Adolescent victimization and self-injurious thoughts and behaviors:
A genetically sensitive cohort study

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**Key points:**

**Question:** Do pre-existing vulnerabilities contribute to the risk for self-injurious thoughts and behaviors in victimized adolescents?

**Findings:** In stringent analyses of a population-representative cohort of 2,232 twins, we found that the experience of adolescent victimization independently contributed to a small elevation in risk for suicidal ideation and self-harm but not to risk for suicide attempt. A large proportion of the observed risks in victimized adolescents was accounted for by non-causal mechanisms involving pre-existing familial and individual vulnerabilities.

**Meaning:** To prevent self-injurious thoughts and behaviors in victimized adolescents, interventions should both address the experience of victimization and target pre-existing vulnerabilities.
Abstract

Importance
Victimized adolescents are at elevated risk of self-injurious thoughts and behaviors. However, poor understanding of causal and non-causal mechanisms underlying this association hampers the development of effective interventions to prevent premature death in adolescents.

Objective
To test the contribution of non-causal mechanisms to the association between adolescent victimization and self-injurious thoughts and behaviors, using co-twin control and propensity score methods.

Design
Prospective birth-cohort study (the Environmental Risk [E-Risk] Longitudinal Twin Study). Assessments were conducted between 1999 and 2014 when participants were aged 5, 7, 10, 12, and 18 years.

Setting
Nationally representative sample from Great Britain assessed through home visits.

Participants
2232 twins (1116 twin pairs) born in England and Wales from January 1, 1994 to December 4, 1995.

Exposure
Adolescent victimization was assessed through interviews with Study members and co-informant questionnaires at the age 18 assessment.
Main outcomes and measures
Suicidal ideation, self-harm, and suicide attempt in adolescence were assessed through interviews with Study members at age 18 years.

Results
Of 2232 participants in the E-Risk Study, 2055 were included in the analysis. Victimized adolescents showed elevated risk for suicidal ideation (odds ratio [OR]=2.17, 95%CI=1.93-2.44), self-harm (OR=2.38, 95%CI=2.10-2.69), and suicide attempt (OR=3.14, 95%CI=2.54-3.88). These associations were largely attenuated after accounting for pre-existing familial and individual vulnerabilities through co-twin control and propensity score analyses, respectively. Nevertheless, in the most stringent analyses using propensity scores within the monozygotic co-twin control design, victimized adolescents still showed elevated risk for suicidal ideation (OR=1.36, 95%CI=1.06-1.76) and self-harm (OR=1.50, 95%CI=1.18-1.91), but not suicide attempt (OR=1.28, 95%CI=0.83-1.98).

Conclusion and Relevance
Over and above pre-existing familial and individual vulnerabilities, exposure to victimization in adolescence was independently associated with a small elevation in risk for suicidal ideation and self-harm. However, a substantial proportion of the observed risk for self-injurious thoughts and behaviors in victimized adolescents was accounted for by non-causal mechanisms involving such prior vulnerabilities. This suggests that primary prevention of adolescent victimization and targeted therapeutic interventions could partly reduce risk for suicidal ideation and self-harm. Furthermore, secondary preventative strategies addressing pre-existing vulnerabilities have the potential to substantially reduce risk for premature death in victimized adolescents.
Suicide is the third leading cause of death among adolescents worldwide.\(^1\) Suicide attempts are often preceded by suicidal ideation and self-harm,\(^2\) which are particularly prevalent in adolescents.\(^3\) To prevent self-injurious thoughts and behaviors in adolescence, it is important to identify proximal risk factors that can be modified through intervention.\(^4,5\)

Here we consider the role of adolescent victimization. One in three adolescents experiences severe victimization,\(^6\) due to exposures both in the community (e.g., crime, sexual victimization, and bullying) and in the family (e.g., maltreatment).\(^7-9\)

Furthermore, these stressful experiences may be particularly harmful to adolescents because of the major neurobiological, emotional, and social changes that take place during this period.\(^10,11\) Previous studies have suggested that victimized adolescents have elevated risk for self-injurious thoughts and behaviors.\(^12-15\) However, confusion about the relative contribution of causal and non-causal mechanisms complicates the interpretation of these findings and hampers the development of effective interventions.\(^16\)

