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Mental Health

Changes in millennial adolescent mental health and health-related behaviours over 10 years: a population cohort comparison study

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Abstract

Background: There is evidence that mental health problems are increasing and substance use behaviours are decreasing. This paper aimed to investigate recent trends in mental ill health and health-related behaviours in two cohorts of UK adolescents in 2005 and 2015.

Methods: Prevalences in mental health (depressive symptoms, self-harm, anti-social behaviours, parent-reported difficulties) and health-related behaviours (substance use, weight, weight perception, sleep, sexual intercourse) were examined at age 14 in two UK birth cohorts; Avon Longitudinal Study of Parents and Children (ALSPAC, $N = 5627$, born 1991–92) and Millennium Cohort Study (MCS, $N = 11\,318$, born 2000–02). Prevalences and trend estimates are presented unadjusted and using propensity score matching and entropy balancing to account for differences between samples.

Results: Depressive symptoms (9% to 14.8%) and self-harm (11.8% to 14.4%) were higher in 2015 compared with 2005. Parent-reported emotional difficulties, conduct problems, hyperactivity and peer problems were higher in 2015 compared with 2005 (5.7–8.9% to 9.7–17.7%). Conversely, substance use (tried smoking, 9.2% to 2.9%; tried alcohol, 52.1% to 43.5%, cannabis, 4.6% to 3.9%), sexual activity (2% to 0.9%) and anti-social behaviours (6.2–40.1% to 1.6–27.7%) were less common or no different. Adolescents in 2015 were spending less time sleeping (<8 h 5.7% to 11.5%), had higher body mass index (BMI) (obese, 3.8% to 7.3%) and a greater proportion perceived themselves as overweight (26.5% to 32.9%). The findings should be interpreted bearing in mind limitations in ability to adequately harmonize certain variables and account for differences in attrition rates and generalizability of the two cohorts.

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Conclusions: Given health-related behaviours are often cited as risk factors for poor mental health, our findings suggest relationships between these factors might be more complex and dynamic in nature than currently understood. Substantial increases in mental health difficulties, BMI and poor sleep-related behaviours highlight an increasing public health challenge.

Key words: Depression, smoking, alcohol, sleep, ALSPAC, Millennium Cohort Study, adolescence

Key Messages

- Large increases are observed in some mental health difficulties (depression, self-harm), obesity and poorer sleeping habits in the 10 years between 2005 and 2015, whereas antisocial behaviour and substance use seem to be decreasing or are unchanged.
- Given health-related behaviours are often cited as risk factors for poor mental health, our findings suggest relationships between these factors might be changing over time.
- The findings have important implications for policy and public health planning related to mental health and substance use.
- Our findings also present data on changes in sleep behaviours and weight perceptions, highlighting the need for further research into the role these behaviours might play in the rising mental health difficulties observed in today's adolescents.

Introduction

The focus on adolescent health has been increasing in recent years,[1] with a growing recognition that these years are pivotal in the development and maintenance of health behaviours and outcomes through the life course.[2,3] Adolescence is a key period for mental health disorder onset, with half of lifetime onset by age 14.[4] Research over previous decades suggests that the prevalences of mental health problems are increasing in UK teenagers,[5,6] which is mirrored in studies across different countries.[7,8] An international systematic review investigating secular trends in adolescent mental health from the previous century into the start of this century concluded that internalizing symptoms seem to be increasing, finding more consistent evidence for increases in girls compared with boys.[9] Most studies in this review focused on internalizing symptoms or general psychological distress, making conclusions about externalizing behaviours less possible. There are few studies comparing changing trends in the millennial generations, and prevalence studies suggest that mental health problems in mid adolescence might have increased even further in recent years.[10,11]

In contrast, whereas prevalence of internalizing mental health problems seems to be increasing, young people in the UK are becoming less likely to be under-age substance users. Office for National Statistics reports collected from secondary school pupils in England have found prevalences of alcohol use, smoking, cannabis use and other drug use among 14-year-olds have consistently fallen since 1982, when the survey was first undertaken.[12] For example, in 1982 16% of 14-year-olds described themselves as regular smokers. In 2014 this had fallen to just 4%, and the drop was consistent across genders. This decrease in use has become particularly pronounced since the early 2000s.[12]

Given that various health behaviours including but not limited to substance use are implicated in risk for poor mental health,[13–18] investigating the relationships between these secular trends is important to explore causal relationships and the aetiology of mental ill-health, and potentially to inform interventions to try to reverse the increasing prevalence of mental health problems. It is therefore surprising that to date there has been little attempt to combine investigations of secular trends in mental health with changes in health-related behaviours. We also know little about trends in other health-related behaviours such as sleep, risky sexual behaviour, body satisfaction and physical activity that might also be causal risk factors for mental ill health and substance use.[13–18]

In the current study we use two cohorts of UK adolescents born a decade apart (1991/92 and 2000/02) in order to identify changes in mental health, considering both internalizing and externalizing symptoms, and a number of health-related behaviours including substance use, sleep behaviours, weight and physical and sexual activity. In

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particular we attempt to make the variables and datasets as comparable as possible, by harmonizing the variables and performing two different techniques (propensity score matching and entropy balancing) to increase the comparability of the cohorts. The prevalences of a number of these behaviours differ between males and females, and some studies report different trends in males and females.[6] We therefore also empirically examine sex differences in changes over time in these outcomes.

Methods

Participants

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a cohort born in 1991–92. ALSPAC recruited 14 541 pregnant women resident in Avon, UK, with expected dates of delivery between 1 April 1991 and 31 December 1992. When the oldest children were approximately 7 years of age, an attempt was made to bolster the initial sample with eligible cases who had failed to join the study originally. The total sample size for analyses using any data collected after the age of 7 years is therefore 15 247 pregnancies, resulting in 15 458 fetuses. Of this total sample of 15 458 fetuses, 14 775 were live births and 14 701 were alive at 1 year of age.[19,20] The study website contains details of all the data that are available through a fully searchable data dictionary and variable search tool [http://www.bristol.ac.uk/alspac/researchers/our-data/]. Ethics approval for the study was obtained from the ALSPAC Ethics and Law Committee and the local research ethics committees. Data were collected frequently via different methods, with clinic visits or postal questionnaires having taken place in adolescence every year. This study uses data from ages 13, 14 and 15. In the current study, data were available from 6132 participants at age 14, representing 41.7% of the 14701 participants alive past 1 year. Attrition is predicted by a range of variables in ALSPAC, including lower educational level, male gender, non-White ethnicity and eligibility for free school meals.[19]

The Millennium Cohort Study (MCS) is a cohort of 19 517 children born in 2000–02, sampled from the whole of the UK.[21] Data so far have been collected in six sweeps at ages 9 months and 3, 5, 7, 11 and 14 years. The study website [https://cls.ucl.ac.uk/cls-studies/millennium-cohort-study/] contains details regarding all the data available and information on accessing the datasets. Ethics approval for the age 14 sweep was obtained from the National Research Ethics Service Research Ethics Committee. At the age 14 sweep, 15 415 families were issued into the field (non-issue was due to emigration, permanent refusal or untraceability), of which 11 726 families participated in the age 14 sweep (representing 60.9% of the original sample).[22] Attrition at the age 14 sweep compared with the full sample is predicted by a range of demographic variables including male gender, Black ethnicity, lower occupational and educational level and single parent family.[23]

For this study, we analysed data from participants who had provided data on at least one of the outcome variables at the age 14 sweeps of the studies (depressive symptoms, smoking, alcohol, cannabis and other drugs; ALSPAC $N = 6132$, MCS $N = 11\ 351$). Furthermore, participants without the demographic data required for increasing the comparability of the datasets (sex, ethnicity, age, maternal education and maternal age) were excluded, resulting in an analysis sample of 5627 from ALSPAC and 11 318 from MCS.

