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A Co-Twin Control Study of the Association Between Bullying Victimization and Self-Harm and Suicide Attempt in Adolescence

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A B S T R A C T

Purpose: The aim of the study was to investigate the magnitude of an independent association between bullying victimization and self-harm and suicide attempt in adolescence after adjusting for unmeasured and measured confounding factors.
Methods: Using the Child and Adolescent Twin Study in Sweden, we examined twins born between 1994 and 1999 (n = 13,852). Twins self-reported bullying victimization at age 15 years and self-harm and suicide attempt at age 18 years. We created a factor score of 13 bullying items, on which self-harm and suicide attempt items were regressed in three models: (1) among unrelated individuals; (2) among co-twins, in which a twin exposed to more bullying was compared with his/her co-twin who was exposed to less; and (3) among co-twins while adjusting for indicators of childhood psychopathology.
Results: Among unrelated individuals, a one standard deviation increase in bullying victimization was associated with increased odds for self-harm (odds ratio [OR], 1.29 [95% confidence interval, 1.23–1.36]) and suicide attempt (OR, 1.68 [1.53–1.85]). Among co-twins, the odds attenuated for self-harm (OR, 1.19 [1.09–1.30]) and suicide attempt (OR, 1.39 [1.17–1.66]). Finally, when accounting for childhood psychopathology, there was a 14% (1.04–1.25) and 25% (1.03–1.52) relative increase in odds of self-harm and suicide attempt, respectively.
Conclusions: The results suggest that bullying victimization was uniquely associated with self-harm and suicide attempt over and above the confounding because of unmeasured and measured factors (i.e., familial vulnerability and pre-existing psychopathy). However, magnitudes

IMPLICATIONS AND CONTRIBUTION

This co-twin control study examined the association between bullying victimization and self-harm and suicide attempt in adolescence. After adjustment for unmeasured and measured confounding, the results showed that bullying victimization was uniquely associated with self-harm and suicide attempt, although the magnitude of association was small.

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were small, suggesting that additional interventions and screenings are needed to address suicidality apart from bullying interventions.

As of 2017, suicide is the second leading cause of death among 10- to 34-year-olds in the U.S. [1]. Adolescence is a crucial developmental period to examine suicidality, as the prevalence of ideation, plan, and attempt increase around puberty [2]. Although a large body of literature has implicated psychiatric problems in suicidal behavior (i.e., attempt and death), there has been a recent push to understand social risk factors specific to adolescent development, such as bullying. Although the rates of bullying victimization vary widely by sample and type of victimization (physical, cyber, and verbal), studies have reported a prevalence of approximately 30% [3].

Numerous cross-sectional and longitudinal studies have identified bullying victimization as a risk factor for internalizing and externalizing problems that persist into young adulthood [4]. A review and meta-analysis suggested that bullying victimization is associated with suicidal ideation and attempt (odds ratios [ORs] ranging from 1.4 to 5.6) [5,6]. When considering potential sources of confounding that could influence both bullying victimization and suicidal behavior, research suggests that the association persists even after adjustment for psychopathology and social factors (externalizing and internalizing behaviors, abuse, harsh parenting) among children [4,7].

However, these studies are limited by cross-sectional designs, minimal adjustment for prior psychopathology, and not accounting for the role of unmeasured factors, namely that of genetic and shared environmental confounding factors [5,6,8]. Causal interpretations in observational designs are strengthened through the examination and elimination of alternative explanations [9]. Prior psychopathology and genetic and shared environmental factors offer possible alternative explanations for the association between bullying victimization and suicidality-related outcomes that need to be ruled out to strengthen a causal interpretation. One approach to examine the presence and magnitude of a potential causal association is through a co-twin control design [10]. By comparing one twin to his/her co-twin, researchers can adjust for all factors that make a twin pair similar, including genetic factors and shared family background (e.g., familial psychiatric problems/suicidality, home environment) [11]. For example, children of low socioeconomic status may be at increased risk for bullying and low socioeconomic status also increases the risk for suicidal behavior, which could confound the association between bullying and suicidal behavior. Therefore, to more rigorously examine a potential causal hypothesis, in this case, whether reducing bullying victimization will reduce suicidal behavior, co-twin studies offer significant insight. A few prior studies have used a co-twin control design and specifically examined bullying victimization and suicidal ideation [12,13], self-harm [13,14], and suicide attempt [13]. Although the amount of confounding differed by study, all reported a remaining environmentally mediated association, consistent with a causal interpretation. The present study addresses several gaps in the literature. First, we examine adolescent bullying exposure, rather than childhood exposure, as the developmental period of exposure may differentially predict suicidal behavior. Second, we use a latent factor of bullying victimization, rather than a dichotomous measure of ever being bullied or frequent bullying victimization, to capture instances, duration, and intensity of victimization. Third, we adjust for prior psychopathology, which may confound the association between victimization and suicidality. Finally, prior co-twin control studies have focused on suicidal ideation and have not examined suicide attempt as separate from self-harm, although the predictors of suicidal ideation differ from those for suicidal behavior [15]. It is, thus, crucial to examine bullying victimization with various suicidality outcomes, especially those of higher risk, within a genetically informative framework.