Victimized adolescents might be at high risk for self-injurious thoughts and behaviors by virtue of exposure to maltreatment, bullying, or crime. Alternatively, their risk might be high due to pre-existing liability and earlier experiences. This alternative, non-causal interpretation is plausible because both family-wide factors (e.g., family history of psychopathology, socio-economic disadvantage) and individual factors (e.g., childhood victimization, cognitive deficits, stress-reactive personality traits) can predispose adolescents to experience victimization\(^5,17,18\) and also influence risk for self-injurious thoughts and behaviors.\(^19\)
Here we report a stringent test of these non-causal interpretations capitalizing on design and analytical features with complementary strengths. To account for family-wide factors, we used a co-twin control design\textsuperscript{20} to test whether adolescents with the same genotype and rearing environment - but different exposure to adolescent victimisation - had different risk for self-injurious thoughts and behaviors. Furthermore, to account for individual factors, we used propensity score matching\textsuperscript{21} to test whether adolescents with similar individual propensity to experience victimization - but different exposure to adolescent victimisation - had different risk for self-injurious thoughts and behaviors.
Method

Study sample

Participants were members of the Environmental Risk (E-Risk) Longitudinal Twin Study, which tracks the development of a birth cohort of 2232 British children. The sample was drawn from a larger birth register of twins born in England and Wales in 1994-95. Full details about the sample are reported elsewhere. Briefly, the E-Risk sample was constructed in 1999-2000, when 1,116 families (93% of those eligible) with same-sex 5-year-old twins participated in home-visit assessments. This sample comprised 56% monozygotic (MZ) and 44% dizygotic (DZ) twin pairs; sex was evenly distributed within zygosity (49% male). Families were recruited to represent the U.K. population of families with newborns in the 1990s, on the basis of residential location throughout England and Wales and mother’s age. Teenaged mothers with twins were over-selected to replace high-risk families who were selectively lost to the register through non-response. Older mothers having twins via assisted reproduction were under-selected to avoid an excess of well-educated older mothers. The study sample represents the full range of socioeconomic conditions in Great Britain, as reflected in the families’ distribution on a neighborhood-level socioeconomic index (ACORN [A Classification of Residential Neighbourhoods], developed by CACI Inc. for commercial use in Great Britain): 25.6% of E-Risk families live in “wealthy achiever” neighborhoods compared to 25.3% nationwide; 5.3% vs. 11.6% live in “urban prosperity” neighborhoods; 29.6% vs. 26.9% live in “comfortably off” neighborhoods; 13.4% vs. 13.9% live in “moderate means” neighborhoods; and 26.1% vs. 20.7% live in “hard-pressed” neighborhoods. E-Risk underrepresents “urban prosperity” neighborhoods because such households are likely to be childless.

Follow-up home visits were conducted when the children were aged 7 (98% participation), 10 (96%), 12 (96%), and 18 (93%). Home visits at ages 5, 7, 10, and
12 years included assessments with participants as well as their mother (or primary caretaker); the home visit at age 18 included interviews only with the participants. Each twin participant was assessed by a different interviewer. The average age of the twins at the time of the assessment was 18.4 years (SD = 0.36); all interviews were conducted after the 18th birthday. There were no differences between the 2,066 participants who took part at age 18 and those who did not in terms of socioeconomic status (SES) assessed when the cohort was initially defined ($\chi^2=0.86, p=0.65$), age-5 IQ scores ($t=0.98, p=0.33$), age-5 internalizing or externalizing behavior problems ($t=0.40, p=0.69$ and $t=0.41, p=0.68$, respectively), or childhood victimization ($z=0.51, p=0.61$). Of the Study members who participated in the age-18 assessment, 99.5% (2055) had complete data on adolescent victimization and self-injurious thoughts and behaviors.

The Joint South London and Maudsley and the Institute of Psychiatry Research Ethics Committee approved each phase of the study. Parents gave informed consent and twins gave assent between 5-12 years and then informed consent at age 18.

