

1 **Is being a victim of bullying or cyberbullying in secondary school associated with**
2 **subsequent risk-taking behaviour in adolescence? A longitudinal study in secondary**
3 **schools**

4
5 **Abstract**

6 **Introduction:** Neurobiological and social changes in adolescence can make victims of
7 bullying more susceptible to subsequent impulsive behaviour. With the high
8 prevalence of bullying in schools and rise in cyberbullying in the UK, it is important that
9 the health impacts of bullying victimisation, including on risk-taking, are understood.
10 Our study aims to investigate whether bullying/cyberbullying victimisation is associated
11 with subsequent health risk-taking behaviour in adolescence. Risk-taking behaviour
12 includes electronic cigarette and cigarette smoking, alcohol consumption, illicit drug
13 use, early sexual debut, weapon carrying, damaging property, and setting fire.

14
15 **Methods:** A secondary quantitative analysis of data from 3337, English, secondary
16 school students in the control arm of the INCLUSIVE trial, constituting an observational
17 cohort. Bullying victimisation was measured at baseline (age 11/12 years) using the
18 Gatehouse Bullying Scale and a separate question on cyberbullying victimisation.
19 Logistic regression was used to test for an association between bullying/cyberbullying
20 victimisation at baseline and risk-taking behaviour at 36 months, adjusting for baseline
21 risk-taking behaviour and other potential confounders, and accounting for school
22 clustering.

23
24 **Results:** There was strong evidence ($p \leq 0.02$) for a positive dose-responsive
25 association between being bullied at baseline and nearly all risk-taking behaviour at
26 follow-up. Although there was no evidence for an association between being bullied at
27 baseline and weapon carrying ($p = 0.102$), there was evidence for a positive association
28 between being cyberbullied at baseline and weapon carrying ($p = 0.036$).

29
30 **Conclusions:** It is plausible that bullying/cyberbullying victimisation increases the
31 likelihood of subsequent risk-taking behaviour in adolescence. Policy options should
32 focus on implementing evidence-based anti-bullying school interventions.

1 socioemotional incentive process system, which amplifies adolescents' affinity for
2 novel, exciting activities (Shulman et al., 2016). This occurs at the same time that the
3 cognitive control system is not yet strong enough to suppress hazardous impulses
4 (Shulman et al., 2016). Theorised social mechanisms focus on the *'rite to passage'*
5 into adulthood, involving increased independence and the desire to engage in
6 behaviours associated with adulthood such as drinking alcohol, smoking and sexual
7 activity (Pound & Campbell, 2015). As bullying victimisation and risk-taking behaviour
8 both commonly manifest in early adolescence, bullying victimisation could therefore be
9 a risk factor, not only for young people's mental health but also for other subsequent
10 specific health-related risk behaviours, such as substance use, sexual risk, and
11 antisocial behaviour.

12
13 Bullying victimisation occurring in early adolescence might contribute towards
14 increased risk behaviours, such as substance use and sexual activity, by contributing
15 towards disinhibition processes. Biologically, the brain during adolescence is plastic
16 (Casey et al., 2008), and can be susceptible to stressors in the environment, such as
17 bullying victimisation (Lovallo, 2013; Östberg et al., 2018). Bullying victimisation in
18 adolescence can lead to reduced stress reactivity which can lead to brain changes that
19 result in increased impulsive behaviour (Ouellet-Morin et al., 2011). Psychologically,
20 bullying victimisation in adolescence may result in subsequent risk-taking behaviour as
21 a coping strategy to manage stress (Hong et al., 2014; Kmett Danielson et al., 2010).
22 Other studies have reported that low self-esteem and depression among bully-victims
23 mediate the process (Farrington et al., 2012; Wild et al., 2004). Social influences play
24 a significant role in adolescent wellbeing. Peer exclusion has been shown to increase
25 risk behaviour by impeding self-regulation (Baumeister et al., 2005) and promoting
26 aggression (Ayduk et al., 2008). Investigating whether bullying victimisation in
27 adolescence leads to subsequent risk-taking behaviour is therefore an important
28 question, as it could mean that bullying prevention is even more central to adolescent
29 health and wellbeing. However, current evidence for associations between bullying
30 victimisation and subsequent risk behaviours in adolescence is patchy.

31 32 ***Current evidence and gaps in research***

33
34 There is some evidence that bullying victimisation is related to risky behaviours among
35 adolescents, according to recent meta-analyses. However, most studies on this topic
36 are conducted in Western contexts and are largely cross-sectional. A meta-analysis
37 that included mainly studies on adolescents aged 13 and above, reported weak

1 evidence for an association between bullying victimisation in childhood and
2 adolescence and alcohol consumption (pooled odds ratio (OR) 1.26 95% CI 1.00-
3 1.58), stronger evidence for an association between bullying victimisation and smoking
4 (pooled OR 1.62 95%CI 1.31-1.99) and weak evidence for an association between
5 bullying victimisation and cannabis use (pooled OR 1.36 95% CI 0.90-2.05; Moore et
6 al., 2017). However, the quality of evidence from this meta-analysis was deemed weak
7 due to the paucity of rigorous longitudinal studies, for example the sub-group analysis
8 for smoking consisted of 26 cross-sectional studies, but only nine prospective cohort
9 studies (Moore et al., 2017). Another meta-analysis consisting of only cross-sectional
10 studies (including 22 studies from Europe, 23 studies from North America, eight
11 studies from Latin America, one study from Australia and New Zealand, three studies
12 from Africa and one from Asia, carried out on 12-18 year olds) reported that those who
13 had been victims of school bullying were more likely (odds ratio=1.79 95% CI 1.38–
14 2.32) to have used drugs compared to those who had not been bullied (Valdebenito et
15 al., 2015). As well as being dominated by cross-sectional studies, this meta-analysis
16 did not include any peer-reviewed studies from the United Kingdom (Valdebenito et al.,
17 2015). Another systematic review (Maniglio, 2015), that included 13 studies that
18 focused on bullying victimisation in adolescence and cannabis use, reported a positive
19 association between bullying victimisation and cannabis use. However, all but one
20 study was cross-sectional, and most studies did not use validated measures of bullying
21 victimisation.

22
23 Previous studies have found an association between bullying/cyberbullying
24 victimisation and early sexual activity among adolescents (Dunn et al., 2014; Hertz et
25 al., 2015). Sexual activity is an important adolescent behaviour. The proportions of
26 young people reporting their first sexual intercourse before the age 16 is increasing
27 (Mercer et al., 2013). As well as unwanted pregnancy, early sexual activity carries the
28 possibility of sexually transmitted infections (STIs). Despite a trend towards lower
29 rates, the UK still has one of the highest teenage birth rates in Europe (Shah et al.,
30 2019). One US study reported that high school students, aged 12-18 years old, who
31 were sexually active had higher odds of being bullied, and when this was stratified by
32 gender, the odds of being bullying increased for girls (OR 1.83; 95% CI, 1.58–2.13)
33 and decreased for boys (OR, 0.94; 95% CI, 0.77–1.16; Dunn et al., 2014). The
34 limitations of this study include the cross-sectional design which means it could not
35 assess the temporality between victimisation and sexual activity (Dunn et al., 2014). In
36 addition, this study did not use validated measures for bullying victimisation (Dunn et

1 al., 2014). Another cross-sectional study conducted in the US on students aged 14-18,
2 reported that females who had been bullied had 2.2 the odds (95%CI 1.7-2.9) of being
3 sexually active, with the odds being 1.3 among boys who had been bullied (95% CI
4 0.9-1.8; Hertz et al., 2015).