In the present study, we used a large-scale, longitudinal twin study from Sweden to investigate the association between bullying victimization and self-harm and suicide attempt (SH/SA) among adolescents while accounting for unmeasured and measured confounding factors.

Methods

Sample

We used data from the Child and Adolescent Twin Study in Sweden, which is an ongoing, longitudinal study beginning in 2004, assessing the psychological and physical concerns of twins. All twins living in Sweden were targeted to participate in the study, with a response rate of approximately 80% at the first wave [16]. Twins and/or their parents were contacted at three times points (i.e., when the twins were aged 9, 15, and 18 years). For the first three years of the study, twins aged 12 years also participated in the first assessment of the study. For the current sample, we included all twins born between 1994 and 1999 who were eligible to participate in age 15 and 18 data collection because the predictor and outcome were derived from these waves ($n = 13,852$). Twin zygosity was determined either from a DNA sample analysis of 48 single-nucleotide polymorphisms or using a five-question measure about twin similarity, which was validated against DNA samples. Monozygotic ($n = 3,689$), dizygotic ($n = 4,844$), opposite-sex dizygotic ($n = 4,772$), and unknown zygosity ($n = 547$) twins were all included. The Internal Review Board at Indiana University and the Regional Ethical Review Board in Stockholm, Sweden, approved this study.

Bullying victimization

At age 15 years, adolescents completed the Revised Olweus Bully/Victim Questionnaire (OBVQ) [17], which has demonstrated validity and reliability across countries as a measure of bullying [18] and is moderately correlated with peer nominations for victimization [19]. Given that previous research examining victimization often sums or creates a latent factor of bullying instances [20,21], we used 10 items indexing specific bullying instances, such as "I was hit, kicked, pushed, shoved around, or locked indoors." However, we also wanted to capture victimization intensity and duration. Therefore, we included three additional items: "By how many students have you usually been bullied," "How long has the

bullying lasted," and "How often have you been bullied at school in the past couple of months?" In total, we included 13 items, which either included five or six response options (Table 1). Adolescents who indicated that they did not know/want to answer were coded as missing. Given the inclusion of items indexing type, intensity, and duration of bullying, we created a factor score in which all 13 items were set to load onto a general factor of bullying, similar to past research [20].

Self-harm and suicide attempt

At age 18 years, adolescents completed the Lifetime History of Aggression questionnaire, which included two questions indexing SH/SA behaviors: "Have you ever deliberately attempted to injure yourself physically when you were angry or despondent?" and "Have you ever deliberately attempted to kill yourself when you were angry or despondent?" Because we were unable to determine intent to die in the former item, we used the term self-harm. From six response options ranging from "Never" to "More times than I can count," we dichotomized each item into absent (0) or ever present (1). We analyzed the SH/SA items separately and together (either SH or SA), consistent with prior research [22].

Covariates

Internalizing symptoms (e.g., loneliness, depression, and anxiety) [23], attention/deficit/hyperactivity disorder [24], and other externalizing behaviors (e.g., substance use, aggression, and delinquency) [25] have all been shown to predict bullying victimization. We included these measures of psychopathology, as children may be targeted for bullying potentially because of pre-existing individual characteristics.

At age 9/12 years, parents completed the Autism—Tics, AD/HD other Comorbidities inventory, which is a validated telephone-based interview assessing various aspects of youth psychiatric symptom clusters that correspond to DSM-IV diagnoses [16]. Each response could be endorsed as "No" (0), "Yes, to some extent" (.5), and "Yes" (1). Based on Anckarsäter et al., we summed all items for concentration/attention (range 0–9), impulsivity/activity (0–10), opposition (0–5), conduct (0–5), eating (0–2), and reality/psychosis (0–1).

