression and promotion of wellbeing among pupils, their parents and their teachers. The greater acceptability may translate in a greater uptake and hence a greater reach of suicide prevention when it is first and foremost offered as a school-based intervention to reduce depressive symptoms and enhance mental well-being. More generally speaking, one would prefer a preventive intervention that is acceptable and effective in generating not a single, but two or a range of beneficial outcomes.

2. Methods

This study is reported in line with the guidelines of the "Preferred Reporting Items for Systematic Reviews and Meta-analysis" (PRISMA) statement (Moher et al., 2009).

2.1. Search strategy and study selection

The PICOS (Participants, Intervention, Comparisons, Outcomes, Study Designs) (Hoogendam et al., 2012) scheme was used to define our study inclusion criteria. Primary studies were eligible for inclusion in our review if: (1) the participants were children or adolescents up to the age of 25, but studies did not only include participants older than 18 years (P), (2) the preventive intervention was offered in the school setting (I), (3) the included studies employed a control group who received either no intervention, placebo, or usual care (C), (4) the outcome of the study included a measure of suicidal thoughts and behaviors (O), (5) assignment of individuals to the intervention and control groups in included studies was random (i.e. conducted as a randomized controlled trial) (S), (6) they were published in the English or Dutch language, (7) the data are reported such that effect sizes could be computed, and (8) studies were using original data.

A literature search to identify relevant articles that were published between 1990 and February 2020 was carried out in Medline, PsycInfo,

Cochrane Central Register of Controlled Trials and EMBASE using the following search terms: (Educational programs OR After school programs OR educational program evaluation OR educational program OR school based intervention) AND (school* OR classroom* OR classes OR classical OR college* OR course*) AND (program* OR intervention* OR preventive OR prevention OR prevent) AND (Self-destructive behavior OR Self-destructive behavior OR Self-injurious behavior OR Self-injurious behavior OR suicide OR suicidal OR suicidality OR suicidology). Furthermore, the references of any reviews yielded by our search were used to identify other articles that might meet the inclusion criteria. Duplicate articles were removed. Of the remaining articles, title and abstract were scanned to see if they met inclusion criteria; when this could not be determined from title and abstract alone, full-texts were retrieved and reviewed in their entirety and independently by two of the authors (MG and SR) to determine whether they met inclusion criteria. All discrepancies between MG and SR were discussed until consensus was reached.

Data were extracted independently by two reviewers (MG and SR) using a standardized data format and subsequently cross-checked for accuracy by both reviewers. After verification of the extracted data all discrepancies were discussed until consensus was reached. The inter-rater agreement between the two reviewers was 93%.

The extracted data included primary and secondary outcomes related to STBs, and included descriptive data about the intervention, the target population, and the methodological characteristics of the reviewed studies (cf. Tables 1 and 2). Furthermore, all outcome data pertaining to STBs were extracted from the primary studies at post-test and follow-up. The length of follow-up varied and, therefore, measurements were clustered into 1) post-intervention data (0–3 months) and, 2) follow-up (3–12 months).

2.2. Data analysis

Standardised mean differences (Cohen's d and Hedges' g) were calculated for all the outcome measures of the interventions to evaluate the efficacy. As data was reported in different formats in the primary studies, different formulas were used to calculate Cohen's d. Relative risks were converted into odds ratios (ORs) using the formula reported in Grant (2014). The formula from Chinn (2000) was used to convert ORs into Cohen's d, while the formula from Morris (2008) was used to calculate Cohen's d for studies reporting means with two groups of unequal sample size. The measurements of STBs outcome differed largely between studies. To correct for small sample bias in d, Hedges' g was calculated using the calculated Cohen's d in StataSE 16 (StataCorp, 2019) with the formula from Hedges and Olkin (1985). Effect sizes were calculated as such that a larger positive effect size indicates a beneficial effect, with $g = 0.20$ indicating a small effect, $g = 0.50$ a medium effect and $g = 0.80$ a large effect. Several studies employed more than one intervention arm. For these studies, the control group was split to match the number of intervention arms as to avoid double counting of the same participants according to the method of Rücker et al. (2017). For instance, a study used two intervention arms, but only one control group. The sample size of the control group was divided by two for calculations of effect size.

Table 1
Study characteristics of included studies.

Study	Sample size (% females)	Study population	Intervention	Provider of intervention	Primary aim of intervention	Outcome measures	Outcome	Type of Intervention	Control condition	Follow-up
Aseltine (2004)	4133 (48.4–51.3)	High school (USA)	SOS1	Teacher /video	STBs	YRBS	SI, SA	Universal with added screening	Non-active	Post-test (3 months)
Britton (2014)	100 (46)	6th grade (USA)	Mindfulness	Teacher	MH	YSR	SI or SH	Universal	Active	Post-test
Klingman (1993)	237 (51)	8th grade junior school (Israel)	Distress prevention program (unnamed)	Experienced school counsellor or psychologist	STBs	IIPS	SR	Universal	Active	Post-test
Newcomer (2016)	1385 (52)	1st grade (USA)	GBG ML	Teacher	Aggressive, disruptive behaviors	NIMH-DISK	SA	Universal	Non-active	Approx.. 20 years
Perry (2014)	380 (NR)	Year 9 and 10 (AUS)	HeadStrong	Teacher	Mental health literacy	MFQ	SI	Universal	Usual care	Post-test; 6 months
Schilling (2014)	386 (52.6)	5th −8th grade (USA)	SOS1	Teacher	STBs	YRBS	SB	Universal with added screening	Non-active	Post-test
Schilling (2016)	1046 (41.7)	9th grade (USA)	SOS1	Teacher	STBs	YRBS	SB	Universal with added screening	Waitlist	Post-test
Tang (2009)	73 (65.7)	High school (Taiwan)	IPT-A	School counsellors	Depression and STBs	BSS	SI	Indicated	Usual care	Post-test
Wasserman (2015)	11,110 (59)	High school; students between 14 and 16 yrs old (Europe)	QPR ProfScreen YAM	Qualified trainer Health professional Teacher	STBs	Paykel hierarchical ladder of suicide	SI, SA	Universal	Usual care	Post-test (3 months); 12 months
Wilcox et al. (2008)	1695 (49–52)	1st and 2nd grade (USA)	GBG ML	Teacher Teacher	Aggressive, disruptive behaviors	NIMH-DISK	SI, SA	Universal	Non-active	Approx. 12 years
Wyman (2010)	2675 (48–52.7)	High school (USA)	SOS2	Peers and adult supervisors	STBs	Two items	SI	Universal	Waitlist	Post-test

Note: AUS: Australia BSS: Beck Scale for Suicide Ideation; GBG: Good Behavior Game; IIPS: Israeli Index of Potential Suicide; IPT-A: Program of Intensive Interpersonal Psychotherapy for depressed adolescents with suicidal risks; ITT: intention-to-treat; MFQ: Moods and Feelings Questionnaire; ML: Mastery Learning; NIMH-DISK: National Institute of Mental Health - Diagnostic Interview Schedule for Children; NR: Not Reported; ProfScreen: screening with assessment by a professional; QPR: Question, Persuade, Refer; SA: Suicide Attempt; SB: Suicidal Behavior; SH: Self-harm; SI; Suicidal Ideation; SR: Suicide Risk; SOS1: Signs of Suicide; SOS2: Sources of Strength; USA: United States of America; YAM: Youth Aware of Mental Health; YRS: Youth Self-Report; YRBS: Youth Risk Behavior Surveillance System.

