

SYSTEMATIC REVIEW



What are the correlates of non-suicidal self-injury in children and adolescents? An umbrella systematic review of global evidence

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BACKGROUND: Non-suicidal self-injury (NSSI) persists as a major public health challenge worldwide. Identifying and strategically targeting risk factors for NSSI constitutes a practical approach to its prevention. We aim to synthesize existing knowledge concerning the range and magnitude of risk factors for NSSI among children and adolescents, and to critically assess the robustness of the available evidence.

METHODS: In this umbrella review, six bibliographic databases were systematically searched for articles published from database inception to Dec 2024. For the assessment of evidence credibility, pre-specified criteria for classifying evidence were utilized, categorized as convincing ("class I"), highly suggestive ("class II"), suggestive ("class III"), weak ("class IV"), or no evidence ("class V"). The Amstar-2 framework was employed to evaluate the quality of the evidence which graded as "high," "moderate," "low," or "critically low" quality.

RESULTS: The study included meta-analyses of observational studies in the past 30 years on risk factors for NSSI in children and adolescents. We identified 16 meta-analyses comprising 410 primary studies on 43 risk factors from 38 countries, involving 2,659,156 children and adolescents. Twenty-three (e.g. LGBTIQ) risk factors were categorized as individual, followed by family level ($n = 8$, e.g. childhood maltreatment), school/peer level ($n = 8$, e.g. bully victims) and multifactorial level ($n = 4$, e.g. no religion). Eighteen (41.86%) risk factors provided highly suggestive (Class II) evidence of association with NSSI. Suggestive evidence (class III) indicated that NSSI was associated with adverse childhood experiences (2.31, 1.77–3.01) and being left-behind children (1.37, 1.11–1.69).

CONCLUSION: A multitude of risk factors spanning diverse domains were identified, highlighting the multifactorial nature of NSSI in adolescents and children. Comprehensive prevention strategies and measures should be conducted for children and adolescents to decrease the risk of NSSI and associated harms in multilevel approaches.

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INTRODUCTION

There are at least 14 million episodes of self-harm annually across the world, translating to an approximate global rate of 60 per 100,000 people per year [1]. The Global Burden of Disease (GBD) Study 2019 delineated that the incidence rates of self-harm were 89.1 (95% UI, 63.8–123.1) and years of life lost were 319.6 (95% UI, 248.9–412.8) per 100,000 young individuals in Europe [2]. The GBD 2019 estimated that there are approximately 20 episodes of self-

harm for every recorded suicide annually [3]. In low-income and middle-income countries (LMICs), prevalence of self-harm is likely underestimated given underreporting and the lack of routine surveillance [1]. Notably, the burden of self-harm among young people aged 10–24 years escalates in nations characterized by a lower sociodemographic index [4, 5].

Non-suicidal self-injury (NSSI) is defined as the intentional damage of one's body tissue without suicidal intent. NSSI is

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different from the deliberate self-harm (DSH) [6, 7], which encompasses suicidal behaviors and typically extends to include acts that indirectly injure the body, involving severe scenarios like substantial drug misuse, taking an overdose of medications, or ingesting sharp objects [8–10]. Globally, the issue of NSSI remains a significant public health concern among adolescents and children, posing persistent challenges to social problems. A meta-analysis was conducted on the global prevalence of NSSI in non-clinical children and adolescents between 2010 and 2021, revealing a lifetime prevalence of 22.0% [11]. According to National Self-Harm Registry data in Ireland, the incidence of NSSI surged by 22% between 2007 and 2016 among individuals aged 10–24 years [12]. Additionally, notable increases in prevalence have been observed, particularly among women and girls aged 16–24 years, where the prevalence escalated from 6.5% (95%CI 4.2–10.0) in 2000, to 19.7% (95%CI 15.7–24.5) in 2014 [6, 13]. Adolescents engaged in NSSI were at heightened risk of several adverse consequences, including diminished academic performance, difficulties in critical development tasks, mental disorders and suicidal behavior, all of which contribute to an increased societal and familial burden [14–17].

The etiology of NSSI was intricate, involving a confluence of factors across individual, family, school, and peer domains [6, 18, 19]. Proactively screening for risk factors among youth and implementing timely interventions can serve as a critical juncture to mitigate NSSI and forestall further adverse consequences including suicide [20]. Individuals factors with psychiatric disorders include anxiety, depression and problem behaviors (e.g. alcohol abuse), which may increase vulnerability to NSSI [21–24]. Familial factors encompass childhood maltreatment, neglect, and family dysfunction, significantly contributing to the risk of NSSI by creating an unstable and unsupportive home environment [25]. Psychosocial factors involve external pressures such as negative life events and school-related stress, which can exacerbate distress and lead to NSSI [26]. Besides, the enduring detrimental impacts of NSSI on individual health outcomes had been well-documented [27].

Over 400 original research articles exploring the risk factors and prevalence of NSSI have been conducted in the past 30 years, and many of these studies have been aggregated into meta-analyses that quantitatively summarize the outcomes. These findings pose critical questions regarding the relative effects of various risk factors on NSSI. However, to date, for all of those factors, there is no conclusive evidence due to the conflicting findings, several types of biases, and the wide variation in hierarchy of robustness of the evidence. To assess the full spectrum of risk factors and ensure consistency, we are initiating an umbrella review of these meta-analyses with standardized assessment tools to compile and integrate the existing insights on risk factors for NSSI in children and adolescents, which can provide a comprehensive overview of the associations between NSSI and a diverse range of significant long-term risk factors. This system (ranging from Class I to Class V) categorizes evidence based on its quantitative strength, the presence of various biases, and the consistency of the association. Simultaneously, we also summarize the region and primary reporting year of all risk factors to identify emerging risk factors during recent years. By systematically evaluating the existing literature, our umbrella review offers an evidence-based categorization designed to inform future preventative measures.

