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Understanding the differential effect of alcohol consumption on the relation between socio-economic position and alcohol-related health problems: results from the Stockholm Public Health Cohort

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ABSTRACT

Aim To test (i) whether the harmful effects of average volume of alcohol consumption (AC) and heavy episodic drinking (HED) differ by socio-economic position (SEP), and (ii) if so, to what extent such differential effects can be attributed to an unequal distribution of harmful levels and patterns of drinking, health, life-style and social factors. **Design** A longitudinal cohort study with baseline in 2002 or 2006, with record-linkage to national registers. **Setting** Stockholm County, Sweden. **Participants** A total of 37484 individuals, aged 25–70 years, responding to the survey in 2002 or 2006. **Measurements** The outcome of alcohol-related health problems was obtained from the National Patient Register and Cause of Death Register using the Swedish index diagnoses related to alcohol use. Self-reported information on occupational class (measure of SEP), AC, HED as well as other health-related factors were extracted from the surveys. Average follow-up time was 13.3 years. **Findings** During follow-up, a total of 1237 first-time events of alcohol-related health problems occurred. After initial adjustments, heavy drinking appeared to be more harmful to individuals with low SEP compared with high SEP ($P = 0.001$). Differences in HED frequency explained the largest part of the differential effect of AC. Engaging in weekly HED was more harmful to individuals with low SEP ($P = 0.031$) than high SEP. Differences in AC, together with other factors, explained a large part of the differential effect of HED. Conclusions The greater adverse impact of alcohol consumption on health in Sweden on people with lower socio-economic position may be largely attributable to higher prevalence of heavy episodic drinking, as well as other behavioral and social risk factors.

Keywords Alcohol, alcohol morbidity, alcohol mortality, differential effect, social inequality, Sweden.

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INTRODUCTION

Evidence of socio-economic differences in alcohol-related morbidity and mortality is well documented in the literature [1–3]. Individuals with lower socio-economic position (SEP) bear a heavier burden of the negative alcohol-related health consequences, even though the overall alcohol consumption is often equally distributed or somewhat higher among drinkers with higher SEP [4,5]. The underlying reason for this 'alcohol-harm paradox' is not fully understood, as there could be several different mechanisms in play.

On one hand, individuals with lower SEP might have more harmful drinking patterns compared to individuals with higher SEP, often referred to as differential exposure. For example, men with higher SEP tend to consume smaller amounts of alcohol more frequently, while men with lower SEP tend to consume larger amounts of alcohol (drinking to get drunk) on fewer occasions [2]. However, on the other hand, a recent review revealed that SEP differences in drinking levels and patterns only explain a part, up to 25%, of the social gradient in alcohol-related morbidity and mortality [3].

Another potential, less-researched, mechanism is differential vulnerability [3], such that other behavioral and social risk factors tend to cluster among low SEP individuals and interact with alcohol use, resulting in an enhanced risk of alcohol-related health problems compared to high SEP individuals [3,6]. While some recent prospective

cohort studies have reported differential effects of alcohol use on the association between SEP and alcohol-related morbidity and mortality [6,7], the recent review by Probst *et al.* concluded that (a) there is not sufficient evidence for effect modification by SEP on alcohol use and (b) there is even less evidence of what factors underlie such increased vulnerability to alcohol in low SEP groups [3].

Previous research suggests that the differential effects of alcohol by SEP remain after accounting for differences in body mass index (BMI) and smoking [6]. Other risk factors that have not been fully investigated in this context include other unhealthy life-style habits, general health status and social support [3,8]. Individuals with lower SEP generally have unhealthier life-style habits that could interact with alcohol, resulting in an increased risk of alcohol-related health problems [9,10]. Also, groups with lower SEP tend to report worse mental health and general wellbeing, which could potentially exacerbate the effects of alcohol [11,12]. Furthermore, previous research has found that men with lower SEP are often unmarried or divorced, which is also associated with an increased risk of alcohol-related health problems [13,14].

Moreover, while the frequency of heavy episodic drinking (HED) tends to explain a larger proportion of the social gradient in alcohol-related harm compared to average alcohol consumption, previous research has not assessed whether the harmful effects of HED differ by SEP [3].

Thus, the current paper aims to test (i) whether the harmful effects of average volume of alcohol consumption and HED differ by SEP, and (ii) if so, to what extent such differential effects can be attributed to an unequal distribution of harmful levels and patterns of drinking, health and life-style and social factors. To this end, we will use a large prospective public health cohort from Stockholm county, with register-linked information on alcohol-related health problems.