Table 2
Effect sizes calculated for included studies.

Study	Sample size experimental condition	Sample size control condition	Post-test		Follow-up		ITT
			SI Hedges' g	SB Hedges' g	SI Hedges' g	SB Hedges' g	
Aseltine (2004)	2039	2094	.094	.255	N/A	N/A	N
Britton (2014)	52	48	N/A	1.099	N/A	N/A	Y
Klingman (1993)	116	121	N/A	.304	N/A	N/A	NR
Newcomer (2016)	296 (GBG)	781	N/A	N/A	N/A	.275	N
	308 (ML)		N/A	N/A	N/A	.134	
Perry (2014)	207	173	−.035	N/A	.287	N/A	Y
Schilling (2014)	299	87	.292	N/A	N/A	N/A	N
Schilling (2016)	650	396	.055	.552	N/A	N/A	N
Tang (2009)	35	38	1.800	N/A	N/A	N/A	NR
Wasserman (2015)	2764 (ProfScreen)	2933	.181	−.053	.189	.238	N
	2692 (QPR)		.205	.264	.028	.197	
	2721 (YAM)		.071	.137	.383	.441	
Wilcox et al. (2008)	351 (GBG)	980	N/A	N/A	.353 (Cohort 1); .140 (Cohort 2)	.162 (Cohort 1); −.012 (Cohort 2)	Y
	373 (ML)		N/A	N/A	.172 (Cohort 1); −.077 (Cohort 2)	.232 (Cohort 1); −.032 (Cohort 2)	
Wyman (2010)	1757	919	.095	N/A	N/A	N/A	Y

Note: GBG: Good Behavior Game; ML: Mastery Learning; N: No; NR: Not Reported; ProfScreen: screening with assessment by a professional; QPR: Question, Persuade, Refer; SB: Suicidal Behaviors; SI; Suicidal Ideation; YAM: Youth Aware of Mental Health; Y: Yes.
Cohort 1 and 2 from Wilcox et al. (2008) refer to the two successive academic years that the study took place.

A multivariate random-effects meta-regression was carried out in Stata (version 16.1) using the multivariate method-of-moments procedure (Jackson et al., 2010) which is an a multivariate generalizations extension of the DerSimonian-Laird random effects model (DerSimonian and Laird, 1986). The meta-analyses were performed for both outcomes, namely suicidal ideation and apart suicidal behaviors. Suicidal ideation refers to thoughts about killing oneself, and suicidal behaviors constitute suicide attempts and self-harming behaviors (Nock et al., 2008). In addition, the meta-analyses for SI and SBs were performed separately for both outcomes at (1) post-test (0–3 months), and (2) follow-up (3–12 months). To analyze whether reducing STBs as the primary aim of preventive program or was measured as a secondary outcome (i.e. upstream intervention) made any difference in effect size, first, a meta-regression analyses was performed. In addition, meta-analyses at post-test were also performed separate for "primary aim of intervention" (i.e. upstream intervention).

Heterogeneity in the studies was tested using the I^2 statistics (Higging and Thompson, 2002). Furthermore, we also accounted for publication bias, as it is well-known that studies that do not find the significant results are less likely to be published (Fanelli, 2010). Possible presence of publication bias was examined with a funnel plot and the Duval and Tweedie procedure (Duval and Tweedie, 2000) was used to estimate the pooled effect size when missing publications would have been included into the meta-analysis.

The Cochrane Risk of Bias tool for cluster randomized trials (Eldridge et al., 2016) was used to assess the quality of the primary studies. This tool focusses on five possible sources of bias in the design, conduct and reporting of trials: Random sequence generation, Allocation concealment, Blinding of outcome assessment, Incomplete outcome data, and Selective reporting. We decided to exclude the risk-of-bias criterion Blinding of participants and personnel, because in psychological interventions blinding of participants and personnel is not feasible. Also, most studies used self-report measurements and this renders any blinding of the outcome assessors impossible. Previous studies showed that using self-report measures does not lead to inflated effect sizes, but could lead to more conservative estimates (Cuijpers et al., 2010). The quality assessment was completed independently by two of the reviewers (MG and SR).

2.3. Sensitivity analyses

Multivariate meta-regression analyses were performed in StataSE 16 to evaluate if quality of the primary studies is systematically covarying with the size of the study's effect size. In light of previous experience, it was expected that studies with higher quality would be associated with smaller effect sizes. Other factors of interest were preventative strategy and year of publication. Meta-regression analyses were performed to test whether any of these factors systematically covaried with the size of the study's effect size as well. Preventive strategy was dichotomized into (0) singular intervention and (1) multimodal intervention. Preventive strategy was considered multimodal when a screening was completed before the start of the intervention and the screening was not examined as a separate intervention. Age was not adequately described in various included studies and as such age could not be included as a factor in the meta-regression analyses.

3. Results

3.1. Study characteristics

The systematic search of the literature identified 2831 articles and an additional 20 articles were identified through reference list checking of previous reviews. Of these, 2733 articles were retained after removing duplicates. These articles were checked for inclusion by title and abstract after which 207 articles remained. From the 207 articles, 11 met the inclusion all criteria after full-text were reviewed. The main reason of exclusion was that the studies did not include any direct measurement of suicidal ideation and suicidal behaviors. Several studies included measurement on "attitude towards suicide" or help-seeking intentions, but not on direct suicidal ideation or suicidal behaviors. Other important reasons for exclusion were the absence of a control group or no randomization. The selection process can be found in the Fig. 1. Finally, we included 11 primary studies with a total of 23,230 participants (Aseltine and DeMartino, 2004; Britton et al., 2014; Klingman and Hochdorf, 1993; Newcomer et al., 2016; Perry et al., 2014; Schilling et al., 2014, 2016; Tang et al., 2009; Wasserman et al., 2015; Wilcox et al., 2008; Wyman et al., 2010).

