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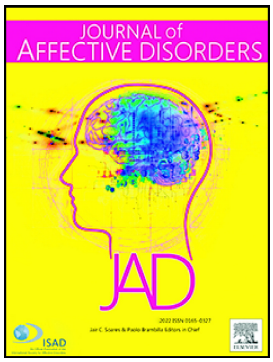

Association between childhood cognitive skills & adult suicidal behavior: A systematic review and meta-analysis

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Association between Childhood Cognitive Skills & Adult Suicidal Behavior: A Systematic Review and Meta-Analysis.

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ABSTRACT

Background: It is unclear whether cognitive skill deficits during childhood carry risk for suicide attempt or mortality later in adulthood at the population level. We conducted a systematic review and meta-analysis of population-based studies examining the association between childhood cognitive skills and adult suicidal behavior, namely attempt and mortality.

***Method*:** We systematically searched databases for articles then extracted study characteristics and estimates on the association between childhood cognitive skills (i.e., IQ or school performance at age ≤18 years) and later suicide attempt and mortality. Random-effect meta-analysis was used to quantify this association across all studies with available data.

***Results*:** Twenty-three studies met the inclusion criteria and suggest an association between lower childhood cognitive skills and increased risk of suicidal behavior. Meta-analysis of the adjusted estimates from 11 studies (N=2,830,191) found the association to be small but statistically significant. Heterogeneity was significant but moderate, and results were unlikely to be influenced by publication bias. In subgroup analyses, associations were significant only for males. No difference in effect size was found between suicide attempt and suicide mortality.

Limitations: Cognitive skills were measured with different cognitive subtests. Heterogeneity in the age of cognitive skills assessment. Meta-regression and subgroup analyses were based on a relatively low number of studies.

Conclusions: Individuals with lower cognitive skills in childhood have a greater risk of suicidal behavior in adulthood, especially males. Although the association was small, interventions improving cognitive skills may yield large effects on suicide prevention at the population level if the association is causal.

Keywords: Suicide attempt, suicide, cognitive skills, IQ, school performances, meta-analysis.

INTRODUCTION

Cognition deficits are involved in the diathesis of suicidal behavior (i.e., behaviors that may result in ending one's life, whether fatal or not) (Turecki et al. 2014; Fernandez-Sevillano et al., 2021; Richard-Devantoy, Berlim, et al., 2014) with several studies reporting that individuals who attempted suicide showed worse performance on cognitive control, decision-making, and verbal fluency tests compared to those who did not attempt suicide (Keilp et al., 2008; Keilp et al., 2001; Richard-Devantoy et al., 2012; Richard-Devantoy et al., 2016; Richard-Devantoy, Szanto, et al., 2014). These cognitive differences may be a consequence of the suicide attempt or of depressive episodes. However, some evidence suggests that they may be present before the attempt and may even have a neurodevelopmental origin (Bridge et al., 2012; Ruch et al., 2020), which has important implications for the understanding of the etiology of suicide and its early prevention.

Previous longitudinal studies have investigated the association between cognitive skills in childhood/adolescence and subsequent suicide attempt (define as "an act in which a person harms himself or herself, with the intention to die, and survives") or suicide (defined as "an act resulting in death which is initiated and carried out by an individual to the end of the action, with the knowledge of a potentially fatal result") (De Leo D et al. 2021) in adulthood using population-based samples (Alaraisanen et al., 2006; Andersson et al., 2008; Bjorkenstam et al., 2010; Geoffroy et al., 2014; Gunnell et al., 2011). The results of these studies are conflicting; while one study from the UK found no association between intelligence quotient (IQ) and adult suicide (Richard-Devantoy et al., 2021), another study from Sweden found that lower childhood IQ was associated with an increased risk of suicide in adulthood (Sorberg Wallin et al., 2017). As a result, it is unclear whether an association

exists between cognitive skills and suicidal behavior over and beyond the heterogeneity of the individual studies.

Additionally, prior studies did not substantially address sex differences in the association between cognitive skills and suicide risk. The few studies that have separately investigated males and females, suggest an association between impaired cognition and suicidal behavior for males, but findings for females are inconsistent (Gunnell et al., 2011). This may be due to several factors, including the lower prevalence of suicide mortality in females than males, the fact that the largest studies on this topic relied on samples from military conscripts (Batty et al., 2010; Gravseth et al., 2010; Gunnell et al., 2005; Osler et al., 2008; Sorberg, Lundin, et al., 2013; Webb et al., 2010; Weiser et al., 2015), as well as the lack of subgroup analysis reported in previous studies (Andersson et al., 2008; Bjorkenstam et al., 2010; Gravseth et al., 2010; Gunnell et al., 2011; Sourander et al., 2009). Yet, given the important sex dimorphism in suicidal behavior, it is important to understand if associations between cognitive skills and suicidal behavior vary across sexes.

Finally, several studies reported that increased IQ was associated with increased risk of suicide among individual with psychosis (Alaraisanen et al., 2006; Andersson et al., 2008; Webb et al., 2010; Weiser et al., 2015). This represents an opposite trend compared to that observed in the general population, where lower IQ was generally associated with increased suicide risk (Alati et al., 2009; Batty et al., 2010; Osler et al., 2008; Sorberg, Allebeck, et al., 2013). For example, in individuals with depression, a well-known risk factor for suicide, the association between IQ and suicidal behavior follows the same pattern as the general population (Hansson Bittar et al., 2019; Lesage et al., 1994; Park et al., 2015), with increased risk for those with lower IQ. Although the literature on the associations between cognitive skills and suicidal behavior in individual with psychopathology is limited, some evidence

suggests that psychosis, but not other forms of psychopathology, may have an important role in the association between childhood cognitive skills and later suicidal behavior.

The objective of this study was to conduct a systematic review and meta-analysis of longitudinal population-based studies investigating the association between childhood (≤18 years) cognitive skills and suicidal behavior in adulthood. We also aimed to clarify whether 1) associations are the same for male and female individuals, and 2) whether similar associations are found for individuals with psychosis.

METHODS AND MATERIAL

Data sources

We conducted a systematic literature search of MEDLINE, Embase, and PsycInfo databases for studies published from January 1st, 1960 to December 31st, 2020. The Medical Subject Heading (MeSH) terms "suicide", “attempted suicide” and “completed suicide” were combined with the MeSH terms "intelligence tests", "academic performance”, and “educational measurement”, and with the Title/Abstract (TIAB) terms “Suicide” and “Intellectual Quotient”, “Intelligence Quotient”, “Intelligence”, “Intellectual ability”, “Academic performance”, “Academic outcome”, “School performance”, “School grades”, “Mathematics”, “Reading” “Wechsler Intelligence Scale for Children”, “WISC”, “Adapted Test for Everyday Attention for Children”, “Raven’s Standard Progressive Matrices”, “Wide Range Achievement Test”, WRAT3, and “OTIS intelligence test”. In addition, reference lists of the selected papers were manually searched to identify additional potential studies.

Study selection

Studies that met the following criteria were included: 1) published in a peer-reviewed journal in English or French; 2) included at least one measure of cognitive skills assessed as either IQ or academic performance (which is usually used as a proxy for IQ; no exclusion criteria on the measure of academic performance was set); 3) included participants with a maximum mean age equal to 18 years at the time of cognitive skills evaluation; 4) assessed suicidal behavior (suicide attempt or suicide) in adulthood (> 18 years old) as outcomes; and 5) were population-based longitudinal studies. For this review, a suicide attempt was defined as any act carried out with a certain intent to die, distinct from non-suicidal self-injury (Mann, 2003).

Studies focusing on suicidal ideation were not considered, as suicidal ideation is considered a different – although related – entity from lethal and non-lethal suicidal behavior (Gunnell et al., 2005), with many studies finding differences between the two (Brokke et al., 2020; Burton et al., 2011; Stewart et al., 2017). Additionally, the assessment of suicidal ideation is often very heterogeneous, with studies not consistently distinguishing between passive suicidal ideation, active suicidal ideation, and suicide plan, thus potentially creating substantial heterogeneity.

Abstracts identified through the literature search were independently screened by two reviewers (IBA and SRD) and discrepancies were resolved with a consensus from all authors. Studies not excluded at this stage were retrieved for full-text review, and were independently assessed against the inclusion criteria.

Quality assessment

Quality of the included studies was evaluated by two reviewers (SRD and IBA) using the Newcastle-Ottawa Scale (NOS) for observational studies (The Ottawa Research Institute, 2014). The NOS consists of 8 items, which are grouped into three categories: selection of the study groups; comparability of the groups; and ascertainment of the exposure or outcome. The scale uses a "star system" in which items meeting the quality criterion earn one star, except for the comparability item, which can get up to two stars.

