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The prevalence and clustering of alcohol consumption, gambling, smoking, and excess weight in an English adult population

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ABSTRACT

Background: The aim of this study was to examine the prevalence and clustering of four health risks (increasing−/higher-risk drinking, current smoking, overweight/obesity, and at-risk gambling), and to examine variation across sociodemographic groups in the English adult population.
Methods: We analysed data from the 2012, 2015, 2016, and 2018 Health Survey for England (n = 20,698). Prevalence odds ratios (POR) were calculated to examine the clustering of risks. We undertook a multinomial multilevel regression model to examine sociodemographic variation in the clustering of health risks.
Results: Overall, 23.8% of the adult English population had two or more co-occurring health risks. The most prevalent was increasing−/higher-risk drinking and overweight/obesity (17.2%). Alcohol consumption and smoking were strongly clustered, particularly higher-risk drinking and smoking (POR = 2.68; 95% CI = 2.31, 3.11; prevalence = 1.7%). Higher-risk drinking and at-risk gambling were also clustered (POR = 2.66; 95% CI = 1.76, 4.01), albeit with a very low prevalence (0.2%). Prevalence of multiple risks was higher among men for all risk combinations except smoking and obesity. The odds of multiple risks were highest for men and women aged 35–64 years. Unemployed men and women with lower educational qualifications had a higher odds of multiple risks. The relationship between deprivation and multiple risks depended on the definition of multiple risks, with the clearest socioeconomic gradients seen for the highest risk health behaviours.
Conclusion: An understanding of the prevalence, clustering, and risk factors for multiple health risks can help inform effective prevention and treatment approaches and may support the design and use of multiple behaviour change interventions.

1. Introduction

Health risks such as smoking, alcohol consumption, poor diet and physical inactivity are strongly associated with ill-health, disability and premature death, contributing to over a third of disease burden in high-income countries in 2019 (Institute of Health Metrics, 2019). In line with international findings, the latest English estimates (2019) of disease burden show the top five risk factors to be smoking, metabolic disease, excess weight, high blood pressure and alcohol consumption (accounting for 43% of overall burden) (Institute for Health Metrics and Evaluation (IHME), 2019). Estimates suggest that in the UK, the mortality risk resulting from the four key health risks is equivalent to an increase in chronological age of about 12 years (Kvaavik et al., 2010). The burden of disease associated with gambling in England is currently unknown, but a 2023 economic analysis estimated that the annual excess cost to the UK government associated with harmful gambling is approximately £1.05 to £1.77 billion in 2021–22 prices (OHID, 2023). This is likely to be an underestimate due to lack of available evidence for quantifying certain gambling-related harms.

Health risks often co-occur, for example, smokers are around three times more likely to drink at risky levels, and risky drinkers are up to 1.6 times more likely to have a poor diet (Meader et al., 2016a). Multiple risks also exhibit a strong social gradient, for example, people with no educational qualifications have a 2–6-fold increased odds of having two or more health risks (Meader et al., 2016a; Noble et al., 2015). Multiple health risks have important clinical consequences. For example, the

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combined effect of alcohol and smoking on head and neck cancers is more than the sum of the independent effects regarding cancers of the head and neck (Mello et al., 2019; Prabhu et al., 2014), and there is a synergistic joint association between alcohol and smoking and liver disease mortality (Hart et al., 2010; Inan-Eroglu et al., 2022).

Despite increasing recognition of gambling-related harm as a public health issue, most UK-based research has focused on associations between alcohol use and smoking and diet and physical activity, with considerably less exploring associations between these health risks and gambling (Meader et al., 2016a). An analysis of representative survey data of British gamblers (2007) highlighted an association between problem gambling and alcohol consumption (Griffiths et al., 2010), and a UK representative survey (2009) reported that problem gamblers were significantly more likely to have probable alcohol dependence (Roberts et al., 2017). Other representative or convenience surveys have found that at-risk or low severity gamblers, but not problem gamblers, had greater odds of binge drinking (Butler et al., 2020) or higher-risk, hazardous, or harmful alcohol consumption (Carrà et al., 2017; Cowlishaw and Kessler, 2016). Data from a representative survey of English adults (2016) reported that compared to non-drinkers, respondents drinking >140 ml of alcohol/week were more likely to engage in harmful gambling, and there was no association between smoking and problem gambling (PHE, 2021). Other surveys across the UK have reported significant associations between gambling and smoking, but whether these associations were significant for problem gamblers (Griffiths et al., 2010), at-risk gamblers (Carrà et al., 2017; Cowlishaw and Kessler, 2016), or both (Butler et al., 2020) varied. Regarding body mass index (BMI), the relationship with gambling has not often been explored, but one survey reported a relationship between at-risk or problem gambling and having an overweight or obese BMI (Cowlishaw and Kessler, 2016).

