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Adverse childhood experiences and adolescent drug use in the UK: The moderating role of socioeconomic position and ethnicity

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ABSTRACT

Rationale: There is a paucity of prospective UK studies exploring the role of Adverse Childhood Experiences (ACEs) on adolescent teenage drug use and even less is known about the complex interplay between ACEs and adolescent social, demographic, and economic characteristics. To address these gaps, we use rich longitudinal data from the nationally representative Millennium Cohort Study.

Methods: Sex-stratified survey logistic regression modelling was applied using data from 9,476 adolescents and their parents to examine associations between ACEs between ages 3 and 14 years and drug use at ages 14 and 17 years. We a) explore the extent to which associations are robust to adjustment for ethnicity, family income, parental social class, and parental education, b) examine whether associations differ by these factors, and c) estimate the proportion of drug use at ages 14 and 17 years attributable to ACEs after controlling for these factors.

Results: Half of MCS cohort members had been exposed to at least one ACE and approximately 1 in 11 were exposed to 3+ ACEs. Multivariable analyses suggest that ACEs were associated with a higher likelihood of drug use at age 14 than age 17, especially for girls. No evidence was found that either advantaged socio-economic position or ethnicity acted as a buffer against the negative effects of ACEs in relation to adolescent drug use. Finally, we found that prevention of exposure to sexual violence, bullying and violence within the household (if causal) is more important for girls' drug use at age 14 than age 17.

Conclusions: ACEs are associated with adolescent drug use with potential consequences on wider aspects of young people's lives, regardless of their social, ethnic, or economic background, adding further urgency to the need to reduce the incidence of these negative experiences.

Introduction

Awareness on adverse childhood experiences (ACEs) and poorer health over the life course has gained substantial global traction and a proliferation of research activity over the last two decades since the publication of the arguably most influential study on ACEs by Felitti and colleagues (Felitti et al., 1998; Struck et al., 2021). However research into ACEs has gained prominence in the UK over the last few years, leading to an increased recognition of the potential lifetime impact of early adversity on educational, physical, and mental health outcomes in the UK and around the globe (Bevilacqua et al., 2021; Gondek et al., 2021; Houtepen et al., 2020; Hughes et al., 2020; Lacey et al., 2020a; Lowthian et al., 2021; Soares et al., 2018). While a widely accepted definition does not exist (Lacey & Minnis, 2020), ACEs can be broadly defined as *"those experiences which require significant adaptation by the developing child in terms of psychological, social, and neurodevelopmental systems, and which are outside of the normal expected environment"* (McLaughlin, 2016). Although, there has been little research into the role ACEs play in adolescent drug use in comparison to research focusing on the relationship between ACEs and adolescent alcohol use/problematic alcohol drinking or/and smoking (Hughes et al., 2017), a recent combined analysis using data from five non-representative UK cross-sectional studies highlighted a graded relationship between the number of ACEs and the risk of drug use, with ACEs accounting for

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58.8% and 52.6% of drug use in the Welsh and the English sample accordingly (Hughes et al., 2020). Similarly a recently published systematic review and metanalysis (Hughes et al., 2021) using data from 17 studies conducted in 13 European countries (UK, Romania, Lithuania, Latvia, Russia, North Macedonia, Turkey, Montenegro, Serbia, Ukraine, Czech Republic, Poland and Moldova) found a graded positive relationship, with a reported 59% increased risk of drug use with exposure to 1 ACE and a 163% increased risk of drug use with exposure to 2 or more ACEs. Similar graded relationships between ACEs and drug use have been reported from individual studies conducted in the US (Anda et al., 2006) and India (Fernandes et al., 2021).

The teenage years can be a time of experimentation for young people regardless of parenting skills and influence (Casey & Jones, 2010; Chambers et al., 2003; Zucker, 2009). Data for England from the most recent NHS Smoking, Drinking and Drug use (SDD) survey suggest that nearly one quarter (23.7%) of 11–15-year-olds in 2018 had ever used drugs, an increase from 14.6% in 2014, (Smoking, 2019). Although further analyses using the SDD survey data revealed that this change was likely to be due to an increased likelihood of pupils not answering questions on whether they had tried individual drugs, some level of genuine increase was however evident (Smoking, 2019). Adolescence represents a particularly sensitive period in terms of transitioning from experimental to regular drug use, when the circuitry underlying incentive salience, habit formation and stress are uniquely vulnerable to commandeering by more frequent drug use, in part due to reduced cortical control and elevated drive of subcortical systems (Jordan & Andersen, 2017). While some use of drugs may be considered a relatively harmless aspect of teenage development, regular drug use has been linked to multiple deleterious health outcomes among adolescents and adults, including sexually transmitted diseases, human immunodeficiency virus, viral hepatitis, as well as a range of social and mental health problems (Hein et al., 1995; WHO, 2016) Data on the prevalence of habitual, and therefore potentially hazardous, drug use among teenagers in the UK are limited, but the 2018 SDD estimated that 17% and 9% of 11-15- year-old teenagers had taken drugs in the last year and in the last month respectively (Zucker, 2009). Yet to the best of our knowledge, only one study, using the Avon Longitudinal Study of Parents and Children Cohort study (ALSPAC), has explored associations between ACEs from 0 to 16 years of age and drug use at age 17 in a UK contemporary context (Houtepen et al., 2020). To date, the mechanisms linking ACEs and drug use are unclear. There is some evidence that psychiatric illness mediates such relationships (Douglas et al., 2010; Kessler et al., 1997; Lo & Cheng, 2007; Sihvola et al., 2008; Simpson Miller, 2002). Further, available literature highlights a protective role of positive parental relationships and positive relationships with other adults or teachers against the possible detrimental effects of ACEs (Brown Shillington, 2017; Forsterm et al., 2017). Moreover, no study has explored links between ACEs and the *timing* of drug use in adolescence, although drug use in the earlier teenage years seems more likely to be linked to adverse outcomes than later use (Andersen, 2019; Jordan & Andersen, 2017). Research also shows associations between both family income and ethnicity and adolescent drug use (Houtepen et al., 2020; Jayakody et al., 2006; Penney et al., 2016; Smoking, 2019), with adolescents from lower income and ethnic minority families reporting lower drug use on average. Nevertheless, there is a paucity of longitudinal UK wide studies exploring the interrelationships between ACEs, ethnicity, and markers of socioeconomic position on adolescent drug use. For instance, little is known about whether the social and cultural advantages conferred by some minority ethnic backgrounds (Bhui et al., 2012; Harding et al., 2015; Read et al., 2018) (e.g. religious affiliation, peer social networks associated with attendance at a place of worship or cross-cultural friendships) could mitigate against the detrimental effects of ACEs on adolescent drug use (one way of conceptualising resilience). An understanding of such mitigating effects could help inform policy efforts to weaken any links between ACEs and problematic drug use. In addition, little is known about whether socio-economic position can either reinforce or buffer the likely negative effects of ACEs on adolescent drug use. Adolescents from families with higher income or advantaged parental social class may have greater access to recreational drugs due to greater material resources, making it easier to seek solace in drug use. Alternatively, more favourable family and social conditions may have a buffering effect, such that the association between ACEs and drug use is stronger for those from disadvantaged socio-economic positions. Adolescents from disadvantaged backgrounds may resort to drug use as an antidote to their problems or lack of support. There are also potentially interesting differential effects by sex. Data show that teenage boys are more likely to report drug use than girls (Smoking, 2019). Yet general strain theory suggests ACEs may trigger differential negative coping for boys (e.g. delinquent behaviour) and girls (substance use) (Agnew et al., 2006), meaning girls may be more vulnerable to exposure to ACEs in this regard. The COVID-19 pandemic has likely increased the risk of adverse experiences to children (and particularly children from low income and minoritised ethnic families) (Crawley et al., 2020; Katz et al., 2022; Knowles et al., 2022), while the support mechanisms in both the NHS and social services were being withdrawn (Garstang et al., 2020; Romanou Belton, 2020; Russell et al., 2022). Despite using data before the COVID-19 pandemic, we believe that the findings of this study will be even more important during the pandemic years.