**Adolescent victimization**

These measures have been described previously and details are provided in the eMethods of the Supplement. Briefly, at age 18, participants were interviewed about exposure to a range of adverse experiences between 12-18 years using the Juvenile Victimization Questionnaire 2nd revision (JVQ-R2) adapted as a clinical interview. Each co-twin was interviewed by a different research worker, and each JVQ question was asked for the period ‘since you were 12’. Age 12 is a salient age for our participants because it is the age when British children leave primary school to enter secondary school. The JVQ has good psychometric properties and was used in the U.K. National Society for the Prevention of Cruelty to Children (NSPCC) national survey, thereby providing important benchmark values for comparisons with our
cohort. Our adapted JVQ-R2 comprised 45 questions covering 7 different forms of victimization: maltreatment, neglect, sexual victimization, family violence, peer/sibling victimization, cyber-victimization, and crime victimization. Exposure to each type of adolescent victimization was coded by trained raters using a 3-point scale, in which “0” indicated “no exposure,” “1” indicated “probable” or “less severe” exposure, and “2” indicated “definite” or “severe” exposure.

The adolescent poly-victimization variable was derived by summing all victimization experiences that received a code of “2”: (i.e., severe exposure): 64.6% of adolescents had zero severe victimization experiences; 19.2% had 1; 9.4% had 2; 4.5% had 3; 1.5% had 4; 0.5% had 5; and 0.2% had 6 severe victimization experiences. We winsorized the adolescent poly-victimization distribution into a four category variable (0, 1, 2, and 3+ severe experiences).

Informant reports of adolescent victimization. At age 18, each study member’s co-twin and parent (usually mother) were asked to reply to a confidential questionnaire which inquired whether the Study member had ever been the victim of each of the 7 different forms of victimization assessed in the adapted JVQ-R2 interview. We summed affirmative responses to these questions, within each reporter. The correlation between co-twin and parental reports was r=0.38; between co-twin and Study members’ JVQ reports, r=0.38; and between parental and Study members’ JVQ reports, r=0.34.

Self-injurious thoughts and behaviors

Study members were privately interviewed at age 18 about suicidal ideation, self-harm and suicide attempts since age 12 using a life history calendar. To assess suicidal ideation, participants were asked whether they thought a lot about death; thought it would be better if they were dead; or thought about a plan to commit suicide. We defined suicidal ideation as an affirmative answer to any of these
questions. To assess self-harm, participants were asked if they had tried to hurt themselves to cope with stress or emotional pain. To assess suicide attempt, participants were asked if they had tried to kill themselves. No Study member completed suicide. Participants who reported self-harm or suicide attempt were further queried about the types of self-injurious behavior that they engaged in.

*Individual characteristics included in the propensity score*

In order to account for pre-existing individual differences between victimized and non-victimized adolescents, we derived a propensity score for adolescent victimization. The propensity score included 11 child-specific characteristics prospectively measured before age 12 years and selected based on previous findings: childhood victimization, social isolation, IQ, internalizing problems, externalizing problems, self-harm, and traits comprising the five-factor model of personality (openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism) (see eTable 1 in the Supplement for details).

Participants with missing data for these covariates (N=119) did not differ from those with complete data (N=1936) according to adolescent victimization and self-injurious thoughts and behaviors (see eTable 2 in the Supplement).

**Statistical analysis**

We first calculated prevalence rates, sex differences in prevalence, and heritability estimates for data on suicidal ideation, self-harm, and suicide attempt. Sex differences in outcomes were estimated using Generalized Estimating Equations (GEE) with binomial function (logistic regression) and an exchangeable correlation structure to account for familial clustering in Stata 15 (StataCorp). Heritability estimates were calculated using ‘Open Mx’ in R.
We next used GEE analyses to test [1] the associations of adolescent poly-victimization with self-injurious thoughts and behaviors; [2] the sensitivity of the findings across informants to examine common-method bias; and [3] the sensitivity of the findings across different measure components (seven individual victimization types).

To test whether family-wide factors confounded the associations, we used a co-twin control design with GEE to parse the effect of adolescent poly-victimization on self-injurious thoughts and behaviors into between-twin pair effects and within-twin pair effects. Because co-twins share their rearing environment as well as half (dizygotic twins) or all (monozygotic twins) their genes, significant within-twin pair effects would indicate that adolescent poly-victimization is associated with self-injurious thoughts and behaviors independent of latent, family-wide factors.