Taken together, there is a need to better understand the relationship between alcohol consumption, smoking, excess weight, and gambling among adults in England, particularly regarding gambling and BMI. In addition, it is important to understand how these relationships vary by socioeconomic factors such as deprivation. Understanding how these health risks co-occur can help inform future research as well as design more effective policy and practice and identify target groups.

In this secondary analysis of repeated cross-sectional survey data, we aim to investigate the prevalence and clustering of four health risks among adults in England: excess alcohol consumption, smoking, excess weight, and at-risk gambling. Additionally, we investigate sociodemographic risk factors for multiple risks to identify the groups that are most at risk.

2. Methods

Our study is written up in accordance with STROBE guidelines (Appendix A) (Von Elm et al., 2007).

2.1. Study design, setting, and participants

We undertook a population-based cross-sectional analysis of the prevalence and determinants of multiple health risks in an English adult population. This is a secondary analysis of data drawn from the repeated cross-sectional Health Survey for England (HSE) which samples different respondents each year. We combined the years 2012, 2015, 2016, and 2018 because these years included questions on gambling. Full survey methods are published elsewhere (NHS Digital, 2022). Briefly, a representative sample was recruited using stratified random sampling of English households in two stages, with postcode sectors as primary sampling units and a random sample of postal addresses selected within these units. Participation rates range between 59% and 64% for the study years. The sample includes respondents from the English adult population aged 16+ years living in private households. Our analysis was limited to adults aged between 18 and 74 years because the HSE only asks adults ≥18 years questions about health behaviours and the number of adults aged ≥75 years was small (8.4% of sample).

2.2. Variables and measurement

Four health risks were used in this study: increasing- and/or higher-risk alcohol consumption, current smoking, overweight and/or obese, and at-risk gambling. Increasing-risk alcohol consumption was defined in line with UK low-risk drinking guidelines as self-reported consumption of >140 ml and ≤ 350/500 ml alcohol/week for women/men respectively, and higher-risk drinking was defined as >350/500 ml alcohol/week (UK Chief Medical Officers', 2016). Smoking was defined as self-reported current regular smoking in line with the definition used by the HSE (NHS Digital, 2022). Overweight and obesity were defined according to a BMI of ≥25 to ≤29.9 and ≥ 30 respectively and were either self-reported or interviewer measured. At-risk gambling was defined as a score of ≥3 on the self-reported validated Problem Gambling Severity Index (PGSI) (Ferris and Wynne, 2001).

We developed two definitions of multiple risks. The first was based on the widest definition of risk: drinking at any level above lower-risk (>140 ml alcohol/week), having a BMI of overweight/obese, current smoking, and at-risk gambling. The second used the narrowest definition of risk: higher-risk drinking (>350/500 ml alcohol/week for males/females respectively), obese BMI, current smoking, and at-risk gambling. We deliberately chose these definitions to capture the largest and smallest number of people with multiple risks and to understand whether the pattern in risk factors changed depending on these definitions. Due to small numbers of problem gamblers across different socioeconomic groups, we used at-risk gambling in both definitions.

The following sociodemographic variables were used in this study: sex (men/women), age (18–24, 25–44, 45–64, 65–74 years), Indices of Multiple Deprivation (IMD) quintile, highest qualification (NVQ3/NVQ4/degree or equivalent, below degree, no qualifications), and employment status (in employment/education, retired, unemployed, and other economically inactive which includes people who are long-term sick or disabled, carers, and people looking after a home).

Overall, 20,698 respondents were included in our complete-case analysis: 11,326 women and 9372 men. The original extract consisted of 44,398 respondents which reduced to 28,058 after 12,599 respondents aged <18 years and 3741 respondents aged ≥75 years were excluded. Of the remaining respondents, 4796 (18.8%) had missing data on one or more of the following covariates: BMI (missing for 12.0% of respondents), PGSC score (missing for 6.9%), alcohol consumption (1.1% of respondents), smoking (0.2% of respondents), and top qualification (0.2% of respondents). Tests for missingness suggested there was no significant association between either age and BMI ($p = 0.272$), or sex and smoking ($p = 1.36$). The relationship between age/sex and alcohol consumption, BMI, and gambling, on the other hand, was significant ($p < 0.01$). In total there were 20,698 respondents with complete data (54.7% female (data not shown).

2.3. Bias

All analyses were non-response weighted in line with standard procedures of HSE analysis (NHS Digital, 2022). Measures of alcohol consumption, smoking and gambling were self-reported and subject to recall and social desirability biases.