Tables 1 and 2 describes key characteristics of the primary studies. Several studies tested the same intervention and three studies had multiple (two or three) intervention arms. Sample sizes ranged from 73 to 11,110, with a total of 14,660 participants in the experimental group and 8570 participants in the control group. The age during implementation of the intervention ranged from first-graders in elementary school to the highest grade in high school. Mean age range was often not

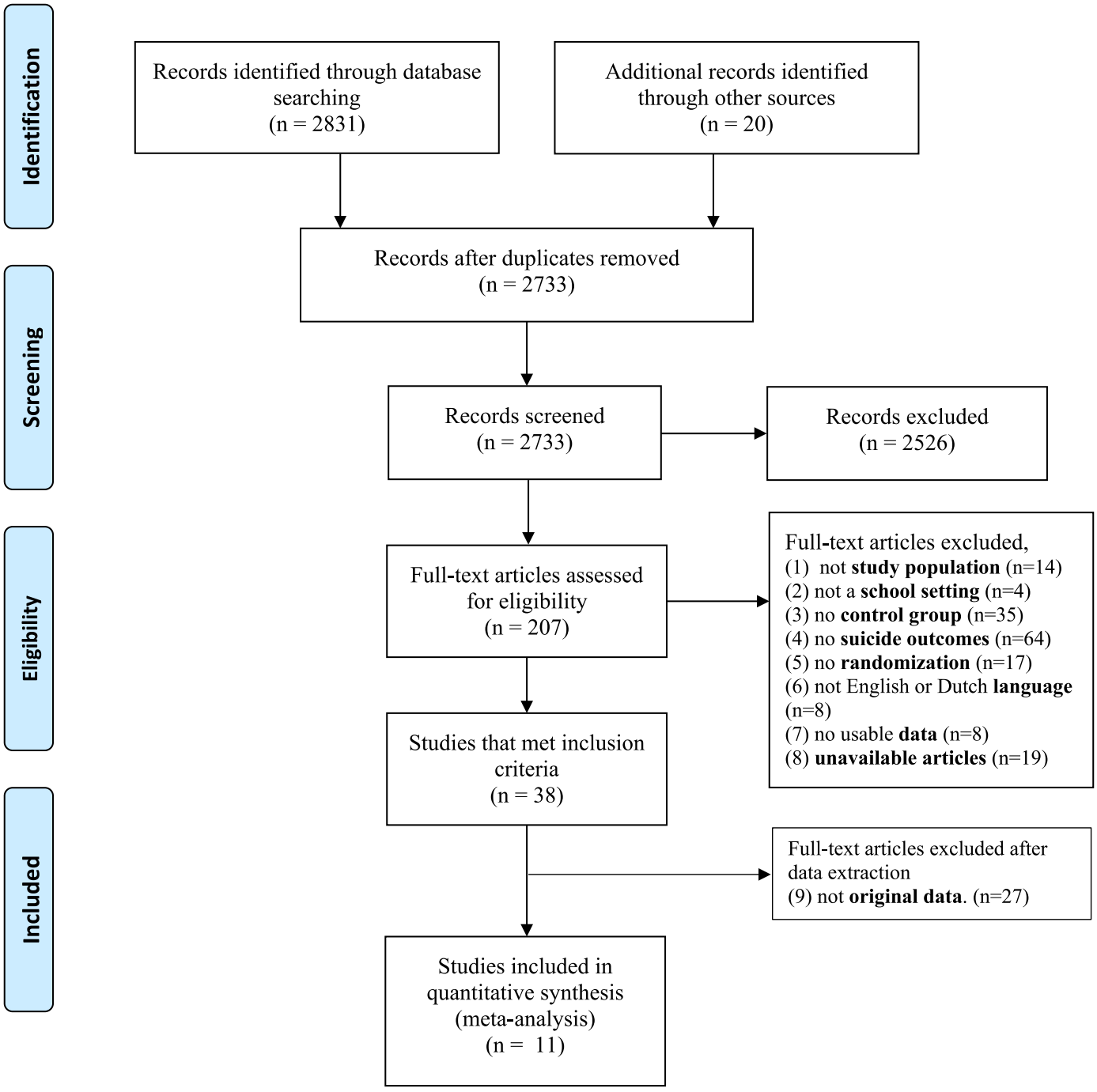

Fig. 1. Flowchart included studies.

described in studies as most studies were restricted to a single grade (i.e. 9th grade). The follow-up period ranged from post-test up to 20 years after initial study inclusion. Of the included studies there were five studies that were not specifically aimed at preventing STBs, but did include measurement of STBs. There were 9 interventions for which SI was reported, while for 7 interventions SBs were reported at post-test. For the short-term follow-up SI was reported for 4 interventions, SBs were reported for 3 interventions. It also noteworthy that several studies ($k = 5$) reported both SI and SBs. In Supplemental Table S1 we report on which outcomes were reported by each study and how these were measured and Supplemental Table S2 reports the outcomes of the primary studies.

There were two publications that reported data that stemmed from the same study, and thus while their effect sizes are reported in Table 2, their data was not included in the subsequent meta-analyses.

For the studies with post-test data there were nine studies with 11 comparisons. The total sample size was 20,141, with 13,332 participants in the intervention group and 6809 participants in the control group. For the studies with follow-up data there were two studies resulting in 4 comparisons. The sample size was 11,490, with 8384 participants in the intervention group and 3106 participants in the control group.

3.2. *Quality assessment*

The quality of the included primary studies was relatively high. Overall results of quality assessment can be found in Figs. 2 and 3. Two

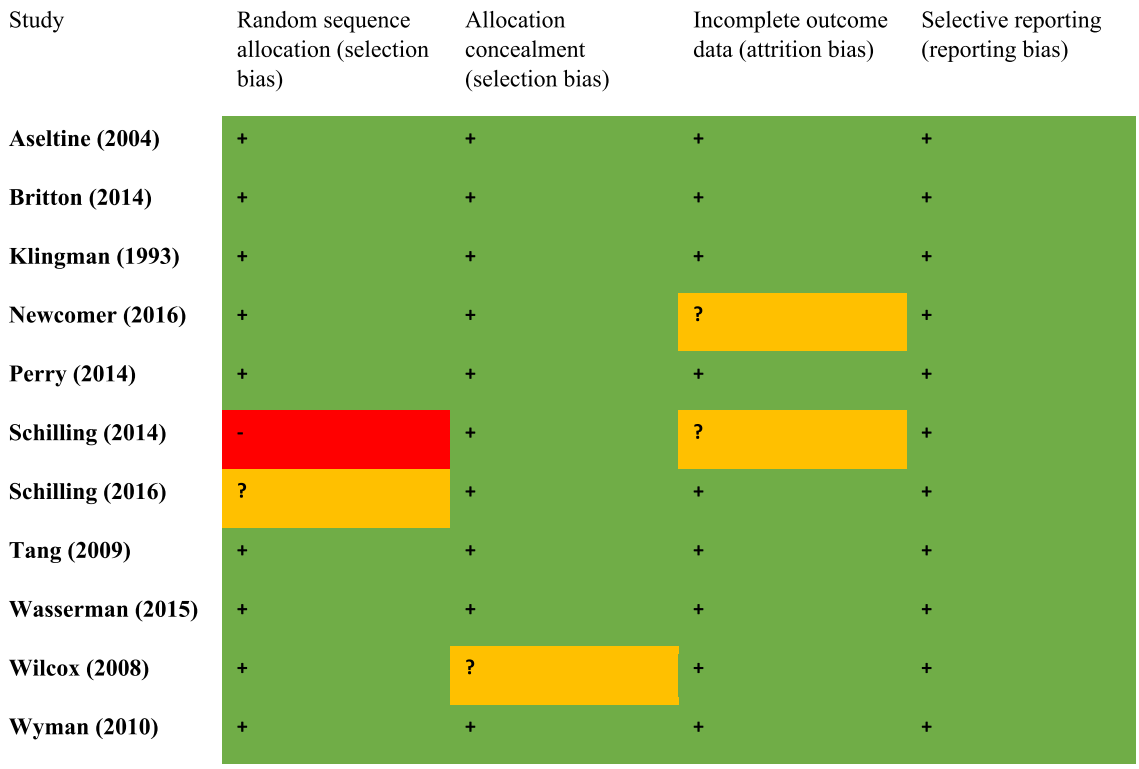

Fig. 2. Risk of bias graph per study.