The aim of this study is to examine associations between individual and cumulative ACE scores from age 3 to age 14, and drug use at both ages 14 and 17 years in a UK wide sample of cohort members drawn from the UK Millennium Cohort Study (MCS). Particularly, we address 3 research questions (RQs);

RQ 1: Are ACEs more important for drug use at age 14 than age 17?
RQ 2: Do associations between ACEs and drug use at ages 14 and 17 differ for girls and boys?
RQ 3: Do associations between ACEs and drug use at ages 14 and 17 vary by cohort member's socio-economic characteristics (indexed by ethnicity, family income and parental social class)?

Finally, given the lack of evidence on the relative importance of each ACE and the number of ACEs on adolescent drug use in a contemporary nationally representative sample, we calculate population attributable fractions (PAFs) with the aim of furthering our understanding of the proportion of cases of drug use at age 14 and age 17 that could potentially be prevented by focusing exclusively on ACEs.

Methods

Participants

The Millennium Cohort Study (MCS) is a longitudinal cohort of 19,244 children born between September 1, 2000 and January 11, 2002, who were living in the United Kingdom (UK) at 9 months and were eligible for child benefits (Connelly & Platt, 2014). The cohort includes children living in non-household situations and children who were not born in the UK but lived in the UK at recruitment. The study used a stratified clustered framework to ensure disadvantaged and ethnic minority groups were adequately represented. The MCS cohort members have been followed from the age of nine months, with survey data collected on seven different occasions (nine months and three, five, seven, eleven, fourteen and seventeen years). From age seven, cohort members completed their own questionnaire, as well as data being gathered in all waves from main carers (97% biological mothers). Ethical approval for all waves of the MCS was obtained via the NHS Research Ethics Committee system and informed consent obtained from all participants.

Measures

Drug use

Questions about drug use were included in the cohort member questionnaire in the sixth and seventh MCS waves. Drug use at age 14 (MCS 6) was assessed through asking MCS cohort members the question *'Have you ever tried Cannabis/Marijuana/Weed?'* Drug use at age 17 (MCS 7) was assessed through the question *'Have you ever taken any of the following: Cannabis/Marijuana/Weed, Cocaine, LSD/Acid, Ecstasy, Speed/Amphetamines, Semeron, Ketamine, Mephedrone, Psychoactive substances?'* In our analysis, these variables were coded as 0 if MCS cohort members responded with "no" and 1 if they responded with "yes". For simplicity, we will be referring to drug use at ages 14 and 17 years for the rest of this study.

Adverse childhood experiences (ACE)

ACEs were captured from age 3 (MCS 2) to age 14 (MCS 6) through responses from both MCS cohort members and their main carers (in almost all cases their mother). Data were used from multiple questions to main carers to generate binary responses for each of the following: regular maternal drug use; maternal alcohol problem drinking; maternal psychological distress; intimate partner violence; and physical punishment. Answers from questions asked to cohort members were used to generate binary responses for each of the following: bullying; sexual assault; and gun violence. A detailed account of the variables used, and the criteria applied to derive the ACEs can be found in Table 1. Finally, a cumulative adversity score (ACE score) was derived after multiple imputation (see discussion below) with the following categories: 0 ACEs, 1 ACE, 2 ACEs and 3+ ACEs for consistency and comparative reasons (Houtepen et al., 2020).

Missing data

Due to the derivation of ACEs over multiple MCS sweeps (age 3 to age 14), there were a lot of missing data on the individual questionnaire items used. To overcome this, we applied multiple imputation. Due to convergence errors (24 highly correlated questions relating to ACEs), we adopted a pragmatic approach to multivariable imputation by applying a scale-level method (creating ACEs dichotomous indicators before imputation) instead of the ideal item-level method (Plumpton et al.,

Table 1
Definition of the analyses' variables.