2.4. Statistical methods

To examine the association between pairs of risks we estimated prevalence odds ratios (PORs) through a series of binomial models with a log-link function and robust standard errors (Coutinho et al., 2008). The PORs were age-adjusted and reported separately by sex.

Although the dependent variable is ordered and an ordered multinomial logistic model would have been appropriate (two risks are higher than one and so on), the required assumption of proportional odds was not met ($P < 0.001$). Thus, to examine the relationship between socio-demographic variables and the number of health risks, we used an unordered multinomial logistic regression, with 'no risks' as the reference category. Models were run separately by sex.

Conducting multiple comparisons increases the probability of false statistically significant findings. Since we did not calculate multiplicity *p*-value corrections, the findings arising from our analyses should be considered exploratory in their nature and useful for hypothesis generating.

All analyses were performed in STATA version 14.

2.5. Ethics

All important information related to the data source is available in published documents (NHS Digital, 2022). The separate datasets are anonymized and exempt from ethical compliance and can be accessed by registered users via the UK Data Archive (UK Data Service, 2022).

3. Results

Table 1 shows the sample characteristics (n = 20,698). Overall, 63.0% of the sample were overweight or obese, 26.1% drank at increasing- or higher-risk levels, 19.2% were current smokers, and 1.6% engaged in at-risk gambling. Using the widest definition of health risks (increasing−/higher-risk drinking, overweight/obese, current smoking, and at-risk gambling), 28.0% of the sample had two or more risks (36.1% of men and 19.8% of women). Using the narrowest definition (higher-risk drinking, obesity, current smoking, and at-risk gambling), 7.6% of the sample had two or more risks (8.4% of men and 6.6% of women).

Table 2 shows the prevalence of co-occurring health risks and accompanying PORs. The most prevalent multiple health risk combination for both sexes was increasing−/higher-risk drinking and overweight/obesity, with almost one in five adults in England having this co-occurring risk (17.2%). The prevalence of multiple risks was higher in men compared to women for all risk combinations except smoking and obesity which had a similar prevalence. Drinking and smoking were significantly clustered, particularly higher-risk drinking and smoking: increasing- or higher-risk drinkers were 1.7 times more likely to also smoke, and higher-risk drinkers were 2.7 times more likely to also smoke. Obesity was significantly associated with at-risk gambling among women, but not men, however the prevalence was low (1.7% in men and 0.5% in women). Smokers were 2.2 times more likely to engage in at-risk gambling, however the prevalence was low (0.7% in men and 0.3% in women).

Tables 3 and 4 reports the results of the multinomial regression model, with the number of lifestyle risk factors as the dependent variable for men and women using the widest definition of risk (increasing−/higher-risk alcohol consumption, current smoking, overweight/obesity, and at-risk gambling). The odds of having two or more risks were highest among men and women aged between 35 and 64 years, and this association was stronger in men. The odds of having two or more risks increased with decreasing IMD quintile among women, however among men, only those in the lowest IMD quintile had a higher odds of multiple risks compared to men in the highest IMD quintile. Both men and women obtaining the highest qualification of below degree or no qualification had a higher odds of having multiple risks. Unemployed men and women had a higher odds of having multiple risks.

Tables 5 and 6 reports the same data as in Tables 3 and 4 using the narrowest definition of health risks: higher-risk alcohol consumption, current smoking, obesity, and at-risk gambling. Using this definition, socioeconomic gradients became more apparent when looking at IMD quintile, which was more pronounced for women. Men and women who were unemployed had higher odds of multiple risks.

Appendix B reports PORs by age group and Appendix C reports PORs for the most and least deprived IMD quintile. The clustering of health

Table 1
Baseline characteristics of the 2012, 2015, 2016, and 2018 Health Survey for England.