METHODS

We conducted this exposure-wide umbrella review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [28]. The systematic approach collected and critically reviewed published meta-analyses that examine risk factors for NSSI. The study protocol is registered on PROSPERO (CRD42024519520) and PRISMA guidelines were followed (Table S1) [29].

Search strategy and eligibility criteria

We systematically searched six electronic databases (Web of Science, PubMed, Embase, Cochrane, CNKI, and Wanfang) for meta-analyses published from database inception to Dec 2023, and updated in Dec 2024, without language limitation. The search strategy used the keywords (“systematic review” OR “meta-analysis”) and (“non-suicidal self-injury” OR “self-injury”) and was listed in Table S2. Additionally, we employed both forward and backward citation chaining and conducted manual searches of the bibliographies from pertinent umbrella reviews to enhance our search strategy (Table S2).

Inclusion and exclusion criteria

Eligible studies were systematic reviews with meta-analysis of observational studies: a) investigated risk factors for NSSI among adolescents and children; b) the mean age of participants at the time of outcome measurement was under 19 years [30]; c) these reviews needed to offer a consolidated measure of the effect size regarding the relationship between a risk factor and NSSI; d) The definition of NSSI referred to the diagnosis in DSM-5 [31].

We excluded: a) systematic reviews without meta-analysis and meta-analyses that only reported on prevalence, incidence rates or suicide outcomes were excluded; b) the primary research that focuses on suicide was eliminated, and the remaining studies were recalculated using the random-effects models (as described below); c) meta-analyses that did not meet these criteria were excluded from our review to ensure the inclusion of the most comprehensive and up-to-date evidence; d) meta-analysis that only includes interventional studies; e) grey literature; f) meta-analysis that were retracted; g) meta-analysis that lacked sufficient data (e.g., the articles did not report quantitative data, and articles reports suicide and NSSI without clear distinction, making it difficult for us to extract adequate NSSI-related outcomes from subsequent rounds of data collection) [32]. Eligibility was assessed by ZZW and JJH and discussed with ZY.

Selection of systematic reviews with meta-analysis and data extraction

Data were independently extracted by four investigators (ZY, ZZW, DJH, and YYF). Any discrepancies encountered during the extraction process were resolved through discussion. For each selected meta-analysis, we recorded the quantity and attributes of the primary studies, including the first author, the country of origin, publication date, number of included studies, type of exposure, effect size and the sample size. Additionally, we captured the specific risk estimates from each study and the aggregated effect size calculated using random-effects models, which included 95% confidence intervals (95% CI) and the relevant heterogeneity statistic (I^2). For primary studies, we recorded the first author, the country of origin, publication date, type of study design, any data useful to calculate the effect size, and dependencies in the data. If details about the study were ambiguous or if estimates at the study level were not disclosed, we reached out to the authors for additional information. In scenarios where reviews presented various levels of adjustment, we chose estimates from models with the minimal adjustments to maintain comparability, given that most studies lacked adjusted estimates. In instances where multiple pooled analyses for the same factors existed, we prioritized including the largest or most recent meta-analysis [33–35]. We also did not split the combined factors into sub-groups because combined outcomes are generally favored due to their larger sample sizes when the meta-analysis presents both combined outcomes and subgroup-specific results [32]. Furthermore, protective factors were inversely reported to standardize the direction of all associations, ensuring clarity and uniformity in the reporting of results. All effect sizes and confidence intervals were standardized into odds ratios to facilitate comparison across different risk factors [30, 36]. This

conversion into a common metric was carried out according to previously established methods and guidelines [33, 37]. We also referred to the practice of Lan et al. to preliminarily include the pooled analysis encompassing two primary articles [33]. Our comprehensive reanalysis process involved several key steps: we recalculated the pooled effect estimates and *P* values and reassessed the between-study heterogeneity. Additionally, we calculated 95% prediction intervals (95% PI) and evaluated excess significance bias and small study effects as part of our thorough reanalysis to rigorously evaluate the strength of the evidence [33]. These tests further refined our understanding of how various risk factors contribute to NSSI across diverse domains, including individual, family, school/peer, and multifactorial factors [19].

***I*² statistic**

We classified heterogeneity levels using established thresholds: a value of 50% was considered indicative of moderate heterogeneity, while a value of 75% or higher was deemed to represent high heterogeneity. This approach allows us to discern the consistency of findings across studies and gauge the reliability of the pooled effect sizes [37].

Prediction intervals

95% PI is used to provide a range within which the effect size of an individual observation from future studies is expected to fall, according to the formula described by Int'Hout et al. [38] If the 95% prediction intervals do not include the null value, the range of effect estimates is statistically significant [39]. The outputs derived from tests of 95% PI, alongside evaluations of small study effects and excess significance bias, are pertinent exclusively to pooled analyses that encompass a minimum of three original research articles.

Excess significance bias

The proportion of the aggregated overall effect size from a meta-analysis relative to the effect size of its largest included study (considered the most precise) was calculated to determine statistical excess bias. A ratio above 1 suggests the presence of excess significance, suggesting a potential overestimation of effect sizes in smaller or less robust studies [30].

Small study effects

We applied the regression asymmetry test developed by Egger et al. to evaluate the occurrence of small-study effects [40]. This test specifically examines the funnel plot for asymmetry, which would indicate a bias in the meta-analysis. *P* value less than 0.10 in this test was considered significant, providing evidence for the presence of small-study effects [41]. All statistical analyses were conducted in Windows environment using R (version 4.3.2) and Stata 12.