	Reported	Available observations	Criterium/Dichotomisation	MCS Sweep	Age in years
Problem drinking behaviour	Mother	6,367	CAGE questionnaire- a score of 2 and above indicating problem drinking behaviour	MCS 2	Age 3
Problem drinking behaviour	Mother	5,954	Positive responses to all 3 questions; Not being able stop drinking, failed to do as expected due to drinking, relatives and friends have been concerned about drinking behaviour	MCS 5	Age 11
Problem drinking behaviour	Mother	6,097	Positive responses to all 3 questions; Not being able stop drinking, failed to do as expected due to drinking, relatives and friends have been concerned about drinking behaviour	MCS 6	Age 14
Problem drinking behaviour	Mother	**4,546**	**Maternal problem drinking behaviour at MCS 2 or MCS 5 or MCS 6**		
Use of drugs the past 12 months	Mother		0 = Never/occasionally, 1 = Regularly	MCS 2	Age 3
Use of drugs the past 12 months	Mother	8,413	0 = Never/occasionally, 1 = Regularly	MCS 3	Age 5
Use of drugs the past 12 months	Mother	8,475	0 = Never/occasionally, 1 = Regularly	MCS 6	Age 14
Regular maternal drug use	Mother	**6,767**	**Use of drugs at MCS 2 or MCS 3 or MCS 6**		
Maternal psychological distress	Mother	7,136	Kessler scale, 0 = score 0/12, 1 = 13/max	MCS 2	Age 3
Maternal psychological distress	Mother	8,525	Kessler scale, 0 = score 0/12, 1 = 13/max	MCS 3	Age 5
Maternal psychological distress	Mother	8,465	Kessler scale, 0 = score 0/12, 1 = 13/max	MCS 4	Age 7
Maternal psychological distress	Mother	8,193	Kessler scale, 0 = score 0/12, 1 = 13/max	MCS 5	Age 11
Maternal psychological distress	Mother	8,418	Kessler scale, 0 = score 0/12, 1 = 13/max	MCS 6	Age 14
Maternal psychological distress	Mother	**6,351**	**Score of 13 or above at MCS 2 or MCS 3 or MCS 4 or MCS 5 or MCS6**		
Physical punishment	Mother	7,567	0 = Never/rarely, 1 = Once a month, once a week or more often, daily	MCS 2	Age 3
Physical punishment	Mother	8,473	0 = Never/rarely, 1 = Once a month, once a week or more often, daily	MCS 3	Age 5
Physical punishment	Mother	8,426	0 = Never/rarely, 1 = Once a month, once a week or more often, daily	MCS 4	Age 7
Physical punishment	Mother	**7,297**	**Child was physically punished at MCS 2 or MCS 3 or MCS 4**		
Partner has ever used force in the relationship?	Mother	6,486	Yes	MCS 2	Age 3
Partner has ever used force in the relationship?	Mother	7,034	Yes	MCS 3	Age 5
Partner has ever used force in the relationship?	Mother	6,891	Yes	MCS 4	Age 7
Partner has ever used force in the relationship?	Mother	6,703	Yes	MCS 5	Age 11
Partner has ever used force in the relationship?	Mother	6,672	Yes	MCS 6	Age 14
Intimate partner violence	**Mother**	**4,666**	**Positive answers at MCS2 or MCS3 or MCS4 or MCS5 or MCS6**		
How often other children hurt you or pick on you on purpose?	Child	8,920	0 = Never/about once a month, 1 = About once a week/most days	MCS 5	Age 11
How often other children hurt you or pick on you on purpose?	Child	9,219	0 = Never/about once a month, 1 = About once a week/most days	MCS 6	Age 14
How often have other children sent you unwanted or nasty emails, texts or messages or posted something nasty about you on a website?	Child	9,220	0 = Never/about once a month, 1 = About once a week/most days	MCS 6	Age 14
Bullying	Child	**8,223**	**Bullied/cyber-bullied at MCS 5 or MCS 6**		
In the past 12 months has anyone done any of these things to you?					
Someone hit you with or used a weapon against you?	Child	9,216	Yes	MCS 6	Age 14
Made an unwelcome sexual approach to you or assaulted you sexually?	Child	9,217	Yes	MCS 6	Age 14

2016). Item non-response for these ACEs dichotomous indicators ranged from 5% for sexual assault/abuse and gun violence to 52% for intimate partner violence. Out of 9,476 cohort members who were present at MCS 6 and MCS 7, only 2,582 (27%) had complete data for all ACEs. Because we expected gendered differences in the prevalence of ACEs and potentially higher-order interactions between adversity and gender, imputation models were stratified by sex. The dichotomous ACE indicators were included in the multivariable imputation models along with drug use at age 14 and age 17 years, all covariables detailed below and maternal age at birth as an auxiliary variable to help predict missingness. Finally, we included interactions between each individual ACE and cohort member's ethnicity, family income and parental social class. Overall, 80 multivariable imputation models were created for male and female participants using the Multiple Imputation by Chained Equations (MICE) method in Stata (Royston & White, 2011). For the descriptive and the multivariable regression modelling analyses, all estimates from the imputed models were combined using Rubin's rules (Marshall et al., 2009). Following recommendations imputed values on the outcomes of interest were deleted (VHP, 2007).

Covariables

We included three key covariables as potential effect modifiers in our analyses: sex, ethnicity, and socio-economic position. Being a girl or boy is likely to be associated differently with separate ACEs, e.g. in a recently published study using the ALSPAC data girls were more likely to report sexual abuse, while boys were more likely to report physical abuse (Lacey et al., 2020b). Additionally, according to general strain theory, ACEs may trigger differential psychological responses for girls and boys (Agnew et al., 2006).

To capture ethnicity, we used the analytic 8-census classification of the MCS cohort member's reported ethnic group (White, Mixed, Indian, Pakistani, Bangladeshi, Black Caribbean, Black African, Other (including Chinese)). Using analytic ethnic group categories allows for consideration of the different migration routes to the UK, something that is lost in less nuanced classifications such as White vs. ethnic minority, or White, Asian, Black, and Other. It also enables exploration of the specific relationships of each ethnic group with separate ACEs, ACE score and drug use.

Socio-economic position was captured using a combination of parental education, family income and parental social class. Highest parental educational qualifications were measured at MCS 6 (National Vocational Qualifications (NVQ) 4/5, NVQ 3, NVQ 2, NVQ 1, Overseas, None). Parental education encompasses a range of non-economic social attributes such as general and health-related knowledge, literacy, problem-solving skills, and prestige that are associated with ACEs and drug use (Galobardes et al., 2004; Straatmann et al., 2020). We also tried to measure socio-economic position in a way that captures wider inequalities, using both family income and parental social class. Family income in the MCS is calculated as the total family income from all sources after tax and before housing costs. It is then adjusted for family size and composition using the modified OECD equivalence scale. Equivalised family income was averaged over the first six available surveys and then divided into fifths (quintiles), rather than using a dichotomy between poor and non-poor households. Parental social class was measured using the National Statistics-Socio-Economic Classification (NS-SEC) occupational schema. Parental social class as a measure of socio-economic disadvantage goes beyond income to capture longer-term economic security, stability, and prospects, as reflected in a person's labour market position. It also reflects power in terms of relationships of authority, command, control, and autonomy within the workplace (Bartley, 2016). Parental social class was based on the highest maternal and partner social class over the first six available MCS surveys according to NS-SEC 5 (managerial, professional, small employed and self-employed, supporting, and technological, semi routine, and routine). NS-SEC was used to maximise the comparability of the current article with wider research using social class as a measure of socio-economic advantage/disadvantage.