There have been changes in sociodemographic characteristics of the country in the 10 years between these cohorts (e.g. higher proportion ethnic minorities, higher education levels) and, in addition, the two cohorts represent different regions that might have different characteristics, with ALPSAC being a regional and MCS a national cohort. For instance, around 20% of the MCS sample are ethnic minorities compared with around 4% in ALSPAC. To minimize the bias in estimates that sociodemographic differences in the samples might cause, we employ two approaches (propensity score matching and entropy balancing) to increase the comparability of the cohorts.

Measures

The measures used in this study (Table 1) include sociodemographic indicators (used for increasing cohort comparability), mental ill health (depressive symptoms, self-harm, parent-reported difficulties), substance use (alcohol, smoking, cannabis and other drugs), antisocial behaviours (assault, graffiti, vandalism, shoplifting and rowdy behaviour) and other health-related behaviours (including sleep, weight, weight perception and sexual activity). In a few instances (self-harm, sleep behaviours, parent-rated difficulties), the variables of interest were not available in ALSPAC at age 14, but were available in the sweep immediately beforehand (age 13) or afterwards (age 15), and where this is the case it is clearly indicated in the table. Table 1 also presents the details of the harmonized variables that were subsequently used in analysis. Some of the variables were more readily comparable than others; for instance both studies used the Short Moods and Feelings Questionnaire[24] to assess depressive symptoms, the parent-rated Strengths and Difficulties Questionnaire[25] to measure difficulties and the same set of questions to record sexual activity. Other variables

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Table 1. Measures in ALSPAC and MCS for each domain and the harmonized variable

Outcome	ALSPAC (2005)	MCS (2015)	Harmonized variable
Depressive symptoms	13-item Short Moods and Feelings Questionnaire[a]	13-item Short Moods and Feelings Questionnaire[b]	Total depressive symptoms score (continuous) Yes/no variable based on clinical threshold >=12
Self-harm	[a](Measured at age 15) Over your whole lifetime have you ever tried to harm yourself or kill yourself?	In the past year have you hurt yourself on purpose in any way?[b]	0 Not self-harmed 1 Have self-harmed (ALSPAC is lifetime but MCS is in past year)
Antisocial behaviours	How often in the past year have you done any of the following? (categorical)[b] - Not at all - Just once - 3-5 times - 6+ times Hit, kicked or punched someone on purpose Been rowdy or rude in a public place so that people complained or you got in to trouble Written things or sprayed paint on a property that did not belong to you Deliberately damaged or destroyed property that did not belong to you Taken something from a shop without paying for it Other items included skipping school, breaking and stealing from various different places, carrying a knife or weapon for protection, setting fire, stealing a vehicle, not paying correct fare on public transport, using force to steal	In the past 12 months have you (yes/no):[b] Pushed or shoved/hit/slapped/punched someone? Been noisy or rude in a public place so that people complained or got you into trouble? Written things or spray painted on a building, fence or train or anywhere else where you shouldn't have? On purpose damaged anything in a public place that didn't belong to you, for example by burning, smashing or breaking things like cars, bus shelters and rubbish bins? Taken something from a shop without paying for it? Other items included using a weapon on someone, stealing from someone, hacking into computers, sending computer viruses.	0 No 1 Yes Assault Rowdy behaviour Graffiti Vandalism Shoplifting
Parent-rated difficulties	(Measured at age 13)[c] Strengths and difficulties Questionnaire	Strengths and difficulties Questionnaire[c]	Five continuous subscale scores Five yes/no variables based on the 'abnormal' cutoff Subscales: emotional symptom, conduct problems, hyperactivity, peer problems, prosocial behaviour
Alcohol use	Have you ever tried alcohol with/without your parents' permission? (yes/no)[a] What is the most alcoholic drinks you've had in a single evening? (continuous variable) How many times have you done this in the past year? (continuous variable)	Have you ever had an alcoholic drink? That is more than a few sips. (yes/no)[b] How many times have you had an alcoholic drink in the past 12 months? (seven response options from never to over 40) Have you ever had five or more alcoholic drinks at a time? A drink is half a pint of lager, beer or cider, one alcopop, a small glass of wine or a measure of spirits (yes/no)	0 Never drank a whole drink 1 Nothing in past 12 months/never drank five or more 2 One to two times drank five or more alcoholic drinks in one evening 3 Three or more times drank five or more alcoholic drinks in one evening

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Table 1. Continued

Outcome	ALSPAC (2005)	MCS (2015)	Harmonized variable
		How many times have you had five or more alcoholic drinks at a time in the past 12 months? - Never - 1-2 times - 3-5 times - 6-9 times - 10 or more time	
Smoking frequency	Frequency teenager has smoked cigarettes in the past 6 months:[a] - 1-3 times - >4 times - once per week - never Number of cigarettes smoked per week in the last 6 months for weekly users (continuous variable)	Please read the following statements carefully and decide which one best describes you. Do not include electronic cigarettes (e-cigarettes)[b] - I have never smoked cigarettes - I have only ever tried smoking cigarettes once - I used to smoke sometimes but I never smoke a cigarette now - I sometimes smoke cigarettes now but I don't smoke 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	0 Non-smoker 1 Occasional smoker, not weekly 2 Smokes one to six cigarettes a week 3 Smokes more than six cigarettes a week
Cannabis	Have you ever used cannabis? (yes/no)[a]	Have you ever tried any of the following things: cannabis (also known as weed, marijuana, dope, hash or skunk)? (yes/no)[b]	0 Never used cannabis 1 Have tried cannabis
Other drugs	Teenager has been offered drugs? (yes/no)[a] If yes to above, has teenager has used drugs other than cannabis to feel good/get high? (yes/no)	Have you ever tried any of the following things?[b]Any other illegal drug (such as ecstasy, cocaine, speed)? (yes/no)	0 Never used other drugs 1 Have tried other drugs
BMI	Height and weight measured by interviewer[a]	Height and weight measured by interviewer[a]	BMI derived from height and weight Obese (0 = no, 1 = yes) derived using IOTF threshold
Weight perception	How do you describe your weight?[b] - Very underweight - Slightly underweight - About the right weight - Slightly overweight - Very overweight	Which of these do you think you are?[b] - Underweight - About the right weight - Slightly overweight - Very overweight	Perceive themselves: 1 Underweight 2 About the right weight 3 Slightly overweight 4 Very overweight
Sleep	(Measured at age 15)[b] What time do you usually get in to bed on school days? (continuous, reported in hours and minutes am/pm) What time do you usually get into bed on weekend days? (continuous, reported in hours and minutes am/pm) What time do you usually wake up on school days? (continuous,	About what time do you usually go to sleep on a school night?[b] About what time do you usually go to sleep on the nights when you do not have school the next day? - Before 9pm - 9-9.59pm - 10-10.59pm - 11pm-midnight - After midnight About what time do you usually wake up on a school day?	Four categorical sleep variables: Schoolday bedtime Non-schoolday bedtime 1 Before 9pm 2 9-9.59pm 3 10-10.59pm 4 11pm-midnight 5 After midnight (11 pm and later classified as late bedtime) Schoolday waketime 1 Before 6am

