Decomposing social inequalities in alcohol consumption in Germany 1995–2015: an age–period–cohort analysis

Alexander Pabst[1], Sandra van der Auwera[2], Daniela Piontek[3], Sebastian E. Baumeister[4,5,6] & Ludwig Kraus[3,7,8]

Institute of Social Medicine, Occupational Health and Public Health (ISAP), Medical Faculty, University of Leipzig, Leipzig, Germany,[1] Department of Psychiatry and Psychotherapy, University Medicine Greifswald, Greifswald, Germany,[2] IFT Institut für Therapieforschung, Munich, Germany,[3] Chair of Epidemiology, Ludwig-Maximilians-Universität München, UNIKA-T, Augsburg, Germany,[4] Independent Research Group Clinical Epidemiology, Helmholtz Zentrum München, German Research Center for Environmental Health, Neuherberg, Germany,[5] Institute for Community Medicine, University Medicine Greifswald, Greifswald, Germany,[6] Department for Public Health Sciences, Stockholm University, Stockholm, Sweden[7] and Institute of Psychology, ELTE Eötvös Loránd University, Budapest, Hungary[8]

Background and aims Previous research indicates that compared with individuals with lower socio-economic status (SES), individuals in higher SES groups are more often drinkers but those who drink report drinking smaller amounts more frequently. We aimed to decompose trends in self-reported alcohol consumption in Germany into age, period and birth cohort effects and examine whether these effects varied by SES. **Design** Age–period–cohort (APC) analysis using data from eight waves of the cross-sectional German Epidemiological Survey of Substance Abuse (ESA) collected between 1995 and 2015. **Setting** Germany. **Participants** The analytical sample included n = 65 821 individuals aged 18–64 years reporting alcohol use within the last 30 days. **Measurements** Alcohol measures included drinking prevalence, alcohol volume and prevalence of episodic heavy drinking (EHD). Educational attainment was used as an indicator of SES. A series of generalized linear and logistic regression models, including both main and interaction effects of age, period and cohort with SES, were estimated. **Findings** Regression models revealed significant interactions between APC effects and SES on two alcohol consumption measures. Higher SES was consistently associated with drinking prevalence across age ($P < 0.001$), period ($P = 0.016$) and cohort ($P = 0.016$), and with volume of drinking in younger cohorts ($P = 0.002$) and 50+-year-olds ($P = 0.001$). Model results were inconclusive as to whether or not APC effects on EHD prevalence differed by SES. **Conclusions** In Germany, there are positive associations between socio-economic status and alcohol consumption during the life-course, over time and among birth cohorts. Three groups appear vulnerable to risky drinking: high socio-economic status young birth cohorts who drink high average quantities, low socio-economic status young birth cohorts who show a risky drinking pattern and high socio-economic status adults in their 50s and older who increase their drinking volume beyond that age.

Keywords Age–period–cohort (APC) analysis, alcohol, inequalities, socio-economic status, trends, general population.

Correspondence to: Alexander Pabst, Institute of Social Medicine, Occupational Health and Public Health (ISAP), Faculty of Medicine, University of Leipzig, Ph.-Rosenthal-Strasse 55, 04103 Leipzig. E-mail: alexander.pabst@medizin.uni-leipzig.de

Submitted 12 October 2018; initial review completed 28 December 2018; final version accepted 12 March 2019

INTRODUCTION

Assessing population trends is essential for understanding the dynamics of alcohol consumption, and for implementing and evaluating suitable policy measures [1]. Since the early 1980s, sales and survey data suggest a constant decrease in alcohol consumption among adults in Germany. Per-capita annual consumption of pure alcohol declined between 1980 and 2015 from 12.2 to 9.6 litres [2]. The reduction during the last 35 years is paralleled by a decline of reported alcohol consumption in the general population. Results of repeated cross-sectional surveys among German adults based on the Epidemiological Survey of Substance Abuse (ESA) found declining trends in both alcohol use and episodic heavy drinking (EHD), while alcohol volume declined only among females [3].

Socio-economic status (SES) is one key factor associated with physical and mental health [4]. Low SES was reported to be strongly associated with a greater burden of disease and correlated risk factors, including obesity, diabetes, smoking and harmful alcohol use [5–7]. While high SES groups were found to drink more frequently, lower SES groups drank higher quantities [8,9] and were more likely to drink excessively [10,11]. Western countries, including Europe, have seen a widening of social inequalities [12] in recent years, and the temporal variation in health-related social disparities has also been observed with regard to drinking patterns. For instance, in Denmark moderate alcohol use increased while heavy use declined in higher- but not in lower-educated individuals between 1982 and 1992 [13]. In Finland, a decreasing trend in alcohol use was observed in all population groups, except among socio-economically deprived adolescents [14]. In contrast, heavy drinking in lower- and higher-educated men in Russia showed a converging temporal trend, with an overall increase in both groups [15].

Most of the previous studies on the variation between SES and alcohol use are restricted to simple time trends. However, change of alcohol consumption over time is composed of differential time-related factors. Age–period–cohort (APC) analysis offers a valuable methodological approach to decompose these time-related aspects of alcohol consumption. It allows for separating the effects of life-course variations (i.e. age), secular historical events (i.e. period) and generational changes (i.e. cohort) to assess the independent contribution of either effect in aggregated trend data [16,17]. APC analyses examining trends in alcohol consumption have been applied in a number of industrialized countries in recent years [18–23]. In addition, six waves of the ESA conducted between 1995 and 2009 have been used in a previous APC analysis on alcohol consumption in Germany [24]. Results revealed a tendency towards riskier drinking patterns among the cohorts born between 1980 and 1990. Period effects indicated a steady declining trend in alcohol use, while age effects showed only minor changes.

The role of SES with regard to APC effects has been insufficiently addressed in studies of alcohol consumption. For example, the steady decline in alcohol consumption in Germany may be attributable to a decreasing proportion of high SES drinkers or to decreasing average quantities among low SES drinkers. Similarly, it may be that the observed overall increase in EHD in the most recent cohorts was due to a particular SES group, which would provide valuable information for the development of targeted intervention measures. Building on our previous APC analysis [24], the present study aims (1) to decompose trends in alcohol consumption in the German general population from 1995 to 2015 into age, period and birth cohort effects and (2) to examine whether these effects vary by SES.

