Preconception health in adolescence and adulthood across generations in the UK: findings from three British birth cohort studies

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Abstract

Optimising preconception health in women and men holds significant potential for improving pregnancy and offspring health outcomes. To create a picture of the state of preconception health in the UK, this study aimed to describe the prevalence of and changes in preconception health indicators reported in three British birth cohort studies: the 1970 British Birth Cohort Study (BCS70; born in 1970; N=17,198), Next Steps (1989-1990; N=15,770), and Millennium Cohort Study (MCS; 2000-2002; N=19,517). The analysis focused on data obtained during participants' adolescence (16-17 years) and subsequent follow-ups at 25-26 years for BCS70 and Next Steps. Self-reported preconception indicators were defined in line with a previously published review and reported as proportions.

Across cohorts, data were available for 14 preconception indicators across four domains: health behaviours and weight, reproductive health and family planning, physical health conditions, and wider determinants of health. Findings revealed persistent suboptimal health behaviours in both genders and across generations, including low intakes of fruit. While alcohol, tobacco, and soft drink intake decreased across generations, obesity prevalence surged. This study underscores the need for public health interventions targeting the root causes of adverse health behaviours towards improvement of fruit consumption, further reduction in alcohol, tobacco, and soft drink consumption, and addressing the escalating obesity rates among individuals of reproductive age. Ongoing monitoring is needed to continue tracking these existing indicators over time, while improved data quality and availability of a wider range of preconception indicators are crucial to comprehensively understanding the complexities of preconception health, enabling the development of more targeted and effective interventions.

Introduction

A life-course approach to improving maternal, paternal, and child health outcomes by optimising parental health before conception, known as preconception health, has attracted interest on a global scale (1). Such an approach is supported by evidence from developmental biology and epidemiological studies that improving preconception health in women and men represents an opportunity to improve pregnancy outcomes, prevent non-communicable diseases in both parents and their offspring, and thus improve the overall health of two generations at a minimum (2–5).

Recent evidence from national population-based studies suggests most women in the UK enter pregnancy with risk factors for pregnancy and birth complications (6,7). For example, among women with an antenatal booking appointment in 2018-19, 73% did not take a folic acid supplement before pregnancy, 22% were living with obesity, and 24% had at least one mental or physical health condition (6). These risk factors are common even among women actively planning pregnancy (7) and disproportionally affect women from disadvantaged backgrounds (6).

Current initiatives to optimise and reduce inequalities in preconception health in the UK exist at both the individual and population levels (8). At the individual level, primary healthcare professionals are, for example, encouraged to assess and manage risk factors in women and couples who are planning a pregnancy (9). Population-level public health strategies can lead to community-level benefits that include improving preconception health by contributing to reducing health inequalities (10). Examples include mandatory flour fortification with folic acid (11), the Soft Drinks Industry Levy (12) and calorie labelling legislation (13).

To monitor progress made towards improving preconception health and to inform and evaluate existing and new initiatives, the UK Preconception Partnership has laid out a framework and made recommendations for the annual reporting of preconception health indicators in England (6,8,14). To date, women's preconception health in England has been described in a first

report card using antenatal booking (first) appointment data from the National Maternity Services Dataset 2018-19 (6). Further work is underway to develop a Preconception Health Profile within the UK government Office for Health Improvement and Disparities' existing surveillance platform to support the annual reporting of preconception indicators (6). Antenatal booking appointment data from the Maternity Services Dataset provides an initial picture of preconception health among women who are pregnant. However, there is currently no national picture of preconception health among men and women of reproductive age across adolescence and adulthood, irrespective of their pregnancy intention and pregnancy status. Such data would inform, develop, and evaluate health initiatives at key stages prior to pregnancy and track progress made towards improving the health of people who may become pregnant in the future. The present study therefore aimed to identify and describe preconception indicators reported among women and men during adolescence and adulthood in three British birth cohort studies (across generations) while also exploring how these indicators changed for cohort members over time.