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Table 1. Continued

Outcome	ALSPAC (2005)	MCS (2015)	Harmonized variable
	reported in hours and minutes am/pm) What time do you usually wake up on weekend days? (continuous, reported in hours and minutes am/pm)	- Before 6am - 6-6.59am - 7-7.59am - 8-8.59am - 9am or later	2 6-6.59am 3 7-7.59am 4 8-8.59am 5 9am or later (before 7 am classified as early waketime)
		About what time do you wake up in the morning on the days when you do not have school? - Before 8am - 8-8.59am - 9-9.59am - 10-10.59am - 11-11.59am - Midday or later	Non-schoolday waketime 1 Before 8am 2 8-8.59am 3 9-9.59am 4 10-10.59am 5 11-11.59am 6 Midday or later (before 9 am classified as early waketime) Sleep duration weekdays: We estimate a sleep duration variable based on these categories (category mid points are used, and for earliest and latest times we use half-hour before or after stated time). Sleep less than 8 h on weekdays is classified as insufficient sleep. based on guidelines for adolescent sleep durations
Sexual intercourse	Series of questions regarding intimate contact with someone else leading to:[b] Have you had sexual intercourse with another person in the past year?	Series of questions regarding intimate contact with someone else leading to[b] In the past 12 months have you had sexual intercourse with another young person?	0 have not had sex 1 had sex
Physical activity	Frequency data available on approximately 80 specific activities (riding a bike, skipping, gardening, walking the dog, cricket etc.)[b]	On how many days in the past week did you do a total of at least an hour of moderate to vigorous physical activity? By moderate to vigorous we mean any physical activity that makes you get warmer, breathe harder and makes your heart beat faster, e.g. riding a bike, running, playing football, swimming, dancing, etc.[b] - Every day - 5-6 days - 3-4 days - 1-2 days - Not at all	Not harmonized

IOTF, International Obesity Task Force.
[a]Measured via interview.
[b]Measured via self-completion.
[c]Parent-reported.

were harmonized through a process of creating new, comparable variables across the datasets (e.g. alcohol, smoking). For self-harm, even after harmonization the resulting variable is not truly comparable due to different time scales of the question asked, which needs to be borne in mind when interpreting findings. Last, some health-related behaviours that we planned to harmonize and investigate (physical activity) were substantially differently measured and harmonized measures could not be derived.

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Analysis

Increasing comparability of the datasets

To increase comparability of the samples by accounting for key sociodemographic differences between these samples, participants from the larger MCS sample were matched or weighted to make them comparable to the ALSPAC sample on key demographic factors including sex, age, ethnicity, maternal education and maternal age at birth. This was done using two approaches: propensity score matching[26] and entropy balancing.[27] Both approaches aim to reduce the probability that differences between samples on outcomes of interest are because of sample differences on relevant demographic variables.[27] Table S1, available as Supplementary data at *IJE* online, shows the differences in these characteristics in the samples before and after these procedures were applied.

Propensity score matching is based on a propensity score, which is derived from weighting schemes based on the criteria that are to be matched to identify individuals from the larger, control group that are most like each of the individuals in the treatment group (in this case ALSPAC) across a range of variables as specified. Propensity score matching was conducted in STATA using psmatch2.[28]

Entropy balancing is a multivariate re-weighting method that calibrates unit weights such that two samples are balanced on a range of pre-specified variables, hence increasing comparability for the estimation of treatment, or in this case cohort, effects.[27] The application of this approach creates an entropy balancing weight value for all participants in the MCS sample, which is then used as a weight when estimating prevalences in the MCS sample. This approach allows the use of the full available MCS cohort, instead of selecting a matched sub-sample like the propensity score matching approach. Entropy balancing was conducted in STATA using ebalance.[29]

Missing data

In ALSPAC, 15.6% of the total cells were missing (ranging from <1% for substance use, 1.8% for mental health, ~24% for antisocial behaviours to ~26% for sleep behaviours). In the MCS samples, 1% of cells were missing in the MCS propensity matched sample and 1.2% in the full MCS sample. Multiple imputations (20 imputations) were carried out using chained equations separately in the two cohorts.

Estimating cohort differences

Four estimates (ALSPAC, MCS nationally representative, MCS propensity matched and MCS entropy balanced) of the prevalences and descriptive statistics [means and percentages with 95% confidene intervals (CIs)] for each of the harmonized outcome variables were first estimated. In addition, we estimated odds ratios (Figure 1) of the cohort effects (MCS compared with ALSPAC) for the prevalence of poor mental health or risky health behaviours using logistic regressions. Last, we also examined sex-into-cohort interactions with the ebalancing weight to examine whether the extent of change in males and females was different. For ease of interpretation for the reader, throughout the rest of the paper we refer to the ALSPAC variables year of collection as 2005 and to the MCS variables as 2015.

Results

There were no differences between the samples in sex distribution or maternal age at birth (Table S1, available as Supplementary data at *IJE* online). Regarding the other characteristics, as expected, MCS had higher proportions of ethnic minorities and higher levels of maternal higher education. The propensity matching resulted in the two samples becoming more similar, for example ethnic minorities were less than 4% in the ALSPAC cohort compared towith more than 20% in the full MCS cohort, whereas the propensity matched MCS cohort consisted of around 10% of minority ethnic individuals. The entropy balancing (based on the generated entropy weights) resulted in matched estimates across demographic characteristics in the two cohorts.

Estimates from the propensity score matched sample and the entropy balancing in the MCS were very similar in most cases and for most outcomes. These adjusted estimates were slightly different from the MCS nationally representative estimates, indicating the importance of adjusting the estimates when estimating cohort differences (Tables 2 and 3). The descriptive statistics indicated that there were more young people with mental health problems, as indicated by greater proportion above the depression threshold and reporting self-harming, in 2015 compared with 2005 (but note that the self-harm behaviour question was limited to the past 12 months in 2015, compared with lifetime in 2005). Antisocial behaviour and substance use rates were lower in 2015 compared with 2005. Parent-reported difficulties highlighted higher rates of emotional, conduct and hyperactivity symptoms and greater levels of problems in getting along with peers in 2015 compared with 2005. With regards to health-related behaviours (Table 3), the proportion who had tried smoking and alcohol had reduced in 2015, but rates of those smoking weekly and having tried cannabis and other drugs were similar in the two cohorts. The more recent cohort had a higher BMI on average and larger numbers also perceived themselves to be overweight. The data on sleep behaviours indicated that on weekdays young people in 2015 were more likely to sleep later and more likely to wake up earlier. Weekend sleep and wake times were more