Bullying variable construction and psychometrics

Although the response rate at age 9/12 years was high, attrition increased over the subsequent waves. To examine the implications of attrition, we predicted SH/SA from a missing indicator at age 15 years. Those who were missing at age 15 years but present at age 18 years were at increased odds of SH/SA at age 18 years compared with those who were not missing at age 15 years (Supplementary Material Table 1). Missing data were attributable both to nonparticipation at Waves 15 and 18 as well as, among participants, nonresponse to specific measures included in the study. Of the adolescents who were eligible to complete age 15 years data collection, 31.9% did not complete any data collection. Of those who participated in at least one questionnaire at age 15 years (n = 9,428), missingness on individual bullying items ranged from 12.2% to 14.5%. Of those eligible to complete age 18 years data collection, 34.6% did not complete any data collection. Of those who participated in some data collection (n = 9,063), 14.1% and 14.2% were missing on SH/SA, respectively.

Given that participants could enter and exit data collection across waves, we multiply imputed on each OBVQ and Lifetime History of Aggression item using the discriminant function within fully conditional specification because of its enhanced flexibility with categorical variables [26]. Each missing value is entered as its own regression model and is iteratively predicted by the other variables. Research has demonstrated fully conditional specification results in less biased estimates [27] and performs similarly to multivariate imputation even when using categorical variables [28].

After conducting 10 imputations in SAS 9.4 [29], we used structural equation modeling to create factor scores for each imputation by loading all 13 bullying items onto a bullying latent factor in *Mplus* 8 [30]. Because of the responses of each bullying item being non-normally distributed, we treated each item as categorical and used the WLSMV estimator. To estimate the reliability between the factor score and latent factor, we included the test information curve for each imputation. Information (i.e., precision) was highest approximately two thetas above zero, indicating that reliability was greater for those who experienced more bullying victimization (Supplementary Figure 1). To assess the validity of our imputed values, we graphed the overlap between the observed and imputed variables (Supplementary Figure 2) based on recommendations from previous research [31]. Across all variables, the distributions between imputed and observed variables were nearly identical.

Analyses

To examine the extent to which the association between bullying and SH/SA was consistent with a causal hypothesis, we conducted three sets of logistic regression analyses in SAS 9.4 for each of the two outcomes. First, we compared unrelated individuals and adjusted for biological sex while also adjusting standard errors for twin pair clustering. We included biological sex, given its association with both bullying and SH/SA (Supplementary Table 2). Second, we conducted a co-twin control analysis adjusted for biological sex by stratifying on twin pair. A co-twin control design compares twins who differ on their exposure to a given risk factor (i.e., bullying). Monozygotic (MZ) and dizygotic (DZ) twins share either 100% or 50% of their segregating alleles, on average, as well as environmental exposures. Examining differentially exposed twins allows researchers to adjust for all unmeasured factors that make twins similar. Third, we additionally adjusted for childhood psychopathology. In all analyses, the factor score was standardized.

Sensitivity analyses

We conducted five sets of sensitivity analyses to examine how methodological decisions may have impacted our results. First, we created a sum score of dichotomized specific bullying instances (range 0–10, mean = .83, standard deviation = 1.43), which allowed us to compare to previous literature that relied on a sum indicator [21]. The factor score and summed score were highly correlated (r = .87, 95% confidence interval [CI], .87–.87; Supplementary Figure 3 shows summed score frequency distribution). Second, we conducted a complete case analysis (n = 4,962) to compare against the multiply imputed data set. This enabled us to examine whether our method of accounting for missing values might have biased our estimates. Third, we reanalyzed the multiply imputed data set but included depression and anxiety as covariates to examine the extent to which depression and anxiety measured at age 9/12 years may be confounding the