Materials and Methods

Study design and population

This study used data from three ongoing longitudinal birth cohort studies, including the 1970 British Birth Cohort Study (BCS70), Next Steps, and the Millennium Cohort Study (MCS) (15–17). Each of these studies follows large, nationally representative groups of people born in the UK and collects information on health and wellbeing, education, employment, and economic circumstances, among other factors. Data are collected through a combination of phone interviews, face-to-face interviews, self-completion questionnaires, interviewer-administered questionnaires, and parental interviews. The most recent data collection time points (sweeps) for each of these birth cohort studies were among individuals of reproductive age (15 – 49 years) and, therefore, relevant to contemporary preconception health (**Table 1**).

Table 1. Overview of data collection sweeps for British birth cohort studies included in the current analysis[a]

1970 British Cohort Study		Next Steps		Millennium Cohort Study	
Year	Participant age (years)	Year	Participant age (years)	Year	Participant age (years)
1970	Birth	2004	14	2001	9 months
1975	5	2005	15	2004	3
1980	10	2006	16[a]	2006	5
1986	16[a]	2007	17	2008	7
1996	26[a]	2008	18	2012	11
2000	30	2009	19	2015	14
2004	34	2010	20	2018	17[a]
2008	38	2015	25[a]	2023	23
2012	42	2022	32		
2016	46				
2021	51				

[a] Sweeps used in the current study based on the alignment of age at the time of data collected during the reproductive years

The BCS70 follows a sample of all people (around 17,000) born in England, Scotland, and Wales during one week in 1970 when data were initially collected from mothers and medical records (15). BCS70 has conducted 11 survey sweeps to date, with the latest sweep conducted in 2021 at age 51 **(Table 1)**. Next Steps, previously known as the Longitudinal Study of Young People in England (LSYPE), follows a sample of around 16,000 people born in England between 1st September 1989 and 31st August 1990 (16). The study began in 2004 when cohort members were 14 years old. The study was sampled using schools and additionally stratified by deprivation levels of those schools, oversampling more deprived schools and oversampling pupils from minority ethnic groups. Design weights were used to return the cohort to representative proportions of individuals from each ethnic group and deprivation stratum. Cohort members were surveyed yearly until 2010, then in 2015 at age 25, and the latest sweep was conducted in 2022 at age 32. The MCS follows a sample of around 19,000 people born across England, Scotland, Wales, and Northern Ireland from 2000-2002 (17). Children from ethnic minorities and disadvantaged backgrounds were oversampled at recruitment, which was accounted for by weighting. There have been seven MCS sweeps, the most recent of which was conducted in 2023 when cohort members were 23 years of age.

For the present study, to allow for comparison of preconception indicators between cohorts, sweeps were selected for analysis based on the cohort members' age at the time of data collection (i.e., aged 15-49 and comparable age across all three cohorts) **(Table 1)**. All three studies conducted a sweep when cohort members were aged 16 or 17 and 25 or 26 years, except MCS, which conducted the latest sweep at age 23 in 2023.

Preconception indicators

Preconception indicators for analysis were based on a previous scoping review by Schoenaker et al (14). Briefly, this scoping review identified indicators relevant to preconception health based on national and international clinical guidelines and policy documents. Preconception indicators were defined as social, behavioural, or medical risk factors or exposures, as well as their wider determinants, that may impact future pregnancies among all individuals of reproductive age. A total of 66 indicators were identified and grouped into 12 domains, spanning wider determinants of health, healthcare, emotional and social health and support, reproductive health and family planning, health behaviours and weight, immunisations and infections, mental and physical health conditions, medication, and genetic risk.

Data dictionaries for each relevant sweep in the BCS70, Next Steps and MCS were searched to identify which of the 66 preconception indicators were assessed. The process of searching the individual data dictionaries was conducted independently by two researchers (OR and DS) to minimise the risk of error. Relevant variables were selected for inclusion if data could be used to define preconception indicators in line with those proposed in Schoenaker et al (14) and indicators were reported in at least two sweeps across all included cohorts.

Education and employment data were available at age 16/17 for all three cohorts. However, the age 16/17 sweeps were not included in the analysis due to the school leaving age in the UK being around or after this age and varying between cohorts.

Statistical analysis

Variables were re-coded in line with preconception indicator definitions proposed in Schoenaker et al (14) **(S1 Table)**. Number of participants and percentages were calculated for each preconception indicator, stratified by sex (female and male). Most indicators were relevant to females only based on reviewing clinical guidelines and policies, but some were also relevant to males, such as smoking, obesity, and diabetes (14). Chi-squared tests were used to compare the prevalence of indicators between; 1) sweeps at age 16/17 and age 25/26 within a cohort (change across age), and 2) sweeps that included participants of a similar age across cohorts (change across generations), where relevant data were available. All statistical analyses were conducted using *Stata* version 17.0.