METHOD

Study population

The Stockholm Public Health Cohort (SPHC) is a repeated cross-sectional survey with several different baseline measures and follow-ups. The SPHC have been linked to various national registers, intended to be representative of the adult population in Stockholm, Sweden [15]. Data was collected by both postal and web-based questionnaires, with at least three reminders. For our study, we used data from the baseline surveys conducted in 2002 (n = 31182; response rate = 62%) and 2006 (n = 34606; response rate = 61%) [15]. For the baseline survey in 2002, the cohort only includes individuals who participated both in 2002 (baseline) and in a 2007 follow-up survey; 76% of the individuals responding in 2002 also took part. This constraint was due to ethical reasons, as it was not until 2007 the cohort members of the 2002 wave were asked to consent to linking their data to the registers.

The study population comprised all individuals aged between 25 and 70 years who had participated in either the 2002 or 2006 SPHC and did not have a prior registered alcohol-related diagnosis (n = 45870). The age restriction was applied, as SEP is generally less established before age 25, and there is a competing risk of mortality due to old age after the age of 70. Individuals with missing information on the measure of SEP (n = 2661), any alcohol measure (n = 3572) or any of the variables used to construct the life-style index (n = 2153) were excluded. Individuals with missing information were more likely to report worse general health and lower social support, but a similar prevalence of alcohol-related health problems compared to the included individuals (Supporting information, **Table S1**). The final analytical sample consisted of 37484 individuals. Ethical approval was obtained from the Regional Ethical Review Board in Stockholm, 2018/2018–31/5.

Measures

SEP

Education, income and occupation are regarded as the most common measures of SEP. In the main analyses occupation was used, as it relates to occupational hierarchy, income, education, level of job responsibility and retirement benefits. Furthermore, education loses its discriminatory power at older ages and income is very susceptible to reverse causality, such that a person's alcohol consumption can negatively affect their income [16]. However, as SEP is multi-dimensional, we provide additional analyses using education as measures of SEP in the Supporting information.

In the survey, respondents indicated their current or previous (if not currently working) occupation, which was classified into six groups according to the Swedish socio-economic classification of occupation [17]. To optimize power, we created three groups: low SEP (unskilled worker, skilled worker), intermediate SEP (low and middle non-manual workers, self-employed) and high SEP (high non-manual workers). Self-employed were included in the intermediate SEP group, as we were unable to specify if they were manual or non-manual workers. Never employed individuals are categorized as unclassified and were excluded from the main analysis, as they were treated as missing observations.

Alcohol consumption

Information on the self-reported average volume of weekly alcohol consumption and frequency of HED was derived from the survey. For each alcoholic beverage (i.e. spirit, wine, beer, cider) the respondents were asked to report

the amount (in centiliters) consumed during a normal week during the last 12 months, which was converted into grams of pure alcohol intake. Subsequently, four separate groups were created with separate cut-off for men and women: abstainers (0 g), light (both: > 0–84 g), moderate (men: > 84–252 g, women: > 84–168 g) and heavy drinkers (men: > 252 g, women: > 168 g) [18,19].

The frequency of HED was defined as the number of times that respondents consumed alcohol equivalent to a minimum of 120 g 100% alcohol (e.g. half-bottle of spirits/two bottles of wine/six cans of strong beer) on one occasion during the past 12 months (the same cut-offs were used for men and women), which was categorized into four separate groups; abstainers, alcohol consumers with no HED, HED ≤ 3 times/month and HED ≥ once a week.

Alcohol-related health problems

Information on the outcome of alcohol-related health problems, according to the Swedish version of the International Statistical Classification of Disease (ICD) version 10 (from 1997), was obtained from the Swedish National Patient Register (in- and outpatient care) and Cause of Death Register [20,21]. The registers have the complete national coverage during the follow-up period [20,21]. The Swedish index of alcohol-related diagnosis, including diagnoses such as alcohol dependency, alcoholic liver disease and the toxic effect of alcohol, was used to define the outcome [22]. A composite measure of alcohol-related health problems was created, combining information on alcohol-related patient care diagnosis and alcohol-related mortality. The first-time admission to in- or outpatient care for an alcohol-related diagnosis was of interest, either as a principal or contributory diagnosis. For alcohol-related mortality, an alcohol-related diagnosis could be the underlying or contributing cause of death.

Covariates

Information on several individual-level factors was extracted from the survey and registers, as they could potentially explain the differential vulnerability to the harmful effects of alcohol [9–14]. The socio-demographic variables included were sex, age and country of birth.

Adapted from previous research [23], a life-style index was created using available information from the surveys on various life-style factors. In line with previous research and general health recommendations [23–25], individuals received 1 point for each unhealthy life-style habit; currently smoking daily, currently using snuff (wet smokeless tobacco) daily, having a BMI < 18.5 or > 25, performing < 150 min per week of moderate physical activity or eating fewer than four portions of fruit and vegetable per day (Supporting information, **Table S2**). The scores were summed for each individual; the minimum score was 0 (indicating a healthier life-style) and the maximum was 5 (indicating an unhealthier life-style). For the analyses, the index was divided into three separate groups; most healthy (0–1 points), moderately healthy (2–3 points) and less healthy (4–5 points) (Supporting information, **Table S3**).