Table 1
Demographics of bullying and SH/SA

Bullying items (age 15 years)	Multiple imputation sample	Complete case sample
	n (%)[a]	n (%)[b]
How often have you been bullied at school in the past couple of months?		
I have not been bullied at school in the past couple of months	7,271 (52.49)	4,376 (88.19)
It has only happened once or twice	713 (5.15)	419 (8.44)
2 or 3 times a month	139 (1.00)	80 (1.61)
About once a week	63 (.45)	34 (.69)
Several times a week	88 (.64)	53 (1.07)
Missing	5,578 (40.27)	-
I was called mean names, was made fun of, or teased in a hurtful way		
It has not happened to me in the past couple of months	6,988 (50.45)	4,216 (84.97)
It has only happened once or twice	983 (7.10)	599 (12.07)
2 or 3 times a month	159 (1.15)	76 (1.53)
About once a week	65 (.47)	34 (.69)
Several times a week	67 (.48)	37 (.75)
Missing	5,590 (40.36)	-
Other students left me out of things on purpose, excluded me from their group of friends, or completely ignored me		
It has not happened to me in the past couple of months	7,436 (53.68)	4,485 (90.39)
It has only happened once or twice	582 (4.20)	336 (6.77)
2 or 3 times a month	112 (.81)	68 (1.37)
About once a week	48 (.35)	29 (.58)
Several times a week	76 (.55)	44 (.89)
Missing	5,598 (40.41)	-
I was hit, kicked, pushed, shoved around, or locked indoors		
It has not happened to me in the past couple of months	7,808 (56.37)	4,717 (95.06)
It has only happened once or twice	368 (2.66)	193 (3.89)
2 or 3 times a month	33 (.24)	21 (.42)
About once a week	22 (.16)	16 (.32)
Several times a week	26 (.19)	15 (.30)
Missing	5,595 (40.39)	-
Other students told lies or spread false rumors about me and tried to make others dislike me		
It has not happened to me in the past couple of months	7,132 (51.49)	4,327 (87.20)
It has only happened once or twice	890 (6.43)	517 (10.42)
2 or 3 times a month	144 (1.04)	82 (1.65)
About once a week	38 (.27)	20 (.40)
Several times a week	50 (.36)	16 (.32)
Missing	5,598 (40.41)	-
I had money or other things taken away from me or damaged		
It has not happened to me in the past couple of months	7,844 (56.63)	4,744 (95.61)
It has only happened once or twice	347 (2.54)	187 (3.77)
2 or 3 times a month	41 (.30)	23 (.46)
About once a week	10 (.07)	5 (.10)
Several times a week	7 (.05)	3 (.06)
Missing	5,603 (40.45)	
I was threatened or forced to do things I did not want to do		
It has not happened to me in the past couple of months	8,043 (58.06)	4,868 (98.11)
It has only happened once or twice	165 (1.19)	76 (1.53)
2 or 3 times a month	16 (.12)	8 (.16)
About once a week	7 (.05)	4 (.08)
Several times a week	12 (.09)	6 (.12)
Missing	5,609 (40.49)	-
I was bullied with mean names or comments about my race or color		
It has not happened to me in the past couple of months	8,037 (58.02)	4,865 (98.05)
It has only happened once or twice	150 (1.08)	72 (1.45)
2 or 3 times a month	26 (.19)	9 (.18)
About once a week	15 (.11)	6 (.12)
Several times a week	17 (.12)	10 (.20)
Missing	5,607 (40.48)	-
I was bullied with mean names, comments, or gestures with a sexual meaning		
It has not happened to me in the past couple of months	7,714 (55.69)	4,668 (94.07)
It has only happened once or twice	380 (2.74)	216 (4.35)
2 or 3 times a month	67 (.48)	46 (.93)
About once a week	29 (.21)	17 (.34)
Several times a week	33 (.24)	15 (.30)
Missing	5,629 (40.64)	-
I was bullied with mean or hurtful messages, calls or pictures, or in other ways on my cell phone or over the Internet (computer)		
It has not happened to me in the past couple of months	7,776 (56.14)	4,718 (95.08)
It has only happened once or twice	354 (2.56)	201 (4.05)
2 or 3 times a month	53 (.38)	25 (.50)