5
6 There are a small number of studies that contribute towards the evidence investigating
7 the relationship between bullying/cyberbullying victimisation and risk-taking/delinquent
8 behaviour (McCuddy & Esbensen, 2017; Valdebenito et al., 2017). Delinquent
9 behaviour is another important adolescent risk behaviour. Adolescents who engage in
10 behaviours such as weapon carrying, damaging property and setting fire on purpose
11 experience worse social and health outcomes, that adversely affect them, their families
12 and society at a large, throughout their life (Colman et al., 2009). Evidence for an
13 association between bullying victimisation and delinquent behaviour appears to be the
14 most consistent. A meta-analysis consisting of 13 cross-sectional studies, reported an
15 adjusted pooled OR of 1.58 (95% CI 1.05 and 2.38) for weapon carrying for those who
16 had experienced bullying victimisation compared to students who had not been bullied,
17 at ages 11-18 (Valdebenito et al., 2017). However, it is difficult to ascertain whether
18 bullying victimisation preceded weapon carrying through cross-sectional studies. A
19 recent longitudinal study on adolescents in the US, with a mean age of 15.1 years,
20 showed a positive significant association between cyberbullying perpetrator/victims
21 and weapon carrying one year later. However, there may be differences in risk-taking
22 behaviour between perpetrator/victims and pure victims. A longitudinal cohort study
23 carried out in the US among secondary school students reported that those students
24 who had been cyberbullied had a greater tendency to misuse substances and be
25 involved in non-violent delinquent behaviour (McCuddy & Esbensen, 2017). These are
26 a small number of studies that contribute towards the evidence investigating the
27 relationship between cyberbullying victimisation and risk-taking/delinquent behaviour.
28 Further high-quality longitudinal studies with longer follow-up periods are required to
29 strengthen the evidence.

30
31 Given the existing patchy evidence on the associations between experience of
32 bullying/cyberbullying and health risk behaviours in adolescence, the reliance on
33 cross-sectional designs and lack of evidence from the UK, we set out to examine these
34 questions drawing on longitudinal evidence from English secondary schools. We
35 hypothesise that experiencing bullying/cyberbullying victimisation at age 11/12 is
36 associated with subsequent involvement in substance use, early sexual activity, and
37 delinquent behaviours at age 14/15.

1
2 **Methods**

3
4 ***Design***

5
6 Following STROBE guidance (von Elm et al., 2008), this study is a secondary analysis
7 of longitudinal quantitative data from the control arm of the '*Initiating change locally in*
8 *bullying and aggression through the school environment*' (INCLUSIVE) randomised
9 controlled trial of a school-based intervention to prevent bullying (Bonell et al., 2017).
10 This provides a large sample of 3337 early adolescents from across 20 English
11 secondary schools followed longitudinally for three years from year 7 (age 11/12) in
12 2014 to year 10 (age 14/15 years) in 2017.

13
14 For full details including sample size calculation, see the protocol and trial report
15 (Bonell et al., 2017, 2019). In summary, a two-arm parallel cluster RCT was
16 undertaken, involving state secondary schools in south-east England, rated by
17 government inspectors of schools as 'requires improvement' or above. Private schools,
18 schools exclusively for those with learning disabilities and pupil referral units were
19 excluded. Eligible schools were approached initially by letter and email with a
20 telephone follow-up. Participating schools were representative of those in south-east
21 England.

22
23 Using computer-generated random numbers, schools were allocated by the trial team
24 1:1 to intervention or control stratified by school: single-sex versus mixed-sex status;
25 student free-school-meal (FSM) eligibility rates, indicating poverty; and General
26 Certificate of Secondary Education (GCSE) results accounting for school-level baseline
27 attainment.

28 The procedures in this study followed the British Sociological Association ethical
29 research practice guidelines (British Sociological Association, 2017) and the UK
30 regulations on consent and data management. Written, informed consent was obtained
31 at school level for random allocation and for the intervention, and at the individual
32 student level for data collection. For students, written age-appropriate information sheets
33 were provided 2–4 weeks before the baseline survey, which included information on
34 their rights, how the data will be used and information on confidentiality and anonymity,
35 together with oral explanation by teachers. Written consent was required from all
36 participating young people, which was collected immediately before conducting the
37 baseline survey. Young people were also asked to take home written information sheets
38 for their parents. Parents who did not want their child to participate were asked to notify

1 this opt-out in writing using a prepared form. Student data were collected using paper
2 questionnaires in classrooms under exam conditions, by trained fieldworkers blind to
3 allocation. All data collected were stored on password-protected drives within a
4 password-protected folder with names and dates of birth removed. However, had any
5 research participants reported that they had been involved in or were at risk of sexual or
6 physical abuse, the research team linked the self-report data via the participant identity
7 code to a separate database of participant names and used this to liaise with the
8 safeguarding lead for the school in question. No such incidents were reported.

9 For this analysis, the control arm of the INCLUSIVE trial (Bonell et al., 2017) was treated
10 as a longitudinal cohort study, measuring bullying/cyberbullying victimisation at
11 baseline, and then measuring the risk-taking and delinquent behaviour outcomes at 36
12 months.

13 **Measures**

14 Bullying and cyberbullying victimisation

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16
17
18 Self-reported experiences of bullying victimisation were measured using the
19 Gatehouse Bullying Scale (GBS) at baseline amongst year 7 students. The GBS is a
20 validated 12-item measure of bullying victimisation that covers four aspects of bullying
21 victimisation (Bond et al., 2007), and includes face-to-face and cyber-bullying within
22 the last 3 months. Students reported the frequency and upset related to each
23 experience. The mean score (ranging from 0-3) across all four domains of bullying
24 victimisation was used as a continuous measure, and therefore was used to assess
25 whether there is a dose-response association between bullying victimisation and
26 subsequent health risk-taking behaviour (Table 1). A higher GBS mean score
27 represents more frequent and upsetting bullying victimisation.

28
29 Self-reported experiences of cyberbullying victimisation were measured at baseline
30 using a question from a previous study (Table 1); (Ortega et al., 2012). Cyberbullying
31 victimisation was dichotomised into been cyberbullied or not been cyberbullied in the
32 past three months.

33 Outcomes

34
35
36 Self-reported outcomes of health risk behaviours were assessed using age-
37 appropriate questions, at 36 months (age 14/15); (Table 1). Primary risk-taking
38 outcomes assessed at 36 months included whether participants had ever smoked e-

1 cigarettes, smoked cigarettes, drunk alcohol, tried illicit drugs, had sexual intercourse,
2 carried a weapon, damaged property on purpose and set fire to something (for
3 example a bus, shelter, or shop) on purpose (see Table 1 for full details). Given the
4 age of participants, in whom risk-taking behaviour prevalence at baseline is low, the
5 outcome measures were dichotomised to ever experienced the behaviour or not, to
6 allow for clearer reporting.

7 8 Covariates

9
10 Self-reported measures for baseline risk behaviours (other than sexual activity) as well
11 as biological sex, socioeconomic status (SES) measured using the Family Affluence
12 Scale (FAS); (Boyce et al., 2006), ethnicity, religion and family structure were
13 assessed at baseline (Table 1).