METHODS

Sample

The present study used data from the German ESA, a nationally representative, repeated cross-sectional survey on the use of psychoactive substances in the adult population. For the present analysis we included data from eight waves of the ESA, carried out between 1995 and 2015 (Supporting information, Table S1). Random samples of adults aged 18 years and older were drawn using random route sampling in 1995 and 1997 and two-stage probability sampling from population registers in later surveys. The upper age limit was 59 years in the surveys until 2003, and 64 years in more recent surveys. In all waves, data were collected via self-administered postal questionnaires, while additional telephone and internet interviews were introduced in 2006 and 2009, respectively. Total sample sizes ranged from 7833 (1995) to 9204 (2015) individuals. Corresponding response rates varied between 45% (2006) and 65% (1995 and 1997). Informed consent was obtained from all participants. The study was approved by the ethics committee of the German Psychological Association (DGPs) (Reg. no: GBLK06102008DGPS).

Of 66 283 individuals who have participated in the eight surveys, those who did not report their age were excluded (n = 160, 0.2%). In addition, individuals with missing responses on 30-day drinking prevalence were discarded (n = 302, 0.5%). Thus, the analytical sample consisted of 65 821 individuals (99.3%) aged 18–64 years. The mean ± standard deviation (SD) age of this subsample was 40.5 ± 12.5 years; 49.3% were female.

MEASURES

Drinking prevalence

Drinking prevalence was defined as the proportion of individuals with at least one drinking occasion within the last 30 days prior to the survey.

Alcohol volume

Alcohol volume was assessed by means of a quantity–frequency measure for beer, wine, spirits, alcopops (in 2006 only) and mixed alcoholic beverages (since 2009). First, respondents were asked about the number of days each beverage type had been consumed within the last 30 days. Next, the average number of glasses of each beverage type that was drunk on a typical drinking day was requested. Taking into account beverage-specific standard ethanol contents [25], alcohol volume (in grams of ethanol per day) was calculated by multiplying frequency and average quantity per drinking day, and dividing the result by 30.

Episodic heavy drinking

Episodic heavy drinking (EHD) was measured by asking respondents whether they had consumed five or more drinks of any alcoholic beverage at least on 1 day within the last 30 days [26]. Based on an estimated alcohol content of 14 g per drink, this amounts to a quantity of 70 g ethanol or more.

Socio-economic status

Education was used as primary indicator of SES in this study, and was preferred over other SES indicators such as income or occupational status due to the generally larger effect of education on adverse drinking outcomes [8,27]. Educational attainment was assessed according to the International Standard Classification of Education (ISCED97) [28]. The ISCED97 comprises a total of seven hierarchical levels of education based on the combination of the participants' responses on their highest school and vocational education. ISCED levels in our study were formed on the basis of the German adaptation of the ISCED97 classification, as provided by the Federal Statistical Office [29]. School education was scored from 1 (no school leaving certificate) to 6 (high school diploma). Levels of vocational education ranged from 'no completed vocational qualification' (scored 1) to 'university degree' (scored 7). Individuals still in education were categorized based on the educational certificate pursued. For the classification of vocational education of individuals in vocational schools and university students, the highest achieved school graduation was applied. After exclusion of pre-primary education (not applicable) and second-stage tertiary education (information not available), the combination of school and vocational education results in five consecutive ISCED97 levels, corresponding to primary, lower secondary, upper secondary, post-secondary and first-stage tertiary education. For analytical purposes, the five levels were finally re-categorized into low (ISCED 1 and ISCED 2; n = 6966), middle (ISCED 3 and ISCED 4; n = 32 755) and high (ISCED 5; n = 16 634) SES [29].

Additional covariates

In order to control for possible confounding, additional variables were assessed. To increase power and interpretability, we did not stratify by gender but included gender as a covariate in all models. Marital status was coded as unmarried, married and divorced or widowed. A variable indicating whether participants were living in East or West Germany was included as a proxy of geographic region. Finally, interview modality (postal versus telephone versus online) was included to adjust for mode effects. Missing values on covariates were imputed using multivariate imputation by chained equations [30].

Analyses

As the three time-related variables are perfectly collinear, i.e. period – age = cohort, the unique identification and estimation of coefficients in conventional linear models is impossible [31]. Various statistical models have been proposed for analysing APC effects while resolving the inherent dependence of the temporal variables ([16]; for a review, see [32,33]). One methodological strategy to handle this 'identification problem' is the definition of different temporal groupings of the three dimensions in the pooled survey data [34]. Applying this approach and assuming a non-linear relationship with drinking, age was included as restricted cubic splines with five knots at fixed centiles, corresponding to 19, 28, 38, 49 and 60 years of age [35]. Period indicates the year in which a given survey was conducted. Year of birth was self-reported or calculated from age and survey year, and grouped into 10 birth cohort groups. Due to the cross-sectional design, the oldest and the youngest cohorts comprise fewer individuals, which made it necessary to collapse birth cohorts at the lower and upper ends of the observation spectrum into larger groups (1935–45 and 1986–97, respectively). All other cohorts were grouped in 5-year cohorts (1946–50, 1951–55, 1956–60, 1961–65, 1966–70, 1971–75, 1976–80 and 1981–85).

This parameterization ensures that regression models are identifiable and converge. In particular, repeated cross-sectional multivariable regression models were used to estimate age, period and cohort effects on alcohol consumption. These models were preferred over other techniques such as cross-classified random-effects models in order to more adequately account for the multi-stage sampling design of the ESA, the oversampling of younger age groups and the post-stratification weighting. For alcohol volume, we fitted a generalized linear model (GLM) with gamma distribution and a power link function. The optimal GLM specification (family, link function) was based on the modified Park test [36] and revealed that a power link of −0.45 fitted the data most effectively. The negative link indicates an inverse relationship, i.e. a change in exposure results in an opposite change in the outcome. For example, a positive effect of cohort on volume would indicate a decline among younger compared to older cohorts. Logistic regression models were used for estimating effects on prevalence measures for drinking and EHD.