Data extraction

A standardized form was used to extract data, which included authors, date of publication, settings, sex of the study participants, outcomes (suicide and/or suicide attempt), and measure of cognitive skills (IQ or school performance). We also extracted the adjusted estimates for the association between cognitive skills and suicidal behavior for the quantitative analysis.

Data analysis

First, a narrative synthesis approach was used to provide a description and overview of all included studies. Second, we performed meta-analysis to estimate a common effect size across studies. To harmonize the exposures, we calculated the effect size for the association between each 1-SD lower cognitive skills (i.e., IQ or school performance) and suicidal behavior. All effect sizes were converted into Cohen's d using standard formulas, whenever necessary (see details in Supplemental material). For studies based on the same sample, we selected the study having the largest sample, the longest follow-up, and assessing suicide (vs suicide attempt) for the primary analysis. We calculated pooled d with 95% CI using random-effect models with Restricted Maximum Likelihood estimator to account for the likely variations of true effect sizes among the included studies (Riley et al., 2011). The obtained effect sizes are usually considered small if <0.3, moderate if comprised between 0.4 and 0.8, and large if >0.8 (Egger et al., 2001). We considered adjusted estimates (i.e., obtained using multivariable models accounting for potential confounding factors), given that previous studies found that socioeconomic, family-level, and individual-level variables may confound the association between cognitive skills and suicidal behavior (Richard-Devantoy et al., 2021). The result of the meta-analysis was represented graphically using a forest plot. Heterogeneity across studies was assessed using the Cochrane Q statistic, and the I^2 statistic (higher values representing higher heterogeneity) (Cooper et al., 2009). We used meta-regression and subgroup analyses to explore multiple potential sources of heterogeneity: sex (males vs females), suicide outcome (suicide mortality vs attempt), maximum age at outcome assessment (>35 years, ≤35 years), age at cognitive skills assessment (>16 years, ≤16 years), and study quality (continuous variable). Risk of publication bias was assessed by visual inspection of the funnel plot, and by using both the Egger test (Egger et al., 1997) and the trim-and-fill method (Duval & Tweedie, 2000). Finally, we conducted a leave-one-out

analysis, in which the pooled estimated was calculated by excluding one study at the time, to investigate whether the exclusion of one study would lead to different conclusions (suggesting that this single study was driving the pooled estimate). Analyses were conducted using R version 4.0.5 and the *metafor* package (Viechtbauer, 2010).

RESULTS

Selection and Inclusion of Studies

After removing duplicates, a total of 1,936 articles were identified as potentially eligible for this study. Following abstract and title screening, 60 studies were selected. Of those, 23 met the final inclusion criteria (**Figure 1**). Reasons for exclusion are summarized in **Figure 1**. Included studies were based on 14 unique samples (i.e., with smaller overlap) and were based on samples from Sweden (35.7%), the UK (12.3%), Finland (12.3%), Israel, the US, Australia, Denmark, and Norway (7.1% each).

Although all studies were drawn from the general population, 10 studies out of 23 investigated association among male military conscripts (**Table 1**) (Batty et al., 2009; Batty et al., 2010; Gravseth et al., 2010; Gunnell et al., 2005; Hansson Bittar et al., 2019; Osler et al., 2008; Sorberg, Allebeck, et al., 2013; Webb et al., 2010; Weiser et al., 2015; Werbeloff et al., 2009). Therefore, studies reporting associations for males outnumbered those reporting associations for both sexes (12 studies provided associations for males only, 5 for males and females separately, 7 for males and females combined without stratification by sex).

Quality Assessment

Most of the articles scored 6 or more (out of nine) on the NOS (**Table S1**). Some quality limitations include self-reporting of suicide attempt outcome (3/23, 13%) and high attrition rate (4/23,17.4%).

Measures of Suicide and Cognitive Skills

Different measures of IQ and school performances were used across studies (**Table 1**). For IQ, measures included: Progressive Matrices such as Raven's, Moray House test number 12 (i.e., a 71-item evaluation assessing verbal and non-verbal reasoning ability), Wechsler Scales or uniquely a modified version of the 'similarities' subtest of the Wechsler Intelligence Scales (assessing verbal comprehension). For school performance, measures

include school grades from national registers, Wide Range Achievements Tests, assessments of mathematics and reading skill, the Boerge Prien's test, and the grade-point averages (GPA).

Risk of Suicide Attempt and Suicide: narrative synthesis

Ten studies investigated the association between cognitive skills and suicide attempt (Alati et al., 2009; Batty et al., 2010; Hansson Bittar et al., 2019; Kosidou et al., 2013; Kosik et al., 2017; Osler et al., 2008; Sorberg, Allebeck, et al., 2013; Sorberg Wallin et al., 2020; Sorberg Wallin et al., 2017; Sourander et al., 2009), while 16 studies investigated the association with suicide mortality (Alaraisanen et al., 2006; Andersson et al., 2008; Batty et al., 2009; Bjorkenstam et al., 2010; Calvin et al., 2017; Geoffroy et al., 2014; Gravseth et al., 2010; Gunnell et al., 2011; Gunnell et al., 2005; Hansson Bittar et al., 2019; Richard-Devantoy et al., 2021; Sorberg, Allebeck, et al., 2013; Sourander et al., 2009; Webb et al., 2010; Weiser et al., 2015; Werbeloff et al., 2009).

Seven out of 10 studies reported an association between lower childhood cognitive skills and increased risk of suicide attempt in adulthood (Alati et al., 2009; Batty et al., 2010; Hansson Bittar et al., 2019; Kosidou et al., 2013; Osler et al., 2008; Sorberg, Allebeck, et al., 2013; Sorberg Wallin et al., 2017), while three studies did not find evidence for this association (Kosik et al., 2017; Sorberg Wallin et al., 2020; Sourander et al., 2009). Sorberg Wallin et al. (2020) and Sorberg Wallin et al. (2017) found that attained education and GPA, respectively, mediated the association between IQ and suicidal behavior (see **Table S2** for a summary of mediators, moderators, and confounding factors investigated in the included studies).

Similarly, 13 out of 16 studies reported that lower cognitive skills were associated with increased risk of suicide mortality (Alaraisanen et al., 2006; Andersson et al., 2008; Batty et al., 2009; Bjorkenstam et al., 2010; Calvin et al., 2017; Gravseth et al., 2010;

Gunnell et al., 2011; Gunnell et al., 2005; Hansson Bittar et al., 2019; Sorberg, Allebeck, et al., 2013; Webb et al., 2010; Weiser et al., 2015; Werbeloff et al., 2009), while the remaining three studies did not support this association (Geoffroy et al., 2014; Richard-Devantoy et al., 2021; Sourander et al., 2009). Similarly, to the previously discussed studies, Gunnel et al. (2005) also found educational attainment to be a mediator for this association. Partial mediating effect by SES and smoking status were also reported (Batty et al., 2009; Calvin et al., 2017; Hansson Bittar et al., 2019). Additionally, a significant mediating effect by early childhood cognitive and emotional factors was found in studies based on the 1958 British Birth Cohort (Geoffroy et al., 2014; Richard-Devantoy et al., 2021). Finally, Weiser et al. (2015) found a moderating effect of proximity to last hospitalization on the association between premorbid IQ and suicide mortality.

A study found a linear dose-response association between lower cognitive skills and increasing risk of both suicide and suicide attempt (Sorberg, Allebeck, et al., 2013). Additionally, when several potentially confounding variables, including indicators of childhood social circumstances, parental characteristics, and children characteristics (Werbeloff et al., 2009), were accounted for in the analyses, associations were reduced in size but showed the same direction and significance.

In studies that conducted conducting stratified analyses by sex, associations were mainly found in males but not in females. A few studies specifically explored associations for males and females separately (Andersson et al., 2008; Bjorkenstam et al., 2010; Gravseth et al., 2010; Gunnell et al., 2011; Sourander et al., 2009), with contradictory results. For example, some studies found that lower cognitive skills were found to be associated with increased risk of suicide in males but not females (Andersson et al., 2008; Gravseth et al., 2010; Gunnell et al., 2011; Richard-Devantoy et al., 2021), while others found similar

associations in males and females (Bjorkenstam et al., 2010; Gravseth et al., 2010). It is worth noting that 10 studies were based on male only samples, such as military conscripts.