14 **Analysis**

15
16
17 Baseline questionnaires were completed by 3337 students in the control arm of the
18 INCLUSIVE trial. The initial analysis used baseline data from all 3337 students in
19 control schools completing the survey at baseline, from which we present descriptive
20 data on prevalence of bullying victimisation and risk-taking behaviour. There were
21 2297 linked pairs of data of students who had completed both baseline and 36-month
22 questionnaires. We analysed for differences in bullying/cyberbullying victimisation and
23 risk-taking behaviour at baseline between students who had completed questionnaires
24 at baseline and at follow-up, and those that had been lost to follow-up and had only
25 completed the baseline questionnaire. Because there was strong evidence that those
26 lost to follow-up had a higher prevalence of engaging in baseline risk-taking (Table 3),
27 multiple imputation (MI) analysis was performed. This involved creating 20 different
28 plausible imputed datasets using MI by chained equations (m=20 following
29 recommendations for data where 10-30% of cases have missing data; Graham et al.,
30 2007). Estimated effects and their corresponding standard errors were calculated
31 within each imputed dataset and then combined using Rubin's rules. Imputed data
32 were generated using all primary outcomes, explanatory variables, and all covariates
33 (Table 1).

34
35 Using the imputed data, univariate associations between risk taking behaviour at 36
36 months and baseline characteristic were estimated using logistic regression, adjusting
37 for school clustering. After assessing unadjusted associations, we examined potential
38 confounders, first assessing for interactions, and then undertaking adjusted analyses.

1 All logistic regression models were fitted with random effects for school to account for
2 clustering. Baseline risk-taking and delinquent behaviour were adjusted for in all
3 multivariate analyses. Other pre-specified covariates were added to models and where
4 there was evidence of confounding, the covariate was retained in multivariate analysis.
5 All variables were checked graphically for normality. Where evidence ($p \leq 0.05$) of
6 interactions was found, we report stratified analyses.
7

8 ***Ethics and registration***

10 The trial was approved by the relevant ethics committee (ref 5248/001). The trial was
11 registered on 30/01/2014 (ISRCTN10751359). This secondary analysis of trial data
12 was also approved by the appropriate ethics committee.
13

14 **Results**

15 ***Descriptive data***

16
17 Table 2 summarises the baseline student characteristics. At baseline, mean age was
18 11.75 years, 1634 (49.85%) students were male and 1644 (50.15%) were female. Just
19 over half (50.64%) of students were of a White ethnicity, 3.73% had a low FAS score
20 and 62.12% lived with both biological parents. 59.48% of students reported
21 experiencing some form of bullying victimisation. The average GBS mean score for all
22 students at baseline was 0.51 (Table 2). 522 (16.04%) students reported being
23 cyberbullied in the past 3 months (Table 2). 5.84% had tried e-cigarettes, 5.67% had
24 smoked cigarettes, 14.96% had tried alcohol, 0.94% had tried illicit drugs, 1.88% had
25 carried a weapon, 2.46% had destroyed property and 1.40% had set fire to something
26 on purpose (Table 2).
27
28

29
30 Table 3 displays differences in baseline bullying/cyberbullying victimisation and risk-
31 taking behaviour among students who were lost to follow-up (non-linked data) and
32 those that were followed-up (linked data). There was no significant difference in
33 cyberbullying victimisation at baseline, between those lost to follow-up (15.44%) and
34 those that were followed up (17.83%); ($p = 0.107$). However, those that were lost to
35 follow up had a significantly higher mean GBS score at baseline (0.73) compared to
36 those that were followed up (0.46). There was also evidence that those that had been
37 lost to follow-up had significantly higher risk-taking behaviour compared to those that
38 were followed-up (Table 3).
39

1 Univariate associations using imputed data between risk-taking behaviour at 36
2 months, baseline bullying, and student characteristics are presented in Table 4. Those
3 that had been cyberbullied at were more likely to report all risk-taking behaviours
4 except carrying a knife/weapon at follow-up. Those reporting higher family affluence
5 were more likely to report they had ever drunk alcohol, ever smoked or ever tried illicit
6 drugs at follow-up (Table 4). The proportion of female students who had tried smoking
7 at follow-up was significantly higher when compared to male students, whereas male
8 students had higher proportions that had had sex, carried a knife/weapon, damaged
9 property and set fire to something on purpose, compared to female students (Table 4).
10 Students who did not identify with a religious group (students who identified their
11 religion as 'none') had higher proportions who had tried e-cigarettes, smoked
12 cigarettes, drunk alcohol, tried illicit drugs, had sex, damaged property, and set fire, at
13 follow-up compared to other religious groups. Students from White British/White
14 backgrounds had higher proportions drinking alcohol at 36 months compared to other
15 ethnic groups. Living with both biological parents was significantly associated with
16 lower proportions of students undertaking risky behaviour at follow-up, except carrying
17 a weapon and setting fire (Table 4).

18 ***Bullying victimisation (GBS mean score) and subsequent risk-taking behaviour***

19
20
21 There was significant evidence that the odds of ever smoking e-cigarettes at follow-up
22 were 1.89; (95% CI 1.44-2.50, $p < 0.001$) for each one-unit increase in the GBS mean
23 score in the adjusted model, showing a dose response (Table 5). There was also
24 evidence for a significant positive association between bullying victimisation at
25 baseline and ever smoked cigarettes at follow-up (Table 5). In the adjusted model the
26 odds of ever smoking a cigarette at 36 months were 1.41 (95% CI 1.07-1.85, $p <$
27 0.013) for each increase in GBS mean score by one unit at baseline (Table 5).

28
29 There was a significant positive association between bullying victimisation at baseline
30 and ever drinking alcohol at follow-up. There were 55% higher odds (95% CI 1.16-
31 2.09, $p = 0.004$) of ever drinking alcohol at follow up, for each unit increase in GBS
32 mean score at baseline, in the adjusted model. There was also significant evidence for
33 a positive association between baseline bullying victimisation and ever tried illicit drugs
34 at follow-up (OR 1.52 95% CI 1.08-2.13, $p = 0.016$) for each unit increase in GBS
35 mean score, in the adjusted model (Table 5).

1 There was a significant positive association between GBS mean score at baseline and
2 ever having sex in the adjusted model. For each unit increase in GBS mean score at
3 baseline there were 75% higher odds (95% CI 1.40-2.18, $p < 0.001$) of ever having sex
4 at age 14/15.

5
6 There was little evidence for a significant positive association between bullying
7 victimisation at baseline and carrying a weapon at 36 months. In the adjusted model
8 the odds of carrying a weapon were 1.60 (95% CI 0.91-2.81 $p = 0.102$) for every
9 increase in GBS mean score (Table 5). In contrast, there was significant evidence for a
10 positive association between bullying victimisation at baseline and damaging property
11 and setting fire at follow-up. The odds of damaging property at 36 months were 2.23
12 (95% CI 1.36-3.63, $p = 0.001$), and the odds of setting fire on purpose at 36 months
13 were 2.36 (95% CI 1.50-3.71, $p < 0.001$), for each one unit increase in GBS mean
14 score at baseline (Table 5).

