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Age, Period and Cohort Effects On Alcohol Consumption In Estonia, 1996–2018

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Abstract

Aims: To analyse the independent effects of age, period and cohort on estimated daily alcohol consumption in Estonia.
Methods: This study used data from nationally representative repeated cross-sectional surveys from 1996 to 2018 and included 11,717 men and 16,513 women aged 16–64 years in total. The dependent variables were consumption of total alcohol and consumption by types of beverages (beer, wine and strong liquor) presented as average daily consumption in grams of absolute alcohol. Mixed-effects negative binomial models stratified by sex were used for age–period–cohort analysis.
Results: Alcohol consumption was highest at ages 20–29 years for both men and women and declined in older ages. Significant period effects were found indicating that total alcohol consumption and consumption of different types of beverages had increased significantly since the 1990s for both men and women. Cohort trends differed for men and women. Men born in the 1990–2000s had significantly lower daily consumption compared to earlier cohorts, whereas the opposite was found for women.
Conclusion: While age-related patterns of alcohol consumption are aligned with life course stages, alcohol use has increased over the study period. Although the total daily consumption among men is nearly four times higher than among women, the cohort trends suggest convergence of alcohol consumption patterns for men and women.

INTRODUCTION

Alcohol is a causal factor in more than 200 disease or injury conditions and results in nearly 3 million annual deaths worldwide (World Health Organization [WHO], 2018). With nearly 9% of all attributable disability-adjusted life years for men and more than 2% for women, alcohol is the leading risk factor for premature death and disability in working age population (GBD 2016 Alcohol Collaborators, 2018).

According to WHO (World Health Organization, 2018), the global average of alcohol consumption per capita is 6.4 l of pure alcohol per year for adults over 15 years of age. While the consumption varies widely across regions, the consumption is highest (≥10 l per capita) in Europe (World Health Organization, 2018), with alcohol-related harms being particularly evident in Central and Eastern European countries (Rehm *et al*., 2007; Mackenbach *et al*., 2015; Trias-Llimós and Janssen, 2018). Alcohol consumption has been very high in Estonia, where it peaked at 14.8 l of pure alcohol per capita in 2007 (Estonian Institute of Economic Research, 2008). The consumption declined to approximately 12 l in 2009–2013 and has remained below 11 l since 2015 (Estonian Institute of Economic Research, 2018). Although Estonia is one of the few countries in The Organisation for Economic Co-operation and Development (OECD) where the average per capita consumption has fallen by more than 3 l during 2007–2017; the 10.3 l per capita is still higher than Organisation for Economic Co-operation and Development (OECD) average of 8.9 l in 2017 (OECD, 2019).

High alcohol consumption has had a substantial impact on population health in Estonia. The increase in alcohol consumption correlates with an increase in alcoholic liver cirrhosis mortality during 1992–2008 (Pärna and Rahu, 2010). Earlier studies have demonstrated that alcohol contributes substantially to health inequalities by education (Leinsalu *et al*., 2009) and ethnicity (Baburin *et al*., 2011), with significantly higher alcohol-related mortality among non-Estonians and those with lower levels of education. Trias-Llimós and Janssen (2008) found that alcohol-related deaths accounted for 6% of total mortality among men and 4.3% among women, respectively, with alcohol explaining approximately one-sixth of the gender gap in life expectancy in Estonia.

Epidemiological studies on alcohol consumption have often focused on age or period trends, whereas the cohort perspective has received relatively little research interest. Studying changes across birth cohorts might shed further light on the temporal and social patterns of alcohol consumption. If birth cohorts have differing levels of alcohol consumption, the related health harm at population level may vary substantially as these cohorts move through periods in their life course presenting different consumption patterns. Results from previous age–period–cohort (APC) analyses indicate that alcohol consumption trends are impacted by such cohort variations (Kerr *et al*., 2009; Meng *et al*., 2014; Kraus *et al*., 2015; Livingston **et al**., 2016; Radaev **et al**., 2018). These studies have reported that cohorts from 1950s to 1970s have generally higher alcohol consumption than more recent cohorts after controlling for age and period effects and other sociodemographic variables. Narrowing gender gap in alcohol consumption (Keyes *et al*., 2011; Slade *et al*., 2016) shows that experiencing the same social and historical events may affect cohort-specific drinking behaviour and influence the alcohol-related harms at the population level.

In this article, we will use the APC framework to study the temporal patterns of alcohol consumption in Estonia during 1996–2018. This period is characterized by large-scale macroeconomic fluctuations (Reile *et al*., 2014) and substantial changes in alcohol policy and taxation (Pärna, 2019) that may have affected alcohol consumption. The aim of the study is to analyse the independent effects of age, period and cohort on estimated daily alcohol consumption in Estonia.