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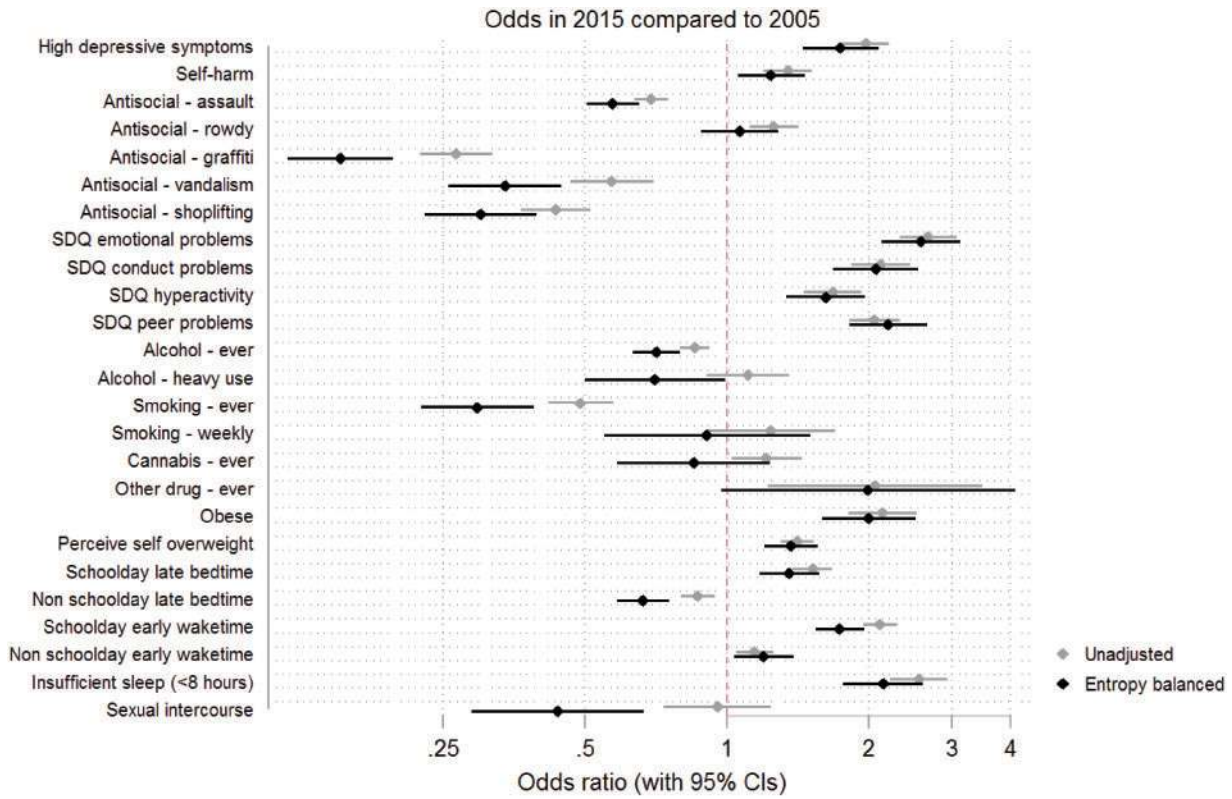

Figure 1. ORs (95% CI) for poorer outcomes in 2015 (MCS) vs 2005 (ALSPAC). Unadjusted estimates and estimates using entropy balancing weights are both presented.

Table 2. Descriptive statistics for mental health outcomes in 2005 (ALSPAC) and 2015 (MCS)

Domain	Variable	2005	2015		
		ALSPAC $N = 5627$	MCS (nationally representative estimates), $N = 11\,318$	MCS (propensity score matched) $N = 5627$	MCS (entropy balanced) $N = 11\,318$
		Mean or % (95% CI)	Mean or % (95% CI)	Mean or % (95% CI)	Mean or % (95% CI)
Depressive symptoms	SMFQ score	4.93 (4.81, 5.05)	5.72 (5.57, 5.86)	5.44 (5.28, 5.59)	5.41 (5.10, 5.73)
	% above clinical cutoff	9.0 (8.3, 9.8)	16.4 (15.5, 17.3)	14.7 (13.8, 15.6)	14.8 (12.7, 16.8)
Self-harm	% Yes	11.9 (10.9, 13.0)	15.4 (14.5, 16.3)	14.8 (13.8, 15.7)	14.4 (12.8, 16.0)
Antisocial behaviours	% Assault	40.1 (38.5, 41.6)	31.6 (30.4, 32.7)	28.9 (27.8, 30.2)	27.7 (25.5, 29.8)
	% Rowdy behaviour	11.5 (10.6, 12.4)	14.1 (13.2, 14.9)	12.5 (11.6, 13.3)	12.1 (10.4, 13.9)
	% Graffiti	9.9 (8.9, 10.9)	2.8 (2.5, 3.2)	2.4 (2.0, 2.8)	1.6 (1.3, 2.0)
	% Vandalism	6.2 (5.4, 7.0)	3.6 (3.1, 4.1)	2.9 (2.5, 3.3)	2.2 (1.7, 2.7)
	% Shoplifting	8.0 (7.1, 8.8)	3.6 (3.1, 4.1)	3.0 (2.5, 3.4)	2.5 (1.9, 3.2)
Parent-reported difficulties (SDQ)	Emotional symptoms	1.42 (1.37, 1.47)	2.08 (2.02, 2.14)	2.02 (1.96, 2.07)	2.03 (1.93, 2.13)
	% above clinical cutoff	5.7 (5.1, 6.3)	13.9 (13.0, 14.8)	13.0 (12.2, 13.9)	13.5 (11.6, 15.3)
	Conduct problems	1.20 (1.16, 1.24)	1.53 (1.48, 1.58)	1.39 (1.35, 1.43)	1.44 (1.35, 1.53)
	% above clinical cutoff	6.0 (5.3, 6.6)	11.9 (11.0, 12.7)	10.0 (9.2, 10.8)	11.6 (9.8, 13.4)
	Hyperactivity symptoms	2.85 (2.79, 2.91)	3.12 (3.06, 3.18)	2.97 (2.91, 3.04)	3.07 (2.95, 3.19)
	% above clinical cutoff	6.2 (5.6, 6.9)	10.0 (9.2, 10.8)	8.7 (7.9, 9.4)	9.7 (8.3, 11.0)
	Peer problems	1.21(1.16, 1.25)	1.82 (1.78, 1.87)	1.73 (1.68, 1.78)	1.85 (1.73, 1.97)
	% above clinical cutoff	8.9 (8.1, 9.7)	16.8 (15.8, 17.8)	15.0 (14.1, 15.9)	17.7 (15.3, 20.1)
	Prosocial behaviours	8.26 (8.21, 8.31)	8.25 (8.20, 8.30)	8.38 (8.34, 8.43)	8.41 (8.32, 8.49)
	% above clinical cutoff	1.2 (0.9, 1.5)	1.9 (1.6, 2.3)	1.4 (1.1, 1.7)	1.4 (0.9, 1.9)

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Table 3. Descriptive statistics for health-related behaviours in 2005 (ALSPAC) and 2015 (MCS)