Ethical approval

Ethical approval was secured by the Centre for Longitudinal Studies from the National Health Service (NHS) Research Ethics Committee, and all participants have given informed consent (15–17). The BCS70, Next Steps and MCS datasets were accessed via the UK Data Service (18). Access requires registration with the UK Data Service and acceptance of their End User Licence (EUL). All applicable conditions were complied with in this study.

Results

Data were available on 14 preconception indicators (25 indicator measures e.g., underweight, overweight, and obesity as measures within the 'weight' indicator) across four domains: wider determinants of health, reproductive health and family planning, health behaviours and weight, and physical health conditions **(Table 2)**. Data on other preconception indicators, were not reported in any of the cohorts (e.g., folic acid supplementation or cervical screening) or were not consistently assessed in at least two sweeps across all included cohorts (e.g., mental health condition or contraception) **(S2 Table)**. The maximum sample size was 11,615 and 9,003 for BCS70 at ages 16 and 26, respectively. Next Steps included 12,439 and 7,707

148 participants at ages 16 and 25, respectively, while 10,757 participants completed the MCS-
149 17y sweep. Each sweep included approximately 50% female and male participants.

150 **Wider determinants of health**

151 *Ethnicity*

152 The ethnicity indicator, defined as the "percentage of women from a minority ethnic group",
153 was assessed in BCS70-16y, BCS70-26y, Next Steps-16y, and Next Steps-25y. In BCS70-
154 16y, 6.5% of participants were from an ethnic minority group, which was slightly lower at 4.8%
155 in BCS70-26y. In Next Steps-16y and Next Steps-26y, 33.6% and 31.4% of participants were
156 from an ethnic minority group (**Table 2**).

157 *Education*

158 The education indicator, defined as the "percentage of women who had not completed high
159 school education" (i.e., before completing A Levels or equivalent in the UK system), was
160 reported in BCS70-26y and Next Steps-25y. In BCS70-26y, 58.9% of participants had not
161 completed high school, compared to a significantly lower 55.2% in Next Steps-26y (p<0.0001)
162 (**Table 2**).

163 *Employment*

164 The employment indicator, defined as the "percentage of women unemployed and seeking
165 work", was reported in BCS70-26y and Next Steps-25y. In BCS70-26y, 5.2% of participants
166 were unemployed and seeking work, compared to 6.2% in Next Steps-26y (p=0.15) **(Table 2)**.

Table 2. Prevalence of preconception indicators and changes across three British birth cohorts

	BCS70		Next Steps		MCS		
Preconception indicator	**Age 16 n (%)**	**Age 26 n (%)**	**Age 16/17 n (%)**	**Age 25 n (%)**	**Age 17 n (%)**	**p value comparing cohorts at age 16/17**	**p value comparing cohorts at age 26/27**
Wider determinants of health							
Ethnic minority[a]	N = 3,068 198 (6.5)	N = 2,328 111 (4.8)	N = 5,753 1,930 (33.6)	N = 5,598 1,757 (31.4)		<0.0001	<0.0001
Not completed high school education[a]		N = 4,831 2,843 (58.9)		N = 4,281 2,382 (55.2)			<0.0001
Unemployed and seeking work[a]		N = 1,578 82 (5.2)		N = 4,266 265 (6.2)			0.15
Homeless[a]				N = 4,269 59 (1.4)	N = 3,913 (<1%)		
Language other than English usually spoken at home[a]	N = 4,775 220 (4.6)				N = 2,623 29 (1.1)	<0.0001	
Reproductive health and family planning							
Previous pregnancy loss[a]				N = 3,099 697 (22.5)	N = 79 55 (69.6)		
Health behaviours and weight							
Fruit not consumed daily[a]	N = 3,004 2,089 (69.5)				N = 2.638 1,950 (73.9)	<0.0001	
Fruit not consumed daily[b]	N = 2,204 1,683 (76.4)				N = 2,312 1,730 (74.8)	0.23	
Soft drink consumption >1 serve/day[a]	N = 2,981 709 (23.8)			N = 4,170 893 (21.4)	N = 2,629 478 (18.2)	<0.0001	
Soft drink consumption >1 serve/day[b]	N = 2,184 673 (30.8)			N = 3,333 914 (27.4)	N = 2,308 429 (18.6)	<0.0001	
Underweight (BMI <18.5 kg/m^2)a[e]	N = 3,015 327 (10.9)			N = 4,281 180 (4.2)	N = 3,682 248 (6.7)	<0.0001	
Overweight (BMI 25.0-29.9 kg/m^2)[a]	N = 3,015 387 (13.2)			N = 4,281 861 (20.1)	N = 3,682 751 (20.4)	<0.0001	
Overweight (BMI 25.0-29.9 kg/m^2)[b]	N = 2,848 297 (10.4)			N = 3,426 1,004 (29.3)	N = 3,251 729 (22.4)	<0.0001	