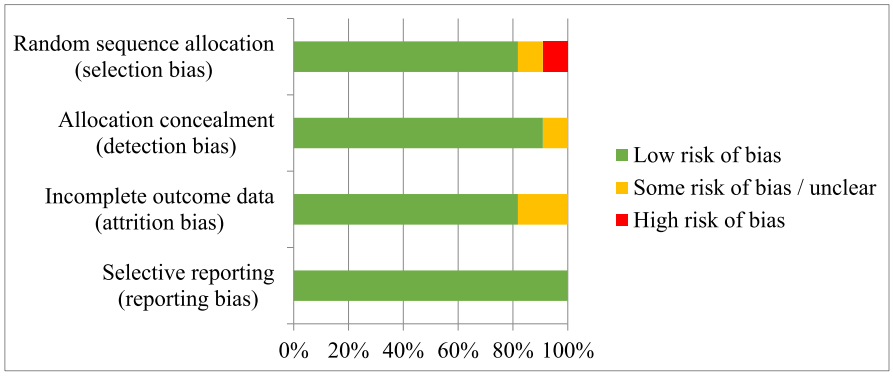

Fig. 3. Overview of risk of bias included studies.

studies had issues with random sequence allocation as in spite of randomization some baseline differences between groups were observed (Schilling et al., 2016, 2014). Most studies scored low risk on allocation concealment. One study was rated as having some risk on allocation concealment as there were participants that were allowed to cross-over to another condition after randomization (Wilcox et al., 2008). The study does not report how often this event occurred, but authors instead stated this was rare. Most studies did not employ an intention-to-treat analysis, to mitigate any bias stemming from loss to follow-up, but attrition bias appeared not to be an issue since dropout rates were low in most studies and dropout appeared not to be selective (i.e. correlated with baseline variables). Nevertheless, two studies were rated as having some risk of attrition bias because there were baseline differences in drop-out (Newcomer et al., 2016; Schilling et al., 2014). There was no study that had any concerns regarding reporting bias. The inter-rater agreement (between MG and SR) was 89%.

3.3. Meta-analysis

The meta-analysis of suicidal ideation at post-test was based on 10 comparisons and showed a small effect (Hedges' $g = 0.15$, 95% CI [.06, 0.24], $p = .001$). Heterogeneity across effect sizes was high ($I^2 = 85$, 95% CI [73, 91]) with one study favoring control over intervention at post-intervention.The results are depicted in a forest plot (Fig. 4). Visual inspection of the funnel plot (Fig. S1) showed that there might be some publication bias since studies with a low sample size and a low effect size appeared to be under-represented. However, Duval and Tweedie's fill and trim procedure did not change the data and no studies were imputed. Meta-regression analyses indicated that targeting STBs as the primary aim of the intervention specifically did not alter the effect size significantly ($b = -0.22$, SEb = 0.15, $z = -1.49$, 95% CI [−0.50, −0.07], $p = .136$).

The meta-analysis of suicidal behaviors at post-test was based on 6 comparisons and showed a small effect (Hedges' $g = 0.30$, 95% CI [.15, 0.45], $p < .001$). Heterogeneity across effect sizes was high ($I^2 = 94$, 95% CI [90, 96]) with one study favoring control over intervention at

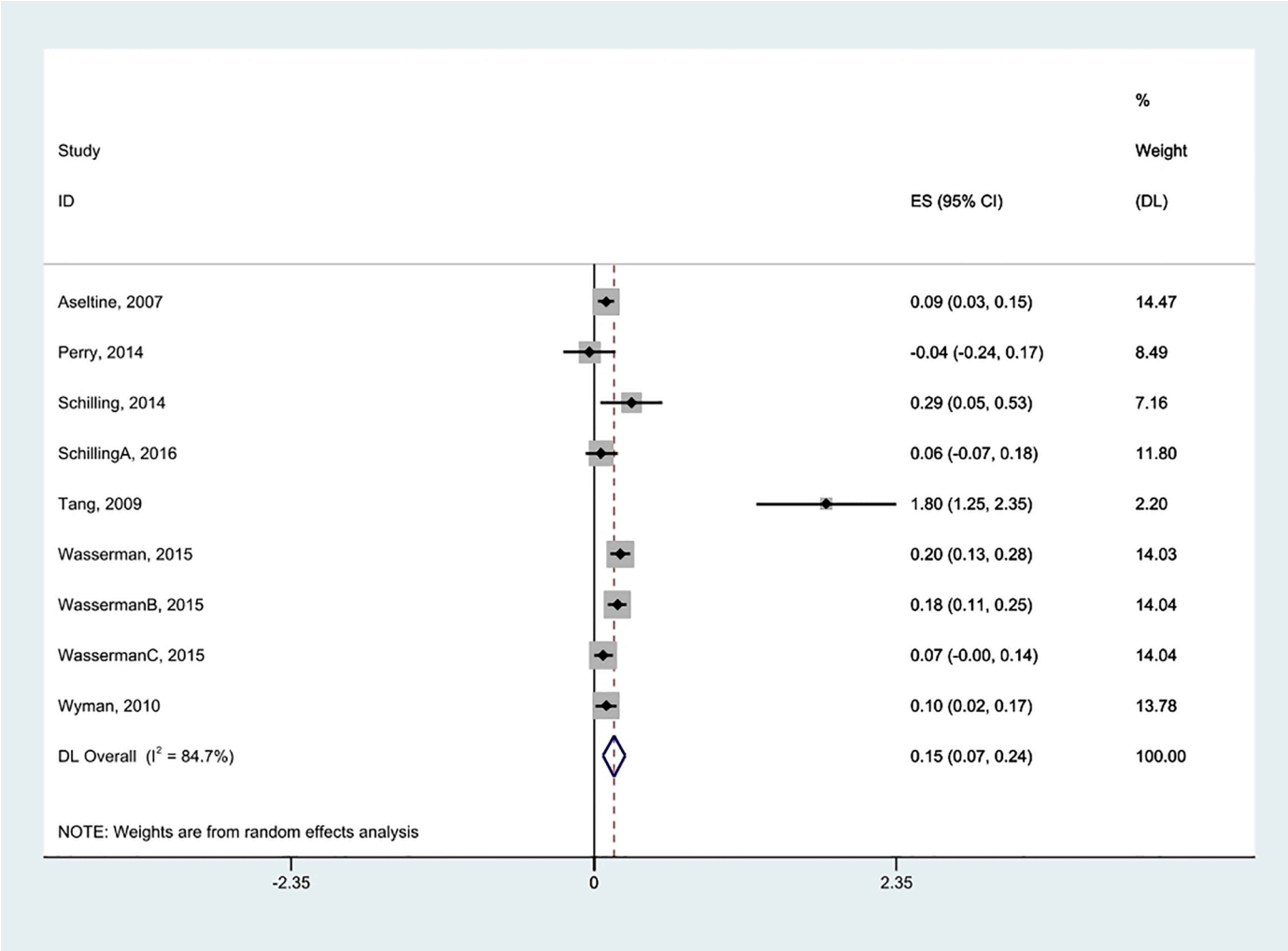

Fig. 4. Forest plot of included studies on suicidal ideation post-test.

post-intervention. The results are depicted in a forest plot (Fig. 5). Visual inspection of the funnel plot (Fig. S2) showed that there might be some publication bias. However, Duval and Tweedie's fill and trim procedure did not change the data and no studies were imputed. Meta-regression analyses indicated that targeting STBs as the primary aim of the intervention specifically reduced the effect size significantly ($b = -0.87$, SEb $= 0.28$, $z = -3.04$, 95% CI [−1.42, −0.31], $p = .002$). The multivariate meta-analyses with only the studies that focused specifically on STBs was however significant for SB (pooled Hedges' $g = 0.23$, $p < .001$). Heterogeneity remained high ($I^2 = 94$, 95% CI [90, 97]). There was, however, only one study (Britton et al., 2014) that included an intervention that was not specifically designed to target STBs.