Five studies conducted subgroup analyses among individuals with psychosis (Alaraisanen et al., 2006; Andersson et al., 2008; Batty et al., 2010; Webb et al., 2010; Weiser et al., 2015), reporting different results compared to those for the general population. Specifically, one study reported that for individuals with psychosis there was no association between cognitive skills and suicide attempt (Batty et al., 2010), while four studies reported that higher cognitive skills were associated with increased risk of suicide in this subpopulation (Alaraisanen et al., 2006; Andersson et al., 2008; Webb et al., 2010; Weiser et al., 2015).

Meta-Analysis

After the exclusion of studies based on the same sample and articles not reporting suitable data (e.g., studies reporting associations for categories of IQ such as low, normal, and high, instead of continuous values), 11 studies were selected for the meta-analysis (Alati et al., 2009; Andersson et al., 2008; Bjorkenstam et al., 2010; Calvin et al., 2017; Gravseth et al., 2010; Gunnell et al., 2005; Kosik et al., 2017; Osler et al., 2008; Richard-Devantoy et al., 2021; Sorberg Wallin et al., 2020; Weiser et al., 2015), including a total of 2,830,191 individuals (≥2,324,830males and ≥495,502 females; note that one study did not report the exact sample size by sex). All these studies assessed IQ except for one (Bjorkenstam et al., 2010) that assessed school performance. As shown in **Figure 2**, the pooled association between cognitive skills and suicidal behavior (combined suicide and suicide attempt) revealed a statistically significant association of small effect size (d for 1 SD lower cognitive skills = 0.13, CI = 0.09-0.17).

Heterogeneity was moderate (I^2 = 61.4%) with a significant heterogeneity test (Q =

30.6, df = 10, p < 0.001). The Funnel Plot was reasonably symmetrical (**Figure 2**), and the Egger regression intercept test was not statistically significant (z = 0.16, p = 0.872), supporting our visual inspection. The Trim & Fill analysis did not detect any missing studies (SE = 2.06), suggesting that publication bias was unlikely to influence our results. Finally, the leave-one-out analysis suggested that results were not influenced by any one of the included studies (**Table S3**).

We investigated sex differences using meta-regression (**Table 2**). Although this analysis did not suggest statistically significant differences in the estimates of the association between cognitive skills and suicidal behavior between sexes (p = 0.221), subgroup analysis showed a significant association for males only (n = 9 studies; N = 2,324,830; d = 0.15, CI = 0.10-0.20), and not for females (n = 4 studies; N = 495,502; d = 0.07, CI = -0.07-0.21), with an effect size twice as large in males than in females. We found no evidence of a moderation effect of study outcome (p = 0.618), with subgroup analyses showing similar effect sizes for studies considering suicide attempt (n = 4; d = 0.16, CI = 0.11-0.21) and those considering suicide mortality (n = 9; d = 0.13, CI = 0.09-0.18) as an outcome. The estimate reported in the study assessing school performance (d = 0.18, CI = 0.16-0.18; (Bjorkenstam et al., 2010)) was similar to the estimates reported in the other studies, and excluding this study from the meta-analysis did not change the results (d = 0.11; CI = 0.07-0.15). Finally, meta-regressions revealed no differences of effect size related to the maximum age at outcome assessment (p = 0.530), the age at cognitive skill assessment (p = 0.469), and the studies' methodological quality (p = 0.281).

DISCUSSION

Summary of the main findings

To our knowledge, this is the first systematic review and meta-analysis on the association between childhood cognitive skills (operationalized as IQ and school performance measures) and adult suicidal behavior. We found that most studies provided evidence of an association between lower cognitive skills and increased risk of suicidal behavior (both suicide attempt and mortality), with meta-analytic effect size (based on 11 studies) showing that this association was statistically significant. Available evidence also suggests that this association may be restricted to males only, although few studies on females were available. Furthermore, studies conducting analyses among individuals with psychosis suggested that the association was in the opposite direction compared to the general population (i.e., higher IQ was associated with increase suicide risk among individuals with psychosis).

Mechanisms explaining the association

Several mechanisms may explain the association between cognitive skills and suicidal behavior. The most supported one involves the link between problem solving and suicide risk (Pollock & Williams, 2004), suggesting that individuals with lower cognitive resources may be less equipped to cope with distress (Gunnell et al., 2005). Reduced cognitive flexibility to contrive alternate ways of solving problems may leave these individuals more vulnerable to stressful situations, and therefore increase their risk of suicidal thoughts and behavior. In line, previous work has documented that individuals with lower IQ experienced suicidal thoughts for longer periods of time and were more likely to act on their suicidal thoughts (Gunnell et al., 2009), suggesting that lower IQ may interfere with the generation of alternative solutions to address problematic situations, which in turn leaves individuals contemplating the idea of suicide for extended periods of time. This is consistent with the abundant literature on the association between problem solving

and suicidality, as well as on experimental evidence suggesting that increasing problem solving skills may reduce risk of suicidal behavior (Gustavson et al., 2016). Some authors have similarly suggested that the persistence of disruptive negative thoughts is controlled through a "pathoplastic" effect (Barnett et al., 2006), that would make individuals with higher intelligence more resilient to stress (Gale et al., 2008; Masten et al., 1995). This theory is consistent with evidence suggesting that lower intelligence may reflect problems in brain development that precede the onset of psychiatric disorders (Armstrong et al., 2012; Koenen et al., 2009). Evidence supporting the neurodevelopmental origins of psychopathology, notably for depression, schizophrenia, as well as suicide, are well documented (Ansorge et al., 2007; Orri et al., 2019).

Finally, lower IQ can be associated with risk factors for suicidal behavior such as social and financial disadvantages later in life (Karnehed et al., 2015). For example, in Sweden, it has been previously shown that cognitive deficits in late adolescence are associated with having a disability pension. In turn, financial problems and social marginalization may increase for the risk of suicidal behavior (Barnett et al., 2006; Sorberg, Lundin, et al., 2013).

Sex differences

An important limitation in the current literature is the disparity between articles examining the association between cognitive skills and suicidal behavior in men and those examining this association in women, with men being disproportionately represented in the included studies. One of the reasons for this is that an important proportion of the longitudinal research on suicide has been conducted using nationwide registers in the Scandinavian countries (especially Sweden) with IQ data available for military conscripts (Batty et al., 2010; Gravseth et al., 2010; Gunnell et al., 2005; Osler et al., 2008; Sorberg, Lundin, et al., 2013; Webb et al., 2010; Weiser et al., 2015). However, until recently, conscription was compulsory for men only, which results in lack of data for women. Nevertheless, relying on meta-analysis, we were able to test the association between cognitive skills and suicidal behavior in a sizable proportion of women. These analyses suggest that increased risk of suicidal behavior for individuals with lower IQ may be restricted to men only.

Opposite sex ratios in the frequency of suicide attempt (more frequent in females) and mortality (more frequent in males) constitutes an intriguing paradox (Hawton & van Heeringen, 2009). The scientific literature suggests that there are many brain and cognitive differences between men and women. For example, evidence shows that male and female intelligence, using IQ and fluid intelligence, were underpinned by different neurobiological correlates, which are consistent with their respective superiority in cognitive domains (i.e., visuospatial abilities for men, verbal ability for women) (Jiang et al., 2020). However, more research is needed to clarify such sex differences.

Psychosis population

Five studies conducted subgroup analyses among individuals with psychosis (Alaraisanen et al., 2006; Andersson et al., 2008; Batty et al., 2010; Webb et al., 2010; Weiser et al., 2015), reporting different results than those based on the general population. Specifically, one study reported that for people with psychosis there was no association between IQ and suicide attempt (Batty et al., 2010), while four studies reported that higher IQ was associated with increased risk of suicide in this subpopulation (Alaraisanen et al., 2006; Andersson et al., 2008; Webb et al., 2010; Weiser et al., 2015).

Research is advancing towards possible explanations for why individuals with higher IQ and a diagnosis of schizophrenia are at greater risk of suicide (Drake, 2008). For example, it was suggested that these individuals might have increased insight of their mental illness and, as a result, an intensified fear of the consequences of their illness. Higher IQ and premorbid cognitive skills may also increase the struggle for these individuals to reconcile the image of themselves as successful people, with the image of themselves as people with a mental illness. Evidence suggests that high suicide rates among college graduates diagnosed with schizophrenia were partly the result of the pressure they applied on themselves to maintain a high level of performance (Drake, 2008). The same authors proposed that people with schizophrenia and high cognitive skills might struggle to cope with the vocational losses associated with schizophrenia (downward drift hypothesis)

(Drake, 2008). Finally, people with psychotic disorders and high IQ may perceive a greater level of stigma, that may in turn act as a barrier to help seeking (Andersson et al., 2008; Webb et al., 2010; Weiser et al., 2015).