	BCS70		Next Steps		MCS		
Preconception indicator	**Age 16 n (%)**	**Age 26 n (%)**	**Age 16/17 n (%)**	**Age 25 n (%)**	**Age 17 n (%)**	**p value comparing cohorts at age 16/17**	**p value comparing cohorts at age 26/27**
Obesity (BMI ≥30 kg/m^2)[a]	N = 3,015 71 (2.4)			N = 4,281 1,044 (24.4)	N = 3,682 422 (11.5)	<0.0001	
Obesity (BMI ≥30 kg/m^2)[b]	N = 2,848 59 (2.1)			N = 3,426 636 (18.6)	N = 3,251 398 (12.2)	<0.0001	
Smoking[a]	N = 3,123 717 (23.0)	N = 4,849 1,743 (36.0)	N = 5,932 1,605 (27.1)	N = 4,130 950 (23.0)	N = 3,863 745 (19.3)	<0.0001	<0.0001
Smoking[b]	N = 2,327 464 (19.9)	N = 4,043 1,585 (39.2)	N = 6,054 1,245 (20.6)	N = 3,291 963 (29.3)	N = 3,383 648 (19.2)	0.26	<0.0001
Any alcohol consumption[a]	N = 3,512 3,201 (91.1)	N = 4,833 4,618 (95.6)	N = 5,919 3,975 (67.2)	N = 4,134 3,082 (74.6)	N = 3,876 3,010 (77.7)	<0.0001	<0.0001
Any alcohol consumption[b]	N = 2,569 2,340 (91.1)	N = 4,044 3,903 (96.5)	N = 6,044 4,040 (66.8)	N = 3,294 2,633 (79.9)	N = 3,396 2,623 (77.2)	<0.0001	<0.0001
Physical health conditions							
Epilepsy[a]		N = 4,901 <1%			N = 3,973 <1%		
Epilepsy[b]		N = 4,102 <1%			N = 3,491 <1%		
Diabetes mellitus[a]		N = 4,901 <1%		N = 830 <1%	N = 3,973 <1%		
Diabetes mellitus[b]		N = 4,102 <1%		N = 529 <1%	N = 3,491 <1%		
Asthma[a]	N = 3,026 110 (3.6)	N = 4,901 439 (9.0)					
History of cancer[b]		N = 4,901 <1%		N = 830 <1%			

For each preconception indicator, the total sample size (N) is reported, as well as the n (%) for participants categorised as 'yes' for each indicator.

[a] Female participants

[b] Male participants

Housing

The housing indicator, originally defined as the "percentage of women who do not have access to safe, comfortable, affordable housing", was assessed in at least two sweeps across all included cohorts: Next Steps-25y and MCS-17y. Among Next Steps-25y participants, 1.4% reported: living in "sheltered housing" or "a hostel for homeless, refuge, YMCA, etc." and <1.0% of MCS-17y participants reported being "homeless" **(Table 2)**.

Language

The language indicator, defined as the "percentage of women speaking a language other than English in the home", was also assessed in two sweeps: BCS70-16y and MCS-17y. In BCS70-16y, 4.6% of participants reported usually speaking a language other than English at home, compared to 1.1% in MCS-17y (p<0.0001) **(Table 2)**.

