

# Bullying fosters interpersonal distrust and degrades adolescent mental health as predicted by Social Safety Theory

Received: 7 July 2023

Accepted: 8 January 2024

Published online: 13 February 2024

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Social Safety Theory predicts that socially threatening experiences such as bullying degrade mental health partly by fostering the belief that others cannot be trusted. Here we tested this prediction by examining how peer bullying in childhood impacted adolescent mental health, and whether this effect was mediated by interpersonal distrust and several other commonly studied mediators—namely diet, sleep and physical activity—in 10,000 youth drawn from the UK's Millennium Cohort Study. Youth bullied in childhood developed more internalizing, externalizing and total mental health problems in late adolescence, and this effect was partially mediated by interpersonal distrust during middle adolescence. Indeed, adolescents who developed greater distrust were approximately 3.5 times more likely to subsequently experience clinically significant mental health problems than those who developed less distrust. Individual and school-based interventions aimed at reducing the negative impact of bullying on mental health may thus benefit from bolstering youths' sense of trust in others.

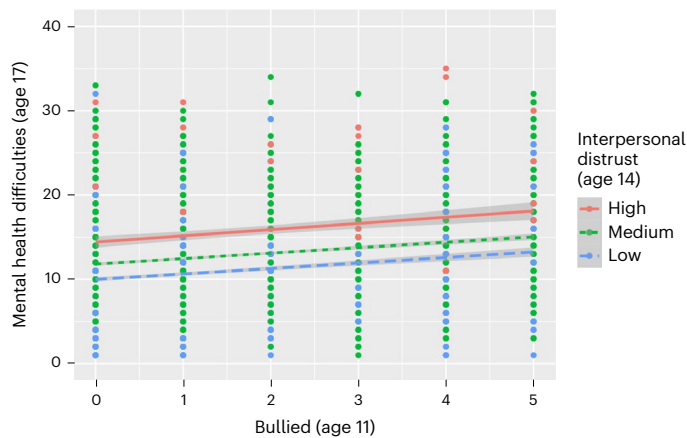
The mental health of children and adolescents has emerged as a major public health concern in recent years<sup>1–4</sup>, with one in four youth experiencing clinically significant symptoms of depression worldwide<sup>5</sup>. Moreover, the Centers for Disease Control and Prevention recently found that 42% of high school students in the USA exhibited persistent sadness or hopelessness and 18% made a suicide plan in 2021 (ref. 6). In a shocking upward trend, one in ten high school adolescents in the USA attempted suicide during 2021 (ref. 7).

One way to understand this crisis is through the lens of Social Safety Theory, which posits that maintaining close social bonds is a fundamental organizing principle of human health and behavior, and that threats to social connection, such as peer bullying and social rejection, are especially detrimental for health<sup>8,9</sup>. Consistent with this theory, an abundance of research has shown that, whereas social rejection and exclusion portend a wide variety of physical and mental health problems, social acceptance, belonging and inclusion promote psychosocial well-being and lengthen life expectancy<sup>10–12</sup>. The reasons for these associations are complex but

partly involve the fact that experiences of social devaluation and exclusion engage neural circuits that upregulate components of the immune system involved in inflammation, which accelerates wound healing and recovery in the short term but causes hypervigilance, anxiety, depression and health-damaging oxidative stress over the long term<sup>8,13–15</sup>. Indeed, there is a growing literature showing that childhood bullying and other social threats degrade health via dysregulated inflammatory dynamics<sup>16–18</sup>.

From a public health perspective, peer bullying—sometimes called peer victimization or bullying victimization—is a very common experience among children and adolescents<sup>19–21</sup>. It is a worldwide problem<sup>22</sup> that negatively impacts both physical<sup>23,24</sup> and mental<sup>25–28</sup> health. A meta-analysis of 165 studies in youth suggested possible causal associations between bullying and several mental and behavioral health difficulties, including substance use, anxiety, depression, self-harm, suicidal ideation and suicidal behaviors<sup>29</sup>. Bullying has also been associated with a variety of negative academic outcomes, including low achievement, motivation and self-esteem<sup>30–33</sup>.