Assessment of evidence credibility

Leveraging data obtained from our reevaluation, including the *P* value, *I*² statistic, 95% PI, small study effects, and excess significance bias, we classified the results of our umbrella review into categories such as convincing ("class I"), highly suggestive ("class II"), suggestive ("class III"), weak ("class IV"), or no evidence ("class V"). The classification on the basis of the criteria outlined in Table S8. We utilized the AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews – second edition) quality assessment tool to evaluate the quality of the included meta-analysis studies, as detailed in Table S7 [42].

RESULTS

Study characteristics

The systematic search identified 108 de-duplicated articles (Fig. 1). We included 16 meta-analysis studies with 2,659,156 children and

adolescents across 43 distinct pooled analyses and 410 primary studies from 38 countries after applying the eligibility criteria [11, 43–57] (Fig. 2, Table S3). All meta-analyses were published between 2003 and 2024, and the primary studies were reported from 1993–2023. The number of studies analyzed in each meta-analysis ranged from 2–75 (with a median of 4) and the number of individuals included ranged from 570–944,921 (Table 1, Table S3). More than half of the primary studies were restricted to data from high-income countries (HICs, 245/410). There are a total of 166 middle-income countries (40.49%), and no data from low-income countries. The top ten regions were China, USA, UK, Sweden, Canada, Australia, Korea, Norway, New Zealand, and Japan across all 16 meta-analyses (Figure S1, 83.46%, 343/410). Forty-three risk factors were identified and divided into individual (*n* = 23), family (*n* = 8), school/peer (*n* = 8), and multifactorial outcomes (*n* = 4) (Fig. 2, Table S4).

Credibility and AMSTAR-2 quality assessments

The meta-analyses under consideration uniformly incorporated summary-level data extracted from the extant literature. A majority (76.74%, 33/43) of the distinct pooled analyses demonstrated direct correlations between various domains and an increased risk of NSSI outcomes (*P* ≤ 0.05). The ORs mostly ranged from 1.03 (95% confidence interval [95% CI]: 1.01–1.05) to 5.45 (1.99–14.91) for individual outcomes, from 1.37 (1.11–1.69) to 2.57 (2.25–2.93) for family outcomes, from 1.41 (1.10–1.81) to 3.39 (1.55–7.42) for school/peer outcomes and from 1.02 (1.016–1.024) to 1.46 (1.25–1.72) for multifactorial outcomes. According to the re-analysis outcomes, prior NSSI history (OR = 5.45, 95% CI: 1.99–14.91), LGBTIQ (OR = 4.12, 95% CI: 3.09–5.47), and the co-occurrence of traditional and cyber-bullying victimization (OR = 3.39, 95% CI: 1.55–7.42) are the strongest associated factors for the risk of NSSI (Fig. 2). Furthermore, among these analyses, 19 pooled analysis retained statistical significance under a more rigorous criterion (*P* < 1 × 10^{−6}). In studies with sufficient data, most studies had a 95% PI that included the null OR of 1. We found evidence of moderate (*I*² = 50–74.9%) to high (*I*² ≥ 75%) heterogeneity in 6 and 27 of the discrete pooled analyses, respectively (Table 1). Based on AMSTAR-2 criteria, 44.19% meta-analyses (19/43) were assessed as overall low confidence, more than half (53.49%, 23/43) as critically low confidence, and one as high confidence. Common limitations were the absence of a list of excluded studies and justification for the exclusions (93.75%, 15/16), or an explicit statement of the review methods (25%, 4/16, Fig. 3).

Individual domains

Pooled effect estimates from 165 primary studies (*n* = 1,123,211) showed direct associations between individual domains and higher risks of NSSI, such as demographic characteristics (e.g. female, older), behavioral factors (smoking, drinking, sexting, loneliness, hopelessness experience, and problem behaviors) and mental and physical health (mental disorders, depression, eating disorder, prior NSSI/suicidal thought/behavior, poor sleep quality, internet addiction, and physical symptoms). Highly suggestive evidence (Class II) included demographic factors such as female (OR = 1.26, 95% CI: 1.12–1.43) and LGBTIQ (OR = 4.12, 95% CI: 3.09–5.47); behavioral factors comprising school absenteeism (OR = 2.14, 95% CI: 1.59–2.89; Amstar-2=High), problem behaviors (e.g., any behavioral diagnosis, smoking, alcohol use, run away from home, opioid/sedative misuse, OR = 1.99, 95% CI: 1.81–2.19) and sexting (OR = 1.98, 95% CI: 1.75–2.25); psychological factors including loneliness (OR = 2.23, 95% CI: 2.02–2.46), poor emotion management (OR = 2.41, 95% CI: 1.77–3.28), and impulsivity (OR = 1.04, 95% CI: 1.03–1.05); personal lifestyle and health-related factors encompassing internet addiction (OR = 2.15, 95% CI: 1.83–2.53), poor sleep quality (e.g., Pittsburgh Sleep Quality Index ≥ 8, OR = 2.08, 95% CI: 1.61–2.70), depression (OR = 1.11, 95% CI: 1.06–1.16), and mental disorders (OR = 1.86, 95%