		Women n = 11,326 (%)	Men n = 9372 (%)	Total n = 20,698 (%)
Socio-demographic variables				
Age	18–24 years	11.8	12.1	12.0
	25–44 years	38.2	39.2	38.7
	45–64 years	36.8	36.0	36.4
	65–74 years	13.2	12.7	12.9
Indices of multiple deprivation quintile	Least deprived	20.3	19.1	19.7
	Second least deprived	19.9	20.0	20.0
	Middle deprived	20.9	21.2	21.1
	Second most deprived	20.1	20.2	20.2
	Most deprived	18.9	19.4	19.1
Qualification	Degree or equivalent	31.9	31.7	31.8
	Below degree	53.6	54.6	54.1
	No qualification	14.5	13.7	14.1
Employment	In employment/ education	65.4	75.8	70.7
	Retired	15.2	13.3	14.2
	Unemployed	13.7	2.8	8.1
	Other economically inactive	5.6	8.2	6.9
Health risks				
Alcohol consumption	Non-drinker	17.3	12.4	14.8
	Lower risk	64.9	53.5	59.1
	Increasing-risk	14.1	28.7	21.5
	Higher-risk	3.8	5.5	4.6
Smoking	Never smoking	60.6	53.4	56.9
	Ex-regular smoking	22.0	25.7	23.9
	Current smoking	17.4	20.9	19.2
Body mass index	Underweight/ normal	42.0	32.1	36.9
	Overweight	30.3	41.2	35.8
	Obese	27.8	26.7	27.2
Gambling	Non-gambler/no risk gambling	97.9	92.8	95.3
	Low risk gambling	1.4	4.6	3.1
	Moderate risk gambling	0.5	1.7	1.1
	Problem gambling	0.1	0.8	0.5
Number of health risks				
Increasing/higher risk drinking; smoking; overweight/obese; at-risk gambling	0	28.4	16.7	22.4
	1	51.9	47.3	49.5
	2	17.2	30.3	23.8
	3	2.5	5.5	4.0
	4	0.1	0.3	0.2
Higher-risk drinking; smoking; overweight/ obese; at-risk gambling	0	33.1	22.4	27.6
	1	54.8	60.3	57.6
	2	11.2	15.5	13.4
	3	0.8	1.8	1.3
	4	0.03	0.06	0.05
Higher-risk drinking; smoking; obese; at-risk gambling	0	57.4	53.5	55.4
	1	35.9	38.0	37.0
	2	6.2	7.7	7.0
	3	0.4	0.7	0.6
	4	0.03	0.01	0.02

Alcohol consumption: lower-risk ≤140 ml alcohol/week; increasing-risk >140 ml and ≤ 350/500 ml alcohol/week for women/men respectively; higher risk >350/500 ml alcohol/week for women/men respectively; BMI: underweight/normal <24.9, overweight ≥25 to ≤29.9, obese ≥30; At-risk gambling: Problem Gambling Severity Index score ≥ 3. Weighted data; may not sum due to rounding.

Table 2
The prevalence and clustering of multiple risks in the English adult population combined years 2012, 2015, 2016, and 2018, $n = 20{,}698$.

Risk 1	Risk 2	Sex	Population prevalence (n) [a]	Sample prevalence (%)	Prevalence odds ratio (95% confidence interval)
Increasing−/higher-risk drinking	Current smoking	Men	1,680,182	8.6	1.55 (1.37, 1.74)
		Women	874,465	4.3	1.72 (1.52, 1.95)
		Total	2,591,770	6.5	1.66 (1.52, 1.81)
		Men	4,688,879	24.0	1.09 (0.98, 1.21)
	Overweight / obese	Women	2,074,312	10.2	0.91 (0.82, 1.01)
		Total	6,858,222	17.2	1.11 (1.03, 1.20)
	Obese	Men	1,719,256	8.8	0.88 (0.79, 0.97)
		Women	854,128	4.2	0.75 (0.67, 0.84)
		Total	2,631,643	6.6	0.82 (0.76, 0.89)
	At-risk gambling	Men	234,444	1.2	1.74 (1.29, 2.35)
		Women	20,336	0.1	2.29 (1.29, 4.07)
		Total	279,114	0.7	2.27 (1.74, 2.96)
Higher-risk drinking	Smoking	Men	410,277	2.1	2.62 (2.13, 3.22)
		Women	264,373	1.3	2.67 (2.16, 3.30)
		Total	677,848	1.7	2.68 (2.31, 3.11)
	Overweight / obese	Men	761,943	3.9	1.12 (0.89, 1.42)
		Women	467,737	2.3	1.10 (0.89, 1.35)
		Total	1,275,948	3.2	1.16 (0.99, 1.36)
	Obese	Men	293,055	1.5	0.98 (0.80, 1.20)
		Women	223,700	1.1	1.01 (0.81, 1.26)
		Total	518,354	1.3	0.99 (0.85, 1.15)
	At-risk gambling	Men	58,611	0.3	2.11 (1.30, 3.42)
		Women	20,336	0.1	4.06 (1.87, 8.81)
		Total	79,747	0.2	2.66 (1.76, 4.01)
Smoking	Overweight / obese	Men	2,403,050	12.3	0.66 (0.58, 0.75)
		Women	1,931,957	9.5	0.91 (0.82, 1.01)
		Total	4,346,199	10.9	0.79 (0.73, 0.86)
	Obese	Men	879,165	4.5	0.77 (0.67, 0.88)
		Women	935,474	4.6	0.92 (0.82, 1.04)
		Total	1,794,302	4.5	0.83 (0.76, 0.91)
	At-risk gambling	Men	175,833	0.9	1.72 (1.25, 2.37)
		Women	61,009	0.3	4.07 (2.46, 6.74)
		Total	239,240	0.6	2.20 (1.68, 2.88)
Overweight / obese	At-risk gambling	Men	351,666	1.8	1.29 (0.93, 1.79)
		Women	81,346	0.4	1.58 (0.92, 2.71)
		Total	438,607	1.1	1.51 (1.15, 1.99)
Obese	At-risk gambling	Men	136,759	0.7	1.20 (0.86, 1.68)
		Women	61,009	0.3	2.17 (1.31, 3.59)
		Total	199,367	0.5	1.33 (1.01, 1.76)