Three measures of health were derived from the SPHC survey: self-rated health, health-related quality of life (HRQoL) and mental health status. Self-rated health was measured by giving the respondents a five-response level (ranging from very good to very bad) to indicate their overall general health condition. HRQoL was measured by Equation 5D (EQ-5D) [26]. The measure specifies five dimensions: mobility, self-care, usual activates, pain/discomfort and anxiety/depression, with three response levels for each dimension ('no problems', 'some problems' or 'severe problems'). The 12-item version of the General Health Questionnaire (GHQ-12) was used to measure mental health status. Following a recent Swedish study, we applied a threshold of a sum score of ≥ 4 to indicate mental health problems, as this appears to be the optimal cut-off point in a Swedish context [27].

Two social factors were included in the analyses: marital status and social support (i.e. having or not having someone who could provide support in case of a personal problem/crisis or in case of illness).

All covariates were categorized as indicated in Table 1.

Statistical analysis

Pearson's χ^2 test was used to test the descriptive differences between the groups. Cox's proportional hazard models were used to investigate the associations between the exposures of interest and alcohol-related health problems. The proportional hazards assumptions were tested using Schoenfeld residuals and found not to be violated (all *P*-values ≥ 0.05). Person-time was calculated from the date of study entry (at the earliest, 6 November 2002 and 14 September 2006 for the 2002 and 2006 waves, respectively) until the date of first alcohol-related diagnosis or alcohol-related death, date of emigration, date of death from other causes or until end of follow-up (31 December 2018), whichever came first.

We tested multiplicative and additive interactions between average alcohol consumption/HED and SEP for the outcome of alcohol-related health problems after initial adjustments. Multiplicative interactions were tested by including an interaction term of alcohol consumption/HED and SEP. We calculated the relative risk due to the interactions (RERI) [RERI = hazard ratio $(HR)_{11} - HR_{10} - HR_{01} + 1$] to assess the presence of an additive interaction, as this is the best choice for Cox models [28]. The 95% confidence intervals (CIs) were estimated according to the Delta method [29]. We also

TABLE 1 Baseline characteristics of the study sample, stratified by socio-economic position (SEP).

	High SEP n (%)/mean (SD)	*Intermediate SEP n (%)/mean (SD)*	*Low SEP n (%)/mean (SD)*	*P-value*
Total	9094 (24.3)	19077 (50.9)	9313 (27.4)	
Age (years)	46.2 (12.2)	47.1 (12.3)	46.6 (12.7)	
Sex				
Male	4698 (51.7)	7785 (40.8)	4607 (49.5)	< 0.001
Female	4396 (48.3)	11292 (59.2)	4706 (50.5)	
Country of birth				
Nordic country	8467 (93.1)	17559 (92.0)	7817 (83.9)	< 0.001
Non-Nordic country	627 (6.9)	1518 (8.0)	1496 (16.1)	
Volume of consumption[a]				
Abstainers	422 (4.6)	1368 (7.2)	1393 (15.0)	< 0.001
Light drinkers	3900 (42.9)	8791 (46.1)	4246 (45.6)	
Moderate drinkers	3798 (41.8)	6875 (36.0)	2764 (29.7)	
Heavy drinkers	974 (10.7)	2043 (10.7)	910 (9.8)	
Heavy episodic drinking (HED)[b]				
Abstainers	422 (4.6)	1368 (7.2)	1393 (15.0)	< 0.001
Drinkers with no HED	5416 (59.6)	10402 (54.5)	3658 (39.3)	
HED ≤ 3 times/month	3000 (33.0)	6465 (33.9)	3654 (39.2)	
HED ≥ once a week	256 (2.8)	842 (4.4)	608 (6.5)	
Lifestyle Index				
More healthy	3040 (33.4)	5526 (29.0)	1688 (18.1)	< 0.001
Moderately healthy	5551 (61.0)	12087 (63.4)	6414 (68.9)	
Less healthy	503 (5.5)	1464 (7.7)	1211 (13.0)	
Self-rated health				
Very good or good	7583 (83.4)	14862 (77.9)	6027 (64.7)	< 0.001
Moderate	1251 (13.8)	3411 (17.9)	2540 (27.3)	
Very bad or bad	215 (2.4)	645 (3.4)	657 (7.1)	
Missing	45 (0.5)	159 (0.8)	89 (1.0)	
Health-related quality of life (EQ-5D)				
No problems	4902 (53.9)	8692 (45.6)	3246 (34.9)	< 0.001
Some or severe problems	4163 (45.8)	10286 (53.9)	6009 (64.5)	
Missing	29 (0.3)	99 (0.5)	58 (0.6)	
Poor mental health (GHQ-12)	1306 (14.4)	2696 (14.1)	1407 (15.1)	0.226
Marital status				
Married	5095 (56.0)	10006 (52.5)	4291 (46.1)	< 0.001
Unmarried/partnership	2788 (30.7)	6171 (32.4)	3411 (36.6)	
Divorced	1080 (11.9)	2548 (13.4)	1418 (15.2)	
Widow/er	125 (1.4)	347 (1.8)	188 (2.0)	
Missing	6 (0.1)	5 (0.1)	5 (0.1)	
Social support				
Have social support	8144 (90.0)	17000 (89.1)	7827 (84.0)	< 0.001
No social support	922 (10.1)	2029 (10.6)	1437 (15.4)	
Missing	28 (0.3)	48 (0.3)	49 (0.5)	
Outcome				
Alcohol-related health problems	219 (2.4)	587 (3.2)	431 (4.9)	