Domain	Variable	2005	2015		
		ALSPAC $N = 5627$	MCS (nationally representative estimates) $N = 11\,318$	MCS (propensity score matched) $N = 5627$	MCS (entropy balanced) $N = 11\,318$
		Mean or % (95% CI)	Mean or % (95% CI)	Mean or % (95% CI)	Mean or % (95% CI)
Alcohol use	% never drank	47.9 (46.6, 49.2)	51.8 (50.6, 53)	57.8 (56.5, 59.1)	56.5 (53.9, 59.0)
	% nothing past 12 months, never heavy drinking	42.1 (40.8, 43.4)	38.3 (37.1, 39.5)	34.7 (33.4, 35.9)	37.2 (34.7, 39.8)
	% heavy drinking 1-2 times in past 12 months	6.7 (6.0, 7.3)	6.2 (5.6, 6.7)	4.8 (4.3, 5.4)	3.9 (3.2, 4.6)
	% heavy drinking >3 times in past 12 months	3.4 (2.9, 3.8)	3.7 (3.2, 4.2)	2.6 (2.2, 3.1)	2.4 (1.7, 3.1)
Smoking	% non-smoker	90.8 (90.0, 91.5)	95.3 (94.7, 95.9)	97.0 (96.6, 97.5)	97.1 (96.4, 97.8)
	% occasional, not weekly	7.2 (6.5, 7.9)	2.1 (1.7, 2.5)	1.4 (1.1, 1.7)	1.2 (0.8, 1.6)
	% 1-6 cigarettes/week	0.6 (0.4, 0.8)	0.9 (0.7, 1.1)	0.6 (0.4, 0.8)	0.4 (0.2, 0.7)
	% >6 cigarettes/week	1.4 (1.1, 1.7)	1.8 (1.4, 2.1)	1.0 (0.8, 1.3)	1.3 (0.7, 1.9)
Cannabis	% tried	4.6 (4.0, 5.1)	5.5 (4.9, 6.1)	3.7 (3.2, 4.2)	3.9 (2.6, 5.2)
Other drugs	% tried	0.4 (0.2, 0.6)	0.8 (0.6, 1.0)	0.6 (0.4, 0.8)	0.8 (0.3, 1.2)
Weight	Mean BMI	20.32 (20.23, 20.41)	21.58 (21.47, 21.69)	21.35 (21.24, 21.46)	21.25 (21.07, 21.44)
	% obese	3.8 (3.3, 4.3)	7.8 (7.1, 8.5)	7.4 (6.7, 8.0)	7.3 (6.1, 8.5)
Weight perception	% underweight	14.3 (13.2, 15.4)	7.0 (6.4, 7.6)	6.9 (6.2, 7.6)	6.8 (5.7, 7.9)
	% about right weight	59.3 (57.9, 60.7)	59.4 (58.2, 60.5)	60.3 (59.1, 61.6)	60.2 (57.7, 62.8)
	% overweight	23.0 (21.8, 24.2)	28.7 (27.6, 29.8)	28.4 (27.3, 29.6)	28.8 (26.3, 31.4)
	% very overweight	3.5 (2.9, 4.0)	4.9 (4.4, 5.5)	4.3 (3.7, 4.8)	4.1 (3.3, 4.9)
Sleep: schoolday bedtime	Before 9pm	0.9 (0.6, 1.2)	5.0 (4.5, 5.6)	4.9 (4.4, 5.5)	6.0 (4.8, 7.1)
	9-9.59 pm	15.3 (14.3, 16.4)	29.2 (28.1, 30.3)	30.1 (28.9, 31.3)	33.1 (30.6, 35.7)
	10-10.59 pm	64.9 (63.4, 66.4)	39.7 (38.5, 40.9)	39.9 (38.7, 41.2)	37.0 (34.7, 39.3)
	11-midnight	16.3 (15.2, 17.4)	19.6 (18.6, 20.5)	19.3 (18.3, 20.4)	18.0 (16.0, 20.0)
	After midnight	2.6 (2.1, 3.0)	6.5 (5.8, 7.1)	5.7 (5.1, 6.3)	5.9 (4.8, 7.1)
Sleep: non-schoolday bedtime	Before 9pm	0.2 (0.1, 0.3)	0.9 (0.6, 1.1)	0.9 (0.6, 1.1)	0.9 (0.4, 1.3)
	9-9.59 pm	2.7 (2.2, 3.2)	5.6 (5.1, 6.1)	6.1 (5.4, 6.7)	7.3 (5.6, 9)
	10-10.59 pm	24.1 (22.9, 25.3)	23.4 (22.4, 24.4)	24.8 (23.7, 26.0)	27.5 (25.3, 29.8)
	11-midnight	42.3 (40.8, 43.8)	36.2 (35.1, 37.4)	36.8 (35.5, 38.1)	33.7 (31.4, 36.0)
	After midnight	30.7 (29.4, 32.1)	33.9 (32.7, 35.0)	31.4 (30.2, 32.6)	30.5 (28.2, 32.8)
Sleep: schoolday wake time	Before 6am	1.0 (0.7, 1.3)	4.4 (3.9, 5)	3.6 (3.1, 4.0)	3.5 (2.6, 4.5)
	6-6.59 am	28.4 (27.0, 29.8)	42.3 (41.1, 43.5)	38.8 (37.5, 40.1)	38.4 (36.0, 40.7)
	7-7.59 pm	66.1 (64.7, 67.5)	49.4 (48.2, 50.6)	53.5 (52.2, 54.8)	54.4 (51.9, 56.9)
	8-8.59am	4.2 (3.7, 4.8)	3.1 (2.7, 3.5)	3.5 (3.0, 4.0)	3.2 (2.5, 4.0)
	After 9am	0.3 (0.1, 0.4)	0.9 (0.5, 1.2)	0.6 (0.4, 0.9)	0.5 (0.2, 0.7)
Sleep: non-schoolday wake time	Before 8am	6.5 (5.8, 7.3)	8.1 (7.4, 8.7)	7.8 (7.1, 8.5)	8.1 (6.6, 9.6)
	8-8.59 am	15.4 (14.3, 16.5)	16.2 (15.3, 17.1)	15.8 (14.9, 16.8)	17.0 (14.9, 19.0)
	9-9.59 pm	26.2 (24.8, 27.5)	24.8 (23.8, 25.8)	25.4 (24.3, 26.5)	25.6 (23.4, 27.9)
	10-10.59am	31.1 (29.7, 32.5)	29.0 (27.9, 30.1)	29.8 (28.6, 31.0)	27.9 (25.7, 30.1)
	11-11.59am	15.0 (14.0, 16.0)	15.0 (14.1, 15.8)	14.8 (13.8, 15.7)	15.2 (13.5, 16.9)
	After midday	5.8 (5.1, 6.5)	6.9 (6.3, 7.6)	6.4 (5.8, 7.0)	6.1 (4.9, 7.4)
Sleep duration (weekday)	Mean sleep duration	8.70 (8.68, 8.73)	8.60 (8.58, 8.63)	8.68 (8.65, 8.71)	8.74 (8.68, 8.79)
	% sleep less than 8 h	5.7 (5.1, 6.4)	13.4 (12.6, 14.3)	11.6 (10.7, 12.4)	11.5 (10.0, 13.1)
Sexual intercourse	% yes	2.1 (1.8, 2.5)	2.0 (1.7, 2.4)	1.2 (0.9, 1.5)	0.9 (0.6, 1.3)

similar between the cohorts. A greater proportion of adolescents in 2005 reported having had sexual intercourse by this age compared with in 2015. Due to the higher comparability and complete sample size using entropy weights and the similar estimates produced with entropy and propensity adjustment, entropy balancing is used for subsequent regression analyses comparing the two cohorts and the sex by cohort interactions.

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Figure 1 illustrates odds of outcomes in the MCS sample (2015) compared with the ALSPAC sample (2005) using both a direct comparison approach and estimates applying the entropy balancing weights. Estimates were similar for most of the mental health and some health-related behaviour outcomes based on the two approaches, but there was some noticeable upward or downward bias for some outcomes; for instance with entropy balancing, the lower odds in 2015 compared with 2005 are more stark for antisocial and risky health behaviours, highlighting the potential relevance of using methods to increase the comparability of cohorts when estimating cohort differences.