We conducted a series of regression models to estimate APC effects on alcohol use. The first set included the three time-related variables, as well as gender, marital status, region, SES and interview modality as covariates. Log-transformed alcohol volume was assessed as an additional covariate in the APC model for EHD. The second set additionally included interaction terms between APC effects and SES (i.e. age × SES, period × SES and cohort × SES) in order to examine whether APC effect estimates were modified by SES. All analyses were weighted to account for the disproportional selection of younger birth cohorts since 2006 and to represent the demographic characteristics (i.e. federal state, community size, gender and birth cohort) of the German general population in a given year. Descriptive patterns of prevalence figures and alcohol volume are presented as percentages and arithmetic means, respectively. Differences in these patterns between SES groups were assessed using Wald tests obtained from logistic regression (prevalence measures) or generalized linear regression models (alcohol volume), with SES as predictor. APC effects on the binary outcome variables are reported as odds ratios (OR); effects in the alcohol volume model are presented as GLM coefficients (β). *P*-values and 95% confidence intervals (CIs) were adjusted for the clustered sampling design of the ESA using Huber/White robust standard errors. Wald tests are reported to evaluate the significance of APC main and interaction effects. Figures showing predictive margins for period and cohort by SES, as obtained from the weighted APC–SES interaction models, are presented. For analytical purposes, age plots using restricted cubic splines were obtained from unweighted SES-stratified models. Corresponding figures for the main-effects models showing the overall effects of age, period and cohort on alcohol consumption are provided in the Supporting information, Figs S1–S3. All analyses were performed using Stata version 15.1 MP (StataCorp LP, College Station, TX, USA).

RESULTS

Descriptive statistics

Summary measures of alcohol consumption by survey year and SES are provided in Table 1. The lowest prevalence rates were consistently found in the low SES group and the highest rates in the high SES group. While drinking prevalence showed a continuous downward trend over time in the low SES group, rates in the medium and high SES groups peaked in 2000 and decreased thereafter. Alcohol volume slightly decreased over time and showed no statistically significant differences across SES groups. Finally, in all SES groups EHD rates were considerably higher in the 1990s compared to more recent surveys. Only few statistically significant differences between SES groups were found, with higher EHD rates in the low SES group compared to the others in the years 2003, 2006 and 2012.

Drinking prevalence

APC model results revealed statistically significant main effects of age, period and birth cohort on the prevalence of drinking (Table 2). Adjusting for all covariates, drinking prevalence showed minor variation with age with a tendency towards higher drinking rates in mid-adulthood, decreasing rates after a peak in 2000 and significantly lower rates in cohorts born in the 1970s compared to those born between 1961 and 1965.

The association of age with drinking prevalence was modified by SES (Fig. 1). In the low SES group, drinking prevalence increased steadily from the age of 30. In contrast, in the high SES group prevalence increased until

Table 1 Drinking prevalence, alcohol volume and prevalence of EHD within the last 30 days by period and SES, ESA 1995–2015.

Year	*Drinking prevalence (%)*					*Alcohol volume (g/day)*[a]					*Prevalence of EHD (%)*[a]					*Total sample*	
	Total	*Low SES*	*Med SES*	*High SES*	*P*	*Total*	*Low SES*	*Med SES*	*High SES*	*P*	*Total*	*Low SES*	*Med SES*	*High SES*	*P*	*n*	*%*
1995	83.1	72.6	82.7	88.4	< 0.001	16.3	18.2	15.9	16.2	0.402	40.6	40.2	40.9	40.2	0.900	7828	11.9
1997	80.9	69.1	80.5	85.7	< 0.001	15.4	14.3	15.1	16.4	0.233	40.4	42.2	40.2	40.3	0.815	8009	12.1
2000	87.6	71.5	87.0	92.5	< 0.001	16.1	17.0	15.6	16.6	0.226	31.0	32.5	31.5	30.1	0.470	8072	12.3
2003	84.1	70.2	83.2	88.7	< 0.001	13.5	13.5	13.1	14.0	0.178	31.4	35.9	31.8	30.0	0.044	7959	12.1
2006	75.6	60.9	73.7	82.4	< 0.001	14.1	14.1	14.5	13.7	0.361	33.2	38.1	36.2	28.4	< 0.001	7770	11.8
2009	77.0	57.5	75.0	83.0	< 0.001	13.3	14.8	13.2	13.3	0.605	33.9	35.8	35.0	32.5	0.163	7958	12.1
2012	75.5	53.8	72.9	82.1	< 0.001	12.8	14.3	13.1	12.2	0.112	34.3	38.5	35.3	32.7	0.035	9041	13.7
2015	75.3	54.3	72.3	81.1	< 0.001	12.9	11.5	13.0	12.9	0.565	34.0	32.2	33.7	34.4	0.729	9184	14.0
Total	79.7	64.7	78.5	85.0	< 0.001	14.2	15.0	14.2	14.1	0.324	34.8	37.4	35.7	33.2	< 0.001	65 821	100.0

[a]Drinkers of the last 30 days only (n = 51 944). EHD = episodic heavy drinking; Med = medium; ESA = Epidemiological Survey of Substance Abuse. Differences in drinking measures by socio-economic status (SES) were tested using Wald tests obtained from logistic regression (prevalence measures) or generalized linear regression models (alcohol volume) with socio-economic status (SES) as single predictor.