SD = standard deviation; EQ-5D = Equation 5D; GHQ = General Health Questionnaire. [a]Grams of 100% alcohol consumed in a normal week. Abstainers (0 g), light (men and women: > 0–84 g), moderate (men: > 84–252 g, women: > 84–168 g) high consumers (men: > 252 g, women: > 168 g); [b]HED = the number of times a respondent consumed beverages corresponding to minimum 120 g 100% alcohol (e.g. two bottles of wine/six cans of strong beer/a half-bottle of spirits) during the last 12 months.

calculated the attributable portion due to interaction (AP) (RERI/HR_{11}). Following recommendations, we present our interaction analyses with a single common reference group by categorizing the sample based on both average alcohol consumption/HED and SEP, to allow for comparison according to the same baseline hazard [29]. The reference group for the analysis on average alcohol consumption and SEP was light drinkers with high SEP. The reference group for the HED analysis was drinkers with no HED and high SEP.

All models were adjusted for sex, age and country of birth. In the second model, additional adjustments were performed for either average alcohol consumption or HED, depending on the exposure, with subsequent models adjusting for life-style factors, health status or social factors, and finally, all potential confounders were included simultaneously.

Missing values on covariates related to health and social factors were coded as separate categories. Sensitivity analyses were conducted in which individuals with missing covariate information were excluded (i.e. complete case analysis). As the analysis was not pre-registered on a publicly available platform, the results should be considered exploratory. All analyses were performed using Stata Statistical Software, release 15.

RESULTS

Table 1 shows the baseline characteristics of the study population. The prevalence of heavy drinkers was similar among all SEP groups, while HED ≥ once a week was more prevalent among individuals with low SEP. In general, the low SEP group reported less healthy life-style habits, poorer self-rated health, lower HRQoL and less social support to a greater extent compared to the other groups.

During the follow-up, a total of 1237 individuals received care or died because of an alcohol-related diagnosis, 431 of whom (4.6%) had low SEP, 587 (3.1%) had intermediate SEP and 219 (2.4%) had high SEP. Approximately 2.2% emigrated and were lost to follow-up. The average follow-up time was 13.3 years.

Main analyses

The separate effects of SEP, average alcohol consumption, HED and all other risk factors on the outcome are shown in Table 2. An increased risk was found among individuals with lower SEP compared to high SEP. Compared to light drinkers, heavy drinkers had an eightfold increased risk, while individuals who partook in weekly HED was associated with a more than 14-fold increased risk compared to drinkers with no HED. All other risk factors were also positively associated with the outcome.

TABLE 2 Hazard ratios (HR) for alcohol-related health problems by socio-economic position (SEP), alcohol use, life-style, health and social factors.

	Adjusted HR (95% CI)
Socio-economic position	
High SEP (ref)	1.00
Intermediate SEP	1.38 (1.18, 1.61)
Low SEP	2.06 (1.75, 2.43)
Volume of consumption[a]	
Abstainers	0.94 (0.66, 1.31)
Light drinkers (ref)	1.00
Moderate drinkers	2.18 (1.86, 2.56)
Heavy drinkers	8.00 (6.82, 9.35)
Heavy episodic drinking (HED)[b]	
Abstainers	1.08 (0.77, 1.52)
Drinkers with no HED (ref)	1.00
HED ≤ 3 times/month	4.02 (3.45, 4.69)
HED ≥ once a week	14.68 (12.38, 17.40)
Lifestyle index	
More healthy (ref)	1.00
Moderately healthy	2.64 (2.18, 3.18)
Less healthy	7.18 (5.80, 8.88)
Self-rated health	
Very good or good (ref)	1.00
Moderate	2.43 (2.15, 2.75)
Very bad or bad	3.70 (3.03, 4.51)
Health related quality of life (EQ-5D)	
No problems (ref)	1.00
Some or severe problems	2.06 (1.82, 2.32)
Poor mental health (GHQ-12)	1.91 (1.65, 2.19)
Marital status	
Married (ref)	1.00
Unmarried/partnership	1.49 (1.28, 1.71)
Divorced	2.11 (1.82, 2.45)
Widow/er	1.75 (1.19, 2.57)
Social support	
Have social support (ref)	1.00
No social support	1.72 (1.49, 1.99)

Adjusted for sex, age (continuous) and country of birth. CI = confidence interval; EQ-5D = Equation 5D; GHQ = General Health Questionnaire.