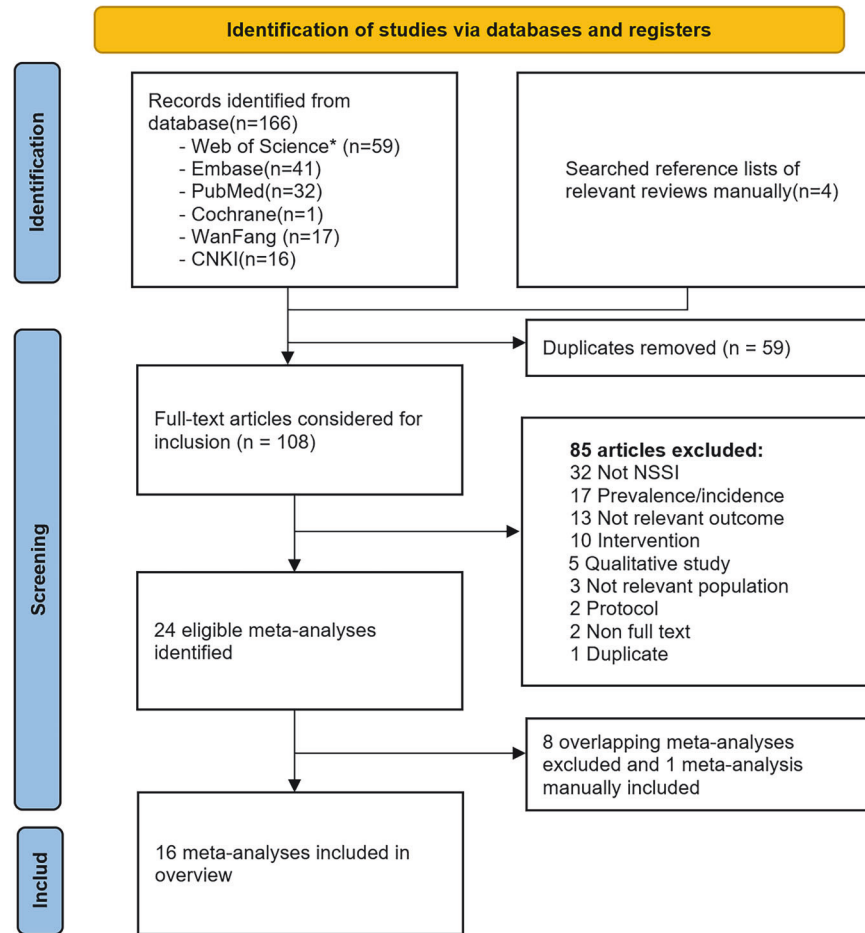


Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart. Web of Science* including Web of Science Core Collection, Preprint Citation Index, MEDLINE, Chinese Science Citation Database, Derwent Innovations Index, Grants Index, KCI-Korean Journal Database, ProQuest™ Dissertations & Theses Citation Index, SciELO Citation Index; Studies can be excluded for multiple reasons; numbers listed are based on the major reasons for exclusion.

CI: 1.60–2.16). Weak evidence (Class IV) encompassed prior NSSI (OR = 5.45, 95% CI: 1.99–14.91; critically low), prior suicidal thought/behavior (OR = 3.67, 95% CI: 2.76–4.82; critically low), older (Age ≥ 14 vs <14 , OR = 1.19, 95% CI: 1.01–1.39; critically low), screen time ≥ 2 h (OR = 1.40, 95% CI: 1.31–1.50; critically low), smoking history (OR = 1.59, 95% CI: 1.22–2.06; low), drinking history (OR = 2.73, 95% CI: 1.36–5.46; low), hopelessness (OR = 1.03, 95% CI: 1.01–1.05; critically low), and physical symptoms (OR = 2.53, 95% CI: 1.31–4.88; low). In addition, we found limited evidence on pooled analyses (Class V, e.g., misc externalizing symptoms). Several emerging risk factors including internet addiction, LGBTIQ, poor sleep quality, and sexting have been identified during recent decades.

Family domains

Examining data from six meta-analysis studies ($k = 119$, $n = 1,224,821$), we found evidence supporting direct associations between family domains and a higher risk of NSSI, such as highly suggestive evidence consisting of childhood maltreatment (OR = 2.57, 95% CI: 2.25–2.93; low) and neglect (OR = 2.28, 95% CI: 1.76–2.94; low). Suggestive evidence included adverse childhood experiences (OR = 2.31, 95% CI: 1.77–3.01; low) and left-behind children (defined as children and adolescents residing in regions, such as rural areas in China, who remain in their home communities while one or both parents migrate to urban areas for employment, OR = 1.37, 95% CI: 1.11–1.69; low). Additionally, weak evidence was composed of single-parent family (OR = 1.51, 95% CI: 1.16–1.97; low). Effect estimates from two meta-analysis showed limited

evidence supporting direct associations (e.g. broken family functioning and structure, and one-child family). Over the last ten years, childhood maltreatment along with challenges faced by left-behind children and teenagers has been found as important emerging risk factors, which were supported by credible evidence.

School/Peer domains

The school/peer domains were examined by synthesizing effect estimates ($k = 107$, $n = 264,596$), which showed direct associations with NSSI. Class II evidence included school absenteeism (OR = 2.14, 95% CI: 1.59–2.89; High), bully-victims (OR = 2.98, 95% CI: 1.84–4.82; low), and traditional bullying victimization (OR = 2.39, 95% CI: 1.91–2.99; critically low). Class IV evidence was made up of the co-occurrence of traditional and cyber-bullying victimization (OR = 3.39, 95% CI: 1.55–7.42; critically low), bullying others (OR = 2.12, 95% CI: 1.38–3.26; low), exposure to peer NSSI (OR = 1.57, 95% CI: 1.21–2.05; critically low) and school stress (OR = 1.41, 95% CI: 1.10–1.81; critically low). Boarding situation represented weak evidence within this domain.

Multifactorial domains

Pooled analysis from 19 primary studies ($n = 46,528$) showed the association between multifactorial domains and a higher risk of NSSI covering no religion (OR = 1.46, 95% CI: 1.25–1.72; low; Class II) and negative life events (OR = 1.02, 95% CI: 1.016–1.024; critically low; Class II). Additionally, the limited evidence was found in low social support and frequency of social media use.