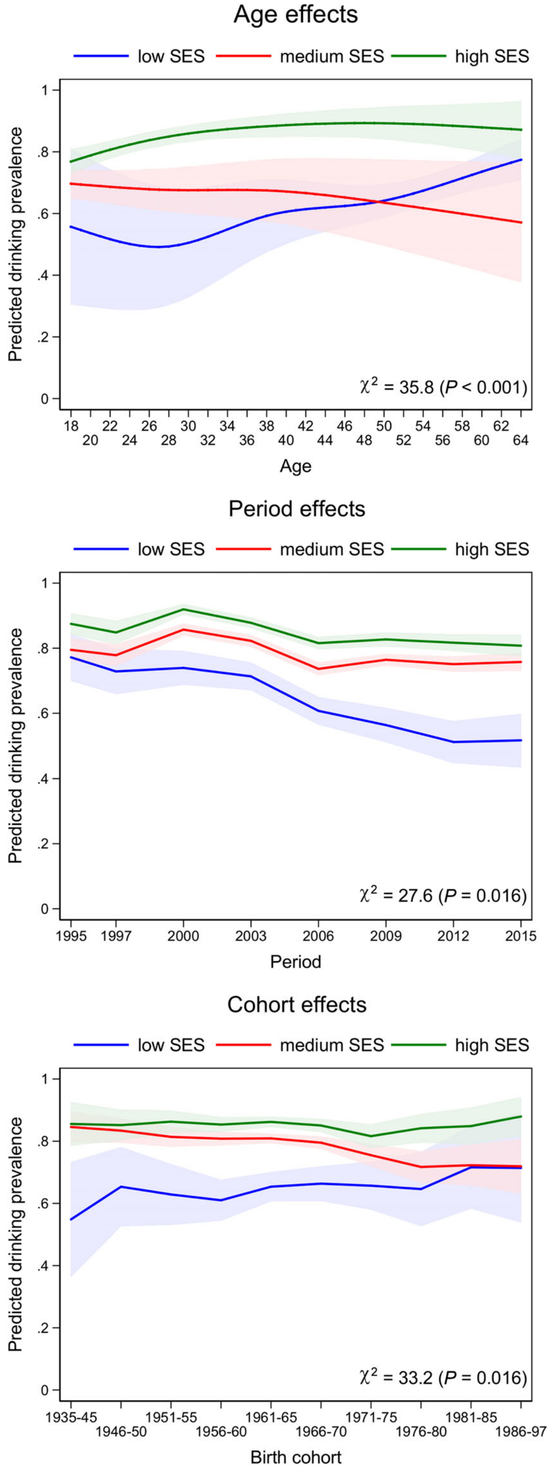

Figure 1 Interaction of age, period and cohort with socio-economic status (SES) on 30-day drinking prevalence. Statistics are Wald tests for the interaction term of SES with age, period and cohort, respectively. The colored area shadings represent 95% confidence intervals

age 50 and levelled off thereafter, while in the medium SES group drinking prevalence generally decreased with age, although CIs widely overlap with those of the low SES group. Over time, the effect modification of SES on drinking prevalence showed a positive gradient, indicating that higher education was consistently associated with higher rates of drinking. A downward trend in drinking prevalence was observed in low SES individuals after 2003, while the mean prevalence remained somewhat stable in medium and high SES individuals. Across birth cohorts, the predictions for drinking prevalence in the high SES group showed a rather constant trend. A diverging trend with a slight decline in cohorts born after 1970 was found in the middle SES group. A positive trend with a slight increase across cohorts was seen in the low SES group.

Alcohol volume

The estimates from the APC main effects model for alcohol volume indicated statistically significant variation by period and birth cohort (Table 2). Overall, volume was lowest in 2003 compared to the reference year 2015; individuals born between 1935 and 1960 reported lower amounts and individuals born between 1966 and 1985 reported higher amounts of alcohol on average compared to the 1961–65 birth cohorts.

Figure 2 shows statistically significant interaction effects of SES with age and cohort; period effects on alcohol volume did not differ by SES. The estimates showed a slightly decreasing trend in consumption for low and medium SES individuals, whereas average daily intake clearly increased among high SES individuals aged 30 and older. In addition, the interaction of SES with birth cohort indicates a cross-over effect. Among birth cohorts born before 1961, the medium SES group reported a higher intake than high SES drinkers. In birth cohorts born between 1961 and 1975, the estimated mean alcohol volume was similar in all SES groups. In more recent cohorts, individuals of the high SES group drank slightly more on average than those in the medium or low SES groups.

Episodic heavy drinking

With regard to EHD, results of the APC models revealed statistically significant main effects for all three time-related variables (Table 2). The prevalence of EHD was highest in young adulthood and decreased steeply with age, and was considerably higher in the 1990s and lower in 2000 compared to 2015. Across cohorts, the results showed increasingly higher EHD rates among cohorts born between 1971 and 1997 compared to the 1961–65 birth cohorts. The interaction of SES with age, period and cohort revealed no statistically significant effects on EHD (Fig. 3).

DISCUSSION

The present study decomposed time trends in alcohol consumption among adults in Germany into age, period and cohort effects and examined the extent to which the

Table 2 Main effects of age, period, and birth cohort on 30-day alcohol consumption as obtained from repeated cross-sectional APC regression models, ESA 1995–2015.

	Drinking prevalence			*Alcohol volume*[a]			*Prevalence of EHD*[a,b]		
	n	*OR*	*95% CI*	*n*	*β*	*95% CI*	*n*	*OR*	*95% CI*
Age[c]									
20 years		0.95	(0.78, 1.16)		−0.007	(−0.023, 0.008)		1.31*	(1.05, 1.64)
30 years		0.96	(0.88, 1.04)		−0.001	(−0.007, 0.006)		1.08	(0.98, 1.19)
35 years		Ref			Ref			Ref	
40 years		1.03	(0.96, 1.11)		−0.001	(−0.007, 0.006)		0.92	(0.84, 1.01)
50 years		0.99	(0.81, 1.21)		−0.001	(−0.017, 0.015)		0.72**	(0.57, 0.92)
60 years		0.88	(0.64, 1.21)		0.004	(−0.021, 0.030)		0.48***	(0.33, 0.69)
Wald		χ^2 = 10.8 (*P* = 0.029)			χ^2 = 3.2 (*P* = 0.530)			χ^2 = 30.8 (*P* < 0.001)	
Period									
1995	7828	1.67***	(1.28, 2.16)	5167	0.001	(−0.020, 0.022)	5167	1.76***	(1.29, 2.40)
1997	8009	1.41**	(1.11, 1.79)	5565	0.007	(−0.014, 0.027)	5276	1.48**	(1.11, 1.96)
2000	8072	2.31***	(1.89, 2.82)	6265	−0.007	(−0.024, 0.009)	6256	0.76*	(0.59, 0.98)
2003	7959	1.71***	(1.43, 2.04)	6177	0.015*	(0.001, 0.029)	6136	0.99	(0.80, 1.23)
2006	7770	1.03	(0.89, 1.19)	5582	0.003	(−0.008, 0.015)	5503	1.00	(0.84, 1.19)
2009	7958	1.11	(0.99, 1.24)	5837	0.001	(−0.008, 0.011)	5807	0.95	(0.83, 1.08)
2012	9041	1.01	(0.92, 1.10)	6500	0.004	(−0.004, 0.012)	6459	1.03	(0.90, 1.18)
2015	9184	Ref		6547	Ref		6520	Ref	
Wald		χ^2 = 218.5 (*P* < 0.001)			χ^2 = 44.6 (*P* < 0.001)			χ^2 = 117.3 (*P* < 0.001)	
Cohort									
1935–45	5925	0.99	(0.75, 1.32)	4085	−0.031**	(−0.053, −0.009)	3991	1.22	(0.88, 1.71)
1946–50	5412	1.01	(0.82, 1.25)	3894	−0.029***	(−0.044, −0.013)	3834	1.05	(0.82, 1.35)
1951–55	6924	0.96	(0.81, 1.12)	5023	−0.018**	(−0.029, −0.006)	4965	1.10	(0.91, 1.33)
1956–60	7187	0.93	(0.83, 1.03)	5255	−0.015***	(−0.023, −0.007)	5197	1.10	(0.95, 1.26)
1961–65	7753	Ref		5783	Ref		5700	Ref	
1966–70	7191	0.95	(0.85, 1.06)	5311	0.017***	(0.008, 0.026)	5244	1.10	(0.98, 1.25)
1971–75	5646	0.78**	(0.66, 0.92)	4024	0.029***	(0.016, 0.042)	3988	1.22*	(1.02, 1.46)
1976–80	5744	0.77*	(0.63, 0.95)	4094	0.042***	(0.025, 0.060)	4070	1.63***	(1.28, 2.09)
1981–85	5336	0.83	(0.64, 1.08)	3858	0.030**	(0.008, 0.051)	3839	2.28***	(1.68, 3.09)
1986–97	8703	0.89	(0.63, 1.26)	6313	0.024	(−0.003, 0.051)	6296	2.78***	(1.88, 4.12)
Wald		χ^2 = 35.9 (*P* < 0.001)			χ^2 = 104.5 (*P* < 0.001)			χ^2 = 165.6 (*P* < 0.001)	
n	65 821			47 640			47 124		