METHODS

Data for this study came from the health behaviour surveys among the Estonian adult population, a series of cross-sectional postal surveys carried out biennially since 1990. The extended time period and even spacing of the survey years make this series well suited for the APC analyses focusing on long-term trends in alcohol consumption patterns. The current study covers data from 12 consecutive surveys in 1996–2018 that have used similar methodology and been based on nationally representative random samples of Estonian residents aged 16–64 years. Survey response rates have varied between 77% in 1996 and 51% in 2018. In total, data on 28,230 respondents (11,717 men and 16,513 women) aged 16–64 years were included in the analysis. All surveys have been approved by Tallinn Medical Research Ethics Committee; detailed information about the survey is available elsewhere (Reile *et al*., 2019).

Dependent variables were average daily alcohol consumption for (a) all alcoholic beverages in total; (b) beer, cider or long drinks; (c) wine and (d) strong liquors. The items were based on separate questions on the consumed amount in bottles, cans, glasses or shots during the past 7 days. These amounts were multiplied by their standard alcohol content (4.5% for light beers, ciders and long drinks; 5.5% for medium and 6.5% for strong beers and 12% for wines and 40% for liquors), specific gravity of alcohol (0.789) and divided by 7 to calculate the daily average consumption in grams of absolute alcohol. Given the skewed distribution, 0.1% of extreme values of total consumption variable by each sex and period strata (9 cases in total for men and 13 for women) were omitted as extreme outliers. Abstainers were included into analysis with a measure of 0 g of daily alcohol consumption.

Age, period and cohort were based on the respondents' age, survey year and respondents' year of birth. To reduce the linear dependency between these variables (e.g. period − age = birth cohort), different interval lengths of temporal variables were used. Respondents' age was aggregated into groups of 16–19, 20–29, 30–39, 40–49, 50–59 and 60–64 years. For period, two consecutive survey years were merged, resulting in six periods: 1996/1998, 2000/2002, 2004/2006, 2008/2010, 2012/2014 and 2016/2018. Cohort was defined by respondents' birth decade and classified as: 1930–1940s, 1950s, 1960s, 1970s, 1980s and 1990–2000s. As earlier and recent cohorts had considerably fewer respondents, we grouped two consecutive birth decades for those cohorts.

Other independent variables included sex, ethnicity and education. Sex was used as a stratifying variable. Respondents' self-reported ethnicity was categorized as: (a) Estonians and (b) other ethnicities. The highest level of completed education was dichotomized into categories of (a) tertiary and (b) less than tertiary education. The descriptive data of study sample summarized by age groups, periods, cohorts, educational level and ethnicity is given in Table 1.

Data analysis

Different methodological approaches and model specifications have been used in previous APC studies. While hierarchical or cross-classified random-effects models (CCREMs) (Yang and Land, 2016) are often used, we chose negative binomial regression with log-transformed outcomes similarly to several other previous APC studies on alcohol consumption (Kerr *et al*., 2013; Meng *et al*., 2014; Lui *et al*., 2018). The negative binomial regression is suitable for overdispersed count data (Payne *et al*., 2017) where excessive zero values can be found, as it is the case for alcohol consumption data. Mixed-effects negative binomial models were estimated using *menbreg* command in Stata 14.2 (Stata Corp., 2015). The results are presented as exponentiated coefficients that can be interpreted as incidence rate ratios (IRRs) along with 95% confidence intervals (95% CI). Model 1 includes variables of age, period and cohort, whereas Model 2 adjusts APC effects to variables of ethnicity and education. The results of estimated mean alcohol consumption (grams of absolute alcohol daily) from adjusted models are graphically presented in Fig. 1. All analyses were carried out for men and women separately.

RESULTS

The results of APC modelling on daily alcohol consumption among men are presented in Table 2. For total consumption, not only age and period but also cohort effects are evident. Compared to 60- to 64-year-old men, the overall consumption is significantly higher among 20- to 49-year-olds. Model estimates were only slightly affected when analysis was adjusted for ethnicity and education. Similar age pattern

Table 1. Description of study sample by period, age and cohort and independent variables

	Men ($n = 11{,}717$)	Women ($n = 16{,}513$)
Age		
16–19	932	1091
20–29	2394	3051
30–39	2416	3310
40–49	2434	3496
50–59	2358	3739
60–64	1183	1826
Period		
2016/2018	2145	3128
2012/2014	2288	3252
2008/2010	2510	3513
2004/2006	2449	3488
2000/2002	1078	1554
1996/1998	1247	1578
Cohort		
1930–1940s	1441	2254
1950s	2424	3743
1960s	2432	3437
1970s	2421	3259
1980s	2221	2826
1990–2000s	778	994
Ethnicity		
Estonian	8413	11,502
Other	3265	4974
Missing	39	37
Education		
Tertiary education	2297	4688
Secondary or lower	9365	11,739
Missing	55	86

was also observed for beer and wine: compared to the reference group, consumption is significantly higher in these age groups. Beer and other light beverages constitute approximately 60% of total daily alcohol intake across all age groups. For wine, the results were more affected by sociodemographic variables (Model 2), and its relative share of total daily consumption among men is relatively small. Age differences in strong liquor consumption are relatively modest, with significantly higher consumption found only for 40- to 49-year-old respondents compared to 60- to 64-year-olds.