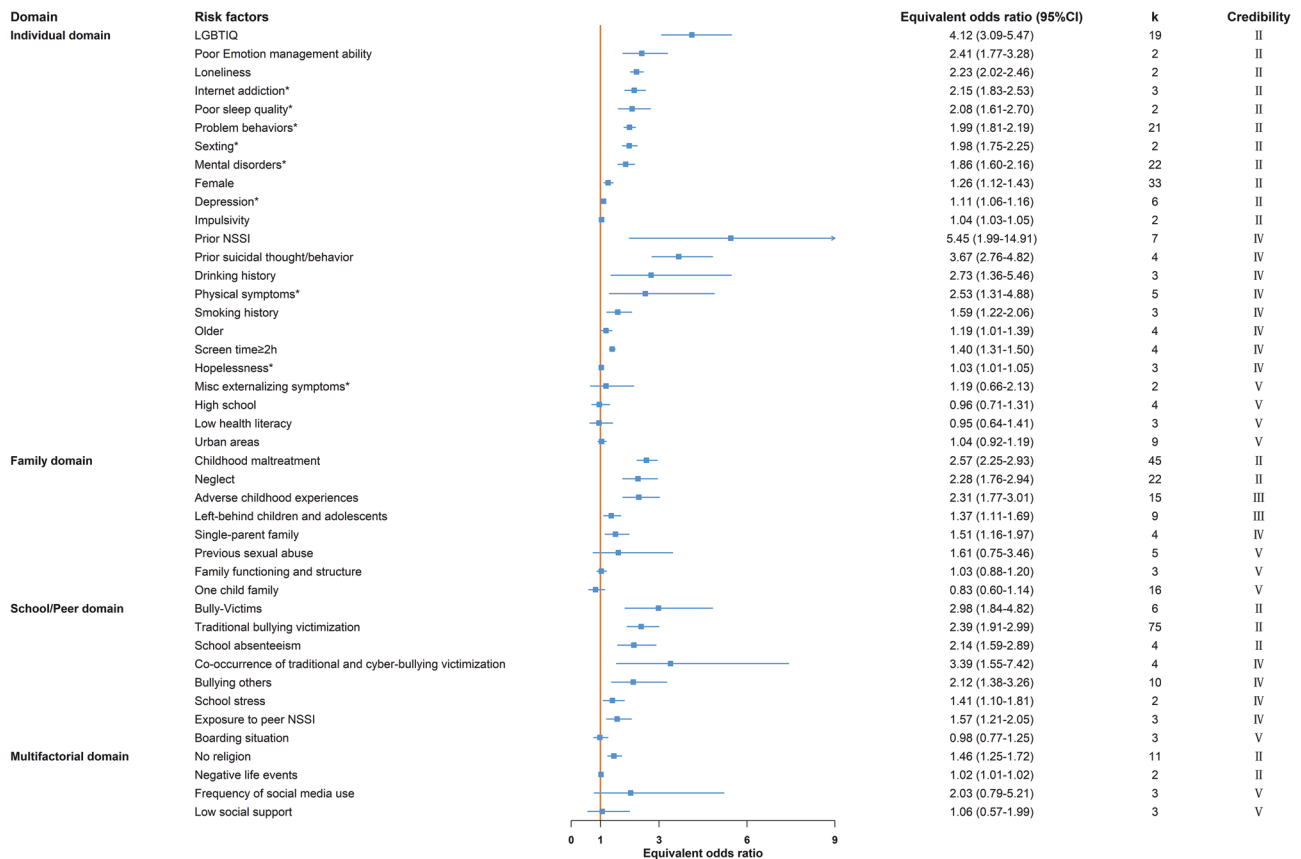


Fig. 2 Forest plot of risk factors for NSSI in adolescents and children, by domain. Overall quality level ranged from I to V, graded as convincing ("class I"), highly suggestive ("class II"), suggestive ("class III"), weak ("class IV"), or no evidence ("class V"); LGBTIQ (lesbian, gay, bisexual, transgender, intersex, queer or questioning); Older (≥ 14 vs < 14); Problem behaviors (any behavioral diagnosis, smoking, alcohol use, run away from home, opioid/sedative misuse et al.); Physical symptoms (somatic Handicap, frequent nightmares, headache, insomnia et al.); * stand for individual mental and physical health.

DISCUSSION

To our knowledge, this is the first umbrella review of risk and protective factors for NSSI in children and adolescents that includes a robust hierarchical classification of the published evidence. This review employs rigorous systematic methodologies to integrate and analyze both established and emerging risk factors across individual, family, school/peer and multifactorial level, providing a more nuanced and comprehensive understanding of the correlates of NSSI. Overall, 16 meta-analyses or systematic reviews, comprising 2,659,156 children and adolescents from 38 countries, were included. Less than half of the factors were characterized by robust evidence or suggestive evidence (class II or III). The factors significantly associated with a high risk of NSSI, supported by highly suggestive evidence, include being female or identifying as a sexual minority within the LGBTIQ spectrum, engaging in multiple problem behaviors, and having mental disorders at the individual level; experiencing childhood maltreatment and neglect at the family level; facing bullying victimization at the school/peer level; and being exposed to negative life events or lacking social support within the multifactorial domain. Meanwhile, we also identified some emerging risk factors of NSSI in youth (e.g. internet addiction, LGBTIQ, bullying) by integrating existing meta-analyses. For example, the issue of bullying has been escalating in the past decade and now represents a significant risk factor for NSSI in children and adolescents. These findings underscore the importance of coordinated comprehensive prevention and intervention strategies across individual, family, and school/peer domains should be implemented to reduce NSSI and improve the wellbeing of children and adolescents globally.