Differential effect of average alcohol consumption

We did not find any substantial evidence of an interaction on the multiplicate scale between average alcohol consumption and SEP on alcohol-related health problems ($P = 0.311$). Compared to light drinkers with high SEP, after initial adjustments additive interactions between average alcohol consumption and SEP on alcohol-related health problems were found among both moderate and heavy drinkers with low SEP and intermediate SEP (Table 3). For example, the risk of heavy drinking increased from 8.7 for individuals with high SEP to 16.4 for individuals with low SEP, and 37% of the increased risk was attributable to the interaction between average alcohol consumption and SEP.

Adjusting for HED attenuated the risk estimates substantially in all groups, especially among heavy drinkers with lower SEP. Adjustment for life-style, health or social factors had little effect on the magnitude of associations seen. In the final model, heavy drinkers had a similarly increased risk of alcohol-related health problems, irrespective of occupational class.

TABLE 3 Adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) for the association of average volume of alcohol consumption and socio-economic (SEP) position on the outcome of alcohol-related health problems.

	High SEP HR (95% CI)	*Intermediate SEP HR (95% CI)*	*Low SEP HR (95% CI)*
Model 1			
Abstainer	1.05 (0.38, 2.96)	0.94 (0.48, 1.85)	2.06 (1.23, 3.46)
Light drinker	1.00	1.25 (0.86, 1.82)	2.54 (1.74, 3.70)
Moderate drinker	2.15 (1.46, 3.16)	3.18 (2.24, 4.50)	5.34 (3.73, 7.65)
Heavy drinker	8.71 (5.93, 12.79)	12.02 (8.50, 17.00)	16.38 (11.42, 23.54)
Model 2			
Abstainer	1.52 (0.54, 4.28)	1.28 (0.65, 2.52)	2.86 (1.70, 4.82)
Light drinker	1.00	1.11 (0.76, 1.62)	1.99 (1.37, 2.91)
Moderate drinker	1.75 (1.19, 2.57)	2.25 (1.58, 3.19)	3.28 (2.28, 4.72)
Heavy drinker	4.73 (3.20, 6.98)	5.70 (4.00, 8.13)	6.54 (4.51, 9.51)
Model 3			
Abstainer	1.00 (0.35, 2.79)	0.82 (0.42, 1.62)	1.68 (1.00, 2.83)
Light drinker	1.00	1.16 (0.80, 1.69)	2.11 (1.45, 3.08)
Moderate drinker	2.07 (1.41, 3.06)	2.84 (2.01, 4.03)	4.34 (3.03, 6.22)
Heavy drinker	7.49 (5.10, 11.01)	9.67 (6.83, 13.69)	11.74 (8.16, 16.91)
Model 4			
Abstainer	0.97 (0.35, 2.73)	0.77 (0.39, 1.51)	1.54 (0.91, 2.58)
Light drinker	1.00	1.19 (0.82, 1.74)	2.08 (1.43, 3.04)
Moderate drinker	2.23 (1.52, 3.28)	3.13 (2.21, 4.44)	4.60 (3.21, 6.59)
Heavy drinker	8.63 (5.87, 16.72)	11.37 (8.04, 16.08)	12.97 (9.02, 18.64)
Model 5			
Abstainer	1.00 (0.35, 2.77)	0.88 (0.45, 1.72)	1.87 (1.12, 3.14)
Light drinker	1.00	1.23 (0.84, 1.79)	2.41 (1.66, 3.52)
Moderate drinker	2.19 (1.50, 3.21)	3.19 (2.25, 4.51)	5.09 (3.55, 7.30)
Heavy drinker	8.42 (5.73, 12.37)	11.64 (8.23, 16.45)	14.98 (10.42, 21.52)
Model 6			
Abstainer	1.27 (0.45, 3.57)	0.95 (0.48, 1.87)	1.84 (1.09, 3.11)
Light drinker	1.00	1.03 (0.70, 1.50)	1.54 (1.05, 2.25)
Moderate drinker	1.80 (1.22, 2.64)	2.17 (1.52, 3.06)	2.65 (1.84, 3.82)
Heavy drinker	4.49 (3.04, 6.63)	4.98 (3.49, 7.11)	4.64 (3.19, 6.77)
Number of events (%)			
Abstainer	4 (1.0)	11 (0.8)	24 (1.7)
Light drinker	37 (1.0)	101 (1.2)	102 (2.4)
Moderate drinker	89 (2.3)	231 (3.4)	158 (5.7)
Heavy drinker	89 (9.1)	244 (11.9)	147 (16.2)