These results suggest that increased cognitive skills should be considered as a risk factor for suicide in individuals with psychosis. Psychoeducational efforts aiming at addressing stigma, help seeking, and integration of illness into individuals' identity may be helpful to prevent suicide among these individuals.

Limitations of the study

This study had several limitations that should be considered when interpreting our findings. First, cognitive skills were measured in several different ways and the psychometric properties of these assessments were not always reported. Similarly, school performance, although highly correlated with IQ, does not uniquely measure cognitive skills but also other noncognitive factors (Andersson et al., 2008; Sorberg Wallin et al., 2017). Despite these differences, our meta-analysis reported only moderated levels of heterogeneity, and no differences were observed across studies measuring cognitive skills in different ways. Another limitation is the heterogeneity in the age of cognitive skills assessment. For example, in some studies, children were assessed as young as 7, whereas in others (e.g., military conscripts) participants were assessed at age 18. However, cognitive skills are usually stable over time (Batty et al., 2007), the moderate heterogeneity of the meta-analysis suggests negligible differences across included studies, and meta-regression found no statistical evidence of age at cognitive assessment. Furthermore, meta-regression and subgroup analyses were based on a relatively low number of studies, therefore results should be interpreted with caution and the meta-analysis should be updated as soon as new studies become available. Finally, our study only focused on suicide attempt and mortality, and associations with other suicide-related outcomes (including suicidal ideation) were not investigated.

Conclusions

This systematic review and meta-analysis found evidence for an association between lower childhood cognitive skills and increased risk of suicidal behavior in adulthood, which may be restricted to male individuals. Our results have important implication for suicide prevention at the population level. Although the sizes of the associations were small, interventions aiming at strengthening cognitive skills and coping strategies may yield large effects on suicide prevention at the general population level by building resilience and reducing vulnerability to suicide. Furthermore, our results also have implications at the clinical level. Indeed, since among individuals with psychosis higher cognitive skills may be associated with increased suicide, clinicians should be aware that additional interventions may be necessary to reduce suicide risk among individuals with psychosis that have high cognitive skills and insight into their illness. Understanding the mediating and moderating factors, with future research examining large longitudinal population-based samples, can further inform the development of suicide prevention and intervention strategies.

CONFLICTS OF INTEREST

None to declare.

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REFERENCES

Alaraisanen, A., Miettunen, J., Lauronen, E., Rasanen, P., & Isohanni, M. (2006). Good school performance is a risk factor of suicide in psychoses: a 35-year follow up of the Northern Finland 1966 Birth Cohort %J Acta Psychiatrica Scandinavica. *114*(5), 357-362. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=med6&AN=17022796

Alati, R., Gunnell, D., Najman, J., Williams, G., & Lawlor, D. (2009). Is IQ in childhood associated with suicidal thoughts and attempts? Findings from the Mater University Study of Pregnancy and its outcomes %J Suicide & Life-Threatening Behavior. *39*(3), 282-293. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=med7&AN=19606920

Andersson, L., Allebeck, P., Gustafsson, J. E., & Gunnell, D. (2008). Association of IQ scores and school achievement with suicide in a 40-year follow-up of a Swedish cohort. *Acta Psychiatr Scand*, *118*(2), 99-105. https://doi.org/10.1111/j.1600-0447.2008.01171.x

Ansorge, M. S., Hen, R., & Gingrich, J. A. (2007). Neurodevelopmental origins of depressive disorders. *Curr Opin Pharmacol*, *7*(1), 8-17. https://doi.org/10.1016/j.coph.2006.11.006

Armstrong, M. J., Naglie, G., Duff-Canning, S., Meaney, C. Gill, D., Eslinger, P. J., Zadikoff, C., Mapstone, M., Chou, K. L., Persad, C., Litvan, I., Mast, B. T., Fox, S., Tang-Wai, D. F., & Marras, C. (2012). Roles of Education and IQ in Cognitive Reserve in Parkinson's Disease-Mild Cognitive Impairment. *Dement Geriatr Cogn Dis Extra*, *2*(1), 343-352. https://doi.org/10.1159/000341782

Barnett, J. H., Salmond, C. H., Jones, P. B., & Sahakian, B. J. (2006). Cognitive reserve in neuropsychiatry. *Psychol Med*, *36*(8), 1053-1064. https://doi.org/10.1017/S0033291706007501

Batty, G. D., Deary, I. J., & Gottfredson, L. S. (2007). Premorbid (early life) IQ and later mortality risk: systematic review. *Ann Epidemiol*, *17*(4), 278-288. https://doi.org/10.1016/j.annepidem.2006.07.010

Batty, G. D., Wennerstad, K. M., Smith, G. D., Gunnell, D., Deary, I. J., Tynelius, P., & Rasmussen, F. (2009). IQ in early adulthood and mortality by middle age: Cohort study of 1 million swedish men. *20*(1), 100-109. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emed11&AN=354975032

Batty, G. D., Whitley, E., Deary, I. J., Gale, C. R., Tynelius, P., & Rasmussen, F. (2010). Psychosis alters association between IQ and future risk of attempted suicide: cohort study of 1,109,475 Swedish men. *BMJ*, *340*, c2506. https://doi.org/10.1136/bmj.c2506

Bjorkenstam, C., Weitoft, G. R., Hjern, A., Nordstrom, P., Hallqvist, J., & Ljung, R. (2010). School grades, parental education and suicide-A national register-based cohort study. *65*(11), 993-998. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emed12&AN=51121244

Bridge, J. A., McBee-Strayer, S. M., Cannon, E. A., Sheftall, A. H., Reynolds, B., Campo, J. V., Pajer, K. A., Barbe, R. P., & Brent, D. A. (2012). Impaired decision making in adolescent suicide attempters. *J Am Acad Child Adolesc Psychiatry*, *51*(4), 394-403. https://doi.org/10.1016/j.jaac.2012.01.002

Brokke, S. S., Landro, N. I., & Haaland, V. O. (2020). Cognitive Control in Suicide Ideators and Suicide Attempters. *Front Psychol*, *11*, 595673. https://doi.org/10.3389/fpsyg.2020.595673

Burton, C. Z., Vella, L., Weller, J. A., & Twamley, E. W. (2011). Differential effects of executive functioning on suicide attempts. *J Neuropsychiatry Clin Neurosci*, *23*(2), 173-179. https://doi.org/10.1176/appi.neuropsych.23.2.173

10.1176/jnp.23.2.jnp173

Calvin, C. M., Batty, G. D., Der, G., Brett, C. E., Taylor, A., Pattie, A., Cukic, I., & Deary, I. J. (2017). Childhood intelligence in relation to major causes of death in 68 year follow-up: prospective population study %J BMJ. *357*, j2708. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=medc&AN=28659274

Cooper, H., Hedges, L. V., & Valentine, J. C. (2009). *The Handbook of Research Synthesis and Meta-Analysis*. Russell Sage Foundation Publications.

De Leo, D., Goodfellow, B., Silverman, M., Berman, A., Mann, J., Arensman, E., Hawton, K., Phillips, M.R., Vijayakumar, L., Andriessen, K., Chavez-Hernandez, A.M., Heisel, M., Kolves, K. (2021) International study of definitions of English-language terms for suicidal behaviours: a survey exploring preferred terminology. *BMJ Open,* 11(2):e043409. doi: 10.1136/bmjopen-2020-043409

Drake, R. J. (2008). Insight into illness: impact on diagnosis and outcome of nonaffective psychosis. *Curr Psychiatry Rep*, *10*(3), 210-216. https://doi.org/10.1007/s11920-008-0035-0

Duval, S., & Tweedie, R. (2000). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, *56*(2), 455-463. https://doi.org/10.1111/j.0006-341x.2000.00455.x

Egger, M., Davey Smith, G., & Altman, D. (2001). *Systematic Reviews in Health Care: Meta-Analysis in Context*. BMJ Publishing Group.