[a] Using mid-year population estimated for 2021; weighted data; adjusted for age; male and female prevalence may not sum to the total due to rounding.

risks broadly mirrored the main results however associations were stronger in the most deprived quintile.

Appendix D reports the results of the multinomial regression model shown in Tables 3-6 using a different definition of multiple risks as follows: higher-risk alcohol consumption, current smoking, overweight/obesity, and at-risk gambling which broadly followed the same pattern as the main results. For both men and women, a socioeconomic gradient was seen for IMD quintile, highest qualification, and economic status.

Appendix E reports results of a multinomial regression model for men and women together, reporting on people with one, two, or three or more risks, and using the following definition: increasing−/higher-risk alcohol consumption, current smoking, overweight/obesity, and at-risk gambling. There was a strong social gradient when looking at the relationship for IMD quintile, highest qualification, and economic status.

4. Discussion

This analysis shows that 28.0% of adults aged 18–74 years in England have at least two of the following health risks: increasing−/higher-risk drinking, overweight/obesity, smoking, and at-risk gambling, equivalent to over 11.2 million people in 2021. Applying the prevalence reported in this study to the 2021 mid-year population estimate, around 6.9 million adults are overweight/obese and drinking at increasing−/higher-risk levels, over 4.3 million adults smoke and are overweight/obese, over 2.6 million adults both smoke and drink at increasing−/higher-risk levels, around 280,000 are at-risk gamblers who drink at increasing−/higher-risk levels, and almost 240,000 are at-risk gamblers who smoke.

The strongest clustering of pairwise risk factors was higher-risk drinking and at-risk gambling, higher-risk drinking and smoking, and smoking and at-risk gambling, however the low prevalence of at-risk gambling and co-occurring risks should be acknowledged. These findings mirror the published literature which suggests alcohol and smoking are the most strongly clustered health risks across a wide range of studied risks, although most of these estimates did not look at gambling (Meader et al., 2016b; Noble et al., 2015; Uusitalo et al., 2019). In a systematic review, the PORs for drinking and smoking in adult populations ranged between 1.81 and 2.89 (Meader et al., 2016b), and ours ranged from 1.55 to 2.68.

In line with previous studies (Meader et al., 2016a), we found there was social disparity in the clustering of health risks. For men and women, the odds were highest among people who were unemployed, with no qualifications, or in the lowest IMD quintile. This socioeconomic gradient was more pronounced when we used the narrowest definition of multiple risks (higher-risk drinking, current smoking, obese, and at-risk gambling), therefore highlighting the importance of multiple risks as a contributor to health inequalities. Multiple health risks have important clinical consequences, for example, the toxicity of alcohol doubles in the clinically obese (Hart et al., 2010; Patra et al., 2021), and the risk from both smoking and drinking on oral cancers is larger than the sum of the independent risks (Maasland et al., 2014; Oze et al., 2019). These synergistic risk associations, alongside the higher prevalence of multiple risks, demonstrates that actions to reduce health inequalities aim to reduce multiple risks in the most deprived groups.

Table 3
The association between sociodemographic variables and number of health risks in adult men in England combined years 2012, 2015, 2016, and 2018, $n = 9372$.