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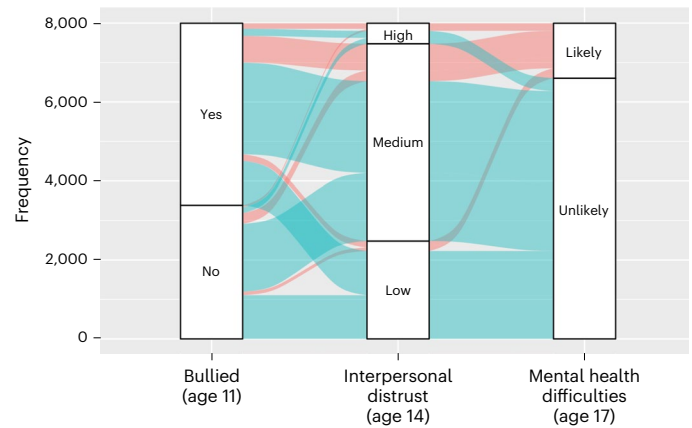


**Fig. 1 | Frequency of peer bullying (at age 11) and mental health problems (at age 17).** Scatterplot showing the association between the frequency of peer bullying at age 11 and total mental health difficulties (that is, internalizing and externalizing problems) at age 17, stratified by three levels of interpersonal distrust at age 14: low, medium and high distrust groups ( $N = 9,755$ ). More frequent bullying in late childhood predicts more mental health difficulties in late adolescence, with level of distrust of other people in middle adolescence mediating this association.

One strategy for addressing this global problem entails eradicating bullying itself. Indeed, interventions aimed at reducing bullying in schools have shown reductions of up to 16% (ref. 34), although the effectiveness of these interventions varies greatly<sup>35–38</sup>. Another, perhaps more tractable strategy could involve reducing the negative health impacts of bullying. The success of any such intervention would depend upon knowing which pathways most strongly link bullying and mental health, but surprisingly little research has examined these underlying mechanisms. On a biological level, sleep has been found to play a mediating role<sup>39,40</sup>, as have diet and physical activity<sup>41–44</sup>. On a psychosocial level, perceptions of social bonding and interpersonal trust<sup>45–47</sup> have been posited as potential pathways linking bullying and poor mental health<sup>10</sup>. From the perspective of Social Safety Theory, a pervasive sense of distrust would be an index of perceived social threat, which, for children and adolescents, indicates the presence of negative social safety schemas<sup>8,10</sup>. Whereas diet, sleep and physical activity have all been the focus of substantial research<sup>48–50</sup>, we know of no bullying interventions that have focused on improving interpersonal trust to enhance individual and collective well-being.

## Present study

The primary purpose of the present study was to test the key prediction from Social Safety Theory that social threat-induced reductions in perceived social safety, characterized by distrust of others, degrades mental health over time. To accomplish this goal, we examined how interpersonal distrust in middle adolescence (age 14 years) mediated the effects of bullying in late childhood (age 11 years) on subsequent mental health difficulties in late adolescence (age 17 years) in a public dataset from the UK's Millennium Cohort Study (MCS), a longitudinal birth cohort that follows around 19,000 children born during 2000–2002. Our second aim was to examine how interpersonal distrust compared to other potential mediating factors linking bullying and mental health—specifically, diet, sleep and physical activity—which could also be candidates for use in large-scale public health promotion and awareness campaigns designed to reduce the negative impact of bullying on youth well-being. Based on the research summarized above, we hypothesized that peer bullying experienced at age 11 would longitudinally predict more emotional and behavioral problems (internalizing, externalizing and total mental health difficulties) at age 17, and that the negative impact of bullying would be mediated by a sense of



**Fig. 2 | Peer bullying, distrust and mental health problems from age 11 to 17 years.** Alluvial plot for peer bullying at age 11 (left), interpersonal distrust at age 14 (middle), and mental health difficulties (that is, internalizing and externalizing problems) at age 17 (right), with corresponding frequency counts on the vertical axis ( $N = 7,997$ ). The large majority of older adolescents facing mental health difficulties had experienced bullying in childhood and subsequently developed significant distrust of others (that is, medium or high levels of distrust).

distrust toward other people at age 14, while controlling for socioeconomic, individual and family context factors. If interpersonal distrust turned out to be significant mediator, we reasoned it would represent a social-cognitive process that could warrant modifying to reduce the negative effects of bullying on health and well-being in the school setting and beyond.

## Results

Figure 1 depicts participants' overall mental health at age 17 as a function of their experience of peer bullying at age 11 for youth who developed low, medium and high levels of interpersonal distrust in middle adolescence (age 14). As hypothesized, being bullied in childhood strongly predicted poorer overall mental health in late adolescence, and this temporal effect was mediated by interpersonal distrust at age 14, with higher levels of distrust being associated with a stronger negative impact of bullying on subsequent mental health. A sample bias analysis (Supplementary Table 1), correlations between the three variables shown in Fig. 1 and the numerical covariates in the models below (Supplementary Table 2), as well as descriptive statistics and a comparison between the three groups—low, medium and high—of interpersonal distrust (Supplementary Table 3), can be found in the Supplementary Information.