Egger, M., Davey Smith, G., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *BMJ*, *315*(7109), 629-634. https://doi.org/10.1136/bmj.315.7109.629

Fernandez-Sevillano, J., Gonzalez-Pinto, A., Rodriguez-Revuelta, J., Alberich, S., Gonzalez-Blanco, L., Zorrilla, I., Velasco, A., Lopez, M. P., Abad, I., & Saiz, P. A. (2021). Suicidal behaviour and cognition: A systematic review with special focus on prefrontal deficits. *J Affect Disord*, *278*, 488-496. https://doi.org/10.1016/j.jad.2020.09.044

Gale, C. R., Batty, G. D., & Deary, I. J. (2008). Locus of control at age 10 years and health outcomes and behaviors at age 30 years: the 1970 British Cohort Study. *Psychosom Med*, *70*(4), 397-403. https://doi.org/10.1097/PSY.0b013e31816a719e

Geoffroy, M. C., Gunnell, D., & Power, C. (2014). Prenatal and childhood antecedents of suicide: 50-year follow-up of the 1958 British Birth Cohort study. *Psychol Med*, *44*(6), 1245-1256. https://doi.org/10.1017/S003329171300189X

Gravseth, H. M., Mehlum, L., Bjerkedal, T., & Kristensen, P. (2010). Suicide in young Norwegians in a life course perspective: population-based cohort study. *J Epidemiol Community Health*, *64*(5), 407-412. http://doi.org/10.1136/jech.2008.083485

Gunnell, D., Harbord, R., Singleton, N., Jenkins, R., & Lewis, G. (2009). Is low IQ associated with an increased risk of developing suicidal thoughts? A cohort study based on an 18-month follow-up of the national psychiatric morbidity survey. *Soc Psychiatry Psychiatr Epidemiol*, *44*(1), 34-38. https://doi.org/10.1007/s00127-008-0404-3

Gunnell, D., Lofving, S., Gustafsson, J. E., & Allebeck, P. (2011). School performance and risk of suicide in early adulthood: follow-up of two national cohorts of Swedish schoolchildren %J Journal of Affective Disorders. *131*(1), 104-112. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=med8&AN=21296426

Gunnell, D., Magnusson, P. K., & Rasmussen, F. (2005). Low intelligence test scores in 18 year old men and risk of suicide: cohort study. *BMJ*, *330*(7484), 167. https://doi.org/10.1136/bmj.38310.473565.8F

Gustavson, K. A., Alexopoulos, G. S., Niu, G. C., McCulloch, C., Meade, T., & Arean, P. A. (2016). Problem-Solving Therapy Reduces Suicidal Ideation In Depressed Older Adults with Executive Dysfunction. *Am J Geriatr Psychiatry*, *24*(1), 11-17. https://doi.org/10.1016/j.jagp.2015.07.010

Hansson Bittar, N., Falkstedt, D., & Sorberg Wallin, A. (2019). How intelligence and emotional control are related to suicidal behavior across the life course - A register-based study with 38-year follow-up %J Psychological Medicine. *50*(13), 2265-2271. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=prem&AN=31594550

Hawton, K., & van Heeringen, K. (2009). Suicide. *Lancet*, *373*(9672), 1372-1381. https://doi.org/10.1016/S0140-6736(09)60372-X

Jiang, R., Calhoun, V. D., Fan, L., Zuo, N., Jung, R., Qi, S., Lin, D., Li, J., Zhuo, C., Song, M., Fu, Z., Jiang, T., & Sui, J. (2020). Gender Differences in Connectome-based Predictions of Individualized Intelligence Quotient and Sub-domain Scores. *Cereb Cortex*, *30*(3), 888-900. https://doi.org/10.1093/cercor/bhz134

Karnehed, N., Rasmussen, F., & Modig, K. (2015). Low IQ has become less important as a risk factor for early disability pension. A longitudinal population-based study across two decades among Swedish men. *J Epidemiol Community Health*, *69*(6), 563-567. https://doi.org/10.1136/jech-2014-204924

Keilp, J. G., Gorlyn, M., Oquendo, M. A., Burke, A. K., & Mann, J. J. (2008). Attention deficit in depressed suicide attempters. *Psychiatry Res*, *159*(1-2), 7-17. https://doi.org/10.1016/j.psychres.2007.08.020

Keilp, J. G., Sackeim, H. A., Brodsky, B. S., Oquendo, M. A., Malone, K. M., & Mann, J. J. (2001). Neuropsychological dysfunction in depressed suicide attempters. *Am J Psychiatry*, *158*(5), 735-741. https://doi.org/10.1176/appi.ajp.158.5.735

Koenen, K. C., Moffitt, T. E., Roberts, A. L., Martin, L. T., Kubzansky, L., Harrington, H., Poulton, R., & Caspi, A. (2009). Childhood IQ and adult mental disorders: a test of the cognitive reserve hypothesis. *Am J Psychiatry*, *166*(1), 50-57. https://doi.org/10.1176/appi.ajp.2008.08030343

Kosidou, K., Dalman, C., Fredlund, P., Lee, B. K., Galanti, R., Isacsson, G., & Magnusson, C. (2013). School performance and the risk of suicide attempts in young adults: a longitudinal population-based study %J Psychological Medicine. *44*(6), 1235-1243. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=med11&AN=23883735

Kosik, R., Fan, A., ell, G., Su, E. P., Nguyen, T., Chen, J., & Buka, S. (2017). Academic performance in childhood and the risk of attempting suicide as an adult. *31*(2), 73-79. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emed18&AN=619505533

Lesage, A. D., Boyer, R., Grunberg, F., Vanier, C., Morissette, R., Menard-Buteau, C., & Loyer, M. (1994). Suicide and mental disorders: a case-control study of young men. *Am J Psychiatry*, *151*(7), 1063-1068. https://doi.org/10.1176/ajp.151.7.1063

Mann, J. J. (2003). Neurobiology of suicidal behaviour. *Nature Reviews. Neuroscience*, *4*, 819-828.

Masten, A. S., Coatsworth, J. D., Neemann, J., Gest, S. D., Tellegen, A., & Garmezy, N. (1995). The structure and coherence of competence from childhood through adolescence. *Child Dev*, *66*(6), 1635-1659. https://www.ncbi.nlm.nih.gov/pubmed/8556890

Orri, M., Gunnell, D., Richard-Devantoy, S., Bolanis, D., Boruff, J., Turecki, G., & Geoffroy, M. C. (2019). In-utero and perinatal influences on suicide risk: a systematic review and meta-analysis. *Lancet Psychiatry*, *6*(6), 477-492. https://doi.org/10.1016/S2215-0366(19)30077-X

Osler, M., Nybo Andersen, A. M., & Nordentoft, M. (2008). Impaired childhood development and suicidal behaviour in a cohort of Danish men born in 1953. *J Epidemiol Community Health*, *62*(1), 23-28. https://doi.org/10.1136/jech.2006.053330

Park, S. J., Yi, K., Lee, J. D., & Hong, J. P. (2015). There Is No Difference in IQ between Suicide and Non-Suicide Psychiatric Patients: A Retrospective Case-Control Study. *Psychiatry Investig*, *12*(3), 330-334. https://doi.org/10.4306/pi.2015.12.3.330

Pollock, L. R., & Williams, J. M. (2004). Problem-solving in suicide attempters. *Psychol Med*, *34*(1), 163-167. https://doi.org/10.1017/s0033291703008092

Richard-Devantoy, S., Berlim, M. T., & Jollant, F. (2014). A meta-analysis of neuropsychological markers of vulnerability to suicidal behavior in mood disorders. *Psychol Med*, *44*(8), 1663-1673. https://doi.org/10.1017/S0033291713002304

Richard-Devantoy, S., Jollant, F., Kefi, Z., Turecki, G., Olie, J. P., Annweiler, C., Beauchet, O., & Le Gall, D. (2012). Deficit of cognitive inhibition in depressed elderly: a neurocognitive marker of suicidal risk. *J Affect Disord*, *140*(2), 193-199. https://doi.org/10.1016/j.jad.2012.03.006

Richard-Devantoy, S., Olie, E., Guillaume, S., & Courtet, P. (2016). Decision-making in unipolar or bipolar suicide attempters. *J Affect Disord*, *190*, 128-136. https://doi.org/10.1016/j.jad.2015.10.001

Richard-Devantoy, S., Orri, M., Bertrand, J. A., Greenway, K. T., Turecki, G., Gunnell, D., Power, C., & Geoffroy, M. C. (2021). Childhood cognitive skill trajectories and suicide by mid-adulthood: an investigation of the 1958 British Birth Cohort. *Psychol Med*, *51*(3), 400-407. https://doi.org/10.1017/S0033291719003143

Richard-Devantoy, S., Szanto, K., Butters, M. A., Kalkus, J., & Dombrovski, A. Y. (2014). Cognitive inhibition in older high-lethality suicide attempters. *Int J Geriatr Psychiatry*. https://doi.org/10.1002/gps.4138