The meta-analysis for short-term follow-up effects (at 3–12 months) was based on 4 comparisons for suicidal ideation and showed a small effect size ($g = 0.22$, 95% CI [.05, 0.39], $p = .01$) and was associated with substantial heterogeneity ($I^2 = 93$, 95% CI [86, 97]). The results are depicted in a forest plot (Fig. 6). Visual inspection of the funnel plot (Fig. S3) showed that there might be some publication bias. However, Duval and Tweedie's fill and trim procedure did not change the data and no studies were imputed. The meta-analysis for short-term follow-up effects was based on 3 comparisons for suicidal behaviors and showed comparable results to post-test. The effect size was small ($g = 0.30$, 95% CI [.16, 0.43], $p < .001$). There were no studies that favoured control over intervention. The results are depicted in a forest plot (Fig. 7). Visual inspection of the funnel plot (Fig. S4) showed that there might be some publication bias. However, Duval and Tweedie's fill and trim procedure did not change the data and no studies were imputed.

There were two publications that were based on the same study, and thus while their effect sizes are reported in Table 2, their data was not suitable for meta-analyses. The reported effect sizes of both studies also indicated a small beneficial effects on both SI and SB after follow-ups at 12 and 20 years.

3.4. Sensitivity analyses

Since substantial heterogeneity was observed in the post-test meta-analysis, meta-regression analyses were conducted in order to see if the differences between studies could be explained by factors that co-vary systematically with the post-treatment effect size. At post-test for suicidal ideation, the effect of trial quality on the overall pooled effect size was statistically non-significant ($b = -0.01$, SEb $= 0.06$, $z = 0.15$, 95% CI [−0.12, 0.14], $p = .883$) as was year of publication ($b = 0.01$, SEb $= 0.02$, $z = -0.94$, 95% CI [−0.05, 0.02], $p = .347$). Preventive strategy (singular versus multimodal preventive intervention) was also a non-significant modifier of effect size ($b = -0.22$, SEb $= 0.15$, $z = -1.49$, 95% CI [−0.50, 0.07], $p = .137$).

Similar results for quality and publication year were found for suicidal behaviors. At post-test suicidal behaviors, the effect of trial quality on the overall pooled effect size was statistically non-significant ($b = -0.04$, SEb $= 0.13$, $z = -0.73$, 95% CI [−0.34, 0.16], $p = .465$) as was year of publication ($b = 0.00$, SEb $= 0.01$, $z = -0.26$, 95% CI [−0.02, 0.02]. $p = .792$). Preventive strategy (singular versus multimodal

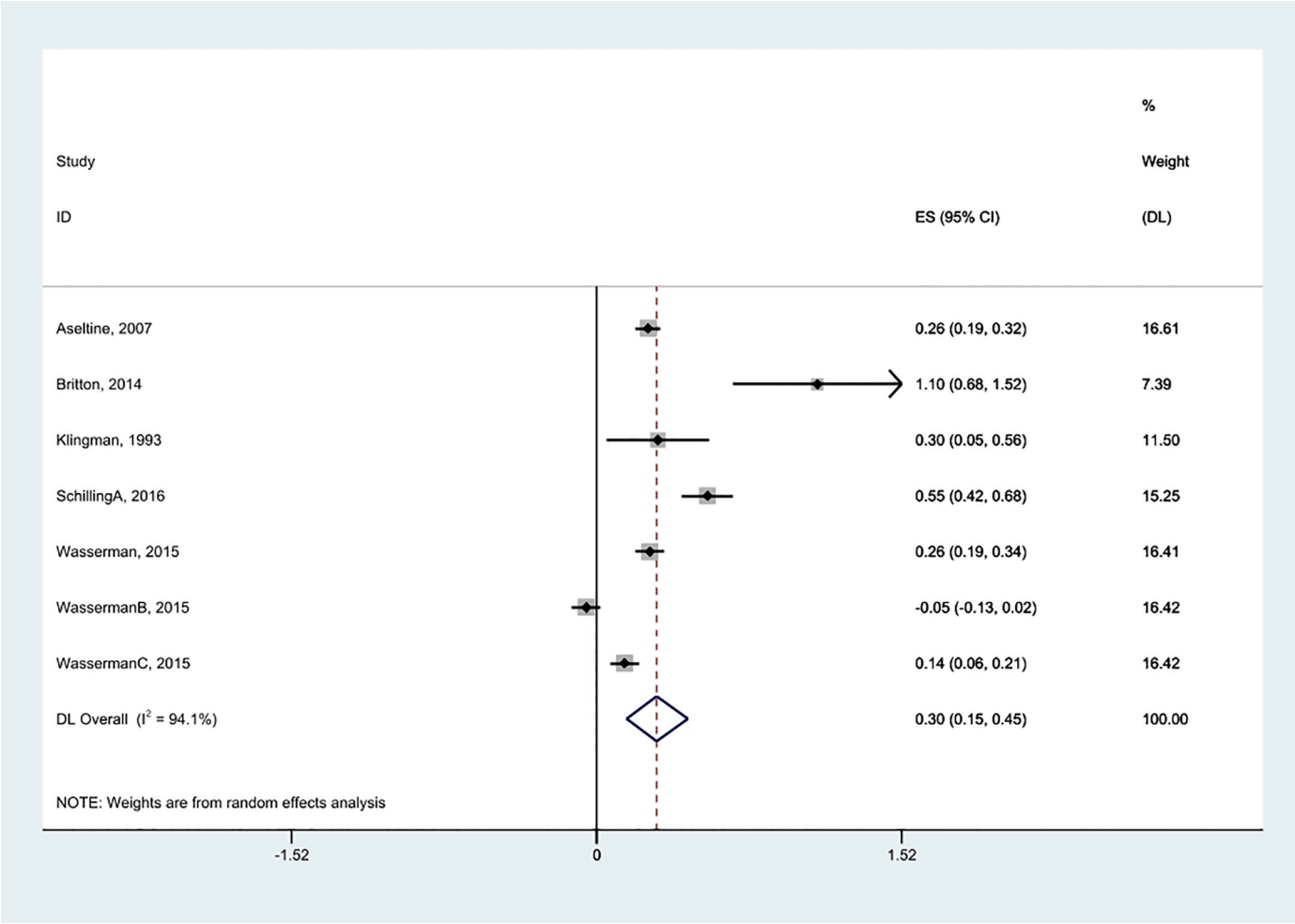

Fig. 5. Forest plot of included studies on suicidal behaviors post-test.

preventive intervention) on the other hand was a significant modifier of effect size ($b = -0.39$, SEb = 0.19, $z = -1.99$, 95% CI [−0.77, −0.01], $p = .046$). There were two studies (Britton et al., 2014; Klingman and Hochdorf, 1993) that did not employ a multimodal preventive strategy. The pooled effect size of the studies that employed a multimodal strategy was slightly reduced after excluding these two studies, albeit still significant (Hedges' $g = 0.22$, 95% CI [.07, 0.38], $p = .004$), while heterogeneity remained high ($I^2 = 95$, 95% CI [91, 97].