Descriptives stratified by sex are presented in Table 4. Depressive symptoms, self-harm and overweight perception were higher in females and antisocial behaviours and peer problems higher in males. Regression analysis with the entropy balancing weight were undertaken to examine sex-by-cohort interactions. Many health-related behaviours showed little or no sex differences in prevalence. There were no sex-by-cohort interactions for most of the variables included in this study, indicating that rates of change or increased/decreased odds were similar in males and females. There was evidence of sex differences in cohort effects for some antisocial behaviours [e.g. assault odds ratio $(OR)_{male} = 0.66$, $OR_{female} = 0.45$], parent-reported conduct problems ($OR_{male} = 2.74$, $OR_{female} = 1.38$) and having tried alcohol ($OR_{male} = 0.85$, $OR_{female} = 0.59$), where odds of these behaviours in 2015 compared with 2005 were lower in females compared with males (irrespective of whether overall odds were lower or higher in 2015). Odds ratios separately by sex were estimated and are presented in Figure 2.

Discussion

The current study examined changes in a range of mental health and health-related behaviour outcomes in mid adolescence over 10 years (2005 to 2015), using two key UK birth cohort studies. Importantly, the study investigated this range of outcomes within the same analytical framework, and employed methodological techniques to provide comparable estimates across the different health outcomes.

Prevalences of depressive symptoms, self-harm and parent-reported mental health difficulties were all higher in 2015 compared with 2005, whereas antisocial behaviours were lower in 2015. Changes in these mental health outcomes were substantial, with a 6% increase (9% in 2005, 14.9% in 2015) in those above the threshold for depression and 20% decrease in those reporting physically assaulting anyone at age 14 (40.1% in 2005, ~28% in 2015). Most antisocial behaviours reported were substantially lower in 2015 compared with 2005, and there was a sex interaction whereby the cohort difference was larger in females. Trends in externalizing behaviours have been under-studied in cohort comparisons, and these data provide clear evidence for changes in antisocial behaviours in the decade between these cohorts.

The increase in internalizing mental health problems was consistent by sex, suggesting that increases in psychological distress and self-harming behaviour are not increasing at higher rates in females. This finding is in contrast to some other studies of adolescent trends that indicated that increases in internalising problems were more consistent and greater in females.[6,9,11] For instance, previous research has reported odds in 2006 compared with 1986 at age 16 of 0.9 in males and 1.5 in females,[6] compared with the increased odds in this study of ~1.8 in both males and females in 2015 compared with 2005. It is striking that the rate of increase of high depressive symptoms is more than 60% in just one decade. Poor mental health at this age predicts a host of lifelong negative consequences such as poorer health, social and economic outcomes,[30] and therefore this sharp increase should cause concern.

Results for health-related behaviours were mixed, with less young people having tried alcohol, binge drinking, smoking and having sex by mid adolescence in 2015, but being more likely to have later bedtimes and wake up earlier, sleep less than the recommended 8 h for adolescents,[31] to perceive themselves as overweight and to have higher BMIs. It is relevant to note that although fewer young people had tried smoking cigarettes in 2015, there was no cohort difference in the proportion smoking weekly at this age, although in absolute terms the number of individuals smoking weekly at age 14 was small (approximately 2% in both cohorts). In terms of sex differences in these cohort effects, the odds for some antisocial behaviours and for ever trying alcohol in 2015 compared with 2005 were even lower in females compared with males, indicating that for some of these behaviours the decreasing prevalences over time were more marked in females. Some of these findings (e.g. under-age substance use, sexual activity) are in line with research that demonstrates a decrease in 'adult activities' among adolescents in recent decades[32]; however, this explanation does not help understand the shorter sleep times, lower anti social behaviours and poorer weight-related outcomes observed in this study.

The health-related behaviours identified in this study are all known risk factors for mental ill health.[13–15,18] In some instances the increasing trends in risky health behaviours, such as decreasing sleep times, increasing weight and perceived overweight status, might help explain the increasing mental health difficulties experienced by adolescents. Where the trends are moving in opposite directions (substance use, antisocial behaviours), the

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Table 4. Descriptive statistics for mental health and health-related behaviours in 2005 (ALSPAC) and 2015 (MCS) by sex