Table 1
Continued

Bullying items (age 15 years)	Multiple imputation sample	Complete case sample
	n (%)[a]	n (%)[b]
About once a week	17 (.12)	9 (.18)
Several times a week	25 (.18)	9 (.18)
Missing	5,627 (40.62)	-
I was bullied in another way		
It has not happened to me in the past couple of months	7,669 (55.36)	4,643 (93.57)
It has only happened once or twice	404 (2.92)	242 (4.88)
2 or 3 times a month	70 (.51)	43 (.87)
About once a week	32 (.23)	18 (.36)
Several times a week	34 (.25)	16 (.32)
Missing	5,643 (40.74)	-
By how many students have you usually been bullied?		
I have not been bullied at school in the past couple of months	7,049 (50.89)	4,265 (87.06)
Mainly by one student	493 (3.56)	299 (6.10)
By a group of 2–3 students	396 (2.86)	232 (4.74)
By a group of 4–9 students	110 (.97)	62 (1.27)
By a group of 10 or more students	8 (.06)	5 (.10)
By several different students or groups of students	65 (.47)	36 (.73)
Missing	5,731 (41.37)	-
How long has the bullying lasted?		
I have not been bullied at school in the past couple of months	7,312 (52.79)	4,415 (90.88)
Mainly by one student	207 (1.49)	117 (2.41)
By a group of 2–3 students	89 (.64)	53 (1.09)
By a group of 4–9 students	103 (.74)	58 (1.19)
By a group of 10 or more students	99 (.71)	64 (1.32)
By several different students or groups of students	247 (1.78)	151 (3.11)
Missing	5,795 (41.84)	-
Self-harm/suicide attempt (age 18 years)		
Self-harm		
Never	5,661 (40.87)	3,644 (73.44)
Once	731 (5.28)	455 (9.17)
2–3 times	630 (4.55)	388 (7.82)
4–9 times	312 (2.25)	203 (4.09)
10+ times	194 (1.40)	115 (2.32)
More times than I can count	253 (1.83)	157 (3.16)
Missing	6,071 (43.83)	-
Suicide attempt		
Never	7,306 (52.74)	4,710 (94.92)
Once	276 (1.99)	148 (2.98)
2–3 times	116 (.84)	61 (1.23)
4–9 times	37 (.27)	24 (.48)
10+ times	19 (.14)	10 (.20)
More times than I can count	22 (.16)	9 (.18)
Missing	6,076 (43.86)	-

SH/SA measured by the Lifetime History of Aggression questionnaire. Female and male refers to biological sex, rather than gender. Note that missing includes both those missing that item, as well as those missing from that particular wave of data collection.

[a] Based on 13,852 unique individuals.

[b] Based on 4,962 unique individuals.

association. The Autism—Tics, AD/HD other Comorbidities inventory modules indexing depression and anxiety had greater missingness (34.3% and 34.3%, respectively), as they were less frequently administered/not administered for the two final birth years. Fourth, rather than examining a sum of bullying instances, previous research has questioned whether specific types of bullying are uniquely associated with suicidality [32]. Therefore, we examined physical (three items), verbal (three items), relational (two items), and cyberbullying (one item) [33]. Finally, we analyzed the MZ and DZ twins separately to examine how differences in genetic confounding adjustment may impact the results.

Results

Those who endorsed a specific type of bullying ranged from 1.5% ("I was bullied with mean names about my race or color") to 8.1% ("Other students told lies or spread false rumors about me and tried to make others dislike me"). In addition, 7.9% reported that they had been bullied by one or more students, and 5.4% reported that it had lasted for more than 1–2 weeks. At age 18 years, 15.3% endorsed self-harming, and 3.4% endorsed attempting suicide (Table 1).

When comparing unrelated individuals, the bullying factor score was associated with increased odds of self-harm (OR, 1.29 [95% CI 1.23–1.36]), suicide attempt (OR, 1.68 [95% CI, 1.53–1.85]), and either self-harm or suicide attempt (OR, 1.35 [95% CI, 1.28–1.42]; Table 2). That is, for every one standard deviation increase in the factor score, there was a 35% increase in the odds of either self-harm or suicide attempt. When adjusting for all unmeasured confounding factors shared within a twin pair, the odds decreased slightly but were still elevated. The factor score was associated with a 19% relative increase in the odds in self-harm (95% CI, 1.09–1.30), 39% in suicide attempt (95% CI, 1.17–1.66), and 21% in either

Table 2
Association between bullying victimization and SH/SA items across the three aims among multiply imputed data set