15
16 Interactions between demographic characteristics (i.e., gender and religion) and
17 bullying victimisation were identified. There was significant evidence for an interaction
18 between gender and bullying victimisation at baseline ($p = 0.006$; Online supplement
19 1). Female students had a positive association with an OR of 2.02 (95% CI 1.06-2.01)
20 compared to male students who had an OR of 1.31 (95% CI 1.03-1.65) for smoking e-
21 cigarettes at follow-up, for every one-unit increase in GBS mean score, in the adjusted
22 model. There was significant evidence for an interaction between bullying victimisation
23 at baseline and gender and having sex at follow up ($p = 0.02$; Online Supplement 2).
24 Females who had been bullied at baseline had an OR of 1.97 (95% CI 1.55-2.50) for
25 having sex at follow-up for each unit increase in GBS mean score, compared to males
26 who had been bullied, who had an OR of 1.58 (95% CI 1.12-2.23). There was
27 evidence for an interaction between bullying victimisation at baseline and religion and
28 having sex at follow-up (Online Supplement 3). Students who identified as Hindu/Sikh
29 had the highest OR of 2.53 (95% CI 1.48-4.32) for having sex at follow-up for each unit
30 increase in GBS score, followed by those who identified as having no religion (OR 2.28
31 95%CI 1.74-3.00); (Online Supplement 3). Those who identified as Muslim had the
32 lowest OR of 1.51 (95% CI 1.25-1.83) for having sex at follow-up, for each unit
33 increase in GBS mean score at baseline.

Cyberbullying and subsequent risk-taking behaviour

Cyberbullying victimisation at baseline was significantly positively associated with all risk-taking behaviour at follow-up (Table 6). Those who had been cyberbullied at baseline had 1.64 the odds (95% CI 1.38-1.95, $p < 0.001$) of e-cigarette use compared to those who had not been cyberbullied. There was also a significant positive association between being cyberbullied at baseline and ever smoking cigarettes at follow-up (Table 6). Those who had been cyberbullied at baseline had 37% higher odds (95% CI 1.15-1.62, $p < 0.001$) of ever smoking at follow-up in the adjusted model, compared to those that had not been cyberbullied.

There was significant evidence that those who had been cyberbullied had 1.40 (95% CI 1.15-1.71, $p = 0.001$) the odds of drinking alcohol at follow-up, compared to those that had not been cyberbullied in the adjusted model (Table 6). Similar results were present for illicit drug use, those who had been cyberbullied had 1.38 (95% CI 1.08-1.76, $p = 0.01$) the odds of trying illicit drugs at follow-up, compared to those who had not been cyberbullied (Table 6).

There was significant evidence for a positive association between being cyberbullied at baseline and having sex at follow-up. In the adjusted model, those who had been cyberbullied had 2.23 the odds (95% CI 1.46-3.40, $p < 0.001$) of having sex at follow-up compared to those who had not been cyberbullied (Table 6).

There was some evidence that cyberbullying victimisation at baseline was positively associated with carrying a knife/weapon at 36 months in the adjusted model (OR 1.49 95% CI 1.03-2.16, $p = 0.036$). There was stronger evidence for a significant positive association between being cyberbullied at baseline and damaging property and setting fire on purpose at 36 months (Table 6). In the adjusted model, those who were cyberbullied at baseline had 1.99 the odds (95% CI 1.43-2.77, $p < 0.001$) of damaging a property on purpose, and 1.77 the odds (95% CI 1.30 2.43 $p < 0.001$) of setting fire on purpose at 36 months, compared to those that had not been cyberbullied at baseline.

There were no significant interactions found when carrying out the cyberbullying victimisation analysis.

1 **Discussion**

2 ***Summary of key findings***

3
4 There was evidence for a dose responsive positive association between baseline GBS
5 mean score and nearly all risk-taking behaviour and delinquency at follow-up. There
6 was a strong positive association between being cyberbullied at baseline and nearly all
7 risk-taking behaviour at follow-up in secondary school students. There was suggestive
8 evidence for a positive association between being cyberbullied and carrying a knife at
9 follow-up. However, there was little evidence to suggest a positive association
10 between bullying victimisation and weapon carrying at follow-up.

11
12 It is plausible that bullying victimisation through chronic stress, could lead to increased
13 risk-taking and delinquent behaviour in adolescence through neurobiological changes.
14 Evidence from animal and human studies have shown that stressful events can alter
15 the hypothalamic-pituitary-adrenal (HPA) axis which contributes toward the
16 behavioural adaption to changing environments (Lupien et al., 2009). Cortisol is a
17 hormone which is the end-product of the HPA axis and one of its function is to release
18 glucose in the blood during stressful situations to enable humans to activate the ‘fight
19 or flight’ response (Sapolsky, 2000). It has been reported that adolescents who are
20 victims of bullying have blunted cortisol responses to psychosocial stress (Ouellet-
21 Morin et al., 2011). Blunted cortisol responses to stress/adversity in adolescence have
22 been linked to impulsive behaviour and risk-taking (Moss et al., 1995). The dose-
23 responsive associations between bullying victimisation and risk-taking behaviours in
24 our study such as smoking (OR 1.41), drinking (OR 1.55), illicit drug use (OR 1.52),
25 could support a neurobiological explanation for an association between increased
26 frequency and intensity of bullying victimisation, potentially leading to increased
27 blunting of cortisol response to adversity, and therefore being associated with
28 increased subsequent risky behaviour.

29
30 The estimates for associations between bullying victimisation and smoking, drinking
31 and illicit drug use in our study are slightly higher than pooled estimates in a meta-
32 analysis mainly including cross-sectional studies (pooled OR for smoking 1.36,
33 drinking, 1.26, and illicit drug use 1.41; Moore et al., 2017). The positive association
34 between cyberbullying and having sex at follow-up in this study is similar (OR 2.23)
35 compared to a cross-sectional study carried out in the US (Hertz et al., 2015), which

1 reported an OR of 2.2 for sexual activity in female adolescents who were bullied online
2 only.

3
4 The dose responsive positive associations between bullying victimisation and
5 subsequent risk-taking that are described in this study may also be explained by social
6 theory. Bullying victimisation tends to increase in frequency during transitions such as
7 in early adolescence when children transition from primary to secondary school, and
8 peaks at time when peer influences are paramount (Peake et al., 2013). It may be
9 plausible that adolescents that have experienced bullying victimisation on a more
10 frequent basis are more likely to be excluded and have more unmet social needs,
11 which may lead them to engage in risk-taking behaviours as a way to network or to
12 gain recognition from their peers (Peake et al., 2013). Engaging in risk-taking
13 behaviour because of social exclusion may also be a way of establishing a non-
14 conforming identity, in effect '*rejecting the rejectors*' (Sampson & Laub, 2018).

15
16 The positive association between bullying victimisation and weapon carrying in this
17 study (OR 1.60) was similar to the pooled OR (1.59) in the meta-analysis (Valdebenito
18 et al., 2017). However, in our study there was little evidence ($p = 0.102$) for this
19 positive association, which may be explained by the mainly cross-sectional studies that
20 were included in the meta-analysis, that did not control for baseline weapon carrying
21 and may therefore tend to exaggerate the association between bullying victimisation
22 and weapon carrying (Valdebenito et al., 2017). Our study did however find suggestive
23 evidence for a positive association between baseline cyberbullying victimisation and
24 subsequent weapon carrying (OR 1.49, $p = 0.036$). The distinct nature of cyberbullying
25 which includes the possibility of reaching a larger audience, relative anonymity,
26 unlimited access to victims, lack of supervision and inability to read non-verbal cues
27 (Sticca & Perren, 2013) may result in an increased perception of threat from
28 perpetrators, which may lead to increased weapon carrying by victims as a method of
29 self-protection in schools, when compared to face-to-face bullying.