Statistical analyses

All analyses were run using Stata V.16 (StataCorp. Stata Statistical Software, 2019). Survey weights were applied to account for the unequal probability of inclusion in the study given the clustered and stratified design of the MCS (Centre for Longitudinal Studies, 2007).

To test associations between individual ACEs, ACEs scores and drug use at age 14 and age 17 years, we employed sex-stratified logistic regression modelling. First, unadjusted models were run. We then ran adjusted models including all covariables. In the final stage we tested interactions between individual ACEs or ACE score and ethnicity, family income, parental education, and social class separately in the all-covariable adjusted models.

Prevalence of the outcomes across exposure categories and risk differences (RDs) and ratios (RRs) were estimated in the imputed data using the *'mim: glm'* command in Stata V.16. PAFs were estimated using the formula $PAF = \frac{P_{pop}x(RR-1)}{P_{pop}x(RR-1)+1}x100$, where *Ppop* is the proportion of exposed participants and RR is the risk ratio. The PAF estimates the percentage of cases of adolescent drug use that would be prevented if the exposure was eliminated (assuming causality and absence of bias). No significant interactions between individual ACEs and ethnicity or markers of socio-economic position were observed, thus pooled PAFs were calculated to show the proportion of drug use that could be prevented at age 14 and age 17 years regardless of ethnicity or socioeconomic position.

Further, we conducted sensitivity analyses by i) conducting complete case analyses to explore differences in the results obtained from the multiply imputed data, and ii) by computing E-values via Stata's *evalue* package (Linden et al., 2020). An E-value evaluates the minimum strength on the odds ratio scale that an unobserved confounder would need to have with both ACEs and reported drug use to fully explain away any observed associations (VanderWeele & Ding, 2017).

Although the rationale of the study and its analyses were pre-registered (Karamanos et al., 2021), we applied more stringent definitions of ACEs and we included a smaller number of ACEs than the ones we initially suggested in the pre-registration.

Data access

The datasets supporting the conclusions of this article are available via the UK Data Service, subject to their end-user license agreement, from the University of Essex (University of London IoE, 2018, p. 8682; University of London IoE, 2003–2005, p. 5350; University of London IoE, 2001–2003, p. 4683; University of London IoE, 2006, p. 5795; University of London IoE, 2008, p. 6411; University of London IoE, 2012, p. 7464; University of London IoE, 2015, p. 8156).

Results

Prevalence of ACEs by gender, ethnicity, and markers of socio-economic position

Table 2 shows that girls and boys experienced similar levels of regular maternal drug use, maternal alcohol problem drinking and maternal psychological distress. Boys were more likely to live in families where incidents of intimate partner violence had taken place than girls (26.4% vs 18.7%) and they were more likely to have been physically punished between ages 3 and 7 years than girls (31.9% vs 24.7%).

Girls and boys reported similar levels of bullying. However, girls were more than three times as likely to report sexual assault at age 14 years than boys (4.7% vs 1.4%), while boys were more likely to report being a victim of gun violence than girls (3.8% vs 1.8%).

Table 2
Prevalence of drug use and ACEs by sexin complete case and multiply imputed data.

	Boys		Girls	
	Complete cases (N = 1171)	Multiply Imputed (N = 4653)	Complete cases (N = 1255)	Multiply imputed (N = 4823)_
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Drug use at 14	3% (2.1%–4.4%)	4.1% (3.3%–4.8%)	2.1% (1.5%–3.1%)	4.1% (3.4%–4.8%)
Drug use at 17	36.9% (33.4%–40.5%)	34.2% (32.1%–36.4%)	28.2% (25.3%–31.3%)	29.2% (27.4%–31.2%)
Individual ACEs				
Regular maternal drug use	1.1% (0.6%–2.1%)	2.7% (1.9%–3.5%)	0.2% (0.1%–0.6%)	2% (1.2%–2.7%)
Maternal alcohol problem drinking	6.1% (4.6%–8%)	13% (11.2%–14.8%)	6.1% (4.8%–7.8%)	11.4% (9.6%–13.2%)
Maternal alcohol problem drinking	6.1% (4.6%–8%)	13% (11.2%–14.8%)	6.1% (4.8%–7.8%)	11.4% (9.6%–13.2%)
Intimate partner violence	10.7% (8.8%–12.8%)	26.4% (24.2%–28.7%)	11% (9.1%–13.1%)	18.7% (16.7%–20.6%)
Maternal psychological distress	3.1% (2.1%–4.6%)	16.9% (15.2%–18.7%)	5.3% (4.2%–6.8%)	18.7% (16.7%–20.6%)
Smacking	24.8% (21.9%–27.9%)	31.9% (30%–33.7%)	16.2% (13.9%–18.9%)	24.3% (22.6%–26%)
Bullying	17.6% (15.5%–19.9%)	20% (18.5%–21.5%)	12% (10.2%–14.2%)	16.5% (15.2%–17.8%)
Sexual assault	0.7% (0.3%–1.4%)	1.4% (1%–1.8%)	4.6% (3.4%–6.1%)	4.7% (3.9%–5.4%)
Gun violence	2.1% (1.3%–3.2%)	3.8% (3.2%–4.5%)	0.8% (0.5%–1.5%)	1.8% (1.4%–2.2%)
ACE score				
0	52.8% (49.3%–56.3%)	50.9% (48.6%–53.1%)	59.2% (56%–62.2%)	52.6% (50.4%–54.7%)
1	32.7% (29.6%–35.9%)	27% (25%–29%)	29.1% (26.3%–32%)	25.9% (24.1%–27.7%)
2	11.1% (9.2%–13.3%)	12.8% (11.2%–14.4%)	9.2% (7.4%–11.2%)	12.7% (11.2%–14.2%)
3+	3.4% (2.5%–4.7%)	9.3% (7.9%–10.7%)	2.7% (1.8%–3.9%)	8.8% (7.4%–10.2%)

When ACEs are grouped together, girls and boys are found to have experienced a similar number, with 8.8% of girls and 9.3% of boys experiencing 3+ ACEs.