4. Discussion

4.1. Main findings

The aim of the current meta-analyses was to evaluate the effectiveness of school-based preventive strategies in suicidal thoughts and behaviours (STBs). Studies that focus on prevention of STBs directly and studies that focus on risk factor of STBs (upstream interventions) were both included in the meta-analysis. Our meta-analysis adds to the evidence-base that prevention of STBs at schools are associated with small effect sizes for both suicidal ideation (pooled Hedges' $g = 0.15$, $p = .001$) and suicidal behaviors (pooled Hedges' $g = 0.30$, $p < .001$) that are statistically significant directly after the intervention's completion. Multivariate meta-regression analyses indicated that studies that were specifically aimed at targeting STBs had a significantly lower effect size for SA ($b = -0.87$, $p = .002$). Yet, there was only one primary study that examined an intervention that did not aim to target STBs primarily. The multivariate meta-analyses with only the studies that focused specifically on STBs was, albeit reduced, still significant for SA (pooled Hedges' $g = 0.23$, $p < .001$). At the 3 - 12 months follow-up, we found that effects of school-based prevention were slightly higher for SI ($g = 0.22$, $p = .01$) and similar for SA ($g = 0.30$, $p < .001$). Unfortunately, most studies did not include a longer-term follow-up (> 10 years) and the only publications that did report on longer-term follow-ups were based on the same study.

It should be noted that the meta-analysis which was based on post-test assessments showed a substantial amount of heterogeneity (i.e. great dispersion about the pooled effect size). Meta-regression was used to verify whether this heterogeneity could be explained. However, meta-regression analyses did neither indicate that the magnitude of the effect sizes at post-test co-varied systematically with the quality or publication year of the primary studies, nor could heterogeneity be explained by whether a multimodal or single preventive strategy was studied.

4.2. Strengths and limitations

A strength of the current study is that we did not only include interventions which were solely designed to target STBs. Studies that could have potential beneficial effects on STBs – upstream interventions - as they target risk factors (e.g. depression or stigma prevention) were also included in this meta-analysis even though they have been left out of previous reviews. As such, this study provides a better overview of school-based programs that are potentially beneficial for reducing STBs than previous reviews have done.

Several limitations of the current meta-analyses should be noted. The

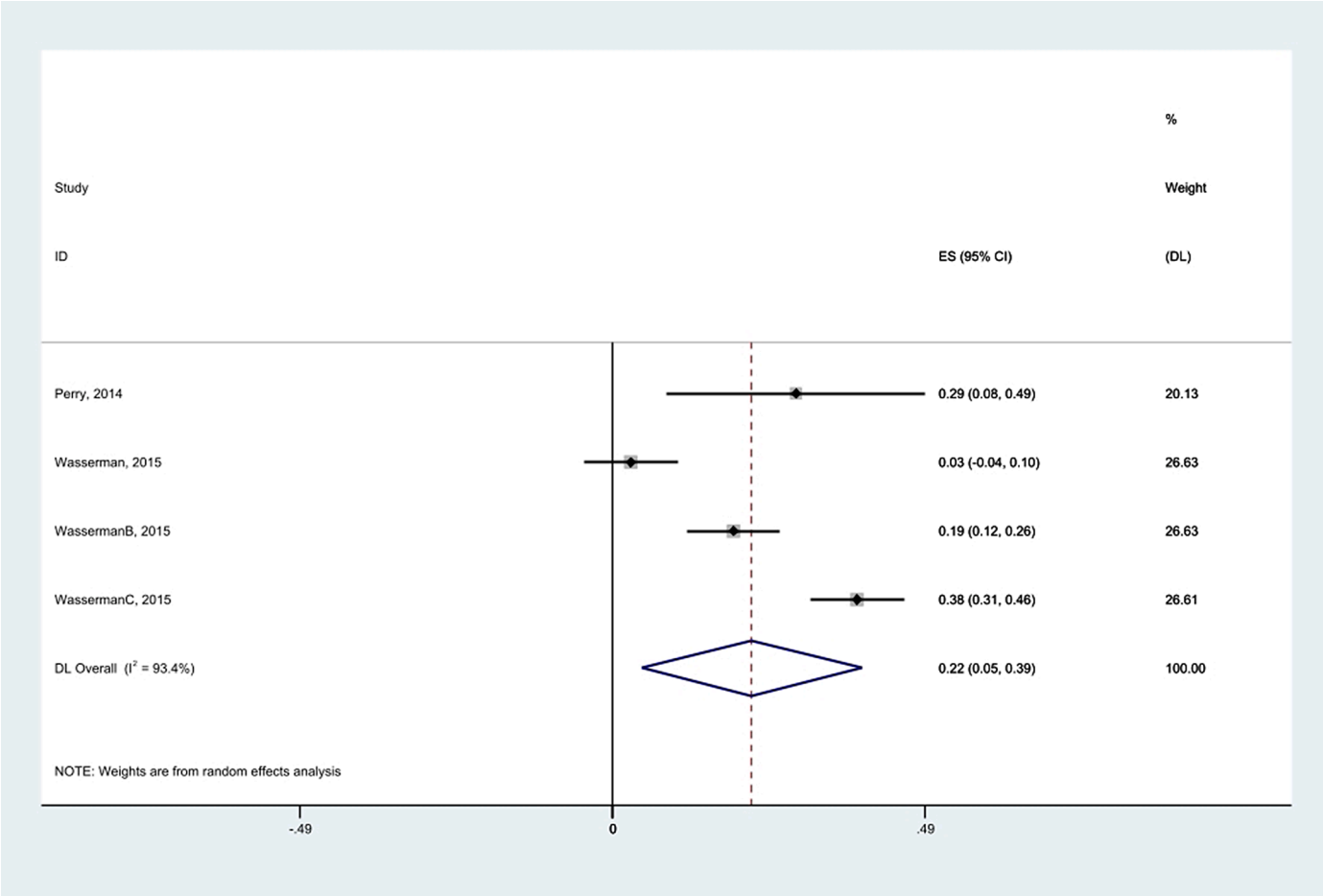

Fig. 6. Forest plot of included studies on suicidal ideation follow-up.