To further interrogate these data, we created an alluvial plot of mental health difficulties as a function of being bullied at age 11 and developing interpersonal distrust at age 14 (Fig. 2). For depiction purposes, overall mental health difficulties are presented as a dichotomous variable, indicating whether youth met the diagnostic criteria for having emotional or behavioral problems as per widely accepted cutoffs for this age group (that is, a value of 'Likely' corresponding to a mean Strengths and Difficulties Questionnaire (SDQ) score of at least 18 (ref. 51)). This alluvial plot indicates that having been bullied at age 11 was much more likely to lead to medium or high levels of interpersonal distrust at age 14, in turn making it much more likely for youth to then experience clinically significant mental health difficulties at age 17. In particular, 44% of adolescents who experienced bullying that fostered high levels of distrust were likely to subsequently develop clinically significant mental health difficulties, whereas only 13% of youth reporting low distrust levels were likely to subsequently experience such difficulties. Stated otherwise, youth who were bullied in childhood (at age 11) and who began significantly distrusting others (at age 14)

**Table 1 | Weighted, imputed models 1, 2 and 3**

	Model 1 (SDQ) estimate (standard error)	Model 2 (INT) estimate (standard error)	Model 3 (EXT) estimate (standard error)
Regression slopes			
Mental health difficulties			
Bullied: yes (c)	1.05 (0.15)***	0.35 (0.07)***	0.19 (0.04)***
Interpersonal distrust (b)	0.41 (0.04)***	0.15 (0.02)***	0.07 (0.01)***
Sex: male	-0.97 (0.15)***	-1.12 (0.07)***	0.19 (0.04)***
Stratum: EN Disadvantaged	-0.12 (0.22)	0.01 (0.09)	-0.05 (0.05)
Stratum: EN Ethnic	-0.19 (0.40)	0.02 (0.16)	-0.08 (0.09)
Stratum: NI Advantaged	-0.77 (0.42)	-0.28 (0.18)	-0.10 (0.10)
Stratum: NI Disadvantaged	-0.24 (0.41)	-0.10 (0.18)	0.01 (0.10)
Stratum: SC Advantaged	-0.04 (0.33)	-0.02 (0.14)	-0.01 (0.08)
Stratum: SC Disadvantaged	-0.20 (0.39)	-0.06 (0.18)	-0.06 (0.08)
Stratum: WA Advantaged	0.02 (0.32)	0.03 (0.15)	-0.02 (0.08)
Stratum: WA Disadvantaged	-0.17 (0.29)	0.02 (0.12)	-0.07 (0.08)
Ethnicity: Black	-1.98 (0.57)***	-0.88 (0.25)***	-0.25 (0.12)*
Ethnicity: Indian	-0.83 (0.65)	-0.56 (0.27)*	0.06 (0.12)
Ethnicity: Mixed	-0.00 (0.39)	-0.08 (0.17)	0.10 (0.10)
Ethnicity: Other	-0.57 (0.57)	-0.18 (0.25)	-0.15 (0.14)
Ethnicity: PaBan	-2.05 (0.53)***	-0.80 (0.22)***	-0.27 (0.13)*
Income	-0.28 (0.07)***	-0.07 (0.03)*	-0.06 (0.02)**
Maternal education	0.08 (0.06)	-0.00 (0.03)	0.03 (0.02)*
Word Score (vocabulary)	0.02 (0.03)	0.04 (0.01)**	-0.02 (0.01)*
Prior mental health difficulties (age 7)	0.15 (0.02)***	0.03 (0.01)***	0.04 (0.00)***
Body mass index	0.00 (0.00)	0.00 (0.00)*	0.00 (0.00)
Maternal mental health: yes	0.57 (0.16)***	0.31 (0.07)***	0.05 (0.04)
NO <sub>2</sub> (air pollution)	-0.03 (0.04)	-0.02 (0.01)	-0.00 (0.01)
Diet: fruit eating (b <sub>1</sub> )	-0.63 (0.12)***	-0.20 (0.05)***	-0.12 (0.03)***
Sleep: chronotype (b <sub>2</sub> )	0.46 (0.08)***	0.12 (0.03)***	0.13 (0.02)***
Physical activity (b <sub>3</sub> )	-0.11 (0.07)	-0.14 (0.03)***	0.04 (0.02)*
Interpersonal distrust			
Bullied: yes (a)	0.42 (0.06)***	0.42 (0.06)***	0.42 (0.06)***
Diet: fruit eating			
Bullied: yes (a <sub>1</sub> )	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)
Sleep: chronotype			
Bullied: yes (a <sub>2</sub> )	-0.01 (0.03)	-0.01 (0.03)	-0.01 (0.03)
Physical activity			
Bullied: yes (a <sub>3</sub> )	0.01 (0.03)	0.01 (0.03)	0.01 (0.03)
Indirect and total effects			
a × b	0.17 (0.03)***	0.06 (0.01)***	0.03 (0.01)***
a × b <sub>1</sub>	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
a × b <sub>2</sub>	0.00 (0.01)	0.00 (0.00)	0.00 (0.00)