Riley, R. D., Higgins, J. P., & Deeks, J. J. (2011). Interpretation of random effects meta-analyses. *BMJ*, *342*, d549. https://doi.org/10.1136/bmj.d549

Ruch, D., Sheftall, A. H., Heck, K., McBee-Strayer, S. M., Tissue, J., Reynolds, B., Ackerman, J., Brent, D. A., Campo, J. V., & Bridge, J. A. (2020). Neurocognitive vulnerability to youth suicidal behavior. *J Psychiatr Res*, *131*, 119-126. https://doi.org/10.1016/j.jpsychires.2020.08.032

Sorberg, A., Allebeck, P., Melin, B., Gunnell, D., & Hemmingsson, T. (2013). Cognitive ability in early adulthood is associated with later suicide and suicide attempt: the role of risk factors over the life course. *Psychol Med*, *43*(1), 49-60. https://doi.org/10.1017/S0033291712001043

Sorberg, A., Lundin, A., Allebeck, P., Melin, B., Falkstedt, D., & Hemmingsson, T. (2013). Cognitive ability in late adolescence and disability pension in middle age: follow-up of a national cohort of Swedish males. *PLoS One*, *8*(10), e78268. https://doi.org/10.1371/journal.pone.0078268

Sorberg Wallin, A., Sorjonen, K., Lager, A., & Falkstedt, D. (2020). Academic performance, subsequent socioeconomic status and suicide attempt in adulthood: path analyses on Swedish cohort data. *12*, 12. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=medp&AN=32796011

Sorberg Wallin, A., Zeebari, Z., Lager, A., Gunnell, D., Allebeck, P., & Falkstedt, D. (2017). Suicide attempt predicted by academic performance and childhood IQ: a cohort study of 26 000 children %J Acta Psychiatrica Scandinavica. *137*(4), 277-286. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=med15&AN=29114860

Sourander, A., Klomek, A. B., Niemela, S., Haavisto, A., Gyllenberg, D., Helenius, H., Sillanmaki, L., Ristkari, T., Kumpulainen, K., Tamminen, T., Moilanen, I., Piha, J., Almqvist, F., & Gould, M. S. (2009). Childhood predictors of completed and severe suicide attempts: findings from the Finnish 1981 Birth Cohort Study. *Arch Gen Psychiatry*, *66*(4), 398-406. https://doi.org/10.1001/archgenpsychiatry.2009.21

Stewart, J. G., Glenn, C. R., Esposito, E. C., Cha, C. B., Nock, M. K., & Auerbach, R. P. (2017). Cognitive Control Deficits Differentiate Adolescent Suicide Ideators From Attempters. *J Clin Psychiatry*, *78*(6), e614-e621. https://doi.org/10.4088/JCP.16m10647

Turecki, G., Brent, D.A., Gunnell, D., O'Connor, R.C., Oquendo, M.A., Pirkis, J, Stanley, B.H.(2014) Suicide and suicide risk. *Nat Rev Dis Primers*, 5(1):74. https://doi.org/10.1038/s41572-019-0121-0

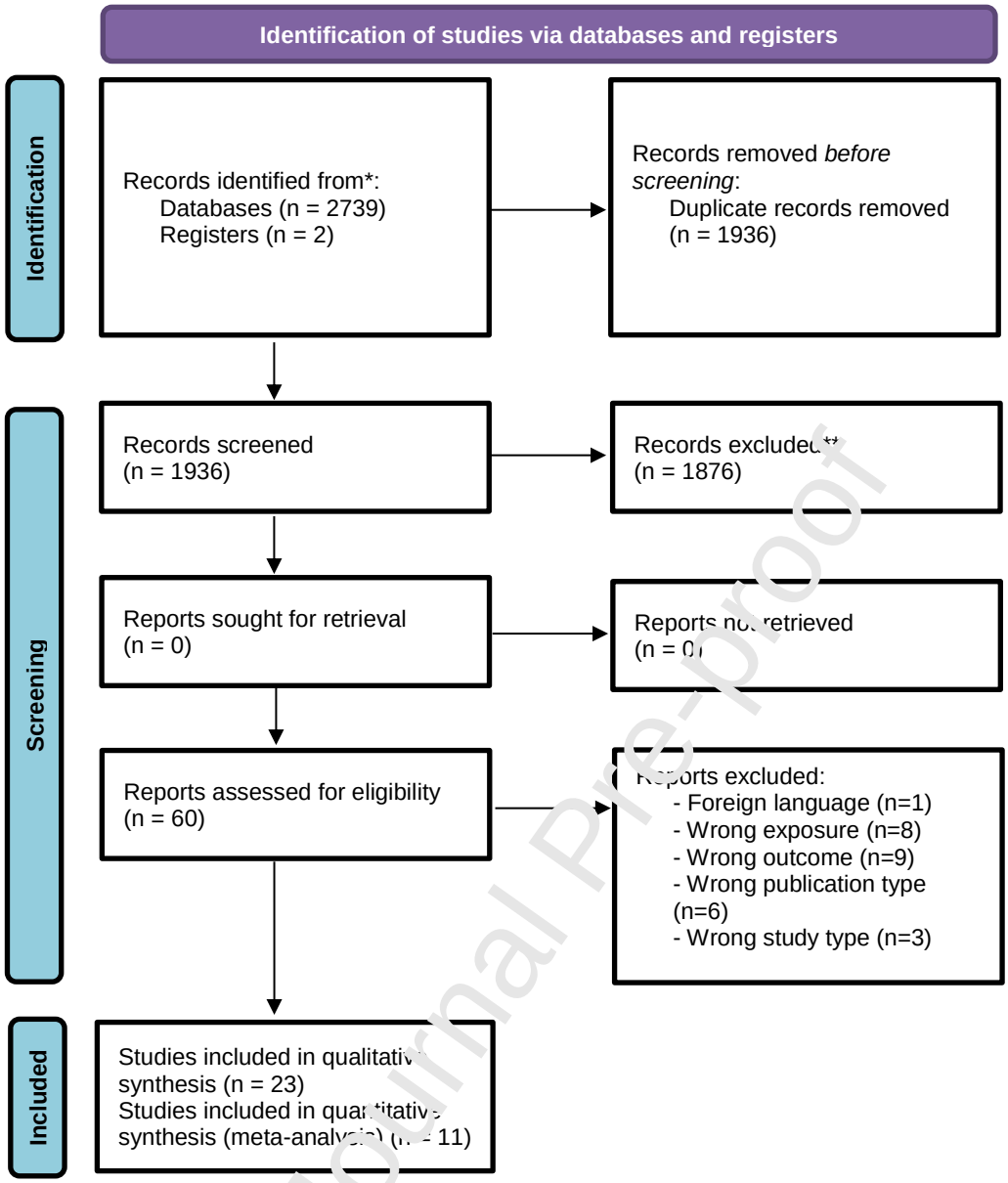
Viechtbauer, W. (2010). Conducting meta-analyses in R with the metafor package. *Journal of Statistical Software*, *36*(3), 1-48.

Webb, R. T., Langstrom, N., Runeson, B., Lichtenstein, P., & Fazel, S. (2010). Violent offending and IQ level as predictors of suicide in schizophrenia: national cohort study %J Schizophrenia Research. *130*(1), 143-147. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=med8&AN=21605959

Weiser, M., Kapra, O., Werbeloff, N., Goldberg, S., Fenchel, D., Reichenberg, A., Yoffe, R., Ginat, K., Fruchter, E., & Davidson, M. (2015). A population-based longitudinal study of suicide risk in male schizophrenia patients: Proximity to hospital discharge and the moderating effect of premorbid IQ. *Schizophr Res*, *169*(1-3), 159-164. https://doi.org/10.1016/j.schres.2015.10.006