Domain	Variable	2005 ALSPAC		2015 MCS (nationally representative estimates)	
		Males	Females	Males	Females
		Mean or % (95% CI)	Mean or % (95% CI)	Mean or % (95% CI)	Mean or % (95% CI)
Depressive symptoms	SMFQ score	4.14 (3.99, 4.28)	5.69 (5.51, 5.87)	4.22 (4.05, 4.39)	7.31 (7.08, 7.54)
	% above clinical cutoff	5.65 (4.78, 6.52)	12.4 (11.1, 13.6)	9.19 (8.13, 10.3)	24.0 (22.5, 25.4)
Self-harm	% yes	6.86 (5.67, 8.05)	16.9 (15.2, 18.6)	8.49 (7.51, 9.47)	22.8 (21.3, 24.2)
Antisocial behaviours	% assault	48.1 (45.9, 50.3)	32.3 (30.3, 34.4)	41.4 (39.7, 43.1)	21.1 (19.7, 22.5)
	% rowdy behaviour	11.0 (9.63, 12.3)	12.0 (10.7, 13.4)	15.3 (14.0, 16.5)	12.7 (11.6, 13.9)
	% graffiti	9.01 (7.56, 10.4)	10.7 (9.38, 12.0)	3.17 (2.61, 3.73)	2.47 (1.95, 2.98)
	% vandalism	7.70 (6.35, 9.06)	4.73 (3.79, 5.67)	4.44 (3.66, 5.22)	2.76 (2.12, 3.40)
	% shoplifting	7.60 (6.44, 8.76)	8.30 (7.14, 9.46)	4.36 (3.67, 5.04)	2.81 (2.25, 3.38)
Parent reported difficulties (SDQ)	Emotional symptoms	1.23 (1.16, 1.30)	1.60 (1.52, 1.67)	1.78 (1.69, 1.86)	2.41 (2.33, 2.48)
	% above clinical cutoff	4.70 (3.89, 5.50)	6.67 (5.73, 7.61)	10.5 (9.35, 11.7)	17.4 (16.1, 18.8)
	Conduct problems	1.24 (1.18, 1.30)	1.16 (1.10, 1.22)	1.60 (1.53, 1.67)	1.46 (1.40, 1.51)
	% above clinical cutoff	6.42 (5.47, 7.36)	5.55 (4.67, 6.43)	13.7 (12.3, 15.1)	9.89 (8.79, 11.0)
	Hyperactivity symptoms	3.28 (3.19, 3.37)	2.44 (2.36, 2.52)	3.54 (3.45, 3.63)	2.67 (2.59, 2.75)
	% above clinical cutoff	8.81 (7.72, 9.90)	3.69 (2.97, 4.42)	13.4 (12.1, 14.6)	6.41 (5.48, 7.34)
	Peer problems	1.36 (1.29, 1.43)	1.06 (0.99, 1.12)	1.92 (1.85, 1.99)	1.73 (1.67, 1.79)
	% above clinical cutoff	11.2 (9.98, 12.4)	6.71 (5.75, 7.67)	18.5 (17.0, 20.0)	14.9 (13.7, 16.1)
	Prosocial behaviours	8.01 (7.93, 8.08)	8.50 (8.43, 8.57)	8.02 (7.95, 8.09)	8.49 (8.42, 8.56)
	% above clinical cutoff	1.67 (1.17, 2.18)	0.72 (0.39, 1.05)	2.35 (1.78, 2.92)	1.51 (1.03, 1.99)
Alcohol use	% never drank	48.7 (46.8, 50.6)	47.1 (45.2, 48.9)	51.3 (49.6, 53.0)	52.4 (50.7, 54.1)
	% nothing past 12 months, never heavy drinking	40.7 (38.9, 42.6)	43.4 (41.6, 45.3)	39.4 (37.7, 41.1)	37.2 (35.6, 38.8)
	% heavy drinking 1-2 times in past 12 months	7.35 (6.37, 8.33)	6.00 (5.11, 6.89)	6.07 (5.26, 6.88)	6.24 (5.38, 7.10)
	% heavy drinking >3 times in past 12 months	3.24 (2.58, 3.91)	3.50 (2.81, 4.19)	3.26 (2.60, 3.92)	4.20 (3.48, 4.92)
Smoking	% non-smoker	93.2 (92.2, 94.1)	88.4 (87.3, 89.6)	96.3 (95.6, 97.0)	94.1 (93.2, 95.0)
	% occasional, not weekly	5.15 (4.33, 5.98)	9.14 (8.08, 10.2)	1.61 (1.11, 2.10)	2.59 (1.98, 3.19)
	% 1-6 cigarettes/week	0.44 (0.19, 0.69)	0.81 (0.48, 1.14)	0.68 (0.39, 0.97)	1.13 (0.75, 1.51)
	% >6 cigarettes/week	1.24 (0.83, 1.65)	1.61 (1.15, 2.08)	1.39 (0.92, 1.86)	2.15 (1.54, 2.76)
Cannabis	% tried	5.32 (4.48, 6.16)	3.86 (3.15, 4.57)	5.57 (0.47, 0.64)	5.43 (4.57, 6.29)
Other drugs	% tried	0.45 (0.18, 0.72)	0.34 (0.12, 0.55)	0.81 (0.48, 1.14)	0.79 (0.49, 1.10)
Weight	Mean BMI	19.9 (19.8, 20.1)	20.7 (20.6, 20.8)	21.0 (20.9, 21.2)	22.2 (22.0, 22.3)
	% obese	3.93 (3.21, 5.66)	3.66 (2.97, 4.35)	7.64 (6.66, 8.61)	7.92 (6.97, 8.87)
Weight perception	% underweight	17.3 (15.6, 18.9)	11.4 (10.1, 12.7)	9.36 (8.33, 10.4)	4.58 (3.87, 5.28)
	% about right weight	61.1 (59.1, 63.1)	57.4 (55.4, 59.5)	63.7 (62.0, 65.3)	54.8 (53.2, 56.5)
	% overweight	19.4 (17.8, 21.0)	26.4 (24.7, 28.2)	23.6 (22.2, 25.1)	34.0 (32.4, 35.6)
	% very overweight	2.20 (1.54, 2.85)	4.68 (3.83, 5.53)	3.34 (2.67, 4.00)	6.59 (5.72, 7.45)
Sleep: schoolday bedtime	before 9pm	0.86 (0.47, 1.26)	0.90 (0.52, 1.28)	5.44 (4.64, 6.23)	4.61 (3.88, 5.35)
	9-9.59 pm	14.8 (13.3, 16.2)	15.9 (14.5, 17.3)	28.5 (27.0, 30.0)	29.9 (28.4, 31.4)
	10-10.59 pm	64.7 (62.5, 67.0)	65.1 (63.2, 67.1)	40.5 (38.8, 42.2)	38.9 (37.3, 40.6)
	11-midnight	16.9 (15.1, 18.6)	15.7 (14.2, 17.2)	18.9 (17.5, 20.2)	20.3 (19.0, 21.7)
	After midnight	2.76 (2.10, 3.42)	2.37 (1.74, 3.01)	6.74 (5.76, 7.73)	6.21 (5.37, 7.06)
Sleep: non-school-day bedtime	Before 9pm	0.18 (0.00, 0.35)	0.22 (0.03, 0.42)	0.88 (0.57, 1.20)	0.82 (0.51, 1.14)
	9-9.59 pm	2.45 (1.78, 3.11)	2.92 (2.18, 3.65)	5.89 (5.09, 6.68)	5.30 (4.58, 6.03)
	10-10.59 pm	22.5 (20.6, 24.4)	25.7 (24.0, 27.4)	22.5 (21.1, 23.9)	24.4 (23.0, 25.8)
	11-midnight	41.6 (39.4, 43.7)	43.0 (40.8, 45.1)	35.2 (33.6, 36.8)	37.3 (35.7, 38.9)
	After midnight	33.3 (31.3, 35.3)	28.2 (26.3, 30.1)	35.5 (33.8, 27.2)	32.1 (30.5, 33.7)
Sleep: schoolday wake time	Before 6am	0.85 (0.47, 1.22)	1.10 (0.68, 1.53)	4.40 (3.61, 5.18)	4.50 (3.77, 5.24)
	6-6.59 am	23.7 (21.7, 25.7)	33.0 (31.1, 34.8)	36.9 (35.2, 38.6)	48.0 (46.3, 49.7)
	7-7.59 pm	69.2 (67.2, 71.1)	63.1 (61.2, 65.0)	53.6 (51.8, 55.3)	44.9 (43.2, 46.5)

(Continued)

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Table 4. Continued

Domain	Variable	2005 ALSPAC		2015 MCS (nationally representative estimates)	
		Males	Females	Males	Females
		Mean or % (95% CI)	Mean or % (95% CI)	Mean or % (95% CI)	Mean or % (95% CI)
	8-8.59am	5.91 (4.88, 6.94)	2.63 (1.97, 3.29)	4.02 (3.36, 4.67)	2.05 (1.59, 2.51)
	After 9am	0.36 (0.10, 0.63)	0.19 (0.00, 0.39)	1.10 (0.46, 1.74)	0.59 (0.35, 0.84)
Sleep: non-school-day wake time	Before 8am	7.70 (6.58, 8.83)	5.36 (4.42, 6.31)	9.74 (8.70, 10.8)	6.31 (5.49, 7.13)
	8-8.59 am	15.5 (13.9, 17.0)	15.3 (13.9, 16.8)	16.8 (15.5, 18.1)	15.5 (14.3, 16.8)
	9-9.59 pm	25.4 (23.4, 27.4)	26.9 (25.0, 28.7)	23.1 (21.7, 24.5)	26.6 (25.1, 28.0)
	10-10.59am	29.9 (27.9, 31.9)	32.3 (30.3, 34.2)	28.0 (26.4, 29.5)	30.1 (28.6, 31.7)
	11-11.59am	15.2 (13.8, 16.6)	14.9 (13.4, 16.4)	14.7 (13.5, 16.0)	13.2 (13.0, 16.5)
	After midday	6.34 (5.35, 7.32)	5.29 (4.37, 6.20)	7.67 (6.58, 8.76)	6.19 (5.37, 7.00)
Sleep duration (weekday)	Mean sleep duration	8.75 (8.72, 8.79)	8.65 (8.62, 8.68)	8.68 (8.64, 8.71)	8.53 (8.49, 8.56)
	% sleep less than 8 h	5.0 (4.1, 5.9)	6.5 (5.5, 7.5)	12.3 (11.1, 13.5)	14.6 (13.4, 15.9)
Sexual intercourse	% yes	2.3 (1.7, 2.8)	2.0 (1.5, 2.5)	2.0 (1.4, 2.5)	2.1 (1.6, 2.6)