OR = odds ratio; CI = confidence interval; β = unstandardized regression coefficient; Ref = reference point the presented levels for age, period and cohort were compared to. The models were adjusted for gender, marital status, region, interview modality and socio-economic status. [a]30-days drinkers only; [b]model additionally adjusted for (ln)alcohol volume; [c]age was included as restricted cubic splines in the regression models; estimates for the association of age with outcomes are shown at representative values of age, using age 35 years as reference. *P < 0.05; **P < 0.01; ***P < 0.001. APC = age-period-cohort; EHD = episodice heavy drinking; ESA = Epidemiological Survey of Substance Abuse.

temporal changes varied by SES. We found positive associations between SES and drinking participation during the life-course, over time and across birth cohorts. With regard to alcohol volume, we found positive effect modification by SES for age, while the negative SES–volume relationship in older cohorts reversed in younger cohorts. The models further indicated no conclusive evidence for differences in trends of EHD prevalence between SES groups.

Drinking prevalence

Our results, indicating a positive social gradient on drinking prevalence with higher rates of abstainers in lower educated individuals, are consistent with earlier research [11,37,38]. Higher drinking rates among higher educated adults were consistently found across age, period and cohort, indicating a constant pattern of social inequality over time.

The period effect showing a peak in the survey year 2000 followed by a decreasing prevalence is most prominent among the low SES group, indicating that the generally decreasing trend in drinking prevalence observed in the past two decades among adults in Germany is driven mainly by an increase in abstinence among the lower-educated. However, while the period effect suggests an increasing divergence in drinking prevalence between the low and the other two SES groups, the cohort effect points at a change only in the medium SES group, with rates

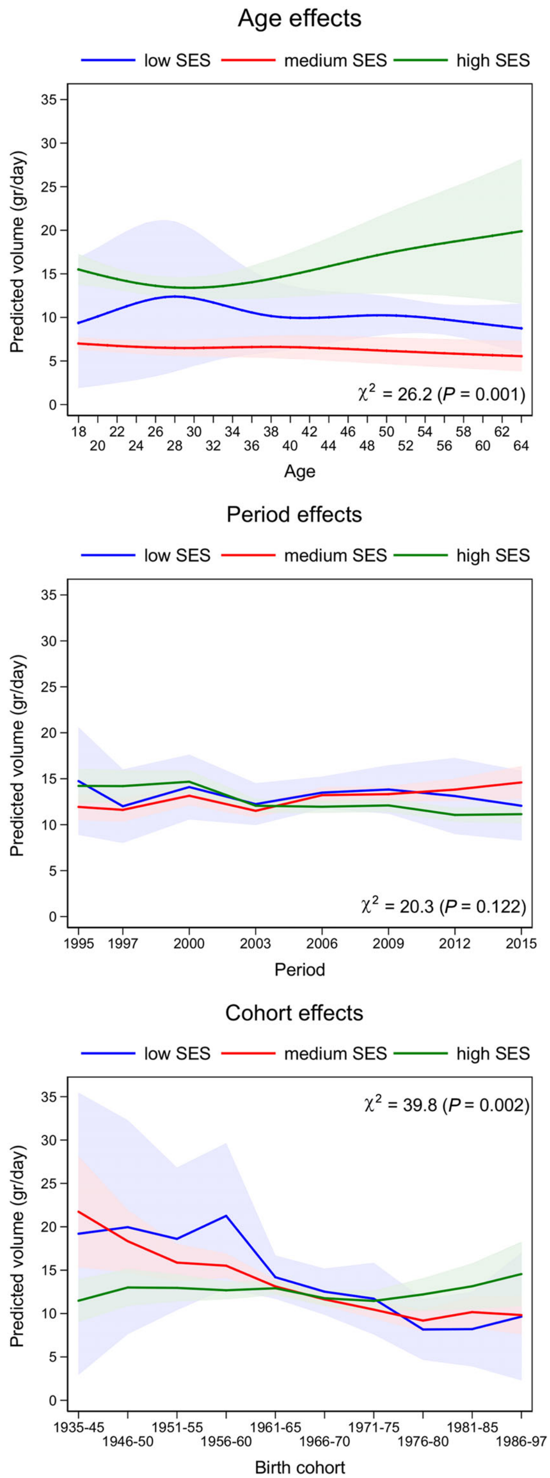

Figure 2 Interaction of age, period and cohort with socio-economic status (SES) on 30-day alcohol volume. Statistics are Wald tests for the interaction term of SES with age, period and cohort, respectively. The colored area shadings represent 95% confidence intervals