To test whether individual factors confounded the associations, we used two propensity-score analyses. First, we used the Stata command ‘teffects psmatch’ (with robust standard errors) to derive a propensity score for adolescent victimization (i.e., exposure to 1, 2, or 3+ types) versus no victimization, and matched victimized and non-victimized adolescents with a similar propensity score. We then estimated the average treatment effect (ATE), which reflects the excess prevalence of self-injurious thoughts and behaviors in victimized adolescents versus non-victimized adolescents matched for the propensity score. Second, to estimate the joint bias owing to family-wide and individual effects, we expanded the above monozygotic co-twin control regression model by also accounting for the propensity score.

Further details of the statistical analyses are provided in the eMethods of the Supplement.
Results

Self-injurious thoughts and behaviors in adolescence

Nearly a quarter (22.9%) of Study members described some form of self-injurious thoughts and behaviors, with 18.4% (N=379) reporting suicidal ideation, 13.4% (N=275) reporting self-harm, 3.8% (N=79) reporting suicide attempt, and substantial overlap between groups (Figure 1, Panel A). Among those who reported self-harm or suicide attempt, cutting was the most prevalent self-injurious behavior (76.1%), followed by overdosing (22.2%), and burning (13.5%) (Figure 1, Panel B). The overall prevalence of self-harm was greater in females than males (OR=1.79, 95%CI=1.34-2.39, p<0.001), but there were no significant sex differences in the prevalence of suicidal ideation (OR=1.04, 95%CI=0.81-1.33, p=0.77) or suicide attempt (OR=1.34, 95%CI=0.82-2.22, p=0.25). Finally, the occurrence of self-injurious thoughts and behaviors was partly explained by genetic influences, with heritability estimates of 48% (95%CI=6%-67%) for suicidal ideation, 58% (95%CI=28%-70%) for self-harm, and 62% (95%CI=0%-80%) for suicide attempt (eFigure 1 in the Supplement).

Are victimized adolescents at greater risk for self-injurious thoughts and behaviors?

Adolescents reporting exposure to more victimization types were at greater risk for suicidal ideation (OR=2.17, 95%CI=1.93-2.44), self-harm (OR=2.38, 95%CI=2.10-2.69), and suicide attempts (OR=3.14, 95%CI=2.54-3.88) between ages 12-18 (Table 1, Model 1; black triangles on Figure 2). Risk estimates in victimized adolescents were similar in males and females (eTable 3 in the Supplement) and, thus, we hereafter present analyses in the overall sample. In sensitivity analyses, we found that adolescents identified by their co-twin or parent as having been victimized also showed elevated risk for self-injurious thoughts and behaviors (Table 1, Models 2 and 3), suggesting that the findings were not due to biased self-reports of
victimization by adolescents who experienced self-injurious thoughts and behaviors. Furthermore, adolescents reporting exposure to each of the seven individual types of victimization showed greater risk for self-injurious thoughts and behaviors compared to unexposed adolescents (eTable 4 in the Supplement).

**Does greater risk for self-injurious thoughts and behaviors in victimized adolescents reflect confounding by family-wide characteristics?**

We next turned to examine the mechanisms underlying these associations. Adolescents experience victimization⁶ and develop self-injurious thoughts and behaviors partly because of family-wide characteristics, such as genotype and the rearing environment (eFigure 1 in the Supplement). Therefore, family-wide characteristics are plausible non-causal mechanisms underlying the observed associations. We tested the role of these family-wide characteristics by examining the association between adolescent victimization and self-injurious thoughts and behaviors within twin pairs who shared their rearing environment as well as half (dizygotic twins) or all (monozygotic twins) of their genes. Twins exposed to more victimization types were at greater risk for suicidal ideation, self-harm, and suicide attempts compared to their co-twin exposed to fewer victimization types (yellow points in Figure 2; eTable 5, Panel B in the Supplement), although these effect sizes were smaller than phenotypic associations in the overall sample. In the more stringent monozygotic co-twin design (red points in Figure 2; eTable 5, Panel D in the Supplement), adolescents exposed to more victimization types were at greater risk for suicidal ideation and self-harm, but not suicide attempt, compared to their co-twin exposed to fewer victimization types.