Supplementary Table 1 shows a clear gradient in the likelihood of experiencing ACEs by socio-economic position. Cohort members from the poorest fifth of family incomes had the highest prevalence in all individual ACEs, with almost a third (32.2%) having experienced 3+ ACEs by age 14 years compared to just 1.8% among the highest income quintile. In a similar vein, cohort members from routine/manual parental social class and those whose parents had lower or no educational qualifications had a higher prevalence of 3+ ACEs. Exposure to ACEs also varies strongly by ethnicity. Some 7.3% of cohort members from a White ethnic background had experienced 3+ ACEs, compared to approximately 25% or more of cohort members of Pakistani, Bangladeshi, Black African and Other heritage.

Prevalence of drug use at age 14 and age 17 years by gender, ethnicity, and markers of socio-economic position

Among 14-year-old girls and boys, 4.1% reported that they had ever smoked cannabis (see Table 2). However, by age 17 years, more boys than girls were likely to report that they had ever used drugs (34.2% vs 29.2%).

Drug use at age 14 was more prevalent among cohort members from the lowest fifth of family incomes (5.8% vs. 2.6% for cohort members in the highest fifth of family incomes) and cohort members with a Mixed ethnic background (7.4% vs. 3.9% for the White cohort members). Conversely, at age 17 years drug use was more prevalent among cohort members from the highest fifth of family incomes (32.8% vs. 25.3% for cohort members from the lowest fifth of family incomes), and for cohort members with parents in a professional/managerial occupation (34.6% vs. 29.5% for cohort members with parents in a routine/manual occupation). MCS cohort members with a Mixed or a Black Caribbean background reported the highest drug use at age 17 (38.4% and 38.2% respectively), whereas Pakistani and Bangladeshi cohort members reported the lowest (12.3% and 9.4% respectively). White cohort members had relatively high rates of drug use at 32.8%.

The effect of ACEs on adolescent drug use

Fig. 1 shows that individual ACEs as well as ACE score were associated with both girls' and boys' drug use at age 14. However, associations were more pronounced for girls. Unadjusted estimates showed that girls with an experience of 3+ ACEs were 9.6 times more likely to report drug use at age 14 than girls with no experience of ACEs (Fig. 1 and S Table 3), while boys with an experience of 3+ ACEs were 3.4 times as likely to report drug use at age 14 as boys with no experience of ACEs (Fig. 1 and S Table 4).

Adjustment for ethnicity, family income, parental social class and highest parental educational qualifications slightly reduced the magnitude of associations between individual ACEs and drug use at age 14 for both girls and boys, implying that social and economic disadvantage were positively contributing to the observed associations at age 14. After adjusting for ethnicity, family income, parental social class and education, girls whose mothers reported regular drug use, alcohol problem drinking behaviour, psychological distress or who had been bullied were 2–4 times as likely to report drug use at age 14 as girls with no reported ACEs. Girls were also 5 to 7 times as likely to report drug use at age 14 if incidents of intimate partner violence had taken place within the household, if they reported being a victim of sexual assault or gun violence, or if they had experienced any two ACEs as opposed to none. Boys were between 2 and 4 times more likely to report drug use at age 14 if their mothers had reported regular drug use, intimate partner violence and if they had experienced 2 or more ACEs. Boys were also more than five times as likely to report drug use at age 14 if they reported being a victim of gun violence.

Figs. 1 and 2 as well as Supplementary Tables 3 and 4 show that the magnitude of the associations between individual ACEs, ACE score, and drug use at age 17 was smaller than the associations observed at age 14 for both boys and girls, indicating that the experience of ACEs is more important in explaining drug use in earlier than later adolescence. Unadjusted estimates showed that the number of ACEs was significantly associated only with girls' drug use at age 17. Adjustment for ethnicity, family income, parental social class and highest parental educational qualifications *increased* the magnitude of the associations between individual ACEs and drug use at age 17 for both girls and boys, highlighting the change in the distribution of drug use by family background between ages 14 and 17. Adjusted estimates showed that girls were between 1.2 and 2 times more likely to report drug use at age 17 if their mother reported alcohol problem drinking behaviour, if incidents of intimate partner violence had taken place within the household or if they had been bullied, with the likelihood of drug use increasing with

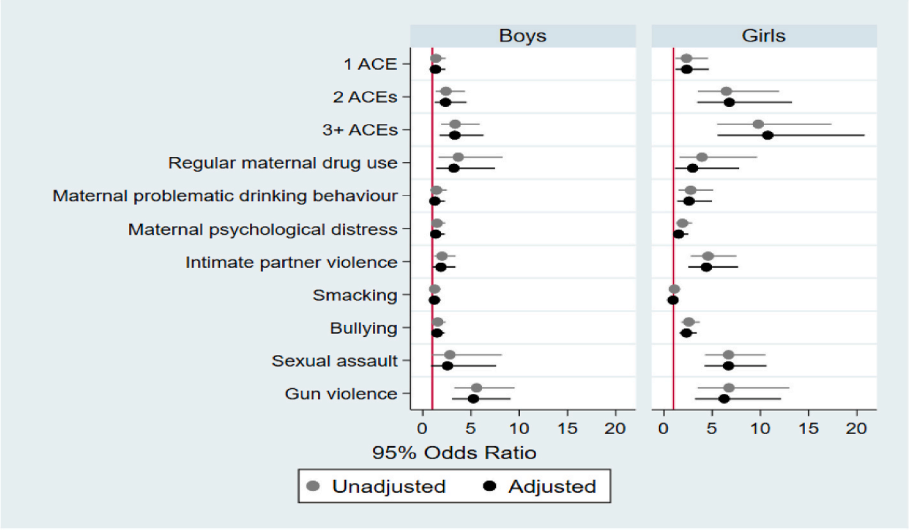

Fig. 1. Coefficient plots for the associations of the ACE score and individual ACEs with drug use at age 14 by sex.
The reference category for each category of the ACE score is experiencing 0 ACEs. The basic model shows associations between ACE score or individual ACE and drug use at age 14. The adjusted model additionally includes parental highest education qualifications, parental social class, family income and ethnicity of the child. 95% confidence intervals are shown around point estimates.

Table 3
Associations of ACEs with drug use at age 14 and age 17 in girls on the RD scale and PAFs.