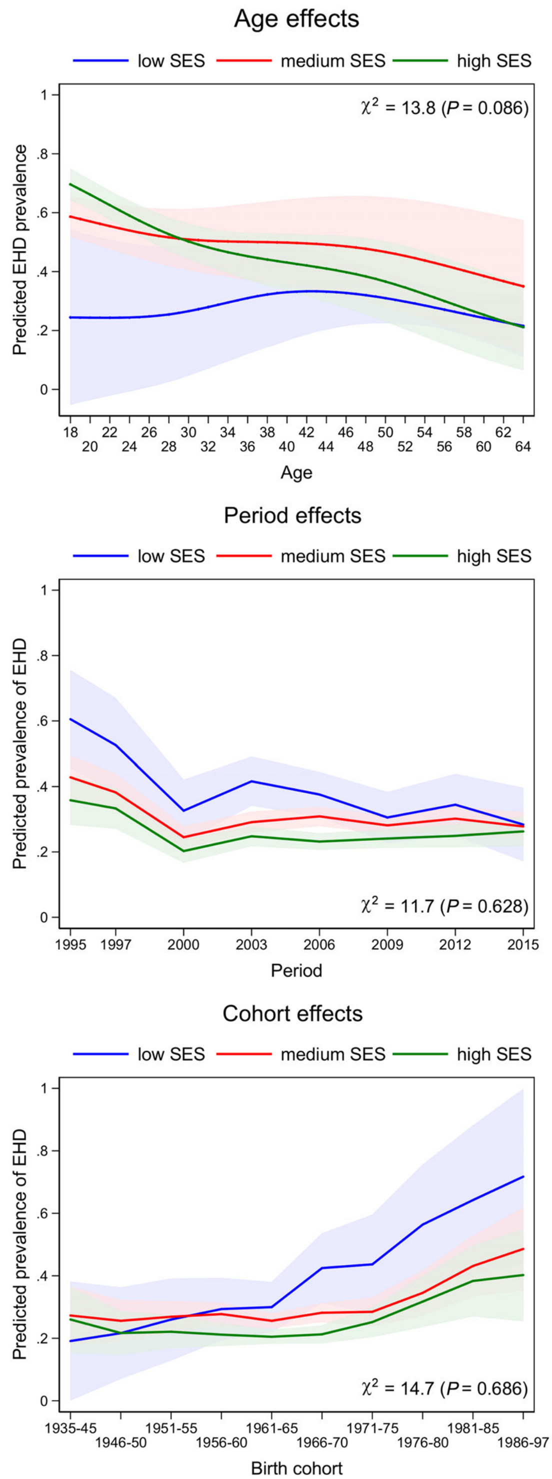

Figure 3 Interaction of age, period and cohort with socio-economic status (SES) on 30-day prevalence of EHD. Statistics are Wald tests for the interaction term of SES with age, period and cohort, respectively. The colored area shadings represent 95% confidence intervals

decreasing from the level of the oldest cohort in the high SES group to the level of the youngest cohort in the low SES group. Thus, only medium SES individuals contribute to the generally lower prevalence rates in younger compared to older cohorts.

In addition, we observed consistently lower drinking rates among low SES individuals born before 1970 and a converging trend with middle SES individuals among those born later. It is difficult to explain this effect, as there are no conclusive indicators for differences in the socialization of older cohorts. One could speculate that the lower drinking rates in older low SES cohorts may have been affected by the poor economic situation of this group after World War II. In the course of continuing economic growth and the rising availability of alcohol, later-born low SES cohorts may have adopted the drinking habits of higher SES groups.

Alcohol volume

Earlier findings of generally higher quantities consumed among those of lower social status are not consistently supported by our results [8,9]. While average alcohol intake was generally higher in the low SES group, results of the APC analysis showed higher volumes in the high SES group from the age of 30 years onwards, as well as in cohorts born after 1971.

Temporal changes in alcohol volume were not susceptible to differences in education, when controlling for the other time-related effects. Given the restrained alcohol policy in Germany during the last three decades [39], no major impact on consumption by SES was to be expected. The generally decreasing trend in alcohol volume seen in aggregated data seems to be driven mainly by younger cohorts constantly drinking lower quantities with a noticeable stronger contribution by low to medium SES individuals. Main cohort effects on alcohol volume similar to our results have recently been reported for Australia [18]. However, the cohort effects in our study are inconsistent with findings from Great Britain, where with the exception of cohorts born after 1985 average alcohol volume generally increased with younger cohorts [22].

Episodic heavy drinking

The overall decreasing trend in EHD prevalence in the German general population seems mainly driven by the period effect. The estimates indicated a strong decrease in heavy drinking prevalence in the second half of the 1990s and the early 2000s followed by a rather constant trend thereafter. However, despite the overall temporal decreasing trend in EHD prevalence a strong cohort effect indicates increasing rates in the prevalence of heavy drinking in cohorts born in the 1970s and later, a trend that is consistent with previous research in Finland and the United States [20,40]. However, unlike in the United States [41], EHD rates in Germany did not fall again in cohorts born after 1985 and revealed no differences by SES. Furthermore, given that our models also revealed no clear evidence of SES differences in the effects of age and period, EHD appears to be a common pattern among the currently young and requires continuing attention by health-care professionals.

Our results can be compared with a similar study on differences in drinking trends by SES, recently conducted in the United States [42]. Despite differences in the time-frame (1979–2010 in the United States and 1995–2015 in Germany), the German findings of educational differences in alcohol use confirm some of the findings in the United States. In particular, individuals of higher SES drank higher quantities. However, this emerged more consistently in the US data than in the German data. Moreover, while the effects of SES on EHD in Germany were statistically not significant, the relationship showed a cross-over effect in the United States, such that higher education in young adulthood was associated with more EHD reversing in mid-adulthood, where higher education was associated with less EHD. Nevertheless, the main effects of age, period and cohort on EHD in both countries were rather similar. The main drivers of reductions in EHD in the 1980s in the United States and also in the first half of the 1990s in Germany levelling off thereafter were independent temporal effects that affected all individuals in a similar manner. However, the increasing rates particularly in cohorts born after 1970 seem to counterbalance the time effect and are of major concern for alcohol policy and prevention.

Several limitations of the study must be mentioned. First, the reported rates of EHD may be biased due to age differences in alcohol-related mortality. It has been shown that alcohol-related mortality considerably increased after reductions in alcohol prices in Finland, most substantially among older-aged individuals with low SES [43]. Thus, EHD levels of individuals of older cohorts with low SES may be underestimated in our sample. Secondly, response and selection biases in the data due to self-reported alcohol use [44] and varying response rates cannot be fully ruled out. Furthermore, there is evidence for a 'middle-class bias' in the ESA surveys of 2006 and 2009, i.e. middle and high SES individuals are over-represented in the data [45,46]. Thirdly, other indicators, such as occupation or income, may be used as alternative measures for SES. Research suggests, however, that occupational inequality greatly depends upon the conceptualization of occupational prestige [47]. More promising were combinations between education and income, particularly in the presence of status inconsistencies. For instance, low-educated individuals with high income were found more likely to be heavy drinkers than individuals in other SES groups [48]. We favoured education over occupation or income in this study, as education is considered a constant trait over time and because in many instances students and females did not report an occupation or were without personal income [38]. Fourthly, due to lack of power, further stratification by gender was not possible. Given the slightly converging trends in volume and EHD between men and women in recent years [3], studies are needed to determine whether the observed trajectories of social inequality in alcohol consumption in Germany differ by gender, as found in part in the United States [42]. Finally, the youngest and the oldest birth cohorts were not interviewed in every wave of the survey. Findings for these groups may be less reliable than findings for the remaining cohorts, and figures must be interpreted with caution due to the wide confidence intervals.