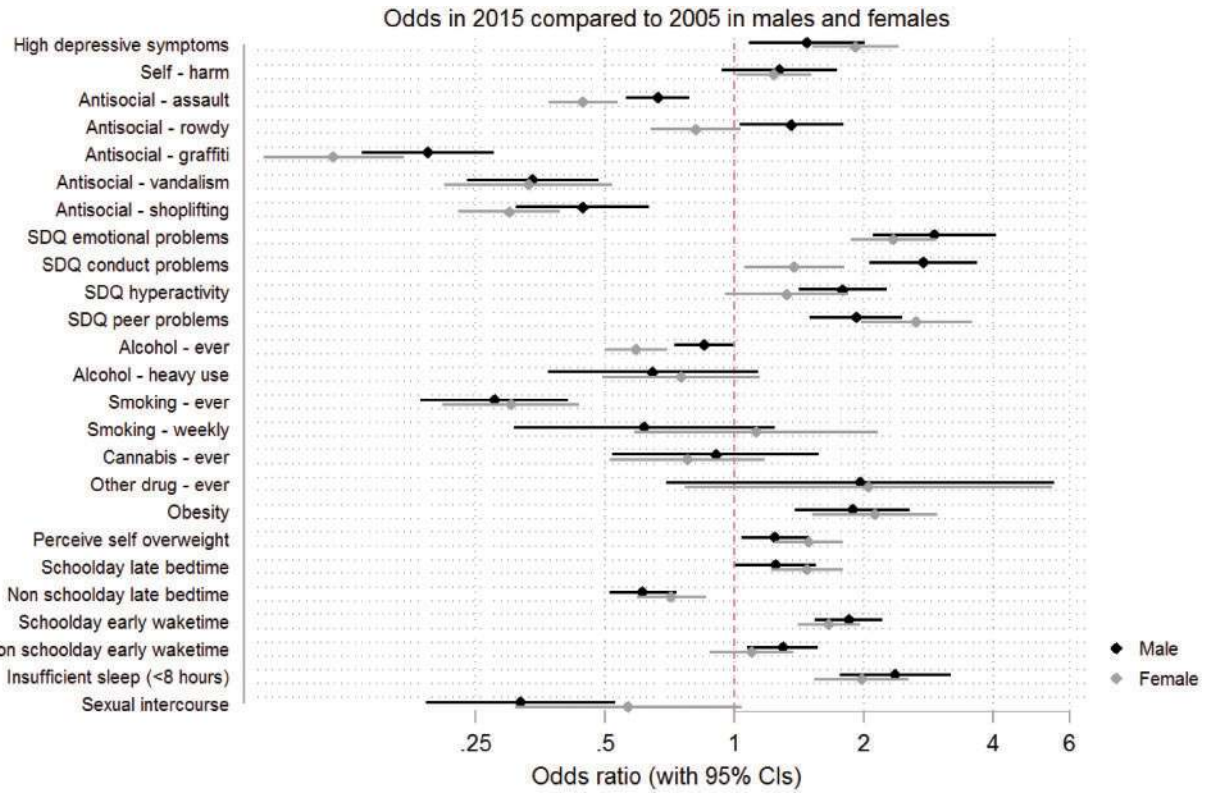

Figure 2. ORs (95% CI) for poorer outcomes in 2015 (MCS) vs 2005 (ALSPAC) for males and females.

interpretation becomes more complicated. It may suggest that the associations between these behaviours and mental health are not consistent over generations and might be changing over time. This is important with regards to trying to identify causal risk factors for poor adolescent health outcomes. Unexpected patterns, such as those seen in our study, could indicate that associations between, for example, cannabis use and depression could be due to residual confounding rather than true causality. However, other factors not included in the study are also likely to have changed over the 10 years of investigation, which may also impact on these associations. Understanding the dynamic relationships between health-related behaviours and mental health should be a priority as adolescent

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mental health problems increase, in order to identify suitable targets for interventions to prevent this upward trend from continuing.

In addition to effectively using two large contemporary birth cohort studies, the study makes several methodological advancements in improving our understanding of changing trends in UK adolescents. Variables in the two cohorts, where dissimilar, were carefully harmonized to ensure comparisons could be made. Unfortunately, this harmonization could not be achieved for certain variables of interest (physical activity), which we were therefore unable to include. Similarly, for other variables the harmonization is imperfect, owing to either different time periods of reference in the questions (e.g. self-harm), or availability only at a slightly different age in the ALSPAC cohort (e.g. sleep times); and this must be borne in mind when interpreting findings. In both these cases, however, the direction of bias is likely to be an underestimation of the increased poorer outcomes in 2015. For instance, with self-harm we estimate lifetime prevalence in ALSPAC and previous year prevalence in MCS.

Although ALSPAC and MCS are large and detailed birth cohorts, one is a regional cohort (ALSPAC) and one is a national cohort (MCS), which could bias our findings. However, regional variation in these outcomes was estimated and was found to be minimal (<1% for mental health, sex, weight variables, <3% for substance use and sleep). Although we employ multiple techniques to increase the comparability of the cohorts, it is possible that some of the differences observed are due to changes in demographic composition over the decade, differences in the study samples or the different rates and predictors of attrition between the two studies. The nationally representative estimates for the MCS at age 14 indicate that across all the investigated variables, the comparable estimates were slightly different from the nationally representative ones, highlighting the value of applying techniques to increase the comparability of these cohorts, but at the same time limiting the generalizability of our secular trend estimates to the UK as a whole. It is also important to note that missing data were higher in ALSPAC than MCS, and although we conducted multiple imputation with sociodemographic and all examined variables informing the imputation to reduce bias in estimates, some estimates might remain biased due to unmeasured factors associated with missingness and their potential association with our outcomes of interest. Finally, two of the measures used in this study are psychometric surveys (SDQ and SMFQ) and our findings assume measurement invariance for these. However we have not tested this, and there is a possibility that the surveys are not measuring the same constructs across the two cohorts.

There are a number of implications highlighted by our findings. Most importantly, the rapidly increasing prevalence of depressive symptoms, self-harm, parent-reported mental health problems, obesity and lesser sleep in adolescents over the past decade is an important finding, and the reasons why this has occurred need thorough investigation. Identifying further factors that have changed over the decade, that might have resulted in UK young people having less support and being at higher risk, should be undertaken as a public health priority. A further implication arising from our findings is that although certain mental health problems are increasing, other problems and health-related behaviours, thought to predict poor mental health, are decreasing. Understanding the nature of these associations and their dynamic nature over time could be extremely valuable in identifying causal risk factors for mental health and potential targets for interventions. Identifying explanations for these high prevalences and changing time trends is key to preventing further increases in poor mental health and health outcomes for future generations of young people.

To conclude, in a large well-powered study across two key UK birth cohorts born a decade apart, depressive symptoms and self-harm behaviours have increased between 2005 and 2015. Adolescents are spending less time sleeping and have higher BMIs. In contrast, other health-related behaviours such as substance use and antisocial behaviours have decreased over the same time period, suggesting that links between mental health problems and health-related behaviours might be more complex and dynamic in nature than currently predicted. The data provide important evidence to help understand health behaviours in millennials and how these are changing, permitting the planning of policy and public health provision.

Supplementary Data

Supplementary data are available at *IJE* online.

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Author Contributions

P.P. and S.G. planned the study, analysed the data and prepared the manuscript for publication. Both P.P. and S.G. have full access to the data presented in this report and act as guarantors for the paper.

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