	Prevalence in exposed	Prevalence in unexposed	PAF %	Prevalence in exposed	Prevalence in unexposed	PAF %
	% (95% CI)	% (95% CI)		% (95% CI)	% (95% CI)	
Regular maternal drug use	12.6% (2.1%–23.1%)	3.9% (3.2%–4.6%)	4%	42.1% (27.1%–57.1%)	28.9% (27%–30.8%)	1%
Maternal alcohol misuse	8.8% (4.7%–12.9%)*	3.4% (2.7%–4.2%)	15%	41.4% (34.3%–48.5%)***	27.6% (25.6–29.6%)	5%
Maternal psychological distress	5.8% (3.5%–8%)	3.7% (2.9%–4.4%)	10%	32% (27.4%–36.6%)	28.5% (26.4%–30.6%)	2%
Intimate partner violence	9.2% (6.9%–11.6%)***	2.3% (1.5%–3.1%)	44%	37.7% (33.2%–42.1%)***	26.2% (24%–28.5%)	7%
Bullying	7.7% (5.4%–10%)	3.3% (2.7%–4%)	18%	32.8% (28.4%–37.3%)	28.4% (26.5%–30.3%)	2%
Smacking	4% (3.3%–4.8%)	4% (3.3%–4.8%)	0%	30.5% (27.1%–34%)	28.7% (26.5%–30.9%)	0%
Gun violence	18.3% (12.6%–24.6%)***	3.3% (2.3%–4%)	7%	39.8% (27.9%–51.7%)	29% (27.1%–30.8%)	1%
Sexual assault	20.4% (10.1%–30.7%)**	3.8% (3.1%–4.4%)	17%	56.8% (48.9%–64.6%)***	27.8% (26%–29.6%)	5%
3+ ACEs	14.2% (9.5%–18.8%)***	1.4% (0.6%–2.1%)	45%	44% (37.4%–51.3%)***	23.9% (21.5%–26.4%)	7%

*** >0.001, ** >0.01, * >0.05.
PAF is the proportion of the adolescent girls reporting drug use, who also experienced an ACE. PAF can be interpreted as the proportion of drug use cases at each age that could be prevented if the exposure was eliminated, assuming causality. Note that the reference categories in this table differ from those in other parts of the manuscript; here, the reference category is all other participants apart from those with the exposure (for example, the reference category for 3+ ACEs here is 0 ACEs).

Table 4
Associations of ACEs with drug use at age 14 and age 17 in boys on the RD scale and PAFs.

	Prevalence in exposed	Prevalence in unexposed	PAF %	Prevalence in exposed	Prevalence in unexposed	PAF %
	% (95% CI)	% (95% CI)	–	% (95% CI)	% (95% CI)	
Regular maternal drug use	12.8% (5%–21.1%)*	3.8% (3%–4.6%)	6%	58.1% (45.7%–70.5%)*	33.5% (31.4%–35.5%)	2%
Maternal alcohol misuse	5.0% (2.5%–7.5%)	3.9% (3.1%–4.7%)	–	38.2% (31.8%–44.6%)	33.5% (31.3%–35.8%)	–
Maternal psychological distress	5.2% (3.0%–7.4%)	3.8% (3.0%–4.7%)	–	34.2% (31.9%–36.5%)	34.1% (29.3–38.9%)	–
Intimate partner violence	6.1% (3.9%–8.4%)*	3.3% (2.3%–4.3%)	18%	37.6% (33.0%–42.1%)	32.9% (30.4–35.4%)	4%
Bullying	5.3% (3.4–7.2%)	3.8% (3.0–4.5%)	–	31.9% (27.8–35.9%)	34.7% (32.5%–37.0)	–
Smacking	4.7% (3.3%–6.1%)	3.8% (2.9%–4.7%)	–	34.4% (30.9%–37.8%)	34.0% (31.8%–36.3%)	–
Gun violence	9.8% (0.4%–19.2%)	4% (3.3%–4.7%)	–	52.7% (37.2%–68.2%)*	33.9% (31.8%–35.9%)	2%
Sexual assault	16.8% (10.5%–23%)***	3.6% (2.8%–4.3%)	5%	50.7% (42.5%–58.9%)***	33.8% (31.5%–35.5%)	<1%
3+ ACEs	9% (5.3%–12.8%)***	2.8% (1.7%–3.8%)	17%	41.7% (34.3%–49%)*	33.1% (30%–36%)	2%

*** >0.001, ** >0.01, * >0.05.
PAF is the proportion of the adolescent girls reporting drug use, who also experienced an ACE. PAF can be interpreted as the proportion of drug use cases at each age that could be prevented if the exposure was eliminated, assuming causality. Note that the reference categories in this table differ from those in other parts of the manuscript; here, the reference category is all other participants apart from those with the exposure (for example, the reference category for 3+ ACEs here is 0 ACEs).

the number of ACEs experienced. Girls were 3.5 times as likely to report drug use at age 17 if they had reported being a victim of sexual assault as girls who had not. Boys were 2–2.5 times more likely to report drug use if their mothers reported regular drug use and if they had reported being a victim of sexual assault or gun violence.

No evidence was found of interactions between either individual ACEs or ACE score and ethnicity, family income or parental education or social class.

Population attributable fractions (PAFs)

For girls (Table 3), differences in the risk of drug use at age 14 ranged from 2.1% for maternal psychological distress to 16.6% for sexual assault. At age 17, differences in the risk of drug use ranged from 3.5% for maternal psychological distress to 29% for sexual assault.