**Does the greater risk for self-injurious thoughts and behaviors in victimized adolescents reflect confounding by individual characteristics?**
Although the co-twin control design accounts for family-wide characteristics, it cannot account for characteristics not shared within the family (i.e., individual characteristics). Victimized and non-victimized adolescents differed on several pre-existing individual characteristics (Figure 3, Panel A; eTable 6, Panel A and eTable 7 in the Supplement), which also predicted self-injurious thoughts and behaviors (eTable 8 in the Supplement) and were, thus, plausible non-causal mechanisms underlying the observed associations. We tested the role of these individual characteristics through propensity score methods.

First, we re-estimated the associations after matching victimized adolescents to non-victimized adolescents with similar propensity for adolescent victimization based on individual characteristics (Figure 3, Panel B; eTable 6, Panel B in the Supplement). Victimized adolescents showed greater risk for suicidal ideation (ATE=20.14%, 95%CI=15.50%-24.79%), self-harm (ATE=19.73%, 95%CI=15.33%-24.14%), and suicide attempt (ATE=8.06%, 95%CI=5.43%-10.68%) than matched non-victimised adolescents, although risk was on average 10% lower than in the original, non-matched analyses (eTable 9 in Supplement).

Finally, to estimate the joint bias owing to family-wide and individual characteristics, we expanded the co-twin control analysis to include the above propensity score. Even when accounting for within-pair differences in individual characteristics, monozygotic twins exposed to more victimization types were at greater risk for suicidal ideation and self-harm than their co-twins exposed to fewer victimization types (blue points in Figure 2; eTable 5, Panel E in the Supplement).
Discussion

We found that victimized adolescents were more likely to engage in self-injurious thoughts and behaviors than their non-victimized peers, consistent with previous research.\textsuperscript{12-15} This risk was marked - exposure to each additional victimization type doubled the odds of suicidal ideation and self-harm and tripled the odds of attempting suicide - and was consistent across different informants and victimization types. Therefore, adolescent victimization is an important risk indicator for self-injurious thoughts and behaviors in young people.

To better understand the contribution of non-causal mechanisms to this association and, thus, inform intervention development, we used a co-twin control design to account for pre-existing family vulnerabilities and propensity score methods to account for pre-existing individual vulnerabilities. Taken together, our results both strengthen the evidence for high risk of self-injurious thoughts and behaviors in victimized adolescents and challenge conventional interpretations. Even in these most stringent analyses, victimized adolescents showed elevated risk for suicidal ideation and self-harm, consistent with likely causal effects of adolescent victimization on psychopathology.\textsuperscript{33} However, these analyses also highlighted the role of pre-existing familial and individual vulnerabilities, and suggested that previous studies may have overestimated the causal association between adolescent victimization and self-injurious thoughts and behaviors.

Our study has limitations. First, assessment of victimization and self-injurious thoughts and behaviors spanned the same observational period, and therefore the direction of effects is unclear. However, the findings were independent of childhood self-harm (included in the propensity score) and are thus unlikely to be explained by continuity in self-injury. Second, adolescent victimization and self-injurious thoughts and behaviors were measured via self-report, potentially giving rise to common-
method bias. Nevertheless, adolescent victimization remained associated with self-injurious thoughts and behaviors when victimization was reported by co-informants.

Third, the effect estimates were less precise for suicide attempt because it is rarer than suicidal ideation and self-harm. Therefore, the non-significant association between victimization and suicide attempts in monozygotic twin analyses might reflect low statistical power, as effect sizes were similar to those observed for other outcomes. Finally, findings in our twin sample may not generalize to singletons. However, the prevalence estimates for victimization and self-injurious thoughts and behaviors reported here are similar to estimates in singleton samples. Despite these limitations, our findings have implications for research and interventions.

With regard to future research, our findings suggest the need to better understand the mechanisms linking adolescent victimization to self-injurious thoughts and behaviors. The experience of victimization might directly evoke negative self-views and, in turn, trigger suicidal ideation and self-harm as a means of escaping negative feelings or punishing oneself. Furthermore, future research should identify pre-existing familial and individual vulnerabilities that contribute to the elevated risk of self-injurious thoughts and behaviors in victimized adolescents. These vulnerabilities might include partly heritable individual traits such as poor emotion regulation, impulsivity, and low self-esteem, as well as unsupportive family environments.