Reproductive health and family planning

Obstetric history

The obstetric history indicator, defined as the "percentage of women (who have previously been pregnant) with a previous miscarriage, termination, or stillbirth", was assessed in two sweeps across all included cohorts: Next Steps-25y and in MCS-17y. In Next Steps-25y, 22.5% of participants reported that they had experienced such outcomes, compared to 69.6% of MCS-17y participants **(Table 2)**.

Health behaviours and weight

Dietary intake

The dietary intake indicator, originally defined as the "percentage of women/men not consuming a healthy diet in line with the national recommendations" (19), was indirectly assessed in BCS70-16y, Next Steps-25y and MCS-17y **(Table 2)**. Two of these sweeps assessed fruit consumption (BCS70-16y and MCS-17y) and three assessed soft drink

consumption (BCS70-16y, Next Steps-25y and MCS-17y) that could be compared to the UK recommendations (20).

At age 16/17, 69.5% and 73.9% of female participants in BCS70-16y and MCS-17y did not consume fruit daily, respectively (p<0.0001). Moreover, in BCS70-16y, 23.8% of female participants consumed more than one glass of soft drink per day compared to 18.2% of MCS-17y female participants (p<0.0001). Among male participants, there was no significant difference in the proportion who did not consume fruit daily (76.4% in BCS70-16y and 74.8% in MCS-17y, p=0.23), but similar to female participants, consuming more than one glass of soft drink per day was more common among male participants in BCS70-16y (30.8%) compared to MCS-17y (18.6%) (p<0.0001). At age 25, excess soft drink consumption was 21.4% among female participants and 27.4% among male participants in Next Steps-25y.

Weight

The weight indicator, defined as the "percentage of women in the underweight, and women/men in the overweight and obesity BMI categories", was assessed in three sweeps across all included cohorts: BCS70-16y, Next Steps-25y and MCS-17y.

At age 16/17, the proportion of female participants with underweight (10.9% and 6.7%), overweight (13.2% and 20.4%) and obesity (2.4% and 11.5%) was significantly different in BCS70-16y and MCS-17y, respectively (p<0.0001). A similar pattern of results was observed for male participants, with the proportions increasing across subsequent cohorts for overweight (10.4% and 22.4% in BCS70-16y and MCS-17y, respectively) and obesity (2.1% and 12.2) (p<0.0001). At age 25, the proportion of female participants with overweight was 20.1%, and 24.4% had obesity. These proportions were 29.3% and 18.6% for overweight and obesity among male participants, respectively **(Table 2)**.

Tobacco use

The tobacco use indicator, defined as the "percentage of women/men who currently smoke", was assessed in all included sweeps. Among female participants, the proportion of those aged 16/17 who smoked was significantly different across sweeps: 23.0% in BCS70-16y, 27.1% in Next Steps-16y and 19.3% in MCS-17y (p<0.0001). These differences were not observed for male participants who smoked at age 16/17: 19.9% in BCS70-16y, 20.6% in Next Steps-16y and 19.2% in MCS17y (p=0.26). At age 25/26, the proportion of both female and male participants who smoked was significantly lower in Next Steps-25y (23.0% and 29.3%, respectively) compared with BCS70-26y (36.0% and 39.2%) (p<0.0001).

These study populations were restricted to those with data at age 16/17 and age 25/26 for BCS70 and Next Steps to show that the proportions of female and male participants who smoked at age 25/26 were significantly higher (30.7% and 31.8% in BCS70 and 22.7% and 29.3% in Next Steps, respectively) compared with the same participants at age 16/17 (21.8% and 18.2% in BCS70 and 24.6% and 16.7% in Next Steps) (p<0.0001) **(Table 3)**.

Alcohol consumption

The alcohol consumption indicator, defined as the "percentage of women/men who consume any alcohol", was assessed in all included sweeps. Among female participants, the proportion of those aged 16/17 who consumed any alcohol was significantly different across sweeps: 91.1% in BCS70-16y, 67.2% in Next Steps-16y and 77.7% in MCS-17y (p<0.0001). Alcohol consumption among male participants at age 16/17 followed a similar pattern: 91.1% in BCS70-16y, 66.8% in Next Steps-16y and 77.2% in MCS17y (p<0.0001). At age 25/26, the proportion of both female and male participants who consumed any alcohol was significantly lower in Next Steps-25y (74.6% and 79.9%, respectively) compared with BCS70-26y (95.6% and 96.5%) (p<0.0001) (**Table 2**).