For boys, differences in the risk of drug use at age 14 ranged from 0.9% for physical punishment to 13.2% for sexual assault, while at age

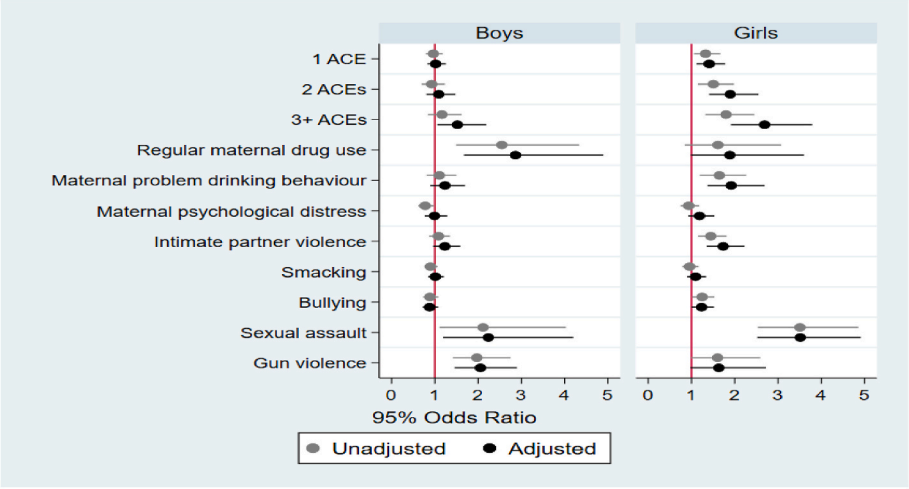

Fig. 2. Coefficient plots for the associations of the ACE score and individual ACEs with drug use at age 17 by sex.
The reference category for each category of the ACE score is experiencing 0 ACEs. The basic model shows associations between ACE score or individual ACE and drug use at age 17. The adjusted model additionally includes parental highest education qualifications, parental social class, family income and ethnicity of the child. 95% confidence intervals are shown around point estimates.

17 differences in the risk of drug use ranged from 0.4% for physical punishment to 18.8% for gun violence.

PAFs differed by age and sex. Among girls, at age 14, the lowest PAF was for regular maternal drug use (4%), reflecting the low prevalence of this ACE. The highest PAF was mother-reported intimate partner violence (44%) followed by bullying (18%) and sexual assault (17%). The PAF for 3+ACEs was 45%. The PAFs at age 17 were considerably lower than age 14, with the highest PAFs observed for mother-reported intimate partner violence (7%), maternal alcohol problem drinking (5%) and sexual assault (5%).

For boys (Table 4), PAFs were considerably lower than those of girls at both age 14 and age 17. Particularly, at age 14, the highest PAF was observed for intimate partner violence (18%) followed by regular maternal drug use (6%) and sexual assault (5%). The PAF for 3+ ACEs was 17%. The PAFs at age 17 were considerably lower, with PAFs ranging from <1% for sexual assault to 4% for intimate partner violence.

Sensitivity analyses

As Supplementary Tables 5 and 6 highlight, complete case analyses showed similar results to those obtained from the multiply imputed analyses. Nevertheless, there was a greater uncertainty around point estimates in the complete case analyses due to considerably larger standard errors.

The size of E values for the significant associations between individual ACEs and girls' drug use at age 14 (Supplementary Table 3) ranged from 4.07 (bullying) to 12.44 (sexual assault) and 20.59 (3+ACEs), indicating that an unmeasured confounding factor would still need to be associated with girls' drug use at age 14 at an odds ratio of 4.07–20.59 to nullify the observed associations. At age 17, E values ranged from 1.76 (bullying) to 6.5 (sexual assault). The E value for 3+ ACEs was 4.82.

For boys (Supplementary Table 4), the size of E values for the significant associations between individual ACEs and drug use at age 14 ranged from 3.13 (intimate partner violence) to 9.99 (gun violence). The E value for 3+ ACEs was 5.99. At age 17, E values were 3.54 (gun violence), 3.91 (sexual assault) and 5.19 (regular maternal drug use).

Discussion

In this UK nationally representative sample of ~9500 cohort members born between 2000 and 2002, one in two girls and boys had been exposed to at least one ACE and approximately one in eleven were exposed to 3+ ACEs by age 14. Our findings on the prevalence of ACEs are consistent with a recent meta-analysis (Bullock, 2019) of five UK studies (Bellis et al., 2014, 2015a, 2015b; Ford et al., 2016; Hughes et al., 2018), which identified a weighted average prevalence of 54.2% of people having experienced no ACEs, 27.5% having experienced one, and 25.3% having experienced two or more.

We found evidence that ACEs – both when considered individually and when combined as an ACE score – were associated with a considerably higher likelihood of drug use at age 14 than drug use at age 17, with these associations being more pronounced in girls than boys. Experience of interparental violence, sexual assault and gun violence were all particularly strongly associated with an increased likelihood of drug use at 14 among girls. Adjustment for ethnicity, family income, parental social class and highest parental educational qualifications slightly reduced associations between individual ACEs and drug use at age 14 for both girls and boys, indicating the importance of social and economic disadvantage for drug use at this age. In contrast, adjustment for these social and economic variables slightly increased associations between ACEs and drug use at age 17 for both girls and boys, reflecting the greater prevalence of drug use at this age among more advantaged socio-economic groups. However, adjusted associations between ACEs and drug use at both ages were still present and similar in magnitude. Both the experience of an individual ACE and of poly-adversity, or multiple ACEs, are more common among cohort members from more disadvantaged backgrounds, in line with previous findings from ALSPAC (Lacey et al., 2020b), but we found no evidence that either advantaged socio-economic position or ethnicity acted as a buffer against the negative effects of ACEs in relation to adolescent drug use, as discussed further below.

When we calculated the proportion of cases of drug use at age 14 and age 17 attributable to 3+ ACEs or individual ACEs, we found that prevention of ACEs (if causal) is more important for earlier (age 14) than later drug use (age 17) in adolescence, especially for younger girls Reported drug use at age 14 in the MCS was relatively rare compared to the more pronounced drug use at age 17. It is therefore plausible that drug use at these different ages carries very different social significance. Drug use at an earlier age in adolescence may function as an "escape" for some teenagers from their life problems (Sinha, 2008), whereas drug use at a later age in adolescence may be a more common part of growing up and experimenting with behaviours such as sex activity, smoking and drinking alcohol (Geier C, 2013). While this is one of the very first studies to examine the association between ACEs and the timing of drug use in adolescence, the finding of a stronger correlation with drug use earlier in adolescence corroborates previously published findings of a small study of 260 children and adolescents aged 9–18 years from Singapore (Gomez et al., 2018) which highlighted that adolescents with experience of multiple forms of ACEs were more likely to initiate drug use at an earlier age.

Our findings are also in line with the gendered expectation of general

strain theory (Agnew et al., 2006). According to this theory, boys are more likely to respond to ACEs with externalising behaviours (e.g. stealing money, running away from abusive parents, engaging in violent behaviour) as a method to reduce or escape from the strains of ACEs. In contrast, girls who had experienced more ACEs have a higher likelihood of drug use (Agnew et al., 2006; Leban & Gibson, 2020).