Bullying factor score	OR (95% CI)		
	Self-harm[a]	Suicide attempt[b]	Either self-harm or suicide attempt[c]
Among unrelated individuals	1.29 (1.23–1.36)	1.68 (1.53–1.85)	1.35 (1.28–1.42)
Co-twin control	1.19 (1.09–1.30)	1.39 (1.17–1.66)	1.21 (1.11–1.33)
Co-twin control with adjustment for psychopathology[d]	1.14 (1.04–1.25)	1.25 (1.03–1.52)	1.14 (1.05–1.24)

Includes adjustment for biological sex. All items derived from Lifetime History of Aggression questionnaire. Based 13,852 unique individuals.
CI = confidence interval; OR = odds ratio.
[a] The number of informative twin pairs ranged from 4,752 to 4,956 across the 10 imputations.
[b] The number of informative twin pairs ranged from 1,420 to 1,584 across the 10 imputations.
[c] The number of informative twin pairs ranged from 4,968 to 5,200 across the 10 imputations.
[d] Adjusted for ATAC summed scores for attention/deficit/hyperactivity disorder, opposition, conduct, psychosis, and eating symptomology.

(95% CI, 1.11–1.33). Finally, when including adjustment for childhood psychopathology, the associations attenuated further but continued to be positive for self-harm (OR, 1.14 [95% CI, 1.04–1.25]), suicide attempt (OR, 1.25 [95% CI, 1.03–1.52]), and either (OR, 1.14 [OR, 1.05–1.24]).

Sensitivity analyses

A summed measure of bullying instances was associated with self-harm (OR, 1.19 [95% CI, 1.15–1.23]), suicide attempt (OR, 1.37 [95% CI, 1.30–1.43]), and either self-harm or suicide attempt (OR, 1.23 [95% CI, 1.19–1.28]). When adjusting for unmeasured and measured confounding factors, an individual was at 11% increased odds of either self-harm or suicide attempt for each instance of bullying (Supplementary Table 3). When examining complete cases (n = 4,962), the pattern of results was similar to the multiply imputed results, although the magnitudes of the associations were larger. Among unrelated individuals, the factor score was associated with a 42% increased odds (95% CI, 1.34–1.51) for SH/SA. The odds were attenuated when adjusting for unmeasured confounding factors shared within twin pairs (OR, 1.24 [95% CI, 1.09–1.40]) and when further adjusting for childhood psychopathology (OR, 1.22 [95% CI, 1.08–1.39]; Supplementary Table 4). When including indices of childhood anxiety and depression as covariates when simultaneously adjusting for other childhood psychopathology, results were similar as to when excluding them (Supplementary Table 5). When examining specific types of bullying, associations were fairly comparable across types for self-harm, suicide attempt, and either. Of note, the magnitude of odds was the highest for cyberbullying and suicide attempt in the models comparing unrelated individuals (OR, 3.51 [95% CI, 2.76–4.49]). When adjusting for unmeasured and measured confounding, the odds attenuated for all types. Cyberbullying continued to be associated with the highest odds of suicide attempt (OR, 1.73 [95% CI, 1.06–2.80]; Supplementary Table 6). Finally, the examination of MZ and DZ twins separately yielded comparable attenuation of odds across the three models, though the MZ twin parameters were estimated with less precision and became nonstatistically significant when adjusting for unmeasured and measured confounding (Supplementary Table 7).

Discussion

Our primary aim was to investigate the magnitude of a potential causal association between bullying victimization and SH/SA after accounting for unmeasured and measured confounding factors to inform bullying interventions. Our results suggest that, consistent with past nongenetically informative research, bullying victimization is associated with increased odds for suicidality-related outcomes [5,14]. When adjusting for unmeasured (genetic and shared environmental) factors and childhood psychopathology, we found that the magnitude of the association (although attenuated) remained elevated. Therefore, the remaining association between bullying victimization and SH/SA may suggest a potential causal interpretation. Sensitivity analyses of a complete case set, including additional covariates, and of specific types of bullying demonstrated a similar pattern of results.

If at least part of the association between bullying and SH/SA were causal, a reduction in SH/SA might occur if interventions successfully prevent bullying. However, given the extent of the attenuation because of adjustment, our results suggest that these interventions also need to take a comprehensive approach that addresses multiple factors, such as underlying psychopathology and a warm, collaborative school culture [34]. This is particularly important, as a recent meta-analysis demonstrated that bullying interventions reduce victimization by 15%–16% [35]. While the present study cannot illuminate specific mechanisms to target bullying interventions, we suggest that programs need to consider factors that may also predispose adolescents to bullying. Universal prevention programs, such as addressing school culture, may offer certain advantages (e.g., cost-effectiveness) but may be augmented with targeted bullying interventions [36].