30
31 In our study we found a significant association between bullying victimisation and
32 subsequent risky behaviour such as damaging property (OR 2.23) or setting fire on
33 purpose (OR 2.36). There may be neurobiological, psychological, and social
34 explanations for why victims of bullying engage in antisocial delinquent behaviour.
35 Lower cortisol responses have been shown to be associated with more social and
36 behavioural difficulties among bullied children, which could lead to subsequent
37 antisocial behaviour (Ouellet-Morin et al., 2011). The General Strain Theory (Agnew,

1 2006) postulates that feelings of stress can cause negative emotions such as anger,
2 frustration, and despair and that these negative emotions, in turn create pressures for
3 remedial actions, with delinquent behaviour being one of the responses. The stress
4 and social isolation caused by bullying victimisation may therefore provide an
5 alternative explanation for a significant association between bullying victimisation and
6 subsequent delinquent behaviour that we found in our study.

7 8 ***Strengths and limitations***

9
10 To our knowledge this is the first study from England looking at the association
11 between bullying/cyberbullying victimisation and subsequent risk-taking behaviour in
12 adolescence, and one of a small number of studies internationally which use a
13 longitudinal design with a long follow-up period. The results from this study are likely to
14 be generalisable to most secondary school students in and around large cities in the
15 UK as the INCLUSIVE trial was carried out in a representative sample of urban and
16 peri-urban settings in south-east England.

17
18 Self-reported outcomes can be open to recall error, but this is likely to be non-
19 differential in this study and therefore would likely have under-estimated the
20 association between bullying victimisation and risk-taking behaviour. The impact of
21 recall error is likely to be low as standardised recall periods of 3 months were used.
22 Due to the nature of the outcomes in this study, the results may be affected by
23 reporting bias as even though the students were reassured that the risk-taking
24 behaviour that they report would remain confidential, they are likely to under-report
25 these in fear of punishment. Students are more likely to under-report risky behaviour
26 compared to bullying victimisation and therefore this may have underestimated the
27 association between bullying/cyberbullying victimisation and risky behaviours in
28 adolescence. There was a 31% loss to follow-up from baseline which could have
29 introduced selection bias if those lost to follow-up differed from those retained, in the
30 extent to which bullying victimisation was associated with risk-taking behaviour. As
31 those that were lost to follow-up had higher rates of risk-taking behaviour and had a
32 higher mean score for bullying victimisation at baseline, one would expect that loss to
33 follow-up would have led to an under-estimation of associations between bullying
34 victimisation and risk behaviours. However, the multiple imputation estimates suggest
35 that any such effects were negligible.

1 Our analysis was able to adjust for various potential confounders including baseline
2 risk behaviours. However, the study did not assess sexual activity at baseline so our
3 results may be confounded by this. However, given the very low prevalence of sexual
4 activity at age 11/12 (Brooks et al., 2015) this is unlikely to be substantial. There is a
5 large possibility that the results from this study could have been affected by unknown,
6 unmeasured confounders such as psychological predisposition to bullying victimisation
7 (Arseneault et al., 2006), other adverse early experiences and other social
8 relationships (Lereya et al., 2013; Wolke, 2012). There were eight separate outcomes
9 in this study which necessitated multiple statistical testing. To mitigate this only pre-
10 specified outcomes were tested.

11 ***Implications for research and policy recommendations***

12
13
14 Experiencing bullying victimisation appears to have wider adverse impacts on
15 adolescent well-being and on subsequent health risk-taking behaviour. Bullying
16 prevention interventions should therefore be evaluated in terms of their longer-term
17 effects on other health behaviours. Bullying prevention should be central to promoting
18 adolescent mental and physical health; and bullying prevention might best be delivered
19 within broader health interventions. Interventions that reduce bullying victimisation in
20 schools may reduce subsequent risk-taking behaviour.

21
22 Further research on the psychobiological and social pathways that lead victims of
23 bullying to engage in risky behaviours is needed, to improve understanding and target
24 victimisation prevention interventions. Differences or similarities in pathways between
25 face-to-face and cyberbullying victimisation and risk-taking behaviour need to also be
26 investigated further. Further research is needed on how the impacts of bullying
27 victimisation on risky behaviours such as having sex are modified by gender and
28 religion in adolescence.

1

Tables

2 **Table 1:**3 ***Variable type, sources, item, and response options and how variables were used in the study***

| Variable type | Variable | Source, Items and Response Options | How variable was used in the study |
|-----------------------------|---|--|--|
| Explanatory variable | Bullying/ cyberbullying Victimisation | <p>Bullying victimisation was assessed with the Gatehouse Bullying Scale (GBS) (Bond et al., 2007), a 12-item validated self-report measure of being the subject of teasing, name-calling or rumours, being left out of things, and receiving physical threats or actual violence from other students within the previous 3 months.</p> <p>The GBS has been validated against items drawn from the Peer Relations Questionnaire (PRQ), which is an established questionnaire that has been used to measure bullying. Percentage agreement between the two measures on bullying victimisation was high. Agreement adjusted for chance was moderate (kappa 0.5). GBS test re-test reliability was moderate to good (rho 0.65). (Bond et al., 2007)</p> <p>The questions and responses were worded to assess bullying occurring either face to face or online.</p> <ul style="list-style-type: none"> • Has anyone teased you or called you names at this school in the last 3 months? • Has anyone spread rumours about you at this school in the last 3 months? • Have you been deliberately left out of things at this school in the last 3 months? • Have you been threatened physically or actually hurt by another student recently at this school? <p>Under each of the four questions above were the following response options:</p> <ul style="list-style-type: none"> • Yes/ No <p>How often?</p> <ul style="list-style-type: none"> • Most days • About once a week • Less than once a week <p>How upsetting was it when you were teased or called names?</p> <ul style="list-style-type: none"> • Not at all • A bit • I was quite upset | <p>A score for bullying victimisation is computed for each of the four types of bullying (teasing, rumours, deliberate exclusion/social isolation, and physical threats/violence). Being bullied frequently and being upset by bullying were considered to have equal value; the presence of both factors was worse than either factor on its own.</p> <p>Thus, the following scale is used to score each of the four types of bullying: 0 = Not bullied 1 = Bullied but not frequently and not upset 2 = Bullied, either frequently or upset, but not both 3 = Bullied frequently and upset</p> <p>A scale score was then used by calculating the mean item score across the four types of bullying Mean GBS score was used as a continuous measure (higher the score the more frequent upsetting victimisation).</p> |
| Explanatory variable | Cyberbullying victimisation | <p>Question from a large previous study on cyberbullying victimisation (Ortega et al., 2012)</p> <p>Have you been bullied through mobile phone use or on the internet in the last three months?</p> <ul style="list-style-type: none"> • No, I haven't • Yes, once, or twice • Yes, two or three times a month • Yes, about once a week • Yes, several times a week or more | <p>Dichotomised into 'been cyberbullied' or 'not been cyberbullied' in the past three months.</p> |