HED = heavy episodic drinker; BMI = body mass index. Measure of alcohol and SEP interaction on additive scale (after initial adjustments): moderate drinker and low SEP: RERI (95% CI) = 1.65 (0.56, 2.74), $P = 0.003$; heavy drinker and low SEP: RERI (95% CI) 6.14 (2.48, 9.80), $P = 0.001$; moderate drinker and intermediate SEP: RERI (95% CI) = 0.78 (0.12, 1.44), $P = 0.020$; and heavy drinker and intermediate SEP: RERI (95% CI) = 3.06 (0.60, 5.52), $P = 0.015$. Model 1: adjusted for sex, country of birth, age (continuous); model 2: adjusted for model 1 and HED (abstainer, drinker with no HED, HED ≤ 3/month, HED ≥ once a week); model 3: Adjusted for model 1 and life-style index (smoking, snuff, BMI, physical activity and fruit and vegetable intake: 0–5-point scale); model 4: adjusted for model 1 and health status: health-related quality of life (Equation 5D), mental health (GHQ12), self-rated health; model 5: adjusted for model 1 and social factors: civil status and social support; and model 6: fully adjusted.

Differential effect of heavy episodic drinking

No evidence of an interaction on the multiplicative scale between HED and SEP on alcohol-related health problems was found after initial adjustments ($P = 0.785$). Evidence of an additive interaction was found among individuals engaging in HED ≤ 3 times/month and HED ≥ once a week with low SEP, which was not replicated among the intermediate SEP group (Table 4). As such, compared to with drinkers with no HED and high SEP, the HR for weekly HED was 12.64 (95% CI = 8.44, 18.94) for high SEP but rose to 19.07 (95% CI = 14.11, 25.77) for individuals with low SEP. Approximately 31% of the increased risk among low SEP individuals with weekly HED was attributable to the interaction between HED and SEP.

Including a measure of average volume of alcohol consumption had a negligible effect on the risk estimates in all groups, except for the individuals engaging in weekly HED. Adjusting for life-style factors appeared to have a greater effect on the risk estimates for all HED and SEP groups compared to health status and social factors. Results in the final model suggest that individuals engaging in HED had a similarly elevated risk of alcohol-related problems, irrespective of SEP status.

TABLE 4 Adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) for the association of frequency of heavy episodic drinking and socio-economic position (SEP) on the outcome of alcohol-related health problems.

	High SEP HR (95% CI)	*Intermediate SEP HR (95% CI)*	*Low SEP HR (95% CI)*
Model 1			
Abstainers	0.91 (0.33, 2.50)	0.78 (0.41, 1.48)	1.76 (1.10, 2.82)
Drinkers with no HED	1.00	1.06 (0.79, 1.42)	1.43 (1.02, 2.02)
HED ≤ 3 times/month	3.50 (2.57, 4.76)	4.25 (3.24, 5.56)	5.60 (4.24, 7.40)
HED ≥ once a week	12.64 (8.44, 18.94)	15.59 (11.64, 20.87)	19.07 (14.11, 25.77)
Model 2			
Abstainers	1.41 (0.51, 3.89)	1.18 (0.62, 2.26)	2.64 (1.63, 4.28)
Drinkers with no HED	1.00	1.10 (0.82, 1.47)	1.66 (1.17, 2.34)
HED ≤ 3 times/month	2.78 (2.04, 3.79)	3.54 (2.70, 4.64)	5.00 (3.78, 6.61)
HED ≥ once a week	6.72 (4.45, 10.14)	8.44 (6.24, 11.41)	10.63 (7.79, 14.49)
Model 3			
Abstainers	0.85 (0.31, 2.33)	0.68 (0.36, 1.30)	1.45 (0.91, 2.33)
Drinkers with no HED	1.00	1.01 (0.75, 1.35)	1.26 (0.89, 1.78)
HED ≤ 3 times/month	3.07 (2.25, 4.18)	3.57 (2.72, 4.68)	4.34 (3.28, 5.75)
HED ≥ once a week	10.46 (6.97, 15.70)	11.77 (8.76, 15.81)	13.71 (10.10, 18.60)
Model 4			
Abstainers	0.82 (0.30, 2.26)	0.63 (0.33, 1.20)	1.32 (0.82, 2.11)
Drinkers with no HED	1.00	1.01 (0.75, 1.36)	1.19 (0.85, 1.69)
HED ≤ 3 times/month	3.36 (2.47, 4.58)	3.96 (3.02, 5.18)	4.60 (3.48, 6.09)
HED ≥ once a week	11.01 (7.34, 16.51)	13.74 (10.24, 18.42)	14.85 (10.96, 20.11)
Model 5			
Abstainers	0.86 (0.31, 2.35)	0.73 (0.39, 1.39)	1.62 (1.01, 2.60)
Drinkers with no HED	1.00	1.06 (0.79, 1.42)	1.39 (0.99, 1.97)
HED ≤ 3 times/month	3.41 (2.51, 4.65)	4.12 (3.15, 5.40)	5.27 (3.99, 6.97)
HED ≥ once a week	11.48 (7.66, 17.22)	14.61 (10.90, 19.59)	17.15 (12.66, 23.22)
Model 6			
Abstainers	1.18 (0.43, 3.26)	0.88 (0.46, 1.69)	1.72 (1.06, 2.78)
Drinkers with no HED	1.00	1.03 (0.77, 1.38)	1.28 (0.90, 1.81)
HED ≤ 3 times/month	2.47 (1.81, 3.37)	2.87 (2.18, 3.76)	3.36 (2.53, 4.47)
HED ≥ once a week	5.03 (3.33, 7.61)	6.02 (4.43, 8.18)	6.32 (4.60, 8.67)
Number of events (%)			
Abstainers	4 (1.0)	11 (0.8)	24 (1.7)
Drinkers with no HED	66 (1.2)	134 (1.3)	64 (1.8)
HED ≤ 3 times/month	112 (3.7)	297 (4.6)	219 (6.0)
HED ≥ once a week	37 (14.5)	145 (17.2)	124 (20.4)