Our meta-analysis reveals a dual pattern in the geographic distribution of NSSI risk factors, with some appearing as universal challenges while others are distinctly region-specific. For example, school absenteeism is a common factor across nearly all regions, indicating a shared challenge in maintaining school attendance [55]. Likewise, various forms of bullying (traditional or cyber) are prevalent in many regions, especially highlighted in North America, Western Europe, and East Asia [52, 53]. Problems like mental disorders are recurrent themes, especially in regions with comprehensive data reporting over multiple years [48]. Mental health issues could be exacerbated by social stigma or lack of mental health services in regions like South and West Asia where the issues are often constrained by cultural perceptions and economic resources [58–60]. In the Arab States, the focus on females highlights the impact of conservative cultural and religious practices on women's mental health and societal roles [61]. Furthermore, our analysis identified no religion as a highly suggestive (Class II) risk factor for NSSI (OR = 1.46, 95% CI: 1.25–1.72). This finding aligns with the ecological framework, where religious beliefs often function as a part of the macrosystem, providing a protective buffer through social support and moral frameworks [19]. Particularly in regions such as the Arab States, the interplay between religious practices and mental health is profound. Additionally, risk factors related to family structure (e.g., single-parent families, one-child families) and societal issues (e.g., LGBTIQ challenges) are repeatedly noted in some East Asian countries (Table S5).

Schools represent a unique and indispensable nexus for NSSI prevention, primarily because adolescents with NSSI are a treatment-avoidant population. However, the urgency of this

Table 1. Credibility ratings of risk factors for NSSI in adolescents and children.

Risk factors	k	Participants	P value	I ²	Prediction interval	Small-study effects	Excess significance	Amstar-2
Highly suggestive (class II)								
School absenteeism [55]	4	31369	<0.001*	88.20%	0.1–44.24	0.87	1.02	high
LGBTIQ [50]	19	236993	<0.001*	96.30%	0.51–33.08	0.34	1.06	low
Bully-Victims [52]	6	8613	<0.001*	82.60%	0.27–33.53	0.91	1.01	low
Problem behaviors [48]	21	272332	<0.001*	67.40%	0.36–11.07	0.25	1.15	low
No religion [57]	11	24514	<0.001*	87.61%	0.18–11.88	0.03	0.97	low
Mental disorders [48]	22	107034	<0.001*	99.00%	0.23–14.8	0.00	1.11	low
Female [11]	33	209758	<0.001*	95.40%	0.18–9.1	0.02	0.98	low
Childhood maltreatment [56]	45	944921	<0.001*	95.71%	0.36–18.55	0.01	1.06	low
Sexting [49]	2	5962	<0.001*	0.00%	..	..	..	low
Neglected [56]	22	20364	<0.001*	95.15%	0.31–16.80	0.98	0.98	low
Poor emotion management ability [45]	2	18719	<0.001*	70.30%	..	..	..	critically low
Traditional bullying victimization [53]	75	174596	<0.001*	98.50%	0.33–17.51	0.14	1.00	critically low
Loneliness [45]	2	29785	<0.001*	0.00%	..	..	..	critically low
Depression [44]	6	14596	<0.001*	91.30%	0.09–12.48	0.11	0.92	critically low
Poor sleep quality [45]	2	18719	<0.001*	0.00%	..	..	..	critically low
Internet addiction [45]	3	18640	<0.001*	0.00%	1.51–3.06	0.48	1.01	critically low
Impulsivity [45]	2	14020	<0.001*	0.00%	..	..	..	critically low
Negative life events [45]	2	3428	<0.001*	0.00%	..	..	..	critically low
Suggestive (class III)								
Adverse childhood experiences [48]	15	94439	<0.001*	95.50%	0.28–19.14	0.00	1.23	low
Left-behind children and adolescents [51]	9	23014	0.003	90.60%	0.15–12.45	0.37	1.08	low
Weak (class IV)								
Drinking history [11]	3	9801	0.005	87.90%	0.04–203.5	0.01	1.16	low
Physical symptoms [48]	5	7773	0.006	91.40%	0.15–42.16	0.03	1.24	low
Bullying others [52]	10	11076	0.001	92.60%	0.23–19.77	0.77	1.02	low
Smoking history [11]	3	5551	0.001	55.50%	0.06–41.21	0.18	1.16	low
Single-parent family [11]	4	3351	0.003	0.00%	0.98–2.33	..	0.90	low
Co-occurrence of traditional and cyber-bullying victimization [53]	4	23698	0.002	97.90%	0.11–101.16	0.35	1.02	critically low
School stress [45]	2	3850	0.007	39.00%	..	..	..	critically low
Age [43]	4	8998	0.033	49.20%	0.13–11.2	0.42	1.59	critically low
Screen time≥2 h [46]	4	..	<0.05	0.00%	1.25–1.56	..	..	critically low
Prior suicidal thought/behavior [43]	4	31339	0.002	80.20%	0.20–65.83	0.50	1.01	critically low
Prior NSSI [54]	7	3340	<0.05	98.40%	0.35–88.83	0.04	0.98	critically low
Exposure to peer NSSI [54]	3	856	<0.05	74.20%	0.04–67.03	0.28	1.07	critically low
Hopelessness [54]	3	2233	<0.05	71.21%	0.03–38.98	0.21	1.01	critically low
No evidence (Class V)								
One child family [11]	16	135416	0.242	98.50%	0.1–7.05	0.80	1.09	low
Urban areas [11]	9	43310	à 0.05	82.90%	0.13–8.77	0.79	1.02	low
Frequency of social media use [49]	3	570	à 0.05	..	..	..	..	low
Previous sexual abuse [47]	5	944	<0.05	69.30%	0.13–20.65	0.49	0.54	critically low
Misc externalizing symptoms [54]	2	2070	à 0.05	87.80%	..	..	1.47	critically low

Table 1. continued

Risk factors	k	Participants	P value	I ²	Prediction interval	Small-study effects	Excess significance	Amstar-2
Family functioning and structure [54]	3	2372	ã 0.05	89.50%	0.02–61.02	0.98	1.16	critically low
Low social support [45]	3	18016	0.851	97.70%	0.01–92.71	0.87	1.07	critically low
Boarding situation [44]	3	10538	0.873	89.10%	0.02–58.95	0.70	1.50	critically low
High school [43]	4	37701	0.798	85.50%	0.05–19	0.60	0.54	critically low
Low health literacy [45]	3	40391	0.799	98.60%	0.01–74.26	0.92	1.04	critically low