**Table 1 (continued) | Weighted, imputed models 1, 2 and 3**

	Model 1 (SDQ) estimate (standard error)	Model 2 (INT) estimate (standard error)	Model 3 (EXT) estimate (standard error)
a × b <sub>3</sub>	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Total	1.22 (0.15)***	0.42 (0.07)***	0.22 (0.04)***
Fit indices			
χ <sup>2</sup>	2,996.33***	3,682.43***	3,102.20***
CFI	0.98	0.97	0.98
TLI	0.97	0.96	0.97
Robust RMSEA	0.06	0.06	0.05
SRMR	0.03	0.03	0.03
Scaled χ <sup>2</sup>	1,590.35 (90)***	1,999.98 (115)***	1,684.49 (115)***

Weighted, imputed model 1 (total difficulties, SDQ); model 2 (internalizing problems, INT); and model 3 (externalizing problems, EXT). Showing unstandardized coefficients (standard errors) for the full analytic sample (N = 10,000). \*P < 0.05, \*\*P < 0.01, \*\*\*P < 0.001 for two-sided Wald z-test. EN, England; NI, Northern Ireland; SC, Scotland; WA, Wales; Black, Black or Black British; PaBan, Pakistani and Bangladeshi; Other, other ethnic group, including Chinese or other; CFI, comparative fit index; TLI, Tucker-Lewis index; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual.

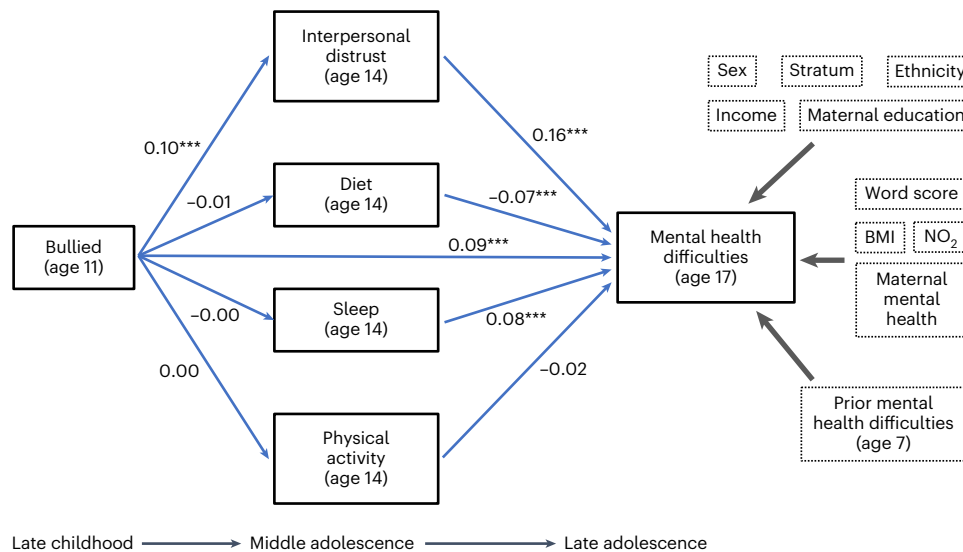
were nearly 3.5 times more likely to experience mental health problems (at age 17) as compared to those who did not go on to develop significant levels of interpersonal distrust after being bullied.

**Structural equation models**

Next, we investigated the survey-weighted, imputed, fully adjusted models corresponding to the three primary outcomes of interest: total, internalizing (emotional and peer) and externalizing (conduct and hyperactivity) difficulties. As shown in Table 1, we found that peer bullying, interpersonal distrust, dietary habits and chronotype were all significantly associated with these three outcomes. Figure 3 displays the main path coefficients of the total mental health difficulties model.

Additionally, as hypothesized, we found that bullying at age 11 years was related to experiencing more total, internalizing and externalizing mental health problems at age 17, and that there was both a direct effect of bullying on mental health and an indirect effect of bullying on mental health through interpersonal distrust. Indeed, interpersonal distrust was the strongest indirect association as compared to other pathways investigated (that is, diet, sleep and physical activity); moreover, distrust was the only significant indirect pathway,  $\alpha\beta = 0.02, z(9,910) = 5.40, P < 0.001$ . (We have used ‘ $\alpha, \beta, \gamma$ ’ for standardized coefficients corresponding to ‘ $a, b, c$ ’). The overall association between peer bullying and mental health difficulties (as a result of all the direct and indirect paths) was moderate and significant,  $\beta_{total} = 0.11, z(9,910) = 7.96, P < 0.001$ .