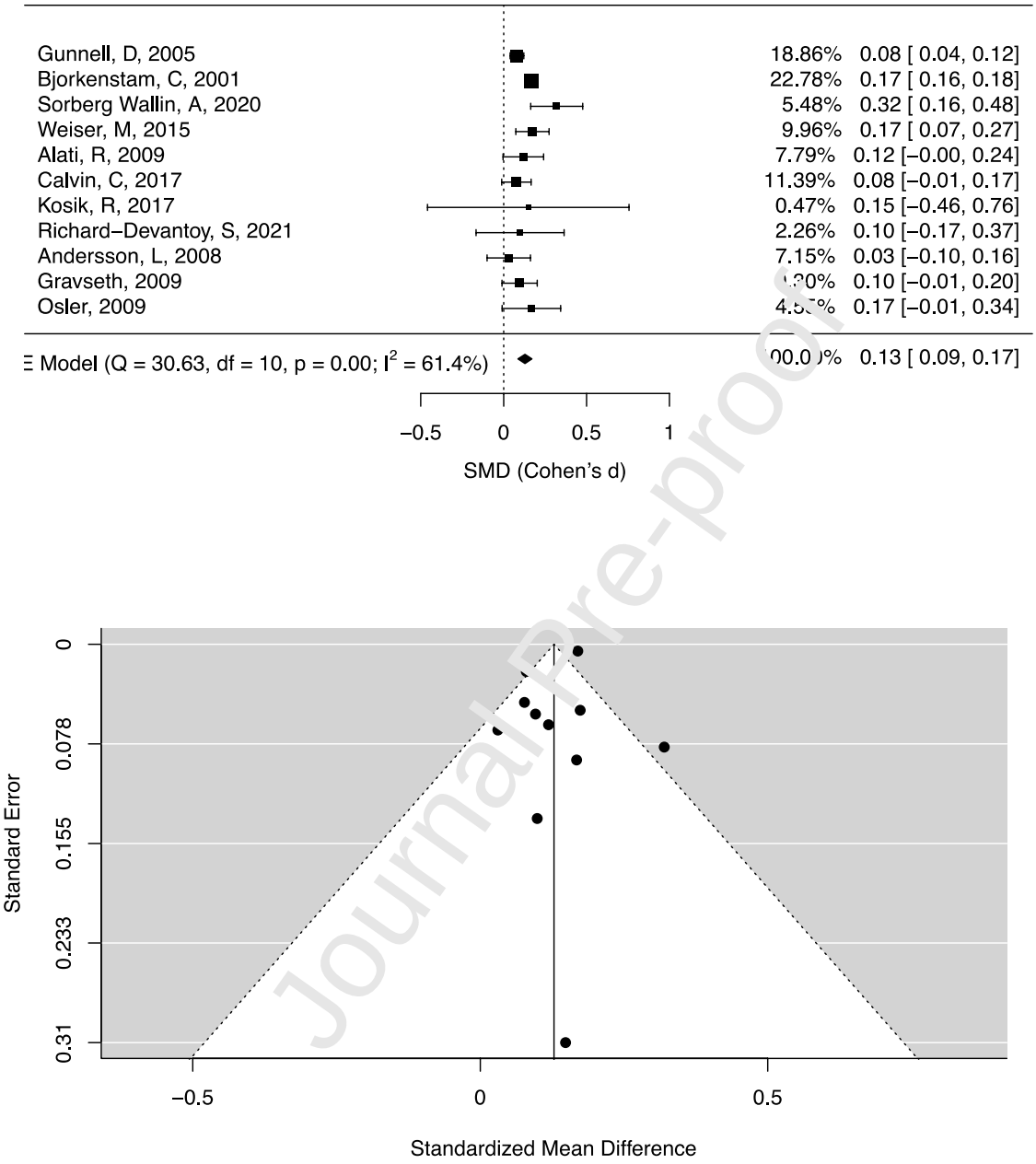
Werbeloff, N., Weiser, M., & Lubin, G. (2009). Social and cognitive functioning as risk factors for suicide: A historical-prospective cohort study. *3*, S341-S342. https://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=emed11&AN=70044539

Figure 1: Selection of studies for Systematic Review and Meta-Analyses



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Figure 2: Meta-analysis for the association between cognitive skills and suicidal behavior



Part A shows a forest plot; results indicate that participants with suicidal behavior in adulthood had significantly lower cognitive skills in childhood compared to those without. Part B shows the funnel plot

Table 1. Description of the articles included in the systematic review and the meta-analysis*

Sample	Study Country	Population N (% of male), type	Max age at follow-up	Outcomes	Exposures	Cognitive skill measure	Evidence for an association? By population groups:				Results details
							Male and female combined	Psychosis population	Men	Women	
1966 Northern Finland Birth Cohort	(Alaraisanen et al., 2006) Finland	N=10,934 (NA) *General population*	35 years	Suicide (ICD-10 code)	School performance at age 16	School marks from the registers of the national application system	Yes	Yes		-	- In the general population: good school performance may protect from suicide (Adjusted HR: 0.28 (95%CI 0.07–1.16)) - In psychosis: good school performances may increase risk of suicide (Adjusted HR: 3.56 (95%CI 0.97–13.05))
1948 and 1953 Swedish Birth Cohort	(Andersson et al., 2008) Sweden	N=21,809 (51%) *General population*	50-55 years	Suicide*	IQ at age 13	IQ measured with the antonyms, metal folding and number series subtests.	-	Yes	Yes	No	- Association between low IQ and an increased risk of suicide in men but not in women. - Evidence of association only for men (OR for increasing IQ, 0.90 (95%CI 0.83–0.99; P = 0.03)), but not women (OR 1.04, 95%CI 0.90–1.20). - In men with psychosis, high IQ associated with increased risk of suicide (OR=1.22 (95%CI 0.98–1.52))
1972-1981 Swedish Birth Cohort	(Bjorkenstam et al., 2010) Sweden	N=898,342 (51%) *General population*	25-34 years	Suicide*	School performance at age 15	Data from the Swedish National School Register (GPA)	-	-	Yes	Yes	- Higher risk of suicide in individuals with low school grades RR= 3.41 (95%CI 1.85–6.29) for women RR= 5.19 (95%CI 3.23–8.33) for men
1936 Scottish Birth Cohort	(Calvin et al., 2017) UK	N=65,765 (51%) *General population*	79 years	Suicide*	IQ at age 10-11	Moray House test number 12 (71 items tapping verbal and non-verbal reasoning ability)	Yes	-	Yes	No	- Association between low childhood IQ and suicide at follow-up (HR for 1SD increase in IQ 0.87 (95%CI 0.74–1.02).
1958 British Birth Cohort	(Geoffroy et al., 2014) UK	N=12,399 (NA) *General population*	49 years	Suicide	School performance at age 7	Mathematics and reading skill	No	-	-	-	- No association between school performance and subsequent suicide
1972 and 1977 Swedish Birth Cohort	(Gunnell et al., 2011) Sweden	N=186,808 (51.1%) *General population*	28-33 years	Suicide	School performance at age 16	grades assigned by combination of test (20 subjects) + personal experience	-	-	Yes	No	- Low school performance associated with suicide in males (HR for 1 SD increase in performance 0.6; (95% CI 0.6–0.7); p=0.001) but not females (1.1; (95%CI 0.9–1.4); p=0.50).
1958 British Birth Cohort	(Richard-Devantoy et al., 2021) UK	N=14,505 (50.7%) *General population*	54 years	Suicide*	IQ at age 11	80-item test approximating general intelligence (e.g., IQ) with verbal and non-verbal scales administered	No	-	No	-	- No significant association between childhood IQ and subsequent suicide in the whole sample and in males only.
1967-1976	(Gravseth et	N=298,50	28-37	Suicide*	IQ	Test of intellectual	-	-	Yes	Yes	- Association between decreased IQ and