Variable	One risk		Two or more risks	
Age (years)	n (%)	Odds ratio (95% confidence interval)	n (%)	Odds ratio (95% confidence interval)
18–24	306 (3.3)	1.00	208 (2.2)	1.00
25–44	1463 (15.6)	2.10 (1.69, 2.61)	1107 (11.8)	2.51 (1.97, 3.19)
45–64	1774 (18.9)	4.38 (3.47, 5.51)	1544 (16.5)	5.71 (4.45, 7.33)
65–74	960 (10.2)	4.27 (3.05, 5.98)	621 (6.6)	3.71 (2.59, 5.31)
Indices of multiple deprivation quintile				
Highest	911 (9.7)	1.00	680 (7.3)	1.00
Second highest	928 (9.9)	1.15 (0.94, 1.41)	735 (7.8)	1.26 (1.02, 1.55)
Middle	945 (10.1)	1.09 (0.89, 1.35)	745 (7.9)	1.15 (0.93, 1.43)
Second lowest	880 (9.4)	1.08 (0.87, 1.33)	646 (6.9)	1.03 (0.83, 1.29)
Lowest	839 (9.0)	1.32 (1.05, 1.66)	674 (7.2)	1.40 (1.10, 1.77)
Highest qualification				
Degree or equivalent	1401 (14.9)	1.00	927 (9.9)	1.00
Below degree	2368 (25.3)	1.46 (1.26, 1.70)	1971 (21.0)	1.84 (1.57, 2.16)
No qualification	734 (7.8)	1.92 (1.47, 2.51)	582 (6.2)	2.35 (1.79, 3.10)
Employment				
Employed/in training/education	3126 (33.4)	1.00	2394 (25.5)	1.00
Retired	924 (9.9)	0.97 (0.73, 1.28)	664 (7.1)	1.14 (0.85, 1.52)
Other economically inactive	124 (1.3)	1.37 (0.89, 2.11)	104 (1.1)	1.32 (0.85, 2.04)
Unemployed	329 (3.5)	1.58 (1.11, 2.27)	318 (3.4)	1.91 (1.35, 2.72)

Definition of health risk: increasing/higher-risk alcohol consumption, smoking, overweight/obese, at-risk gambling; weighted data.

Table 4
The association between sociodemographic variables and number of health risks in adult women in England combined years 2012, 2015, 2016, and 2018, n = 11,326.

Variable	One risk		Two or more risks	
Age (years)	n (%)	Odds ratio (95% confidence interval)	n (%)	Odds ratio (95% confidence interval)
18–24	372 (3.3)	1.00	176 (1.6)	1.00
25–44	2039 (18.0)	1.67 (1.40, 2.00)	809 (7.1)	1.66 (1.33, 2.08)
45–64	2422 (21.4)	2.80 (2.33, 3.35)	1041 (9.2)	2.75 (2.20, 3.44)
65–74	1113 (9.8)	2.84 (2.19, 3.69)	296 (2.6)	1.57 (1.12, 2.18)
Indices of multiple deprivation quintile				
Highest	1197 (10.6)	1.00	405 (3.6)	1.00
Second highest	1171 (10.3)	1.08 (0.94, 1.25)	434 (3.8)	1.19 (1.00, 1.43)
Middle	1248 (11.0)	1.37 (1.19, 1.59)	466 (4.1)	1.41 (1,17, 1.69)
Second lowest	1164 (10.3)	1.33 (1.15, 1.55)	466 (4.1)	1.39 (1.15, 1.68)
Lowest	1166 (10.3)	1.91 (1.62, 2.25)	551 (4.9)	2.26 (1.86, 2.76)
Highest qualification				
Degree or equivalent	1726 (15.2)	1.00	517 (4.6)	1.00
Below degree	3201 (28.3)	1.48 (1.33, 1.65)	1396 (12.3)	2.20 (1.91, 2.52)
No qualification	1019 (9.0)	1.80 (1.50, 2.15)	409 (3.6)	2.69 (2.17, 3.33)
Employment				
Employed/in training/education	3536 (31.2)	1.00	1421 (12.5)	1.00
Retired	1223 (10.8)	1.09 (0.89, 1.32)	387 (3.4)	1.20 (0.95, 1.53)
Other economically inactive	848 (7.5)	1.13 (0.97, 1.31)	309 (2.7)	0.93 (0.78, 1.12)
Unemployed	339 (3.0)	1.62 (1.25, 2.11)	205 (1.8)	2.01 (1.52, 2.66)

Definition of health risk: increasing/higher-risk alcohol consumption, smoking, overweight/obese, at-risk gambling; weighted data.

Data on whether, and which, health risks cluster can help inform the development and implementation of effective policies and interventions. These can be implemented at the population- or individual-level. At the population-level, evidence suggests increases in price, limits on marketing, and reduced availability for alcohol, tobacco, and unhealthy foods are effective ways of reducing non-communicable diseases (WHO, 2017). There is an emerging consensus for similar approaches in gambling (Regan et al., 2022). These upstream approaches are likely to have a larger, more rapid impact, be more equitable, and have greater cost-savings relative to downstream individually-targeted interventions (Babor et al., 2022; Burton et al., 2017).