Most notably, the association between interpersonal distrust and subsequent mental health difficulties corresponded to the strongest direct effect,  $\beta = 0.16, z(9,910) = 11.56, P < 0.001$ , which was stronger than the direct association between bullying and total mental health difficulties,  $\gamma = 0.09, z(9,910) = 7.01, P < 0.001$ . The second strongest association was between prior mental health difficulties (parent-reported SDQ at age 7) and youth mental health problems,  $\beta_{SDQ7} = 0.15, z(9,910) = 8.01, P < 0.001$ . Biological sex was also associated with youth mental health,  $\beta_{male} = -0.09, z(9,910) = -6.30, P < 0.001$ . Specifically for internalizing problems, we found that the strongest association occurred for sex, with males experiencing fewer emotional and peer problems than females,  $\beta_{male}^{INT} = -0.30, z(9,910) = -17.27, P < 0.001$ . Distrust showed the second strongest association overall and was the strongest mediator for internalizing problems. Table 2 ranks these associations on the basis of their relative strength with total mental health difficulties as the outcome. Supplementary Table 4 presents the results in the case of the numerical



**Fig. 3 | Path diagram of the main model.** Simplified depiction of the survey-weighted, imputed model with paths of main interest between peer bullying at age 11 and mental health difficulties at age 17, with interpersonal distrust, dietary habits, ‘evening’ chronotype (sleep) and physical activity all measured at age 14 (N = 10,000; showing standardized regression coefficients, with notation β\*\*\*

corresponding to  $P < 0.001$  for two-sided Wald z-test). The control variables on the right-hand side of the figure (that is, sex, stratum, ethnicity, income, maternal education, word score (vocabulary ability), body mass index (BMI), NO<sub>2</sub> air pollution, maternal mental health and the cohort member’s prior mental health difficulties at age 7) were taken from the survey sweep at age 14 years or earlier.

**Table 2 | Standardized slopes of direct effects in model 1**

	Standardized estimate	Relative strength	Rank
Bullied: yes (γ)	0.09***	1.00	3
Interpersonal distrust (β)	0.16***	1.72	1
Sex: male	-0.09***	0.94	4
Black or Black British	-0.06***	0.65	9
Pakistani and Bangladeshi	-0.06***	0.68	8
Income	-0.07***	0.74	6
Maternal education	0.02	0.21	>10
Word score (vocabulary)	0.01	0.09	>10
Prior mental health difficulties (age 7)	0.15***	1.55	2
Body mass index	0.03	0.27	>10
Maternal mental health: yes	0.05***	0.51	10
NO <sub>2</sub> (air pollution)	-0.02	0.18	>10
Diet: fruit eating (β <sub>1</sub> )	-0.07***	0.71	7
Sleep: chronotype (β <sub>2</sub> )	0.08***	0.85	5
Physical activity (β <sub>3</sub> )	-0.02	0.24	>10

Slopes are ranked by relative strength. \* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$  for two-sided Wald z-test. Exact P values and other details can be found in the Supplementary Information (and ref. 5 therein).

form—interval variable—of the exposure variable (that is, frequency of being bullied), and the findings remain robust in this case, as expected.

In a further sensitivity analysis, presented in full in Supplementary Table 4, the emotion subscale of the SDQ was used as an outcome variable on its own right, as was the Kessler (six-item, short form) psychological distress scale (see Supplementary Tables 5 and 6, respectively, in that document). The findings remain robust, as expected, in these cases.

### Discussion

The present data demonstrate that peer bullying is prospectively associated with increases in interpersonal distrust, which, in turn, portends

greater internalizing and externalizing problems in a representative, population-based sample of 10,000 youth who were followed longitudinally during the developmentally critical period spanning late childhood to late adolescence. In analyses that further interrogated the role of interpersonal distrust, we found that (1) distrust had the strongest direct association with adolescent mental health compared to several other factors, and that (2) distrust was the only significant mediator linking peer bullying and adolescent mental health while also considering diet, sleep and physical activity. This was true even while controlling for socioeconomic variables (that is, area disadvantage, family income and maternal education) and individual characteristics (that is, biological sex, ethnicity, verbal ability, body mass index and prior mental health difficulties at age 7), in addition to maternal mental health and neighborhood air pollution.

Considered together, these results suggest that interpersonal distrust mediates the negative effects of peer bullying on internalizing and externalizing behaviors in youth. We interpret these findings through the lens of Social Safety Theory, which views peer bullying as a fundamental form of social threat that degrades health<sup>8–10</sup>. According to this theory, bullying, social devaluation and exclusion instill and reinforce maladaptive schemas about the social self, world and future—collectively called ‘social safety schemas’—that can lead to psychological, biological and behavioral difficulties. For instance, bullying may cause a child to begin believing that ‘people are hurtful’, ‘the world is dangerous’ or ‘others cannot be trusted’. These perceptions can directly lead to internalizing and externalizing difficulties by damaging self-esteem and self-efficacy, but they can also indirectly cause mental and behavioral health problems by influencing how youth perceive and interact with caregivers, teachers and peers—essentially creating the negative social reality they fear.