Older (≥ 14 vs < 14); Problem behaviors (any behavioral diagnosis, smoking, alcohol use, run away from home, opioid/sedative misuse et al.); Physical symptoms (somatic handicap, frequent nightmares, headache, insomnia et al.); Childhood maltreatment (emotional abuse, physical abuse, sexual abuse); Neglect (emotional and physical neglect); Adverse childhood experiences (high adolescent childhood experience scores, family loneliness, parents' substance abuse, no religious or spiritual context, friend had attempted suicide, episodes of childhood abuse etc); Left-behind children and adolescents (children and adolescents residing in regions, such as rural areas in China, who remain in their home communities while one or both parents migrate to urban areas for employment); *stand for $P < 1 \times 10^{-6}$

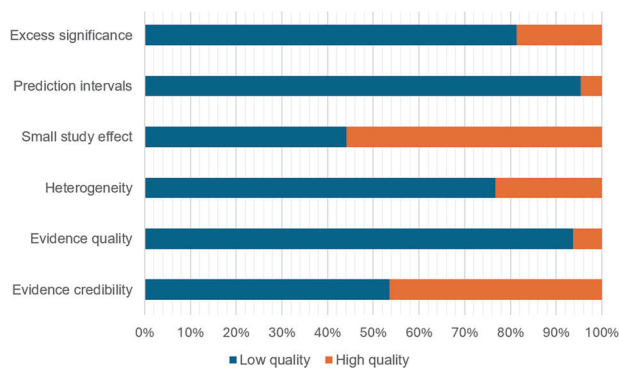


Fig. 3 Overall quality assessment of risk factors. Excess significance: Yes vs. No; Prediction intervals: No significant vs significant. Heterogeneity: High vs. Low and moderate; Evidence quality: Low and critically low vs. High; Evidence credibility: Weak ("class IV"), and no evidence ("class V") vs. Convincing ("class I"), highly suggestive ("class II") and suggestive ("class III").

issue is underscored by the immense scale of educational exclusion. UNESCO reported that the number of out-of-school children remains significant, with 250 million children excluded from schooling despite efforts by countries [62]. Persisting with current trajectories of educational exclusion could potentially restrain the global economy by an estimated US\$10 trillion annually, a sum exceeding the combined annual GDPs of France and Japan [63]. Meanwhile, it has been observed that approximately 60% of adults and an alarming 90% of adolescents who have inflicted harm upon themselves refrain from contacting healthcare services for support and intervention [64, 65]. Given the critical developmental of children and adolescents and the strong association between school absenteeism and NSSI, school-based mental health programs are essential [66–69]. An effective strategy requires action at multiple levels. At the policy level, compulsory education guidelines should be enhanced to not only foster collaboration between educational institutions and mental health services but also grant school mental health professionals the legal authority and resources for home visits and community-based interventions [70–72]. Such a mandate is critical for establishing contact with students who have disengaged from the school system, an at-risk group for whom traditional school-based programs are often insufficient. Furthermore, educational policies should mandate the inclusion of mental health education in school curricula, encompassing topics such as emotional regulation, stress management, resilience building and anti-bullying [73–75]. Educators and school staff should be trained to

recognize early signs of distress and provide appropriate referrals [76]. Rather than merely focusing on attendance incentives, school-based programs must offer mentorship and personalized support that directly address the school-based stressors driving absenteeism such as peer victimization and academic pressure.

Given the pivotal role of family dynamics in the development of NSSI behaviors, family-centred strategies are essential for both prevention and intervention [77, 78]. Foundational strategies like parent training and therapy, can reduce childhood neglect and maltreatment by improving parenting and communication, helping prevent mental problems and adverse childhood experiences [79]. These core skills could be effective in resolving conflicts, fostering emotional regulation, and building supportive family structures [80, 81]. For instance, fostering open communication about internet use and establishing clear guidelines can also help families manage and mitigate excessive or harmful online behaviors. In the meantime, the program that involves parents in anti-bullying efforts, such as parenting workshops and family counseling, can reinforce positive behaviors at home. Furthermore, when families collaborate with schools to address bullying, children can benefit from a comprehensive network of support, enhancing their ability to handle and prevent bullying situations. Additionally, family-centered support is critical for addressing school absenteeism, which often reflects underlying issues like economic hardship or mental health challenges within the family unit. Interventions such as home visits, family therapy, and parental education programs can create a stable and supportive environment for their children [82]. Programs that educate parents on the signs and risks of NSSI, as well as how to support their children, can empower them to provide direct support to their children. By strengthening family dynamics and addressing these root vulnerabilities, these interventions not only reduce absenteeism but, more importantly, mitigate the core family-level risks for NSSI.

The proliferation of digital platforms has introduced significant new risk factors for NSSI, including internet addiction, sexting, and cyberbullying [83–85]. These challenges are particularly prominent in regions with advanced technological infrastructure, such as North America, Western Europe and East Asia (Table S5). In our work, we have observed an increasing trend where adolescents are drawn to online groups focused on NSSI. As the age threshold for internet use decreases, adolescents increasingly share their personal experiences with NSSI within these communities, thereby creating what can be described as an "echo chamber" effect. Addressing these digital-age risks requires a dual approach. Digital well-being initiatives are essential for managing and preventing problematic internet use, including educating students about the risks of excessive screen time, providing tools for self-regulation, and promoting healthy online habits. By fostering self-regulation

and promoting a balanced approach to technology, digital well-being initiatives effectively reduce problematic internet behaviors. Simultaneously, regulatory frameworks should be established to ensure the safety and well-being of adolescents in the digital space, including enforcing age-appropriate content, protecting against cyberbullying, and promoting digital literacy [86, 87].