In light of generally decreasing trends in alcohol participation, alcohol volume and heavy drinking in Germany, our study revealed statistically significant differences between socio-economic groups in the independent temporal effects of age, period and cohort on alcohol consumption. The main vulnerable groups that could be identified are young cohorts born after 1975 whose drinking styles differ considerably by education. High SES young cohorts drink higher quantities on average than their low SES peers, while low SES young cohorts are more likely heavy drinkers than high SES peers. A third group of concern are high SES adults, who increase their drinking volume even beyond age 50. In order for the decreasing trends in alcohol consumption to continue and to further reduce alcohol-related acute and long-term negative consequences, these groups need special attention. However, the reasons and mechanisms of various possible factors contributing to the generally observed reductions in alcohol use in high-income countries, particularly among the younger generations [49], still need to be understood.

Declaration of interests

L.K. and D.P. declare having received a grant from Lundbeck GmbH for a research project on alcohol epidemiology not related to this study.

Acknowledgements

Funding of the Epidemiological Survey of Substance Abuse was provided by the German Federal Ministry of Health (grant 119-4914-8/32).

References

1. Babor T. F., Caetano R., Casswell S., Edwards G., Giesbrecht N., Graham K., *et al. Alcohol: No Ordinary Commodity, 2nd edn. Oxford: Oxford University Press; 2010.*
2. Deutsche Hauptstelle für Suchtfragen e.V. (DHS). *Jahrbuch Sucht 2017*. Langerich: Pabst Science Publishers; 2017.
3. Kraus L., Piontek D., Atzendorf J., Gomes de Matos E. Zeitliche Entwicklungen im Substanzkonsum in der deutschen Allgemeinbevölkerung. Ein Rückblick auf zwei Dekaden [Time trends in substance use in the German general population: a review of two decades]. *Sucht* 2016; **62**: 283–94.
4. Berkman L. F., Kawachi I., Glymour M. *Social Epidemiology, 2nd edn.* Oxford: Oxford University Press; 2014.
5. Mackenbach J. P., Kulhanova I., Bopp M., Borrell C., Deboosere P., Kovacs K., *et al*. Inequalities in alcohol-related mortality in 17 European countries: a retrospective analysis of mortality registers. *PLOS Med* 2015; 1001909.
6. Marmot M. *Health inequalities in the EU: Final Report of a Consortium*. Brussels: European Commission; 2013.
7. Braveman P. A., Cubbin C., Egerter S., Williams D. R., Pamuk E. Socioeconomic disparities in health in the United States: what the patterns tell us. *Am J Public Health* 2010; **100**: S186–S196.
8. Casswell S., Pledger M., Hooper R. Socioeconomic status and drinking patterns in young adults. *Addiction* 2003; **98**: 601–10.
9. Huckle T., You R. Q., Casswell S. Socio-economic status predicts drinking patterns but not alcohol-related consequences independently. *Addiction* 2010; **105**: 1192–202.
10. Droomers M., Schrijvers C. T., Stronks K., van de Mheen D., Mackenbach J. P. Educational differences in excessive alcohol consumption: the role of psychosocial and material stressors. *Prev Med* 1999; **29**: 1–10.
11. Grittner U., Kuntsche S., Gmel G., Bloomfield K. Alcohol consumption and social inequality at the individual and country levels-results from an international study. *Eur J Public Health* 2012; **23**: 332–9.
12. Siegrist J., Marmot M. *Social inequalities in health*. Oxford: Oxford University Press; 2006.
13. Osler M., Jorgensen T., Davidsen M., Gronbaek M., Bronnum-Hansen H., Madsen M., *et al*. Socioeconomic status and trends in alcohol drinking in the Danish MONICA population, 1982–92. *Scand J Public Health* 2001; **29**: 40–3.
14. Torikka A., Kaltiala-Heino R., Luukkaala T., Rimpelä A. Trends in alcohol use among adolescents from 2000 to 2011: the role of socioeconomic status and depression. *Alcohol Alcohol* 2017; **52**: 95–103.
15. Malyutina S., Bobak M., Kurilovitch S., Nikitin Y., Marmot M. Trends in alcohol intake by education and marital status in urban population in Russia between the mid 1980s and the mid 1990s. *Alcohol Alcohol* 2004; **39**: 69.
16. Yang Y., Land K. C. *Age–period–Cohort Analysis: New Models, Methods, and Empirical Applications*, Chapman & Hall/CRC Interdisciplinary Statistics Series. Boca Raton, Fla: CRC Press; 2013.
17. Robertson C., Boyle P. Age–period–cohort analysis of chronic disease rates. I: Modelling approach. *Stat Med* 1998; **17**: 1305–23.
18. Livingston M., Raninen J., Slade T., Sift W., Lloyd B., Dietze P. Understanding trends in Australian alcohol consumption—an age–period–cohort model. *Addiction* 2016; **111**: 1590–8.
19. Bjork C., Thygesen L. C., Vinther-Larsen M., Gronbaek M. N. Time trends in heavy drinking among middle-aged and older adults in Denmark. *Alcohol Clin Exp Res* 2008; **32**: 120–7.
20. Härkönen J. T., Mäkelä P. Age, period and cohort analysis of light and binge drinking in Finland, 1968-2008. *Alcohol Alcohol* 2011; **46**: 349–56.
21. Kraus L., Tinghög E. M., Lindell A., Pabst A., Piontek D., Room R. Age, period and cohort effects on time trends in alcohol consumption in the Swedish adult population 1979–2011. *Alcohol Alcohol* 2015; **50**: 319–27.
22. Meng Y., Holmes J., Hill-McManus D., Brennan A., Meier P. S. Trend analysis and modelling of gender-specific age, period and birth cohort effects on alcohol abstention and consumption level for drinkers in Great Britain using the General Lifestyle Survey 1984–2009. *Addiction* 2014; **109**: 206–15.
23. Kerr W. C., Greenfield T. K., Bond J., Ye Y., Rehm J. Age, period and cohort influences on beer, wine and spirits consumption trends in the US National Alcohol Surveys. *Addiction* 2004; **99**: 1111–20.