We are not aware of any studies that have examined prospective associations between peer bullying, interpersonal distrust and mental health. We also do not know of any studies that have investigated the link between interpersonal distrust and depression in adolescence. However, one prior longitudinal study in South Korea<sup>52</sup> found that interpersonal trust was negatively associated with the development of depression in adults. In addition, one study<sup>53</sup> found that depressed patients and healthy participants reporting high levels of distrust had similar volumetric reduction in brain areas associated with social

cognition<sup>54,55</sup>, suggesting possible neurobiological similarities between interpersonal distrust and depression. Broadly speaking, these findings are consistent with—and can be used to extend—neuroeconomic models of trust in cooperative behaviors<sup>56</sup> and may help us understand how bullying and interpersonal distrust alter human health and behavior.

### Limitations and future directions

The present study has several limitations. First, analyses were restricted to the time points available—based on the MCS sweeps at ages 11, 14 and 17 years—and lacked more granular temporal information. Second, the mental health difficulties assessed at age 17 were self-reported, and although these reports have self-evident value, additional research based on independent clinical evaluation would be highly informative. Third, there are several ways to assess peer bullying and interpersonal trust, and in the present research, we relied on participants' overall experiences of these constructs without further identifying what exactly the experiences entailed (for example, persistent peer victimization at school, both peer and sibling bullying, and some other combination of bullying experiences). Although this can be viewed as a limitation—perhaps because they are overly simplified—we believe there is also inherent value in understanding these global perceptions from both a mechanistic and public health perspective, and thus considered them to be important in their own right. Finally, in the absence of randomized groups, causality cannot be strictly inferred from the evidence presented, despite the fact that the longitudinal study design allowed for a rigorous statistical model that included a variety of potential confounders and variables that were correctly temporally ordered.

Looking forward, additional research is needed to elucidate the biological processes linking peer bullying, interpersonal distrust and mental health in youth. One intriguing mechanism is the neuroendocrine network<sup>37</sup>, with substantial evidence indicating that prosocial behaviors and perceptions of trust are mediated by oxytocin pathways (that is, oxytocin, vasopressin and the corresponding receptors)<sup>58–61</sup>. A potential hypothesis, therefore, is that oxytocin system dysregulation is associated with stronger distrust, which is in turn related to increased risk for developing depression. Consistent with this possibility, recent research has linked oxytocin dysregulation with depression<sup>62–64</sup>, possibly through oxytocin's interactions with inflammatory factors that modify stress reactivity and promote depressive symptoms<sup>65–67</sup>. Given the absence of biological data in MCS, these interactions represent potentially fruitful topics that will have to be examined in other datasets.

### Conclusion

In conclusion, the present study provides robust empirical evidence that distrusting others leads to significant mental health difficulties in adolescence and, in addition, that distrust mediates the link between experiences of bullying in childhood and the development of internalizing, externalizing and total mental health problems in late adolescence. These findings are consistent with Social Safety Theory, which posits that social threats lead to mental and physical health problems by negatively impacting how people think about themselves, others and the future. Adolescents with more positive social safety schemas, as indexed by lower levels of distrust, were much less likely to experience internalizing and externalizing difficulties, and were more protected against the negative impacts of bullying. This finding can thus inform interventions for bullying<sup>38</sup>, which so far have lacked evidence on the intervention components that could be used to reduce socio-emotional problems<sup>68</sup>. Indeed, a sense of trust of others emerged as the single most important pathway we examined linking bullying and adolescent mental health.

### Methods

More than 19,000 children born during 2000–2002 were tracked by the MCS<sup>69</sup> in survey waves every 2–3 years. The study was funded by the

Economic and Social Research Council, as well as several UK Government departments through a consortium. The sampling frame was given by electoral wards in the UK<sup>70</sup>, such that it adequately represented families living in high-child-poverty areas in all four UK countries, and families living in high-ethnic-minority wards in England. The information was obtained using interviews with the main adult respondent (in most cases this was the mother), and self-completion questionnaires in the child's home. Multi-Centre Ethics Committees, led by the National Health Service Research Ethics Committee system, provided ethical approval across survey waves (for example, MREC/01/6/19, MREC/03/2/022, 05/MRE02/46 and 07/MRE03/32), and parents gave informed consent before any interviews or assessments, whereas cohort members provided their assent at age 11 and consent at ages 14 and 17 years. In the age 14 sweep, there were 11,717 singletons or first-born twins or triplets: the analytic sample was composed of these cohort members, but who also had valid data on the self-reported peer bullying at age 11. Given this criterion of inclusion, 10,000 cohort members (51% female) remained in the analytic sample.