Table 3. Prevalence of preconception indicators and changes across age in three British birth cohorts

	BCS70			Next Steps		
Preconception indicator	**Age 16 n (%)**	**Age 26 n (%)**	**p value**	**Age 16/17 n (%)**	**Age 25 n (%)**	**p value**
Health behaviours and weight						
Smoking[a]	N = 2,361	N = 2,361		N = 3,531	N = 3,531	
	515 (21.8)	724 (30.7)	<0.0001	870 (24.6)	802 (22.7)	<0.0001
Smoking[b]	N = 1,487	N = 1,487		N = 2,833	N = 2,833	
	270 (18.2)	473 (31.8)	<0.0001	473 (16.7)	829 (29.3)	<0.0001
Any alcohol consumption[a]	N = 2,630	N = 2,630		N = 3,529	N = 3,529	
	2,413 (91.8)	2,525 (96.0)	<0.0001	2,442 (69.2)	2,661 (75.4)	<0.0001
Any alcohol consumption[b]	N = 1,670	N = 1,670		N = 2,823	N = 2,823	
	1,545 (92.5)	1,619 (97.0)	<0.0001	1,897 (67.2)	2,296 (81.3)	<0.0001
Physical health conditions						
Asthma[a]	N = 2,183	N = 2,183				
	80 (3.7)	182 (8.3)	<0.0001			

For each preconception indicator, the total sample size (N) is reported, as well as the n (%) for participants categorised as 'yes' for each indicator.

For this analysis comparing the prevalence of an indicator across sweeps within a cohort, the sample size is restricted to participants with valid data at both sweeps.

[a] Female participants

[b] Male participants

When restricting these study populations to those with data at age 16/17 and age 25/26 for BCS70 and Next Steps, proportions of female and male participants who consumed any alcohol at age 25/26 was slightly higher (96.0% and 97.0% in BCS70 and 75.4% and 81.3% in Next Steps, respectively) compared with the same participants at age 16/17 (91.8% and 92.5% in BCS70 and 69.2% and 67.2% in Next Steps, respectively) (p<0.0001) (**Table 3**).

Physical health conditions

In terms of physical health conditions, epilepsy, diabetes mellitus, asthma, and cancer were assessed in at least two sweeps across all included cohorts (**Table 2**). The proportion of participants with epilepsy (female and male; BCS70-26y, MCS-17y), diabetes mellitus (female and male; BCS70-26y, Next Steps-25y, MCS-17y) and cancer (female; Next Steps-25y, BCS70-26y) was <1.0% at each sweep. The asthma indicator, originally defined as the "percentage of women with (uncontrolled or unreviewed) asthma", was assessed in BCS70-16y and BCS70-26y, with the proportion of female participants reporting asthma significantly increased between these time points from 3.7% to 8.3% (p<0.0001) (**Table 3**).

Discussion

This study aimed to identify and describe preconception indicators in men and women across adolescence and adulthood in three British birth cohort studies, examining changes over time across age and between generations. In sweeps conducted at ages 16/17 and 25/26 years, data were available on 14 preconception indicators across four domains: health behaviours and weight, reproductive health and family planning, physical health conditions, and wider determinants of health.

The study revealed persistent suboptimal preconception health behaviours across generations during adolescence and adulthood, affecting both females and males. The prevalence of overweight and obesity displayed an upward trajectory over time, with adolescents in the MCS-17y cohort being around five times (females) to six times (males) more likely to live with obesity when compared to their counterparts in the BCS70-16y cohort.

In the Next Steps-25y cohort, 24.4% of female adults were living with obesity, which is in line with the 22% obesity rate reported in a prior study involving women attending antenatal booking appointments in 2018-19 (6). Moreover, this study's findings align with existing literature indicating a rising trend in obesity among UK adolescents and young adults across generations (5) and underscores the urgent need for preconception obesity prevention and weight management to mitigate pregnancy-related complications associated with elevated BMI, such as gestational diabetes, preeclampsia, and intrauterine death (21).