HED = heavy episodic drinker; BMI = body mass index. Measure of HED and SEP interaction on additive scale (after initial adjustments): HED ≤ 3 times/month and low SEP: RERI (95% CI) = 1.70 (0.64, 2.76), $P = 0.002$; HED ≥ once a week and low SEP: RERI (95% CI) 5.98 (0.54, 11.41), $P = 0.031$; HED ≤ 3 times/month and intermediate SEP: RERI (95% CI) = 0.73 (−0.10, 1.55), $P = 0.085$; and HED ≥ once a week and intermediate SEP: RERI (95% CI) = 2.77 (−2.04, 7.60), $P = 0.259$. Model 1: adjusted for sex, country of birth, age (continuous); model 2: adjusted for model 1 and average alcohol consumption (abstainer, light drinker, moderate drinker, heavy drinker); model 3: adjusted for model 1 and life-style index (smoking, snuff, BMI, physical activity and fruit and vegetable intake: 0–5-point scale); model 4: adjusted for model 1 and health status: health-related quality of life (Equation 5D), mental health (GHQ12), self-rated health; model 5: Adjusted for model 1 and social factors: civil status and social support; and model 6: fully adjusted.

Sensitivity analysis

The results of the complete case analyses, where individuals missing information on covariates were excluded ($n = 1329$) (Supporting information, **Tables S4** and S5), demonstrated similar conclusions as in the main analyses; thus, missing values were coded as separate categories for each covariate in the analyses. Sensitivity analyses using education (Supporting information, **Tables S6** and S7) as a marker of SEP was conducted, yielding similar findings as in the main results.

DISCUSSION

The results from this study revealed a differential effect of both the average volume of alcohol and HED on the association between SEP and alcohol-related health problems, so that a given level or pattern of drinking was associated with a higher risk of harm in low compared to high SEP groups. However, this differential vulnerability could largely be attributed to an unequal distribution of harmful levels and patterns of drinking, health, life-style and social factors.

Hence, the current results support and further extend previous research on the social gradient in alcohol-related harm. Similar to previous research we found evidence of effect modification, on the additive scale but not on the multiplicative scale, such that average volume of consumption appeared to have a differential effect on the association between SEP and alcohol-related health problems [6,7]. To address our second aim, we included several other factors related to life-style, health and social support to investigate if a third factor could explain the differential vulnerability found. Including a measure of drinking pattern (i.e. frequency of HED) explained the largest proportion of the differences in vulnerability, especially among the heavy drinkers, which is concurrent with previous research [3,6,7,30]. Extending previous research, which investigated if differences in BMI or smoking could further explain the differential vulnerability to alcohol use [6], we included factors related to health and social support that also differ between the two groups, and could have potentially explained the difference in vulnerability [11–14]. In line with previous research, we found that each factor by themselves only explained a small part of the differential effect of alcohol concerning the association between SEP and alcohol-related health problems [6]. However, the results of the final model suggest that together the different factors explain a large part of the differences in vulnerability, which has not been seen in previous research when only two additional factors were considered [6].

Furthermore, previous research has found that HED explains a larger proportion of the association between SEP and alcohol-related disorders compared to the volume of consumption [3,19]. Subsequently, extending the current research, we also investigated and found evidence for a differential effect of HED on the association between SEP and alcohol-related health problems. Contrasting average alcohol consumption, no single factor explained a large proportion of the differential effect of HED; instead, all factors included in the model each explained a small part and together explained the differential effect of HED found in the initial model.