### Peer bullying (age 11)

The frequency of having experienced peer bullying at age 11 years was reported by the cohort member through the item: 'How often do other children hurt or pick on you on purpose?' There were six responses, ranging from 1 (most days) and 2 (about once a week) to 6 (never), which were recoded from 0 (never) to 5 (most days). The dichotomous variable ('Bullied') was the primary exposure, with the values 'No' (corresponding to 0) and 'Yes' (corresponding to responses from 1 to 5). Results are presented in terms of the dichotomous variable (except for the scatterplot in Fig. 1); although, for completeness, we provide results for the numerical case (interval variable) in Supplementary Table 4.

### Interpersonal distrust (age 14)

Cohort members were asked how much they trust others ('On a scale from 0–10, where 0 means not at all and 10 means completely, how much would you say you trust other people?'). Interpersonal distrust was an interval variable, ranging from 1 (completely trusting others) to 11 (not at all trusting others). Interpersonal distrust can be grouped into low (values  $\leq 3$ ), medium (values 4–8) and high (values  $\geq 9$ ) distrust groups. The cutoff values have been chosen on an equal split basis (three lowest values versus three highest values, and four in-between).

### Mental health difficulties (age 17)

The primary outcome variable was the total score derived from 20 items in the SDQ<sup>71</sup>, completed by the cohort members at age 17. Items included statements such as 'I get very angry and often lose my temper' with a choice of three responses: 'not true', 'somewhat true' or 'certainly true'. The total score was an interval variable, ranging from 1 to 41. Consistent with prior research<sup>72</sup>, the self-reported SDQ at age 17 had very good internal reliability (Cronbach's  $\alpha = 0.80$ ). The 20 items load onto four subscales: emotional, peer, conduct, and hyperactivity or attentional problems. The first of these two subscales combine into internalizing problems (variable 'INT') and the latter two combine into externalizing problems ('EXT'), and each of them is an outcome of interest here. Both had good internal reliability, with Cronbach's  $\alpha_{\text{int}} = 0.74$  and  $\alpha_{\text{ext}} = 0.75$ , respectively.

In an additional sensitivity analysis (presented in Supplementary Table 5), the emotion subscale of the SDQ was also considered on its own right, so that it can be analyzed separately from the peer subscale (in this sensitivity analysis, the short form of the Kessler psychological distress scale was also used).

### Mediators

In addition to distrust, we considered three other mediators—namely diet, sleep and physical activity. Diet, primarily fruit eating<sup>73</sup>, frequency of rigorous physical activity<sup>74</sup>, and sleep ('evening' chronotype)<sup>75</sup> have

all been associated with adolescent psychopathology and studied as potential mediators linking bullying or peer victimization and mental health difficulties<sup>39–42</sup>. Cohort members self-reported (at age 14) the amount of fruit in their diet, time they fell asleep, and level of physical activity. Consumption of at least two portions of fruit daily (fruit eating) was a dichotomous variable (yes/no), sleep/‘evening’ chronotype was an interval variable from 1 (going to bed before 21:00 on school nights) to 5 (after midnight), and the weekly frequency of moderate to vigorous physical activity was an interval variable from 1 (not at all) to 5 (every day).

### Covariates

Several variables were included as control variables based on their known association with mental health. Specifically, mental health outcomes in adolescence are known to be related to sex, race, ethnicity and socioeconomic characteristics<sup>76</sup>, which were all included. Mental health has also been related to body mass index<sup>77</sup>, neighborhood ecology<sup>78</sup> and maternal mental health<sup>79,80</sup>, which were also included.

Social background in the present study was approximated by the survey’s sampling variable (Stratum), which corresponds to a type of electoral ward within each UK country and tracks the area’s deprivation based on the Child Poverty Index. Each UK country had two strata: advantaged and disadvantaged, with area disadvantage being determined by whether a ward was in the upper quartile (poorest 25%) of the Child Poverty Index. In England only, an ethnic minority stratum indexed areas from the 1991 Census with at least 30% of their population falling into the Census-defined categories of ‘Black’ (Black Caribbean, Black African and Black Other) or ‘Asian’ (Indian, Pakistani and Bangladeshi). The family’s income was provided in OECD equivalized income quintiles. Maternal education was the highest educational level of the main respondent (primarily the mother), based on the UK’s National Vocational Qualifications and its equivalents (interval variable ranging from 1 to 6). All three factors were included as covariates.