24. Pabst A., Kraus L., Piontek D., Müller S. Age, period, and cohort effects on time trends in alcohol consumption in the German adult population. *Sucht* 2010; **56**: 349–59.
25. Bühringer G., Augustin R., Bergmann E., Bloomfield K., Funk W., Junge B., *et al. Alcohol Consumption and Alcohol-Related Problems in Germany.* Göttingen: Hogrefe & Huber; 2002.
26. Gmel G., Rehm J., Kuntsche E. Binge drinking in Europe: definitions, epidemiology, and consequences. *Sucht* 2003; **49**: 105–16.
27. Mulia N., Karriker-Jaffe K. J. Interactive influences of neighborhood and individual socioeconomic status on alcohol consumption and problems. *Alcohol Alcohol* 2012; **47**: 178–86.
28. UNESCO Institute for Statistics. *International Standard Classification of Education ISCED 1997*. Paris: United Nations Educational, Scientific and Cultural Organization (UNESCO); 2006.
29. Schroedter J. H., Lechert Y., Lüttinger P. *Die Umsetzung der Bildungsskala ISCED-1997 für die Volkszählung 1970, die Mikrozensus-Zusatzerhebung 1971 und die Mikrozensen 1976–2004 [The implementation of the ISCED 1997 for the 1970 and 1971 censuses, and the 1976–2004 micro-censuses].* ZUMA-Methodenbericht 2006/08; 2006. Available at: https://www.gesis.org/fileadmin/upload/forschung/publikationen/gesis_reihen/gesis_methodenberichte/2006/06_08_Schroedter.pdf (accessed 4 April 2019) (Archived at http://www.webcitation.org/77O2s8A1q on 4 April 2019).
30. van Buuren S. *Flexible Imputation of Missing Data*, Chapman & Hall/CRC Interdisciplinary Statistics Series. Boca Raton, FL: CRC Press; 2012.
31. Mason W., Fienberg S. E. *Cohort Analysis in Social Research: Beyond the Identification Problem*. New York: Springer; 1985.
32. Kupper L. L., Janis J. M., Karmous A., Greenberg B. G. Statistical age–period–cohort analysis: a review and critique. *J Chronic Dis* 1985; **38**: 811–30.
33. Robertson C., Gandini S., Boyle P. Age–period–cohort models: a comparative study of available methodologies. *J Clin Epidemiol* 1999; **52**: 569–83.
34. Yang Y., Land K. C. Age–period–cohort analysis of repeated cross-section surveys: fixed or random effects? *Sociol Methods Res* 2008; **36**: 297–326.
35. Harrell F. E. *Regression Modeling Strategies: With Applications to Linear Models, Logistic and Ordinal Regression, and Survival Analysis, 2nd edn, Springer Series in Statistics.* Basel: Springer International Publishing; 2015.
36. Manning W. G., Mullahy J. Estimating log models: to transform or not to transform? *J Health Econ* 2001; **20**: 461–94.
37. Marmot M. Inequality, deprivation and alcohol use. *Addiction* 1997; **92**: 13–20.
38. van Oers J. A., Bongers I. M., van de Goor L. A., Garretsen H. F. Alcohol consumption, alcohol-related problems, problem drinking, and socioeconomic status. *Alcohol Alcohol* 1999; **34**: 78–88.
39. Kraus L., Müller S., Pabst A. Alkoholpolitik [Alcohol control policy]. *Suchttherapie* 2008; **9**: 103–10.
40. Kerr W. C., Greenfield T. K., Bond J., Ye Y., Rehm J. Age–period–cohort modelling of alcohol volume and heavy drinking days in the US National Alcohol Surveys: divergence in younger and older adult trends. *Addiction* 2009; **104**: 27–37.
41. Kerr W. C., Greenfield T. K., Ye Y., Bond J., Rehm J. Are the 1976–1985 birth cohorts heavier drinkers? Age–period–cohort analyses of the National Alcohol Surveys 1979-2010. *Addiction* 2013; **108**: 1038–48.
42. Lui C. K., Kerr W. C., Mulia N., Ye Y. Educational differences in alcohol consumption and heavy drinking: an age–period–cohort perspective. *Drug Alcohol Depend* 2018; **186**: 36–43.
43. Herttua K., Mäkelä P., Martikainen P. Changes in alcohol-related mortality and its socioeconomic differences after a large reduction in alcohol prices: a natural experiment based on register data. *Am J Epidemiol* 2008; **168**: 1110–8.
44. Dawson D. A. Volume of ethanol consumption: effects of different approaches to measurement. *J Stud Alcohol* 1998; **59**: 191–7.
45. Kraus L., Baumeister S. E. Studiendesign und Methodik des Epidemiologischen Suchtsurveys 2006 [Study design and methodology of the 2006 Epidemiological Survey of Substance Abuse]. *Sucht* 2008; **54**: S6–S15.
46. Kraus L., Pabst A. Studiendesign und Methodik des Epidemiologischen Suchtsurveys 2009 [Study design and methodology of the 2009 Epidemiological Survey of Substance Abuse]. *Sucht* 2010; **56**: 315–26.
47. Maron J., Kraus L., Pogarell O., Gomes de Matos E., Piontek D. Occupational inequalities in psychoactive substance use: a question of conceptualization? *Addict Res Theory* 2016; **24**: 186–98.
48. Grittner U., Bloomfield K., Kramer S., Kuntsche S., Gmel G. Die Konstruktion eines empirisch bestimmten Sozialschichtindexes mittels optimaler Skalierung am Beispiel von Deutschland [The construction of an empirically based social status index through optimal scaling as illustrated by Germany]. *Gesundheitswesen* 2006; **68**: 116–22.
49. Kraus L., Seitz N.-N., Piontek D., Molinaro S., Siciliano V., Guttormsson U., *et al.* 'Are the times a-changin'? Trends in adolescent substance use in Europe. *Addiction* 2018; **113**: 1317–32.

Supporting Information

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

Table S1 Overview of the methodology of the ESA surveys 1995 - 2015.
Figure S1 Main effects of age, period and cohort on 30-day drinking prevalence.
Figure S2 Main effects of age, period and cohort on 30-day alcohol volume (drinkers only).
Figure S3 Main effects of age, period and cohort on 30-day prevalence of EHD (drinkers only).