Leveraging artificial intelligence (AI) offers a powerful strategy for enhancing online safety for adolescents [88]. Through collaboration with technology companies, AI-driven tools could be developed to proactively identify harmful content and cyberbullying patterns in real time across platforms like search engines, social media, and email [89–91]. A critical component of this approach is integrating AI detection with rapid response systems. These systems should be user-friendly and provide immediate support or intervention [92]. Additionally, online support groups and resources can provide adolescents with safe spaces to discuss their challenges and seek help [85]. Ultimately, creating a safer digital environment hinge on partnerships with tech companies to implement and enforce robust anti-cyberbullying policies, thereby protecting vulnerable youth.

Global surveillance systems for NSSI are notably limited, with an even more pronounced scarcity in LMICs [18]. A critical finding of this meta-analysis is the disproportionate and under-documented burden of NSSI in LMICs. As the results show, NSSI is not evenly distributed globally, with LMICs experiencing significantly higher rates due to factors such as poverty and lack of mental health services [18] (Figure S1, Table S5). Adolescents in LMICs are often exposed to severe stressors, including economic hardships, limited access to education, and inadequate healthcare, which increase the risk of engaging in self-harm [1, 18, 93]. This difference highlights the need for region-specific prevention strategies and emphasizes the role of cultural, social, and economic factors in shaping NSSI behaviors. The burden of self-harm among young people aged 10–24 years escalates in nations characterized by a lower sociodemographic index [4, 5]. Adolescents, in particular, are hesitant to seek help due to stigma, privacy concerns, and fear of judgment, which increases their vulnerability to repeated episodes and subsequent fatal outcomes [1]. This evidence highlights an urgent need to address the long-standing neglect of NSSI in LMICs. Research and policies have often been biased toward high-income settings, leading to gaps in knowledge and care for those most in need. Therefore, addressing this global inequity requires a concerted public health response within LMICs, focused on building foundational support systems. Policymakers should first formulate and implement comprehensive mental health policies that prioritize early intervention, prevention, and treatment of NSSI [94, 95]. Next, mental health promotion should be integrated into primary care settings, with healthcare providers trained to screen for NSSI risk factors. Additionally, early identification and treatment of mental disorders such as depression, anxiety, and impulsivity are also critical in preventing NSSI.

NSSI in adolescents and children is a complex and challenging multifactorial problem.

Crucially, school absenteeism should not be viewed merely as a standalone cause of NSSI, but rather as a downstream manifestation of other underlying vulnerabilities, such as peer victimization (e.g., bullying) or family dysfunction. Therefore, addressing this issue requires moving beyond treating absenteeism as a simple causal lever. A collaborative, multi-stakeholder approach is essential to target the root causes, enabling early prevention (led by individuals and families), timely detection (by families and schools), and prompt referral (to medical and rehabilitation institutions). Our umbrella review of existing observational epidemiological studies offers an insight for public health, especially considering the current discussions about significant risk factors for NSSI via public health interventions. Compared to the recent review completed by Richardson et al., we searched more databases and included articles with a broader time range, resulting in detailed and well-supported

findings with better research depth and richness [96]. The elucidation of these findings could significantly enhance the strategic allocation of public health and clinical interventions by delineating their prioritization according to comparative risk assessments. Such insights are instrumental in guiding policy-makers towards the optimal deployment of resources, thereby maximizing efficacy and efficiency within healthcare frameworks.

Generally, one limitation of our review is the quality and credibility of evidence observed in the analysis. Although numerous risk factors have been explored, robust evidence supporting these associations remains sparse. Associations were downgraded largely owing to high heterogeneity or a 95% prediction interval. The review found no convincing evidence for risk factors linked to NSSI. Second, our focus was restricted to factors that have undergone meta-analytical scrutiny and potential risk factors explored through narrative or systematic reviews lacking quantitative synthesis remained unaddressed. Third, our conclusions are pertinent solely to NSSI within the children and adolescents primarily from middle to high-income countries, thereby limiting their applicability to other populations or regions at elevated risk, where effect magnitudes may be notably diminished. Lastly, in instances where multiple meta-analyses reported identical risk factors with overlapping data sets, a singular analysis was chosen for inclusion so as to preclude redundancy though it must be acknowledged that this selection process could potentially affect outcomes. Preference was given to the largest or latest meta-analysis to encapsulate the broadest evidence base.

In conclusion, this umbrella review identified a wide array of correlates, highlighting the multifarious nature of NSSI in children and adolescents. Based on existing evidence, we recommend implementing effective prevention strategies, including school-based programs and family-centered support. Crucially, we advocate for policy frameworks that empower school staff with formal mandates for home-based outreach. These measures, alongside digital well-being initiatives and comprehensive mental health policies, are essential to reduce NSSI prevalence and enhance the well-being of youth.

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AUTHOR CONTRIBUTIONS

L Lu, YP Bao, XX Liu, and Y Zhong proposed the topic of the meta-analysis. Y Zhong, ZW Zhang, JH Ding, YB Zheng, YF Yu and ZC Guan performed the literature search, data curation, and data visualization. Y Zhong, ZW Zhang, and JH Ding wrote the original manuscript, and XX Liu, YP Bao, D Wasserman and L Lu checked the data and critically revised the manuscript. YB Zheng, SZ Su, W Yan, J Sun, YF Yu, ZC Guan, YM Gong, Z Wang, WF Mi, YM Wang, L Shi, YK Sun, A Javed, and D Wasserman commented on and revised the manuscript. All authors were involved in reviewing and editing the manuscript.

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COMPETING INTEREST

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