Suboptimal dietary intakes were observed across all three cohorts in females and males. A substantial majority of both female and male adolescents in BCS70-16y (69.5% and 76.4%, respectively) and MCS-17y (73.9% and 74.8%) did not consume a portion of fruit daily. This aligns with prior studies, including the UK National Diet and Nutrition Survey (2019), which found that 76% of women and men aged 19-64 consumed fewer than five portions of fruit and vegetables each day (22). These consistent findings suggest that more attention is needed at a population level to encourage fruit consumption in those of reproductive age, for example, through increasing awareness about the nutritional value of fruit, emphasising its role in providing nutrients which are vital for overall health and are especially important to support sperm and egg quality and contribute to improved preconception health (23).

Sugar-sweetened soft drinks are classified under "foods high in sugar and fat" in The Eatwell Guide (19), which are recommended to be consumed "less often [than daily] and in smaller amounts". Data from BCS70-16y and MCS-17y revealed high weekly intakes among adolescents in both cohorts, with between 18.2% (females, MCS017y) and 30.8% (males, BCS70-16y) of participants drinking at least one serving per day. However, a significant decline in intakes between cohorts was observed, potentially indicative of heightened public awareness following the introduction of the Soft Drinks Industry Levy in April 2018 (12) and an increased choice of alternatives in the marketplace, such as flavoured waters and sugar-free soft drinks.

Similarly, a decline was observed in any alcohol consumption between cohorts. However, in all five cohorts, most women and girls reported drinking some alcohol, which warrants greater attention given the association between maternal preconception exposure to alcohol and adverse perinatal outcomes independent of gestational exposure (24). Similarly, most men and boys in all five sweeps reported drinking some alcohol, albeit with a discernible decline among female and male adolescents and adults across generations. Moreover, national data indicate that the amount drinkers report consuming has fallen in the UK since 2005, particularly among younger drinkers (25).

Tobacco use data revealed a significant decrease in smoking prevalence among both female and male adults between BCS70-26y and Next Steps-25y. This finding aligns with existing data indicating that the proportion of those aged 16 and over smoking tobacco in Great Britain has declined since 1974, when national surveys on smoking began (26). When the study populations were restricted to those with data at age 16/17 and age 25/26 for BCS70 and Next Steps, a higher percentage of both females and males reported smoking at age 25/26 (30.7% and 31.8%, respectively) compared to when they were 16/17 (21.8% and 18.2% respectively), emphasising the importance of ongoing public health campaigns and policies to discourage tobacco consumption among those of reproductive age. Insufficient research exists on the safety of e-cigarettes during the preconception period and pregnancy (27). More data are needed to comprehensively evaluate vaping behaviours among those of reproductive age to foster a nuanced understanding of the associated health implications. Since almost half of all pregnancies are unplanned (28), many women of reproductive age will become pregnant without realising it. Thus, preconception and early prenatal exposure to smoking and vaping are likely to impact pregnancy and offspring outcomes.

This study found a consistently low prevalence (<1%) of physical health conditions, including epilepsy, diabetes mellitus, asthma, and cancer, across sweeps. However, existing evidence shows a rapid rise in pregestational type 2 diabetes mellitus between 1995 and 2012 in the UK (29). Moreover, increases of 33-44% of pregnancies complicated by type 1 diabetes and

90-111% of pregnancies complicated by type 2 diabetes have been reported in Northern Europe (30,31). These data highlight the importance of ongoing monitoring of physical health conditions due to their potential impact on pregnancy outcomes and the need for specialised care pathways (32).

Regarding wider determinants of health, this study revealed varying proportions of ethnic minority study participants across the cohorts, reflecting deliberate oversampling of ethnic minority groups (Indian, Pakistani, Bangladeshi, Black African, Black Caribbean, and Mixed) to ensure adequate sample sizes (33). UK census data show an increase in the proportion of the population who are from an ethnic minority background (from 13.8% in 2011 to 18.0% in 2021) (34). While we recognise that ethnicity as a preconception indicator is not modifiable, ethnic inequalities in health have been linked to wider social, economic, and environmental factors (35). Public health interventions addressing such (intersectional) inequalities in ethnic minority communities are therefore highly relevant to improving population-level preconception health (36,37). Educational differences were also evident, with slightly fewer BCS70-16y females completing high school compared to Next Steps-26y (58.9% vs. 55.2%, respectively) in line with trends observed in UK census data (38). These findings highlight the importance of tailoring public health interventions and healthcare to changing social and cultural contexts to ensure equitable reproductive health outcomes.