search strategy was limited to Dutch and English language articles and seven studies were excluded because they published in other languages. Additionally, our funnel plot suggested some publication bias, but the fill and trim procedure did not yield any different outcomes. Also, there was substantial heterogeneity as both the measurements of STBs and delivery or type of interventions differed greatly between the primary studies. There is no standardized measurement of STBs and researchers are also still struggling with a clear definition of STBs (Nock et al., 2008). The included studies evaluated outcomes, such as presence of suicidal ideation, number of attempts or questionnaires on STBs. Therefore, we decided to dichotomize outcomes into suicidal ideation and suicidal behaviors. As these constructs (SI and SB) are correlated and measured among the same participants, a multivariate meta-analysis was conducted as this takes into account that constructs are not independent (White, 2011). Furthermore, the outcome measures were also heterogeneous, which may indicate that studies possibly did not measure exactly the same construct. To illustrate, Wasserman et al. (2015) measured suicidal ideation by asking about thoughts and making plans, while other studies only ask about thoughts and not about making plans (for example Wilcox et al., 2008). As such, several studies measured ideation, but this does not mean their constructs are identical. Also, often singular items are commonly used in studies to assess presence of ideation of behaviors. Therefore, it is unclear if these measures are validated for young participants. Additionally, the time period for questionnaires differed between outcome measures. For suicidal ideation recall periods of two weeks, three months, the past year or lifetime were used across studies. This may be problematic as prior research has shown recall bias among youth populations, where especially those with lower rates of prior suicidal ideation in the past were prone to forget about the suicidal ideation they reported six year prior (Klimes-Dougan et al., 2007). However, this study also indicated that accuracy for suicidal behaviors (e.g. attempts) was mostly accurate and only one study (Wilcox et al., 2008) used a lifetime measure for suicidal ideation. Additionally, with regards to outcome measures, most studies used a single item measurement for either suicidal ideation or suicidal behaviors. The single-item measurement is relatively common in research about suicidal thoughts or behaviors (Nock et al., 2008; Millner et al., 2015). Yet, a study by Millner et al., (2015) found this led to misclassification (false positives and false negatives) and therefore may lead to a misinterpretation of results. All in all, this further underlines the importance of using validated and standardized measurements for both adult and youth populations in future research (Batterham et al., 2015; Robinson et al., 2018).

Only three studies with a focus on potential risk factors (i.e. upstream interventions) for STBs could be identified in our search. These were studies with relatively small sample sizes. However, the quality of all three studies was high. As such, conclusions on up-stream interventions should be interpreted with caution and considered preliminary.

Here, we should also reiterate that the scope of the meta-analysis was perhaps somewhat narrowly focussed on preventive interventions that could impact on STBs severity in a target population of school-going adolescents. This is important as this meta-analysis is only able to make conclusions about preventing adolescent STBs via school-based preventive interventions.

4.3. Findings in context

Previous reviews have often identified screening (with referral) and

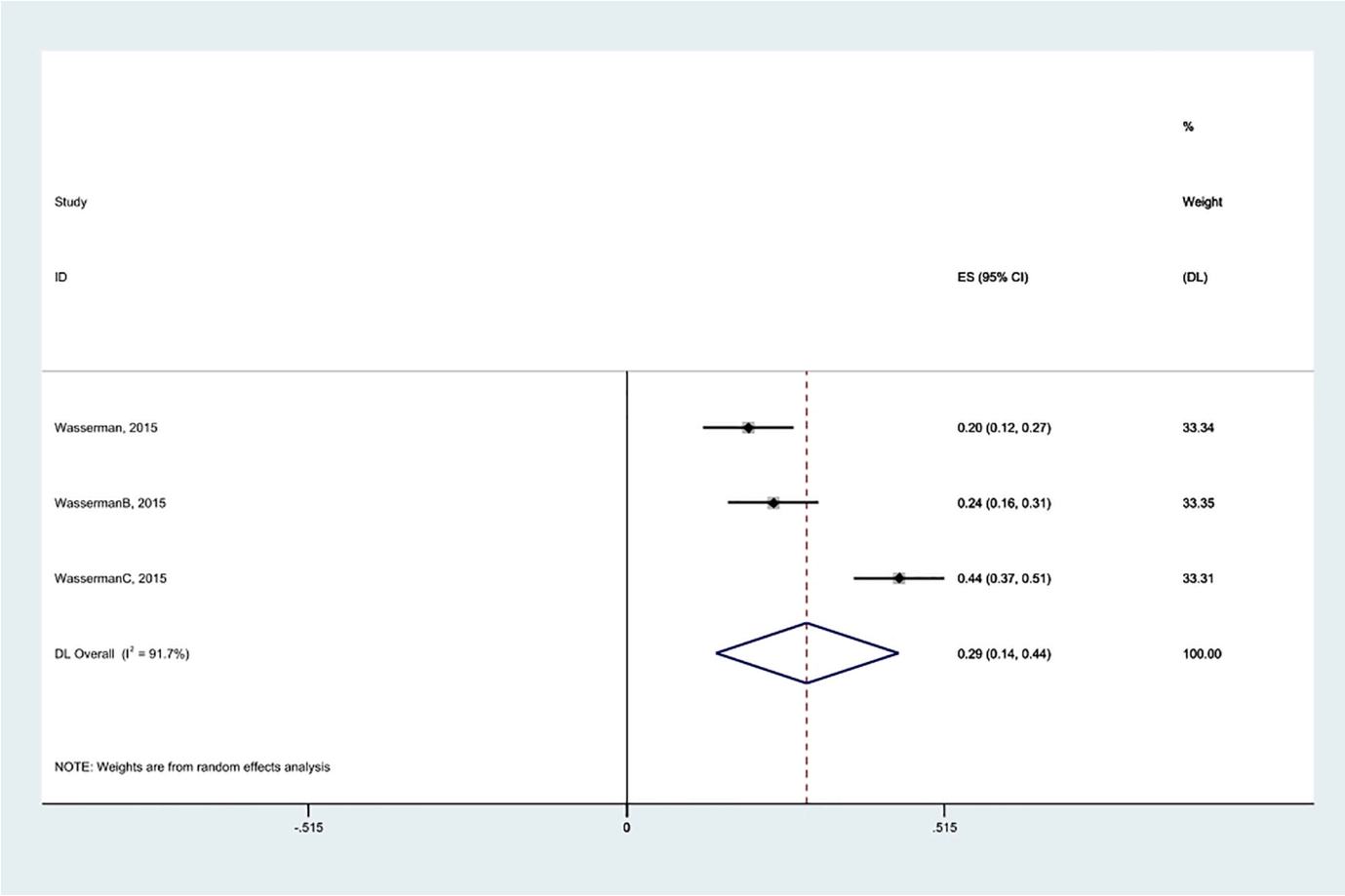

Fig. 7. Forest plot of included studies on suicidal behaviors follow-up.

gatekeepers' training as the most promising strategies for school-based suicide prevention (Cooper et al., 2011; Cusimano and Sameem, 2011; Kalafat, 2003; Katz et al., 2013; Miller et al., 2009; Robinson et al., 2018, 2013). Most of the studies assessing screening and gatekeepers' training could not be included in the current review, because these studies did not measure their effectiveness on STBs. Rather, they included more indirect measurements of STBs, such as psychological distress, knowledge, attitudes and so on. Yet, this alone does not necessarily indicate effectiveness on STBs. Nonetheless, the current search yielded one study (Wasserman et al., 2015) that tested both the effect of screening and looked (apart) at the effect of the gatekeepers' training on direct measures of SI and SBs. Wasserman et al. (2015) found positive effects of both screening combined with active referral and the gatekeepers' training, which is promising. More studies should consider examining the specific effects of both screening plus referral and the gatekeepers' training, specifically on STBs in a population that does not consist solely of the gatekeepers themselves before statements about their efficacy on a school-going population can be made.