When adjusting for all genetic and environmental factors shared within twin pairs, in addition to measured childhood psychopathology, there was a 14% and 25% increased risk for SH/SA for every standard deviation increase in bullying victimization. Although statistically significant, these results are smaller in magnitude compared with a prior co-twin control study examining victimization and maltreatment predicting SH/SA in adolescence (ORs 1.82 and 2.02, respectively) [13]. Our results are consistent with the possibility that bullying is one potential causal risk factor among many.

Strengths

The present study was strengthened by several factors. First, this was the largest twin study of bullying victimization and SH/SA to date. Second, this study was the first to examine the association between bullying and SH/SA using a genetically informative design among adolescents. Third, we also included a separate measure of suicide attempt, rather than a single measure of suicidal behavior. SH/SA remains an important risk factor to examine, especially given its association with future suicidality [37]. Fourth, by comparing differentially exposed twins, we were able to adjust for shared genetic and environmental factors

that have been largely unaccounted for in prior research. Fifth, we examined a factor score that captured a wide variety of bullying victimization. Previous research has focused on specific instances of bullying or a dichotomous measure of ever being bullied/types of bullying [5,7], while our measure included intensity and duration.

Limitations

First, the OBVQ is a measure of self-reported bullying victimization, which is subject to disclosure bias. Prior research has found that 30%–50% of victims do not report their victimization experience to friends, family, or teachers [38]. It is possible that confidential self-report may be a more reliable way to assess bullying than disclosure to others. Second, we did not include measures of bullying perpetration. Research suggests that adolescents who endorse both victimization and perpetration have comorbid externalizing and internalizing, increased suicidal ideation, and poorer overall adjustment to a variety of outcomes [39]. In our sample, victimization was moderately correlated with perpetration (polychoric correlation = .44). However, our single time point measure of bullying at age 15 years precluded us from being able to tease apart the extent to which perpetration may have served as a confounder or mediator for the present associations. Third, the OBVQ only included one item related to cyberbullying. Although researchers have debated the extent to which cyberbullying has increased over the past decade [40], future research on cyberbullying within a genetically informative framework is needed [13]. Fourth, our measures of SH/SA were derived from an aggression questionnaire, which is limited in its ability to measure other suicidality, such as suicidal ideation. All our measures were also lifetime measures, which lacked temporal specify in the outcome. It is possible that those who endorsed SH/SA at age 18 years had expressed suicidality before age 15 years, which may have then led to bullying. One study has suggested that suicidal ideation predicts being both a victim and a perpetrator [39]. Fifth, we lacked sufficient power to differentiate MZ and DZ twin pairs to conduct quantitative behavior genetic modeling. Sixth, we could not evaluate the generalizability of the Child and Adolescent Twin Study in Sweden sample to the Swedish population. Finally, the co-twin control design cannot establish causality and is limited by numerous assumptions. The design does not adjust for nonshared confounders (e.g., factors that differ between twins, such as academic performance or problem-solving skills) and assumes that there are no carry-over effects [41]. However, if carry-over effects were operating, the independent association between bullying and SH/SA would be underestimated.

Implications and future directions

The present study adds to a body of literature supporting the hypothesis that bullying victimization may uniquely increase the risk for a variety of child and adolescent mental health problems. It is possible that interventions targeting victimization may reduce the prevalence of suicidality. However, school-based bullying intervention programs appear to only minimally impact bullying behaviors [36]. In addition, given the small-to-moderate magnitudes of the present associations, bullying intervention programs alone may be of limited clinical utility on the reduction in suicidality without additional mental health interventions [42]. Instead, the results highlight the potential benefit of supplementing bullying interventions with (1) family-based interventions that reduce risk factors in the family environment and (2) practices such as widespread and continual screening of suicide risk, most notably in schools. In addition to screening in schools, our results highlight the importance of asking about bullying victimization when assessing suicidality risk in health care settings (e.g., pediatric/adolescent care providers). Future genetically informative studies that examine how perpetration and victimization are associated with suicidality, as well as the association among sexuality, gender, and race/ethnicity minority groups will significantly contribute to the field.

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Supplementary data

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