| | | | |
|------------------|---|--|--|
| Outcome | Ever-smoked e-cigarettes | Age-appropriate questions in national surveys (Social Care Information Centre, 2010) Which of the following best describes you? <ul style="list-style-type: none"> I currently smoke e-cigarettes I have tried e-cigarettes in the past 12 months but do not currently smoke them I have tried e-cigarettes longer than 12 months ago but do not currently smoke them I have never tried e-cigarettes | Dichotomised into those that have ever tried cigarettes and those that have never tried e-cigarettes |
| Outcome | Ever smoked cigarettes | Age-appropriate questions in national surveys (Social Care Information Centre, 2010) Select which option describes you the best <ul style="list-style-type: none"> I have never smoked I have tried smoking but have never smoked regularly I used to smoke regularly but I never smoke a cigarette now I smoke cigarettes regularly but not as many as one a week I usually smoke between one and six cigarettes a week I usually smoke more than six cigarettes a week | Dichotomised into those that have ever smoked cigarettes and those that have never smoked cigarettes |
| Outcome | Ever drunk alcohol | Age-appropriate questions in national surveys (Social Care Information Centre, 2010) Have you ever drunk alcohol (more than just a sip)? Yes/No | Dichotomised into those that have drunk alcohol before and those that have not consumed alcohol |
| Outcome | Ever tried illicit drugs | Age-appropriate questions in national surveys (Social Care Information Centre, 2010) Has anyone ever offered you any drugs? <ul style="list-style-type: none"> No, I've never been offered drugs Yes, I've been offered drugs, <u>but I didn't try them</u> Yes, I've been offered drugs <u>and I tried them</u> | Dichotomised into those that have tried illicit drugs and those that have not tried illicit drugs. |
| Outcome | Ever had sex with girl/woman* | Measures used in the RIPPLE trial (Stephenson et al., 2008) Have you ever had sex (sexual intercourse) with a girl or woman? Yes/No | Dichotomised |
| Outcome | Ever had sex with a boy/man* | Measured used in the RIPPLE trial (Stephenson et al., 2008) Have you ever had sex (sexual intercourse) with a boy or man? Yes/No | Dichotomised |
| Outcome | Carried a weapon/knife to school in the past 3 months | Measure from the Self-Reported Delinquency (SRD) scale (Thornberry et al., 2003) During the last 3 months, did you ever carry a knife or other weapon with you for protection or in case it was needed in a fight? Yes/No | Dichotomised |
| Outcome | Damaged/destroyed property in the past 3 months | Measure from the SRD scale (Thornberry et al., 2003) During the last 3 months, did you damage or destroy property that did not belong to you on purpose (e.g., windows, cars, or streetlights)? Yes/No | Dichotomised |
| Outcome | Set fire to something | Measure from the SRD scale (Thornberry et al., 2003) During the last 3 months, did you ever set fire or try to set fire to something on purpose (e.g., bus shelter, shop, etc.)? Yes/No | Dichotomised |
| Covariate | Biological sex | Self-reported | Male/Female |

| | | | |
|------------------|-----------------------|---|---|
| Covariate | Socio-economic status | <p>Family Affluence Scale – Validated measure developed to specifically describe the SES of young people. Validated against the Gross Domestic Product (Kappa 0.57) (Boyce et al., 2006).</p> <p>Composite FAS score was calculated for each student based on his/her responses to four items relating to family car ownership, children having their own bedroom, the number of computers at home, and the number of holidays taken in the past 12 months.</p> | Scores were collapsed into tertiles of low (score = 0,1 and 2), medium (score = 3,4 and 5), and high (score = 6,7,8 and 9) family affluence. |
| Covariate | Ethnicity | <p>Self-reported Which ethnicity best describes you?</p> <ul style="list-style-type: none"> • White British • White other • Asian/Asian British • Black/Black British • Chinese/ Chinese British • Mixed Ethnicity • Other ethnic group | <p>Four categories created:</p> <ul style="list-style-type: none"> • White British/White other • Asian/Asian British (included Chinese and Chinese) • Black/Black British • Other – consisted of Mixed ethnicity and 'Other' combined |
| Covariate | Religion | <p>Self-reported Which religious group or church do you belong to?</p> <ul style="list-style-type: none"> • Christian • Muslim/Islam • Hindu • Sikh • Jewish • I Don't know/Not sure • Other religion | <p>Five categories created:</p> <ul style="list-style-type: none"> • Christian • Muslim/Islam, • Hindu/Sikh • None • Don't know/other (included Jewish because of very small numbers) |
| Covariate | Family Structure | <p>Self-reported measure of which adults the child lives with Which adult or adults (not including older siblings) do you live with?</p> <ul style="list-style-type: none"> • My mother • My father • My stepmother • My stepfather • My foster-mother • My foster-father • Someone else | Dichotomised – into those that live with two biological parents and those that do not. |

*These outcomes were only measured at 36 months

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1 **Table 2:**

2 **Baseline student characteristics (n=3337†)**

| Student Characteristics | Description | |
|--|---|--------------------------|
| Age, mean SD | | 11.75 (0.44) |
| Sex, n (%) | Male | 1634 (49.85) |
| | Female | 1644 (50.15) |
| Ethnicity, n (%) | White British/White Other | 1673 (50.64) |
| | Asian/Asian British/ Chinese | 870 (26.33) |
| | Black/Black British | 384 (11.62) |
| | Other | 377 (14.41) |
| Family Affluence Scale n (%) | Low | 121 (3.73) |
| | Medium | 1073 (33.08) |
| | High | 2050 (63.19) |
| Religion n (%) | None | 978 (29.53) |
| | Christian | 1070(32.31) |
| | Muslim/Islam | 877 (26.48) |
| | Hindu/Sikh | 161 (4.86) |
| | Other/Don't know | 226 (6.82) |
| Family Structure n (%) | Lives with both biological parents | 2432 (62.12) |
| GBS score, mean (SD) | GBS overall mean score | 0.51(0.63) |
| | Teasing | 0.79(0.98) |
| | Rumours | 0.52 (0.85) |
| | Deliberate exclusion | 0.40 (0.79) |
| | Threatened or hurt | 0.36 (0.74) |
| Cyberbullying victimisation n (%) | Had been cyberbullied through mobile phone in the last 3 months | 522 (16.04) |
| | Had tried e-cigarettes n (%) | 187 (5.84) |
| | Had smoked cigarettes n (%) | 185(5.67) |
| | Had drunk alcohol n (%) | 483 (14.96) |
| | | 30 (0.94) |
| Baseline risk-taking behaviour | Had tried illicit drugs n (%) | |
| | Had sex n (%) | Not measured at baseline |
| | Had carried a knife or weapon in the last 3 months n (%) | 62 (1.88) |
| | Had destroyed property in the last 3 months (%) | 81 (2.46) |
| | Had set fire in the last 3 months n (%) | 46(1.40) |

† The number of students who responded at this survey; actual number of responses to each question varies
SD=standard deviation, n=number

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1 **Table 3**

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3 ***Loss to follow-up sensitivity analysis***

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5 Differences in baseline bullying/cyberbullying victimisation and risk-taking and behaviour amongst
6 students who were lost to follow up (non-linked data) and those that were followed-