Sex (male or female) and ethnicity (White, Mixed, Indian, Pakistani and Bangladeshi, Black or Black British, Other Ethnic group including Chinese or Other) were provided by the main respondent, and the possible values for these variables were determined by the UK Census. Vocabulary ability (word score) was measured by showing a word (such as ‘conceal’) and asking the cohort member to pick the right synonym (‘hide’) among several options; this was an interval variable ranging from 1 to 20. Body mass index was a derived continuous variable. Prior mental health difficulties were also controlled for through parent-reported SDQ when the cohort members were aged 7 years. The mother self-reported previous diagnoses of depression or anxiety (maternal mental health, dichotomous). Linked MEDIX variables tracked the area’s air pollution with nitrogen dioxide (NO<sub>2</sub>) given in deciles<sup>81</sup>. These factors were included in our final model, as explained below.

### Analytic strategy

First, we identified differences between participants who were included versus excluded in the analytic sample due to attrition and non-response in MCS; next, we performed analyses to ensure that sample missingness was both low and that values were missing at random, performed correlation analysis on the numerical variables, and described the analytic sample in terms of distrust level groups. These results are reported in the Supplementary Information (for example, see Supplementary Text and Supplementary Tables 1–3). To better understand the data, we produced scatterplots of SDQ scores against bullying scores, stratified by distrust, as well as an alluvial plot of these variables. Correlations between all interval variables were also calculated at this stage. In all subsequent analyses based on structural equation models, missing data were treated using multiple imputation by chained equations<sup>82</sup>, and the imputed datasets ( $n = 100$ ) were combined with Rubin’s rules<sup>83</sup>. Calculations were performed in R (ref. 84) (for additional details, see the Supplementary Information and its

references). Certain methodological steps and measures were similar to the ones reported in recent work<sup>85</sup>, which built upon the present study but appeared in print earlier.

### Structural equation model

Turning to survey-weighted, imputed structural equation models, we considered peer bullying (age 11) as the primary exposure (exogenous variable) and SDQ scores (total, internalizing and externalizing scales at age 17) as the primary outcomes (main endogenous variable), with interpersonal distrust, fruit eating (diet), chronotype (time to sleep) and physical activity at age 14 as mediators, while controlling for the relevant variables described below. This ‘fully adjusted’ model can be written as follows:

$$\text{SDQ} = c \times \text{Bullied} + b \times \text{Distrust} + b_1 \times \text{Diet} + b_2 \times \text{Sleep} + b_3 \times \text{Activity} + \text{control variables} + \text{indirect effects.}$$

The control variables included were sex at birth, area (stratum) deprivation, ethnicity, income, maternal education, body mass index, word score (vocabulary ability), neighborhood air pollution (NO<sub>2</sub>) and maternal mental health (all reported at age 14), as well as the cohort member’s prior mental health difficulties (parent-reported SDQ scores at age 7 years). In a second model, the main outcome was internalizing (INT) problems, while a third model had externalizing problems (EXT) as the main outcome. In each case, as depicted in Fig. 3, we considered both the direct effects on these outcomes due to bullying (age 11), interpersonal distrust (age 14), dietary habits (fruit eating), ‘evening’ chronotype (bedtimes on school nights) and physical activity—all at age 14—and also the indirect effects of bullying on mental health through interpersonal distrust, dietary habits, chronotype and physical activity.

### Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

### Data availability

The data that support the findings of the present study are publicly available from the Millennium Cohort Study (UK Data Service) by application, under license. For further information on how to obtain the dataset, visit the UK Data Service website (<https://ukdataservice.ac.uk/>) or the relevant website of the Centre for Longitudinal Studies (<https://cls.ucl.ac.uk/cls-studies/millennium-cohort-study/>).

### Code availability

Details of all the variable names, their processing and the full output of the R code are available on the Open Science Framework website (<https://osf.io/zjq9a>; ref. 5 in the Supplementary Information). D.I.T. accessed the data and wrote the code.

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## Acknowledgements

D.I.T. was partially supported by Alphablocks Nursery School Ltd. G.M.S. was supported by grant #OPR21101 from the California Governor's Office of Planning and Research/California Initiative to Advance Precision Medicine.

## Author contributions

This article is the work of both authors (D.I.T. and G.M.S.).

## Competing interests

The authors have no competing interests. The funders had no role in designing or planning this study; in collecting, analyzing or interpreting the data; in writing the article; or in deciding to submit this article for publication.

## Additional information

**Supplementary information** The online version contains supplementary material available at <https://doi.org/10.1038/s44220-024-00203-7>.

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**Peer review information** *Nature Mental Health* thanks Carolina Guzman Holst and the other, anonymous, reviewers for their contribution to the peer review of this work.

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