With regard to interventions, our findings suggest that primary prevention of adolescent victimization and targeted therapeutic interventions could partly reduce risk for suicidal ideation and self-harm. Furthermore, secondary preventative strategies addressing pre-existing vulnerabilities to self-injurious thoughts and behaviors in victimized adolescents could substantially reduce risk for premature death.
Acknowledgements:

The E-Risk Study is funded by the Medical Research Council (grant G1002190). Additional support was provided by National Institute of Child Health and Development (grant HD077482), the Jacobs Foundation, the Nuffield Foundation, the National Society for Prevention of Cruelty to Children (NSPCC) and the Economic and Social Research Council (ESRC). J.R.B is funded by the ESRC. L.A is the Mental Health Leadership Fellow for the UK ESRC. H.L.F is supported by an MQ Fellows Award (MQ14F40). C.O is a Jacobs Foundation and Canadian Institutes for Advanced Research Fellow. R.T. is funded by the JSPS (JP16H05653), the Royal Society, and the British Academy as a Newton International Fellow Alumnus. We report no conflict of interests. We are grateful to the study mothers and fathers, the twins, and the twins' teachers for their participation and to members of the E-Risk team for their dedication, hard work, and insights.
References


Figure 1. Distribution of self-injurious thoughts and behaviors in adolescence.

LEGEND: Panel A shows the overlap between adolescent suicidal ideation, self-harm, and suicide attempt. The size of the circles and their overlap is proportional to the number of participants (total N=2,055). Suicidal ideation was correlated with self-harm (r = 0.77, p<0.001) and suicide attempt (r = 0.84, p<0.001). Self-harm was correlated with suicide attempt (r = 0.79, p<0.001). Panel B shows the prevalence of self-injurious behaviors endorsed by >1% of those who reported self-harm or suicide attempt. Females and males did not differ in the types of self-injury reported, except for cutting/stabbing self (more prevalent in females: OR=1.94, p=0.021), and hitting self/object (less prevalent in females: OR=0.24, p<0.001).

Figure 2. Association between adolescent victimization and self-injurious thoughts and behaviors. LEGEND: Note. MZ=monozygotic; DZ=dizygotic.

Figure 3. Propensity score for adolescent victimization in non-victimized and victimized adolescents based on child-specific characteristics. LEGEND: The propensity score was derived based on the following child-specific characteristics: childhood victimization, social isolation, IQ, internalizing problems, externalizing problems, self-harm, openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. We used 1:1 nearest neighbor matching with replacement to match each Study member to a Study member with a similar propensity score in the opposite “treatment” group (e.g., victimization [N=671] or no victimization [N=1265]).
Table 1. Association between adolescent victimization and self-injurious thoughts and behaviors.

<table>
<thead>
<tr>
<th>Model</th>
<th>Suicide attempt</th>
<th>Self-harm</th>
<th>Suicidal ideation</th>
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</thead>
<tbody>
<tr>
<td>N=1676</td>
<td>2.08 (1.54-2.79)</td>
<td>2.73 (2.13-3.39)</td>
<td>3.14 (2.44-3.88)</td>
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<td>N=1985</td>
<td>2.07 (1.74-2.50)</td>
<td>2.09 (1.71-2.50)</td>
<td>2.17 (1.93-2.44)</td>
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<td>N=2005</td>
<td>2.01 (1.66-2.34)</td>
<td>2.00 (1.71-2.34)</td>
<td>2.17 (1.93-2.44)</td>
</tr>
</tbody>
</table>

Results are presented as Odds Ratios and 95% confidence intervals.
Figure 1. Distribution of self-injurious thoughts and behaviors in adolescence.
Figure 2. Association between adolescent victimization and self-injurious thoughts and behaviors.

**Figure 2**: Association between adolescent victimization and self-injurious thoughts and behaviors.
Figure 3. Propensity score for adolescent victimization in non-victimized and victimized adolescents based on child-specific characteristics.