7

| Baseline characteristic | Linked Data (follow-up) | Unlinked data (lost to follow-up) | P-value for difference between linked and unlinked data at baseline |
|---|--------------------------------|--|--|
| Been cyberbullied in past 3 months n/N(%) | 146/2436 (17.83%) | 376/819 (15.44%) | 0.107 |
| GBS mean score base (SD) | 0.46 (0.59) | 0.73 (0.73) | <0.001* |
| Ever smoked cigarettes n/N(%) | 106/2440 (4.34%) | 79/822 (9.61%) | <0.001 |
| Ever tried e-cigarettes n/N(%) | 112/2405 (4.66%) | 75/796 (9.42%) | <0.001 |
| Ever drunk alcohol n/N(%) | 327/2422 (13.50%) | 156/806 (19.35%) | <0.001 |
| Ever tried illicit drugs n/N(%) | 14/2406 (0.58%) | 16/797(2.01%) | <0.001 |
| Carried a knife/weapon in the past 3 months n/N(%) | 31/2465 (1.26%) | 31/831 (3.73%) | <0.001 |
| Damaged or destroyed property on purpose in the past 3 months n/N(%) | 51/2460 (2.07%) | 30/831 (3.61%) | 0.013 |
| Set fire on purpose in the past 3 months n/N(%) | 23/2456 (0.94%) | 23/829 (2.77%) | <0.001 |

n - total number of students with the baseline characteristic

N = total number of people included in each analysis

p=values were calculated using chi squared for difference in proportions between linked and non-linked data except for *GBS mean score which was calculated using the t-test two way with unequal variance for difference in means

SD = standard deviation

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Table 4

Multiple imputation estimates of univariate associations between risk-taking/delinquent behaviour at 36 months and baseline characteristics (n= 3337)

| | Description | % of students at baseline (95% CI) | % tried e-cigarettes (95% CI) | % who ever smoked (95% CI) | % who ever drunk alcohol (95% CI) | % who tried illicit drugs (95% CI) | % who had sex (95% CI) | % who carried a weapon/knife (95% CI) | % who damaged property (95% CI) | % who set fire on purpose (95% CI) |
|-------------------------------|------------------------------------|------------------------------------|-------------------------------|----------------------------|-----------------------------------|------------------------------------|------------------------|---------------------------------------|---------------------------------|------------------------------------|
| Been cyberbullied | Yes | 16.04 | 33.16 (28.26-38.06)*** | 31.41 (26.31-36.51)*** | 57.80(52.58-63.02)*** | 16.02(11.99-20.06)** | 16.49(12.46-20.53)*** | 4.94(2.82-7.07) | 7.12(4.48-9.75)** | 7.03(4.50-9.57)*** |
| | No | 83.96 | 19.91 (18.12-21.70) | 21.02 (19.26-22.77) | 42.87 (40.57-45.17) | 10.31(8.96-11.65) | 9.02(7.60-10.43) | 3.73(2.87-4.59) | 4.06(3.14-4.98) | 3.49(2.63-4.36) |
| Sex | Male | 49.85 | 23.32 (20.88-25.77) | 20.17(17.90-22.44)* | 4.21(3.92-4.50) | 11.01(9.18-12.83) | 12.94(10.80-15.08)*** | 6.17(4.78-7.55)*** | 6.40(4.86-7.95)*** | 5.50(4.16-6.83)** |
| | Female | 50.15 | 20.83(18.49-23.16) | 25.08(22.73-27.44) | 4.82(4.54-5.10) | 11.39(9.57-13.21) | 7.46(5.85-9.08) | 1.73(0.99-2.47) | 2.71(1.80-3.63) | 2.76(1.81-3.71) |
| Family affluence scale | Low | 3.73 | 18.87(10.50-27.25) | 14.13(6.46-21.79)* | 28.18(19.06-37.30)*** | 6.17(0.16-12.18)* | 7.39(1.60-13.17) | 4.29(-0.60-9.17) | 3.26(-0.72-7.24) | 4.82(0.13-9.51) |
| | Medium | 33.08 | 20.54(17.69-23.39) | 20.13(17.34-22.93) | 33.33(29.90-36.76) | 9.16(7.03-11.28) | 8.30(6.40-10.22) | 3.18(1.91-4.45) | 3.59(2.13-5.05) | 3.22(2.00-4.44) |
| | High | 63.19 | 22.97(20.77-25.18) | 24.60(22.32-26.88) | 52.75(50.20-55.30) | 12.75(10.97-14.53) | 11.48(9.61-13.35) | 5.19 (3.99-6.40) | 5.19(3.99-6.40) | 4.57(3.43-5.71) |
| Ethnicity | White British/White other | 50.64 | 25.85(23.33-28.37) | 27.57(25.03-30.11) | 63.65(60.88-66.41)*** | 14.04 (12.00-16.09) | 11.80 (9.75-13.86) | 3.99 (2.86-5.13) | 4.68 (3.38-5.98) | 5.11(3.86-6.35) |
| | Asian/Asian British | 26.33 | 15.59(12.90-18.28) | 12.70(10.27-15.13) | 15.23 (12.46-18.00) | 4.63 (3.06-6.20) | 6.59 (4.68-8.50) | 3.93 (2.50-5.35) | 3.47 (2.11-4.82) | 2.71 (1.45-3.98) |
| | Black/Black British | 11.62 | 21.02(15.97-26.07) | 23.75(18.43-29.07) | 36.79 (30.65-42.94) | 13.19 (8.89-17.49) | 9.34 (5.57-13.11) | 3.89 (1.46-6.25) | 5.29 (2.57-8.01) | 2.71 (0.52-4.91) |
| | Other | 11.41 | 20.36(15.62-25.10) | 22.71(18.05-27.38) | 40.26 (34.70-45.81) | 12.30 (8.05-16.55) | 12.74 (8.76 – 16.73) | 3.61 (1.32-5.89) | 5.61 (2.79-8.44) | 3.71 (1.32-6.11) |
| | | | | | | | | | | |
| Religion | None | 29.53 | 29.53 (20.14-26.04)*** | 32.75 (29.43-36.06)*** | 68.01 (64.61-71.41)*** | 17.15 (14.33-19.98)*** | 13.10 (10.51-15.69)** | 4.55 (2.96-6.14) | 6.79 (4.77-8.81)** | 6.51 (4.63-8.39)*** |
| | Christian | 32.31 | 23.09 (20.14-26.04) | 23.80 (20.82-26.78) | 53.15 (49.53-56.77) | 12.53(10.18-14.88) | 11.83 (9.44-14.22) | 3.92 (2.63-5.20) | 4.31(2.84-5.78) | 3.70 (2.35-5.04) |
| | Muslim/Islam | 26.48 | 16.25 (13.29-19.21) | 16.25 (13.29-19.21) | 12.92 (10.11-15.74) | 4.74(2.99-6.49) | 6.79 (4.86-8.71) | 4.11 (2.64-5.59) | 3.57 (2.16-4.98) | 2.74 (1.47-4.02) |
| | Hindu/Sikh | 4.86 | 4.62 (0.76-8.47) | 4.62 (0.76-8.47) | 19.75 (13.37-26.13) | 3.61 (0.52-6.69) | 3.28 (0.27-6.29) | 0.79 (-0.70-2.29) | 1.39 (-0.51-3.29) | 1.50 (-0.50-3.50) |
| | Other/Don't Know | 6.82 | 18.57 (12.31-24.84) | 18.57 (12.31-24.84) | 51.05 (43.73-58.36) | 11.40 (6.86-15.94) | 9.23 (4.70-13.76) | 2.25 (-0.19-4.70) | 1.78(-0.24-3.79) | 2.36 (-0.05-4.77) |
| Family structure | Lives with both biological parents | 62.12 | 18.96 (17.10-20.83)*** | 19.46(17.68-21.25)*** | 41.50 (39.20-43.79)*** | 9.48 (8.06-10.89)*** | 8.81 (7.39-10.23) *** | 3.41 (2.56-4.26) | 3.78 2.82-4.74)** | 3.64(2.75-4.53) |
| | Does not live biological parents | 37.88 | 28.46 (25.76-31.16) | 29.69 (26.99-32.38) | 50.12 (47.10-53.14) | 14.79 (12.51-17.07) | 12.92 (10.83-15.03) | 4.66 (3.37-5.94) | 5.36 (3.93-6.78) | 4.48 93.24-5.73) |