Norwegian Birth Cohort	al., 2010) Norway	3 (51.2%) *Military conscripts*	years		at 18 (men)	performance				increased risk of suicide in unadjusted models only.
Swedish conscripts born in 1950-1976	(Batty et al., 2009) Sweden	N=994,262 (100%) *Military conscripts*	24-51 years	Suicide	IQ at age 18.3 (range 16-26)	Four subtests representing logical, spatial, verbal, and technical abilities	-	-	Yes	-	- Association between low IQ and an increased risk of suicide (HR 1.22 (95%CI 1.18–1.26)
Swedish conscripts born in 1950-1976	(Gunnell et al., 2005) Sweden	N=987 308 (100%) *Military conscripts*	23-49 years	Suicide*	IQ at age 18	Four subtests representing logical, spatial, verbal, and technical abilities	-	-	Yes	-	- Association between low IQ and increased risk of suicide in men - The strongest associations were seen with the logic test: for each unit increase in test score the risk of suicide decreased by 12% (95%CI 10%–14%).
Swedish conscripts born in 1950-1987	(Webb et al., 2010) Sweden	N=8,890 (64.4%) *Military conscripts with psychosis*	7-541 years	Suicide	IQ at age 18	Four subtests representing logical, spatial, verbal, and technical abilities	-	Yes	-	-	- Low IQ in men with schizophrenia associated with decreased risk of suicide (rate ratio for low IQ compared to medium/high IQ, 0.71 (95%CI 0.58–0.86)
Israeli military conscripts	(Weiser et al., 2015) Israel	N=930,589 (100%) *Military conscripts*	38-39 years	Suicide*	IQ at age 16-17	IQ measured by 4 subtests: -Modified Otis-type verbal intelligence test -Modified version of the 'similarities' subtest of the WAIS -Mathematical knowledge -Modified version of Raven's Progressive Matrices.	-	Yes	Yes	-	- In schizophrenia: High IQ associated with high risk of suicide (HR = 4.45 (95%CI 1.37–14.43)) - The time of peak risk is during the first year after the last hospitalization discharge. - In non-schizophrenia group: Low IQ associated with high risk of suicide (HR = 1.35 (95%CI 1.02–1.77)).
Israeli military conscripts	(Werbeloff et al., 2009) Israel	N=757,216 (100%) *Military conscripts*	26–27 year average	Suicide	IQ at age 16-17	Army-specific test battery comprising of four subtests (arithmetic, similarities, spatial analogies test, OTIS-R, a modified verbal intelligence test)	-	-	Yes	-	- Association between low IQ and increased risk of suicide (adjusted HR=1.44 (95%CI 1.18–1.76)).
Swedish conscripts born in 1969–1970	(Hansson Bittar et al., 2019) Sweden	N=48,738 (100%) *Military conscripts*	59 years	Suicide & Suicide attempt	IQ at age 18	Four subtests representing logical, spatial, verbal, and technical abilities	-	-	Yes	-	- Association between decreasing IQ and increasing risk of suicidal behavior. E.g., six-fold higher risk of suicidal behavior in men in the lowest IQ category compared with men in the highest intelligence category (HR 6.29 (95%CI 4.48–8.83)).

Swedish conscripts born in 1949-1952	(Sorberg, Allebeck, et al., 2013) Sweden	49 321 (100%) *Military conscripts*	57 years	Suicide & Suicide attempt	IQ at age 18	Four subtests representing logical, spatial, verbal, and technical abilities	-	-	Yes	-	- Association between decreasing IQ and increasing risk of suicide (adjusted HR for 1 SD decrease in QI 1.10 (95% CI 1.04–1.18). - For suicide attempt, the adjusted HR: 1.14 (95% CI 1.09–1.20).
Finnish 1981 Birth Cohort Study	(Sourander et al., 2009) Finland	N=5,302 (50.1%) *General population*	24 years	Suicide & Suicide attempt	School performance at age 8	Rated by teachers on a scale of 1 to 3, with 1 being better than average and 3 being poor	-	-	No	No	- Poor school performance was not associated with suicide or suicide attempt for either boys (OR 1.5 (95%CI 0.6–3.8)) or girls (OR 0.4 (95%CI 0.1–2.9))
Brisbane Australia longitudinal pre-birth cohort study	(Alati et al., 2009) Australia	N=1,975 (NA) *General population*	21 years	Suicide attempt*	IQ at age 14	WRAT3 Raven's SPM	Yes	-	-	-	- WRAT3: No association between IQ and suicide attempt - Raven's test: Weak association between low IQ and suicide attempt (adjusted OR per SD decrease in Raven's SPM: 1.24 (95%CI 1.00–1.56) for suicide attempt).
Swedish conscripts born in 1950-1976	(Batty et al., 2010) Sweden	N=1,109,475 (100%) *Military conscripts*	30-56 years	Suicide attempt	IQ at age 18	Four subtests representing logical, spatial, verbal, and technical abilities	-	No	Yes	-	- In men free from psychosis, association between low IQ and higher risk of suicide attempt (HR=1.57 (95%CI 1.54–1.60) - Men with psychosis: No evidence of an association between IQ and suicide attempt.
Stockholm Public Health Cohort	(Kosidou et al., 2013) Sweden	N=6,146 (41.4%) *General population*	37-38 years	Suicide attempt	School performance at age 16	Grade-point averages in the final year of compulsory education (year 9), National School Register	Yes	-	-	-	- Association between lower school grades and suicide attempt (OR for lowest vs highest grade quartile, 3.35 (95%CI 1.88–5.96). - No differences between men and women (P for interaction, 0.98).
Providence National Collaborative Perinatal Project	(Kosik et al., 2017) USA	N=1,253 (52.5%) *General population*	18-39 years	Suicide attempt*	IQ at age 7	Wechsler Intelligence Scale for Children (WISC) Wide Range Achievement Test (WRAT)	Yes/No	-	Yes	Yes	- No association between childhood IQ (WISC) and subsequent suicide attempt later in life. - Association between low WRAT sub-scores (reading, spelling, and arithmetic) and increased risk of adult suicide attempt.
1953 Danish Metropolit cohort conscripts	(Osler et al., 2008) Demark	N= 9359 (100%) *Military conscripts*	19-49 years	Suicide & Suicide attempt*	School performance at age 12 and 18	Härnquist school test at 12 (consisted of spatial, arithmetic, verbal subtests) Boerge Prien's test at 18	-	-	Yes	-	- Association between cognitive test score at the age of 12 (HR for 1 SD decreasing score, 0.81 (95CI 0.66–1.02)) and 18 years and suicide attempt (HR 0.85 (95%CI 0.72–1.01))
Evaluation Through Follow-up study	(Sorberg Wallin et al., 2020). Sweden	The 1950 cohort – N=17, 555 (51.6%) The 1970 cohort – N=14, 987 (51.4%) *General population*	43-63 years	Suicide attempt*	School performance at age 13/16 IQ at age 13	GPA at age 13 (6^{th} grade) in the 1950 cohort and at age 16 (9^{th} grade) in the 1970 cohort IQ test assessing verbal ability, spatial ability, and induction/reasoning	Yes	-	-	-	- Association between low IQ at age 13 and subsequent suicide attempt - Association between low GPA at age 13/16 and subsequent suicide attempt
Evaluation Through	(Sorberg Wallin et al.,	N=26,315 (NA)	46 years	Suicide attempt	School performance	GPA extracted from Swedish National School	Yes	-	-	-	- GPA and IQ were both associated with suicide attempt at follow-up, with dose–

Follow-up study	2017) Sweden	*General population*			at age 16 IQ at age 13	Register IQ test assessing logical, spatial, verbal, and technical abilities					response gradients - Stronger association between GPA at age 16 and suicide attempt (HR 4.9 (95%CI 3.6–6.7)) than association between IQ at age 13 and suicide attempt (HR 2.3 (95%CI 1.7–3.0).

*: Studies included in the meta-analysis; IQ: Intelligence quotient; GPA: Grade point average; NA: Not available; CI: Confidence interval; SD: Standard Deviation; HR: Hazard ratio; OR: Odds ratio; RR: Relative risk; OTIS-R: Otis Redding; Raven's SPM: Raven's standard progressive matrices; WAIS: Wechsler Adult Intelligence Scale; WISC: Wechsler Intelligence Scale for Children; WRAT3: Wide Range Achievements Test version 3.

Table 2: Results of the meta-regression and subgroup analyses

	N	d (95% CI)	P-value
Sex			0.221
Males (n = 9)	2,324,830	0.15 (0.10 to 0.20)	
Females (n = 4)	495,502	0.07 (-0.07 to 0.21)	
Study outcome			0.618
Suicide attempt (n = 4)	1,122,062	0.16 (0.11 to 0.21)	
Suicide mortality (n = 9)	2,826,963	0.13 (0.09 to 0.18)	
Max age at outcome assessment			0.530
<35 years (n = 2)	900,317	0.17 (0.16 to 0.19)	
≤35 years (n = 11)	3,048,708	0.13 (0.09 to 0.17)	
Age at cognitive skills assessment			0.469
< 16 years (n = 6)	1,003,649	0.12 (0.06 to 0.18)	
16-18 years (n = 7)	2,945,376	0.15 (0.10 to 0.20)	
Study methodological quality*	2,830,191	-	0.281

P-value refers to the Q test for group difference/meta-regression; N is the sample size in each subgroup (for subgroup analyses)

* continuous measure

Highlights

- Meta-analysis suggests an association between lower childhood cognitive skills and increased risk of suicidal behavior.

- Meta-analysis of the adjusted estimates found that this association was small but statistically significant.

- Found that heterogeneity was significant but moderate, and results were unlikely to be influenced by publication bias.

- In subgroup analyses, associations were significant only for males.

- No difference in effect size was found between suicide attempt and suicide mortality.