One of the study's aims was to explore the possibility that a cohort member's ethnic background could act to mitigate the effects of ACEs, and/or whether higher family income and parental social class could either buffer or exacerbate associations between ACEs and drug use in adolescence. We found that associations were of similar magnitude for girls and boys from a White, Mixed, Indian, Pakistani, Bangladeshi, Black Caribbean, Black African and Other ethnic background, from low- and high-income families, and from routine/manual and managerial/professional social classes. These findings are consistent with those from a study using ALSPAC data, which also found no differences in the associations between ACEs and drug use in adolescence by socioeconomic position or ethnicity (Houtepen et al., 2020), although that study categorised ethnicity using a simple White/ethnic minority binary grouping. Nevertheless, caution should be exercised when interpreting the absence of evidence on intersections between ACEs. Absence of evidence on interactions between ACEs and adolescent social, demographic, and economic characteristics does not mean that there are no interactions. That might be the case, but it could also be the case that there are interactions but the data from the MCS survey could not establish that they exist. Lack of evidence on interactions can be attributed to several reasons such as the lack of statistical power to detect effect modification especially at age 14 when drug use in the MCS was relatively rare (4.1%), the small number of ethnic minority adolescents within the MCS survey or the potential inaccuracy of the MCS family income measure as a reliable indicator of family material living circumstances given the omission of state benefits such as Housing Benefit and Council Tax Benefit when estimating the total family net income (Hansen, 2014).

One of the strengths of this study is the use of prospective data from a UK nationally representative sample of participants from age 3 to age 17 to avoid issues of recall bias and reverse causality. Nevertheless, there are a number of limitations. First, data missingness posed a challenge to the analysis. We sought to remedy this by imputing the missing data under the Missing at Random assumption according to which participants who had missing data were disproportionately those experiencing ACEs, ethnic minorities, and those from disadvantaged socio-economic positions. Multiple imputed data allowed us to use the maximum available information in the study and gain in efficiency as the prevalence of ACEs was higher in the multiple imputed data for both boys and girls. Second, loss of follow up or differential attrition bias is also likely in our study. Participants who were present at MCS 6 (Age 14) and MCS 7 (Age 17) were, on average, from a White ethnic background, an advantaged socio-economic position and they were less likely to experience ACEs. It is therefore plausible that we have underestimated the magnitude of association between ACEs and drug use at age 14 and 17 years. Loss of follow up in the MCS might have also resulted in reduction of statistical power in observing heterogenous associations between ACEs and drug use by ethnicity and markers of socio-economic position. For consistency with other studies, we analysed each individual ACE separately and we did not adjust for other ACEs as covariates. The rationale for this is that the causal structure linking ACEs is complex and largely unknown. Some adjustments would have led to overadjustment, removing some of the effect of interest. Future studies should focus on how different clusters of ACEs associate with drug use in adolescence. Third, attempts to partition causality via PAFs may be limited by the definition of individual ACEs rather than a valuable understanding about causality, and the consideration of drug use as attributable to (or caused by) exposure to one ACE (rather than another ACE) is often arbitrary when multiple ACEs cluster (Levine, 2007). Finally, the estimates of this study related to pre-pandemic years (2015 and 2018) and may not entirely reflect the situation under the COVID-19 pandemic years.

To conclude, our results stress that associations of ACEs and drug use were stronger at age 14 than age 17, and that they were robust to adjustment for demographic and economic factors. We also found that associations were particularly strong for girls, and for experiences of sexual assault, gun violence and intimate partner violence. Our results highlighted that prevention of ACEs or improved support for children and adolescents with experience of ACEs, whilst beneficial, would not prevent the vast majority of those who are going to use drugs in adolescence. Nonetheless, they could potentially make a sizeable contribution to reducing drug use among younger teenagers, especially girls. The impact of the COVID-19 pandemic on individuals with and without ACEs remains to be quantified in future studies, but a strong focus on reduction of intimate partner violence in the household, on bullying and sexual assault, and on better support for those who experience these adversities, is important.

Developing policies to tackle these factors is not straightforward. In an exploration of early intervention policies in 2016, the Early Intervention Foundation (EIF) found no interventions which demonstrated effectiveness in addressing sexual abuse (Intervention Foundation, 2018). Sexual violence usually takes place in unsupervised spaces, such as parties or parks without adults present (Ofsted, 2021). Nonetheless, schools may have a special role in preventing sexual abuse from occurring, as well as in tackling bullying. In two recent reports, the Children's Commissioner and the Office for Standards in Education (Ofsted) highlighted the important role of schools as a context for prevention of sexual assault through Personal, Social, Health and Economic education (PHSE) and relationships and sex education (RSE), and through the availability of trusted adults and emotional and pastoral support within the school environment (Ofsted, 2021; Children's Commisioner, 2017). In addition, the Children's Commissioner recommended that PHSE and compulsory relationships and sex education in schools can create opportunities to develop a culture where all kinds of sexual harassment and abuse are recognised and addressed. Further, schools could be an environment where staff model respectful and appropriate behaviour, where children and young people are clear about what is acceptable and unacceptable behaviour, and where they are confident to ask for help and support when they need it (Children's Commisioner, 2017). Our findings show that exposure to sexual violence, bullying and violence within the household, has knock-on consequences on wider aspects of young people's lives, whatever their social, ethnic, or economic background, adding further urgency to the need to reduce the incidence of these negative experiences.

Ethical statement

Ethical approval for all waves of the MCS was obtained via the NHS Research Ethics Committee system and informed consent obtained from all participants.

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CRediT authorship contribution statement

A. Karamanos: Conceptualization, the study. contributed equally to the following, Methodology, Validation, Writing – original draft, conducted the Statistical Analysis. contributed equally to, Writing – review & editing, Formal analysis. **K. Stewart:** contributed equally to the following, Methodology, Validation, Writing – original draft, contributed equally to, Writing – review & editing. **S. Harding:** contributed equally to, Writing – review & editing. **Y. Kelly:** contributed equally to

the following, Methodology, Validation, Writing – original draft, contributed equally to, Writing – review & editing. **R.E. Lacey:** Conceptualization, the study. contributed equally to the following, Methodology, Validation, Writing – original draft, contributed equally to, Writing – review & editing.

Declaration of competing interest

None declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2022.101142.

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