Abbreviations CI= confidence interval, *p-values were obtained using the Wald test for univariate associations between variables listed and risk-taking/delinquent behaviour at 36 months, after controlling for 20 school clusters *** = p-value ≤0.001 ** = 0.05>p>0.001 (placed at the top of each category to represent associations between the whole variable and risk-taking behaviour

Table 5

Multiple imputation estimates for adjusted estimates of odd ratios (OR) for association between mean gatehouse bullying scale score (continuous) at baseline and risk-taking behaviour at 36 months using logistic regression, robust standard errors to adjust for within school clustering, assuming no interaction (n= 3337†).

| Outcome | Adjusted OR* (95% CI) | p-value (for adjusted OR) |
|--|-------------------------------|--------------------------------------|
| Ever smoked e-cigarettes | 1.89 (1.44-2.50) | <0.001 |
| Ever smoked cigarettes | 1.41 (1.07-1.85) | 0.013 |
| Ever drank alcohol | 1.55 (1.16-2.09) | 0.004 |
| Ever tried drugs | 1.52 (1.08-2.13) | 0.016 |
| Ever had sex | 1.75 (1.40-2.18) | <0.001 |
| Carried a knife/weapon in the last 3 months | 1.60 (0.91-2.81) ⁷ | 0.102 |
| Damaged or destroyed property on purpose in past 3 months | 2.23 (1.36-3.63) ⁸ | 0.001 |
| Set fire on purpose in past 3 months | 2.36 (1.50-3.71) | <0.001 |

*Odds ratios adjusted for baseline risk-taking (except for having sex as this was not measured at baseline), gender, family affluence, ethnicity, religion, family structure and school clusters

Odds Ratio (OR) Confidence intervals (CI)

† The total number of students included in the analysis, actual number of responses to each question varies, the number of observations per model is provided in the table above.

P-values are calculated using the Wald test.

As GBS score is continuous the ORs for risky behaviour represents the odds of risk-taking behaviour for an increase in GBS score by one unit.

Online supplement 1

Multiple imputation adjusted estimates of the association between GBS mean score and ever tried e-cigarettes at 36 months, using a logistic regression model with robust standard errors to control for clustering within schools, stratified by gender (n=2742).

| Gender | % who smoked e-cigarettes at 36-months | S-S adjusted OR for the effect of GBS score on e-cigarette use at 36 months for (95% CI) | p-value for interaction |
|--------|--|--|-------------------------|
| Male | 23.8 | 1.31 (1.03-2.65)* | 0.006 |
| Female | 20.7 | 2.02 (1.60-2.54)* | |

*adjusted for baseline e-cigarette smoking, family affluence, ethnicity, religion, family structure and for 20 school clusters, p-value obtained using the Wald test.

Odds ratio (OR) Confidence interval (CI)

As the GBS mean score is continuous the OR represents the odds of risk for each one unit increase in GBS mean score

Online supplement 2

Multiple imputation adjusted estimates of the association between GBS mean score and ever had sex at 36 months, using a logistic regression model with robust standard errors to control for clustering within schools, stratified by gender (n=2791).

| Gender | % who had sex at 36 months | S-S adjusted OR for the effect of GBS score on e-cigarette use at 36 months for (95% CI) | p-value for interaction |
|--------|----------------------------|--|-------------------------|
| Male | 12.94 | 1.58(1.12-2.23)* | 0.02 |
| Female | 7.46 | 1.97 (1.55-2.50)* | |

*adjusted family affluence, ethnicity, religion, family structure and for 20 school clusters, p-value obtained using the Wald test.

Odds ratio (OR) Confidence interval (CI)

As the GBS mean score is continuous the OR represents the odds of risk for each one unit increase in GBS mean score.

Online Supplement 3

Multiple imputation adjusted estimates of the association between GBS mean score and ever had sex at 36 months, using a logistic regression model with robust standard errors to control for clustering within schools, stratified by religion (n=2791).

| Religion | % who had sex at 36 months | S-S adjusted OR for the effect of GBS score on e-cigarette use at 36 months for (95% CI) | p-value for interaction |
|------------------|----------------------------|--|-------------------------|
| None | 13.10 | 2.28 (1.74-3.00)* | 0.016 |
| Christian | 11.83 | 1.59(1.21-2.09)* | |
| Muslim/Islam | 6.79 | 1.51 (1.25-1.83)* | |
| Hindu/Sikh | 3.28 | 2.53 (1.48-4.32)* | |
| Other/Don't Know | 9.23 | 1.75 (1.30-2.36)* | |

*adjusted for gender, family affluence, ethnicity, family structure and for 20 school clusters, p-value obtained using the Wald test.

Odds ratio (OR) Confidence interval (CI)

As the GBS mean score is continuous the OR represents the odds of risk for each one unit increase in GBS mean score

Table 6

Multiple imputation estimates of adjusted odd ratios (OR) for association between ever been cyberbullied at baseline and risk-taking behaviour at 36 months using logistic regression, robust standard errors to adjust for within school clustering, assuming no interaction. The reference group is 'not been cyberbullied in the past 3 months' (n= 3337†).

| Outcome | Adjusted OR* (95% CI) | p-value (for adjusted OR) |
|--|-------------------------------|--------------------------------------|
| Ever smoked e-cigarettes | 1.64 (1.38-1.95) | <0.001 |
| Ever smoked cigarettes | 1.37 (1.15-1.62) | <0.001 |
| Ever drank alcohol | 1.40 (1.15-1.71) | 0.001 |
| Ever tried drugs | 1.38 (1.08-1.76) | 0.010 |
| Ever had sex | 2.23 (1.46-3.40) | <0.001 |
| Carried a knife/weapon in the last 3 months | 1.49 (1.03-2.16) | 0.036 |
| Damaged/ destroyed property on purpose in past 3 months | 1.99 (1.43-2.77) | <0.001 |
| Set fire on purpose in past 3 months | 1.77 (1.30-2.43) ⁹ | <0.001 |

Odds Ratio (OR) Confidence intervals (CI)

*Odds ratios adjusted for baseline risk-taking (except for having sex as this was not measured at baseline), gender, family affluence, ethnicity, religion, family structure and school clusters

† The number of students included in the analysis, actual number of responses to each question varies, the number of observations per model is provided in the table above. P-values are calculated using the Wald test.

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