Strengths and limitations

This study provides a picture of preconception health over three generations, strengthened by the large-scale national datasets and reflecting the changing demographics in the UK, particularly the increasing representation of ethnic minority groups in later cohorts. However, it is not without limitations. Foremost among these limitations is the substantial proportion of preconception indicators (52 out of 66) that were either inconsistently reported across cohorts due to variance in definitions or questions or not collected entirely. The unavailability of data

curtailed both the inter-cohort comparability and impeded the study's ability to paint a full picture of preconception health. For example, none of the datasets in this study assessed intention to conceive, which is an especially important indicator in the context of preconception health and its heightened relevance to those planning pregnancy. Moreover, even though data were available on some health behaviours such as diet, alcohol consumption and smoking, data on physical activity were not or inconsistently recorded across the sweeps. Pregnancy intention and physical activity data are also not routinely collected in healthcare datasets (6,14), highlighting a gap in national surveillance for these key preconception indicators.

Secondly, missing data was a limitation of this study, as not all cohort members answered all questions. For example, only 44.8% of BCS70-16y cohort members (5,208 out of 11,622) reported their fruit intake. The potential non-random nature of this missing data raises concerns about potential bias, cautioning the interpretation of findings. Furthermore, although common in longitudinal studies, the loss-to-follow-up may mean the cohort samples were not as representative of the UK population in later sweeps as in earlier sweeps, depending on which individuals dropped out, again emphasising the need for careful result interpretation.

Reliance on self-reported data may also have introduced bias, as participants may have provided subjective or socially desirable responses, affecting the accuracy of the findings. Finally, the study was limited by a lack of indicator detail. Limited detail in distinguishing pregnancy complications may explain the observed disparity between women from Next Steps-25y and girls from MCS-17y who reported pregnancy complications (22.5% and 69.6%, respectively). For example, more adolescents in MCS-17y may have accounted for pregnancy termination as a complication, while adult women in Next Steps-25y may not have categorised it as such, especially in cases of unintended teenage pregnancies. Moreover, dietary measures didn't align precisely with the categories in The Eatwell Guide (19). For instance, "take-aways" (Next Steps-25y) and "fast food" (MCS-17y) frequencies might not truly represent habitual consumption of “foods high in sugar and fat” which is why we couldn’t

include this in the analysis. Additionally, cross-cohort comparisons were restricted to fresh fruit and soft drink intake, which may not adequately reflect overall diet quality.

Implications

Despite its limitations, this study's findings contribute to understanding the current state of preconception health among adolescent and adult women and men in the UK, and how this has changed across generations. The findings highlight the need to identify and support individuals who are planning pregnancy, for example through healthcare interactions, but also the need for public health strategies that reach everyone, irrespective of pregnancy intention, from as early as adolescence, to reduce common risk factors that are often shaped by structural social, economic and environmental determinants. The findings also call for the use of standardised questions and data collection on key public health measures across sweeps and birth cohorts, to support ongoing monitoring of preconception health indicators in British birth cohorts. This could be used alongside other data sources to track progress towards optimising preconception health across critical life stages in women and men who may become pregnant, and inform the need for and development of new strategies.

Conclusion

The findings of this study add to a body of research indicating that, while trends in preconception tobacco and soft drink consumption have decreased, overweight and obesity have increased, and fresh fruit consumption remains low. Since almost half of all pregnancies are unplanned, many women of reproductive age will become pregnant without realising it. Thus, the suboptimal health behaviours observed in this study are highly likely to impact pregnancy and offspring outcomes through preconception and early prenatal exposure. These findings serve as essential benchmarks for designing targeted interventions and shaping

405 public health policies to address obesity, improve dietary patterns, and reduce alcohol and
406 tobacco consumption further, and to ensure the overall well-being of the preconception
407 population.

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Writing – original draft: OR

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Supporting information captions

S1 Table. Overview and definitions of preconception indicators consistently recorded in at least two sweeps at age 16/17 and/or age 25/26 years in the 1970 British Birth Cohort Study (BCS70), Next Steps and Millennium Cohort Study (MCS)

S2 Table. List of preconception indicators not consistently recorded in at least two sweeps at age 16/17 and/or age 25/26 years in the 1970 British Birth Cohort Study (BCS70), Next Steps and Millennium Cohort Study (MCS)