Overall, our findings support the notion that the differential vulnerability to the harmful effects of alcohol may be largely attributed to the clustering of behavioral and social risk factors among low SEP groups [3], and also adds that this pertains to both the average volume of alcohol and frequency of HED. Moreover, our findings underline the importance of considering several different factors when trying to understand the underlying mechanisms of the alcohol harm paradox. Other factors that could be of importance and should be the focus of future research include differential access to health care, environmental stressors [3] and socio-economic disadvantage in early life. Evidence suggests that early life circumstances can independently influence the risk of later health problems [31,32]. With regard to later alcohol consumption and related harm, previous research has produced conflicting results [33–35].

Addressing health inequalities requires a combination of universal and targeted intervention strategies. The findings of the current study strengthen the notion that the unequal burden of alcohol-related health problems is not only a result of differential exposure to hazardous levels and patterns of drinking across SEP groups, but also of differential vulnerability to the negative effects of alcohol [3]. When such differential vulnerability exists, policy interventions that affect the entire population will tend to have a larger impact among those that are more vulnerable [36,37] which, in our case, are the groups with low SEP. Consequently, universal interventions that effectively reduce the total alcohol consumption as well as the patterns of HED in society not only have the potential of decreasing the overall burden of alcohol-related harm, but may also help to reduce the social gradient of this outcome.

Strengths and limitations

The large study sample, register-derived data with a long-term follow-up and having information on level and patterns of alcohol use are major strengths. A weakness, however, is that we only have information on alcohol habits at one time-point, which could introduce misclassification bias, as there are changes in alcohol consumption during the life-span. Similar to previous research [6,7], there were cases of alcohol-related health problems among the group of abstainers and light drinkers which could reflect previous consumption patterns. Furthermore, using self-reported alcohol consumption could result in under- or over-reporting of actual consumption due to social desirability [38]. Given that systematic differences could exist between the SEP groups, we included another measure of SEP (education) to minimize this potential bias. Additionally, previous research suggests that drinking patterns are more strongly associated with under-reporting of alcohol consumption compared to SEP [39].

The outcome of alcohol-related health problems was collected from high-quality national registers, minimizing the risk of recall bias and bias due to attrition. To reduce potential misclassification of the outcome we only included diagnoses that are 100% attributable to alcohol; subsequently, diagnoses where alcohol is a known risk factor but not a necessary cause (i.e. cardiovascular diseases, cancers) were not included [40]. Consequently, we only captured a small proportion of the health problems attributable to alcohol and therefore the total impact of alcohol is most probably greater than estimated in the current study. To minimize the issue of reverse causation, we excluded individuals with an alcohol-related diagnosis before completing the SPHC.

Another potential drawback of the current study is the use of survey data to gain information on the exposures and covariates. Although survey data provide richer and more detailed data compared to register-derived data, they increase the risk of missingness, attrition and selection bias. Potential selection bias due to systematic non-response could be of concern in the current study, given that the 60% response rate in the surveys, as well as individuals in the 2002 cohort, only included individuals who also participated in the follow-up (2007). Heavy drinkers in general and perhaps heavy drinkers with lower SEP are in particular less likely to participate in surveys, which could have influenced our results.

This study was conducted in Stockholm, Sweden and findings might be difficult to generalize to a different context, especially considering that alcohol norms and alcohol policy differences between countries. Despite this, our findings are harmonized with previous research conducted in different countries, strengthening the external validity of the current study [6,7,30].

CONCLUSION

The results of this study show that consuming alcohol and engaging in HED appears to be more harmful to individuals with low SEP compared to individuals with high SEP in Stockholm, Sweden. The differential effects of average alcohol consumption were mainly explained by an equal distribution of HED. For the differential effects of HED, all factors included contributed a little towards explaining the SEP differences in alcohol-related health problems.

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Declaration of interests

None.

Author contributions

Emelie Thern: Data curation; formal analysis; methodology. **Jonas Landberg:** Conceptualization; data curation; formal analysis; funding acquisition; methodology.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. Baseline characteristics of the individuals included and excluded in the study population
Table S2: Lifestyle index
Table S3: Lifestyle score
Table S4. Complete case analysis excluding 1329 individuals with missing information on covariates, adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) for the association of average volume of alcohol consumption and socioeconomic position on the outcome of alcohol-related health problems.
Table S5. Complete case analysis excluding 1329 individuals with missing information on covariates, adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) for the association of frequency of heavy episodic drinking and socioeconomic position on the outcome of alcohol-related health problems.
Table S6. Adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) for the association of average volume of alcohol consumption and level of education and on the outcome of alcohol-related health problems.
Table S7. Adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) for the association of frequency of heavy episodic drinking and level of education on the outcome of alcohol-related health problems.