Health interventions tackling multiple risks may offer potential for reducing risks of ill-health and disease. Studies evaluating the effect of multiple health behaviour change interventions have primarily focused on providing educational and skills training to individuals, targeting diet and physical activity and, to a lesser extent, smoking, diet, and physical activity (King et al., 2015). No interventions aimed at changing multiple behaviours were identified that included gambling, which is perhaps unsurprising given the lack of research exploring associations between gambling and other health risks (Meader et al., 2016a). There is a notable lack of multiple behaviour change interventions focusing on smoking and non-dependent alcohol consumption (King et al., 2015), which may be an important omission given the strength of clustering observed in this study.

An older review of randomised controlled trials (RCTs) published before 2009 suggested there was no additional benefit of multiple behaviour change interventions targeting diet and physical activity beyond interventions that targeted each risk in isolation (Prochaska and Prochaska, 2011). However a more recent review of RCTs suggests superior modest advantages of pairing diet and physical activity (Meader et al., 2017). Multiple behaviour change interventions which lead to improvements in smoking may have a negative impact on diet and physical activity (Meader et al., 2017), which might explain the lack of significant findings seen in trials which only measure behaviour change.

Compared to the general population, multiple behaviour change interventions tend to be more effective in at-risk or unwell populations (Sisti et al., 2018). Among patients who are overweight or obese, or patients at-risk of diabetes or cardiovascular disease, interventions simultaneously tackling diet and exercise led to greater measured improvements in weight, fat mass, blood lipids, and blood pressure, compared to interventions which tackled either only diet or only exercise (Mudaliar et al., 2016; Schwingshackl et al., 2014), although other reviews have reported mixed findings (De Waure et al., 2013; Ebrahim et al., 2011). The intensity of multiple behaviour change interventions seems to influence outcomes, with moderate or high intensity

Table 5
The association between sociodemographic variables and number of health risks in adult men in England. combined years 2012, 2015, 2016, and 2018, $n = 9372$.

Variable	One risk		Two or more risks	
Age (years)	n (%)	Odds ratio (95% confidence interval)	n (%)	Odds ratio (95% confidence interval)
18–24	246 (2.6)	1.00	63 (0.7)	1.00
25–44	1169 (12.5)	1.65 (1.35, 2.00)	269 (2.9)	1.45 (1.03, 2.04)
45–64	1523 (16.3)	1.95 (1.61, 2.36)	349 (3.7)	1.58 (1.13, 2.21)
65–74	670 (7.1)	1.55 (1.20, 2.00)	87 (0.9)	0.65 (0.40, 1.05)
Indices of multiple deprivation quintile				
Highest	615 (6.6)	1.00	98 (1.0)	1.00
Second highest	683 (7.3)	1.16 (1.00, 1.35)	126 (1.3)	1.37 (1.01, 1.86)
Middle	758 (8.1)	1.33 (1.14, 1.54)	148 (1.6)	1.48 (1.10, 1.98)
Second lowest	736 (7.9)	1.40 (1.20, 1.64)	173 (1.8)	1.73 (1.29, 2.32)
Lowest	816 (8.7)	2.00 (1.70, 2.35)	223 (2.4)	2.36 (1.76, 3.16)
Highest qualification				
Degree or equivalent	847 (9.0)	1.00	118 (1.3)	1.00
Below degree	2070 (22.1)	1.84 (1.64, 2.06)	468 (5.0)	3.12 (2.45, 3.96)
No qualification	691 (7.4)	2.26 (1.92, 2.67)	182 (1.9)	4.86 (3.62, 6.51)
Employment				
Employed/in training/ education	2441 (26.0)	1.00	497 (5.3)	1.00
Retired	677 (7.2)	0.98 (0.81, 1.18)	102 (1.1)	1.09 (0.77, 1.54)
Other economically inactive	117 (1.2)	1.46 (1.08, 1.97)	36 (0.4)	1.90 (1.23, 2.93)
Unemployed	373 (4.0)	2.04 (1.67, 2.51)	133 (1.4)	2.87 (2.18, 3.78)

Definition of health risk: higher-risk alcohol consumption, smoking, obesity, at-risk gambling; weighted data.

Table 6
The association between sociodemographic variables and number of health risks in adult women in England combined years 2012, 2015, 2016, and 2018, n = 11,326.