In our review, the pooled effect size for SBs was slightly larger than the pooled effect size for SI, indicating that school-based preventive strategies are seemingly more effective in reducing SBs than SI. However, fewer studies were included that measure SBs than SI. Ideation is often a precursor to behavior and the several ideation-to-action frameworks suggest that a person needs to overcome a certain threshold to progress to suicidal behaviors (Klonsky et al., 2018). Ideation, on the other hand, has often been present for longer and might be more internalised over time. Therefore, it might take longer for suicidal ideation to lower. This is supported by the results of the current meta-analyses considering the effect size for the short-term follow-up for SI was slightly larger than at post-test. For instance, a study by Kyron et al. (2019) found that about half of adult patients with high baseline levels of SI, where likely to still have high SI after treatment. It is important to determine whether and which baseline characteristics might be associated with delayed reductions in SI, as the current study could not.

Previous reviews have furthermore concluded that combining several strategies could increase efficacy (Katz et al., 2013). Our study indicated that effect size was not modified by type of intervention (multimodal versus singular) for SI at post-test, meaning that both might be equally effective in prevention of SI. On the other hand, for SB we found that multimodal intervention strategies had a slightly lower effect size compared to singular interventions. However, any analyses regarding moderation should be interpreted with caution as only few studies were included.

4.4. *Implications for school-based prevention of STBs*

School-based prevention of STBs shows promising results within three months post-interventions and possibly could have effects that are sustained over time. Thus, schools can implement suicide prevention strategies.

Suicide prevention is not an easy topic for implementing strategies within a school-setting. Schools fear opposition from parents (Whitney et al., 2011) about implementing strategies that delve into suicidal behaviors. Previous studies into acceptability of suicide prevention program at schools have found that schools prefer curriculum-based programs over screening measures as this requires reliance on people outside the school-environment, such as a MDs, psychologists or nurses (Eckert et al., 2003; Miller et al., 1999; Scherff et al., 2005). Schools have described screening measures as 'intrusive' (Scherff et al., 2005).

Schools rate the gatekeepers' training programs for suicide prevention as most acceptable (Scherff et al., 2005) even though evidence regarding the effect of implementing a gatekeepers' training at schools on reducing STBs in adolescents is still lacking so far. Moreover, a recent survey in the UK shows that only one fifth of trainees found the training useful in practice (Evans et al., 2019). Another reason why schools may find it hard to implement suicide prevention programs is that schools believe that talking about suicide might induce suicidality in their students, or encourage suicidal thoughts and behaviors (Evans et al., 2019). For example, one of the excluded studies on prevention in schools reported that a school decided to omit any questions relating to STBs after more students than expected scored high for STBs on a screening (Hallfors et al., 2006). Scholars have actually found that screening of suicidal thoughts and behaviours has no iatrogenic effects (Gould et al., 2005). In fact, they have found that suicide items in questionnaires or assessing presence of STBs does not cause extra strain or distress among participants, even youth. Moreover, it has been shown that students are fine with completing questionnaires about self-harm, which can be considered an STB, and understand the added value these questionnaires could have (Lockwood et al., 2018).

Interestingly, our study also indicated that the primary aim of the preventive strategy does not need to be a reduction of STBs; interventions that target risk factors (i.e. "upstream interventions") seem to be equally effective in reducing suicidal ideation within three months. Risk factors that upstream intervention that could be targeted included in the current study were depression or internalizing problems, and mental health literacy. However, only two studies with a reported outcome of SI could be included and thus results should be considered preliminary and interpreted with caution.

For suicidal behaviors, we noted that there was only one primary study (Britton et al., 2014) that examined an intervention that was not specifically targeted at suicidal behaviors, but rather stress reduction in general. Results indicated that the pooled Hedges' g was significantly reduced when not including this study (pooled Hedges' g remaining studies = 0.23, $p = .001$). Based on one study, no conclusion can be drawn whether upstream interventions might be more, less or equally effective in reducing suicidal behaviors. Important risk factors of SI and SA that could be of interest are worrying and/ or rumination (Kerkhof and van Spijker, 2011), resilience (O'Connor and Kirtley, 2018), and entrapment (O'Connor and Kirtley, 2018). Implementing upstream interventions might increase feasibility of school-based projects that could reduce SI as acceptability of less sensitive topics is higher among school administrations. However, more research is needed to examine whether interventions that target these risk factors indeed reduce suicidal ideation or suicidal behaviors.

4.5. Implications for future research

The implications of adding upstream interventions are also important for how future studies are designed. Unfortunately, the current study was not able to include many studies that were aimed at reducing risk factors for STBs, and also included measurements on STBs ($N_{SI} = 2$ and $N_{SB} = 1$). To illustrate, most studies that investigated preventive strategies for depression, one of the most important risk factors for the development of STBs in adolescents (Runeson et al., 1996), had to be excluded for not including direct suicide-related outcomes (Barry et al., 2017; Burns and Hickie, 2002; Merritt et al., 2007; Michael et al., 2016; Tak et al., 2016; Wong et al., 2012). Some studies described that they excluded the suicide-item(s) in questionnaires as they were concerned these items might be too straining on their participants (Gillham et al., 2012, 2006; Kowalenko et al., 2005; Rooney et al., 2013; Shochet et al., 2001) or they excluded youth that already reported presence of STBs (Bella-Awusah et al., 2016). Yet, as previously mentioned screening of suicidal thoughts and behaviours has no iatrogenic effects (Gould et al., 2005). There is no need for researchers to hesitate about including suicide-related measurements, when they are studying intervention that target known risk factors of STBs. Therefore, more studies that investigate interventions that target known risk factors for STBs should consider including measures of STBs.

In addition, studies should extend their follow-up measurements to at least 12 months but preferably more as there were few studies that included long-term follow-up, which makes it questionable if the so called preventive interventions did indeed prevent or at least substantially delay onset of STBs or just reduced STBs severity momentarily. Moreover, it is unknown whether deaths by suicide are prevented as most studies do not measure suicides considering it is statistically a rare event among youth and as such most studies are underpowered to find an effect on suicides.

In conclusion, school-based prevention programs show small effects in reducing both SI and SA at the short-term . More research that focuses on known risk factors of STBs should include suicide-related measures. Also, studies need to include longer-term follow-up in their design.

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CRediT authorship contribution statement

Mandy W.M. Gijzen: Investigation, Data curation, Software, Formal analysis, Writing – original draft. **Sanne P.A. Rasing:** Data curation, Software, Supervision. **Daan H.M. Creemers:** . **Rutger C.M.E. Engels:** . **Filip Smit:** Supervision.

Declaration of Competing Interest

The authors have no financial conflicts of interest to declare.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2021.10.062.

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