Variable	One risk		Two or more risks	
Age (years)	n (%)	Odds ratio (95% confidence interval)	n (%)	Odds ratio (95% confidence interval)
18–24	276 (2.4)	1.00	73 (0.6)	1.00
25–44	1416 (12.5)	1.52 (1.27, 1.82)	309 (2.7)	1.45 (1.08, 1.96)
45–64	1760 (15.5)	1.93 (1.62, 2.31)	317 (2.8)	1.43 (1.06, 1.94)
65–74	707 (6.2)	1.59 (1.26, 2.02)	65 (0.6)	0.65 (0.40, 1.05)
Indices of multiple deprivation quintile				
Highest	674 (6.0)	1.00	68 (0.6)	1.00
Second highest	736 (6.5)	1.17 (1.02, 1.34)	117 (1.0)	1.80 (1.31, 2.49)
Middle	860 (7.6)	1.47 (1.29, 1.68)	141 (1.2)	2.13 (1.56, 2.93)
Second lowest	894 (7.9)	1.70 (1.48, 1.95)	168 (1.5)	2.47 (1.80, 3.39)
Lowest	995 (8.8)	2.37 (2.05, 2.74)	270 (2.4)	4.69 (3.45, 6.37)
Highest qualification				
Degree or equivalent	982 (8.7)	1.00	111 (1.0)	1.00
Below degree	2371 (20.9)	1.75 (1.58, 1.93)	471 (4.2)	3.20 (2.54, 4.03)
No qualification	806 (7.1)	2.07 (1.78, 2.40)	182 (1.6)	4.60 (3.45, 6.13)
Employment				
Employed/in training/ education	2396 (21.2)	1.00	433 (3.8)	1.00
Retired	812 (7.2)	1.13 (0.96, 1.33)	86 (0.8)	1.03 (0.72, 1.47)
Other economically inactive	611 (5.4)	1.13 (0.99, 1.29)	135 (1.2)	1.13 (0.90, 1.42)
Unemployed	340 (3.0)	2.30 (1.86, 2.85)	110 (1.0)	3.03 (2.28, 4.04)

Definition of health risk: higher-risk alcohol consumption, smoking, obesity, at-risk gambling; weighted data.

interventions showing greater improvements in diet and physical activity compared to low intensity interventions among people at-risk of cardiovascular disease or diabetes (Angermayr et al., 2010).

There is a lack of clarity regarding whether an intervention that tackles multiple risks should be delivered in parallel or sequentially. Three of six RCTs in a review reported a difference between sequential and simultaneous delivery, two of which favoured a sequential approach for smoking when coupled with diet and exercise interventions (James et al., 2016). This is perhaps expected given evidence suggesting smoking cessation may occur at the expense of improvements in diet and activity (Meader et al., 2017; Sweet and Fortier, 2010). Further research is needed to understand the most effective way to deliver multiple behaviour change interventions, particularly for health risks which are strongly clustered, and to consider how gambling interventions might be incorporated in multiple behaviour change interventions. In relation to the findings of our study, this would mean developing a greater understanding of whether alcohol, smoking, and gambling interventions should be delivered in parallel or sequentially, and if sequentially, in what order.

The main strength of this analysis is the use of a nationally representative population survey which is the foremost resource for monitoring the health of adults in England. Including the years of the survey with gambling questions enabled an assessment of how gambling co-occurs and clusters with other major health risks in England and to our knowledge, this is the first time this has been explored using the HSE.

Due to a low prevalence of at-risk gambling for certain sociodemographic breakdowns, we had to combine several survey years to enable fair comparisons, however the HSE remains the most robust source available for estimating at-risk gambling among adults in England. However, the HSE is a repeated cross-sectional survey which demonstrates associations at one point in time and not causal links.

A number of studies have reported the prevalence and clustering of multiple health risks, all exploring different risks and often using different definitions or cut-offs (Meader et al., 2016a). We selected cut-off points for risks in accordance with UK health recommendations, which may limit the generalisability of these findings. Nonetheless, we used the narrowest and widest definition of risks to show the impact of these definitions on our results within the context of England.

This exploratory study adopted a complete case analysis. While it is possible that this approach can produce unbiased results in cases where data are not missing completely at random (Hughes et al., 2019), future research could consider techniques such as multiple imputation to handle missing data and improve generalisability.

5. Conclusion

Multiple health risks among adults living in England are common, with increasing−/higher-risk drinking and overweight/obesity being the most prevalent co-occurring risk. Multiple risks are more prevalent and strongly clustered in men compared to women. Generally, there is a social gradient with people from more deprived groups, of lower educational attainment, or without employment, having a higher odds of two or more health risks.

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CRediT authorship contribution statement

Robyn Burton: Conceptualization, Methodology, Formal analysis, Validation, Visualization, Writing – original draft, Writing – review & editing. **Casey Sharpe:** Conceptualization, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Nick Sheron:** Conceptualization, Methodology, Writing – review & editing. **Clive Henn:** Conceptualization, Writing – review & editing. **Sandy Knight:** Formal analysis, Validation, Writing – review & editing. **Virginia Musto Wright:** Formal analysis, Writing – review & editing. **Mark Cook:** Data curation, Formal analysis, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2023.107683.

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