Period effects indicate that total alcohol consumption among men has increased significantly over the study period, with later periods having higher consumption compared to the reference period of 1996/1998 (Table 2). The trend can be seen in Fig. 1, where the estimated daily mean of 11.5 g in 1996/1998 reached 15.2 g in the 2016/2018 data. Statistically significant increase in consumption can be seen for all types of beverages, but the increase took mostly place from 1996 to 2006 and has been stable since then (strong liquor) or slightly declined (beer and other light drinks). Consumption of wine is an exception as its consumption has significantly increased since 2004/2006.

Estimated alcohol consumption differed also by birth cohort, with men born in the 1990/2000s having significantly lower total daily consumption compared to men born in the 1960–1980s (Table 2). The mean daily consumption was highest (15.9 g daily) in the 1960s cohort and lowest (12.7 g daily) among the 1990/2000s cohort. When comparing different beverages, the cohort consumption patterns slightly differ (Fig. 1). Daily alcohol amounts for beer increased from the earliest cohort until peaking at 9.6 g in the 1980s cohort followed by a decline in the youngest cohort (7.8 g). Model estimates (Table 2) indicate that the latest cohort had significantly lower daily consumption of beer compared to those born in the 1970s and the 1980s. Those born in the 1990s or later had considerably lower daily consumption of wine and strong liquor compared to earlier cohorts, although the results were statistically not significant.

Table 3 presents the APC results on daily alcohol consumption for women. As with men, the overall consumption is significantly higher at younger ages, but the variation in daily amounts is substantially smaller. The overall consumption is highest in the 20- to 29-year-olds (4.6 g) and lowest (1.0 g) in the 60- to 64-year-olds (Fig. 1). The age effects differed by type of beverage, with women in their 20s and 40s having significantly higher daily consumption of both beer and strong liquor than the 60- to 64-year-olds. However, no significant age variation in consumption of wine was found in the data.

Period effects indicate that women's alcohol consumption has increased significantly since 1996/1998 (Table 3). The mean daily consumption was 2.9 g in 1996/1998 compared to 4.3 g in 2016/2018 data (Fig. 1). The change is especially evident not only for the consumption of wine (significantly higher in all later periods) but also for beer (in 2004–2010 and 2016/2018) and liquor (in 2004/2010). The latest period on 2016/2018 represents a decline in consumption for the latter cases.

Estimated alcohol consumption differed also by birth cohort, but contrary to men, women born in the 1990–2000s had a significantly higher total daily consumption than women born in the 1970s and those born before the 1960s. The mean daily consumption was highest (4.4 g daily) in the 1990–2000s cohort and lowest (2.9 g) in the 1930s–1940s cohort. The cohort differences are most evident for consumption of beer and other light drinks, whereas the differences for wine consumption were found only in comparison with the 1930–1940s cohort and for strong liquor with the 1970s/1980s cohorts.

The differences between unadjusted and adjusted models indicate that ethnicity and education contribute to APC patterns in alcohol consumption. Additional analysis (data not shown) demonstrated that the total alcohol consumption was lower for non-Estonian men compared to Estonian men (IRR 0.8 [0.8–0.9]), with non-Estonian men consuming less beer (IRR 0.66 [0.61–0.71] but more strong liquor (1.1 [1.0–1.2]) than Estonian men. For women, ethnic background did not affect the total alcohol consumption, but non-Estonian women consumed less beer and more strong liquor (IRR 0.9 [0.8–0.99] and 1.3 [1.2–1.5] correspondingly) than Estonian women. Similarly, educational background had a significant impact on alcohol consumption. For men, the total alcohol consumption was higher for those with less than tertiary education (IRR 1.2 [1.1–1.3]). These groups vary also by the type of alcohol consumed. Men with low education drank more beer and strong liquor (1.2 [1.1–1.3]) compared to men with high education, while high-educated men consumed more wine (1.5 [1.4–1.7]). For women, no statistically significant differences between educational groups were found, although beer and strong liquor prevailed in consumption patterns among the low-educated and wine drinking was dominant in high-educated groups.

DISCUSSION

This study explored the age, period and cohort variations of daily alcohol consumption in Estonia. Substantial age differences were

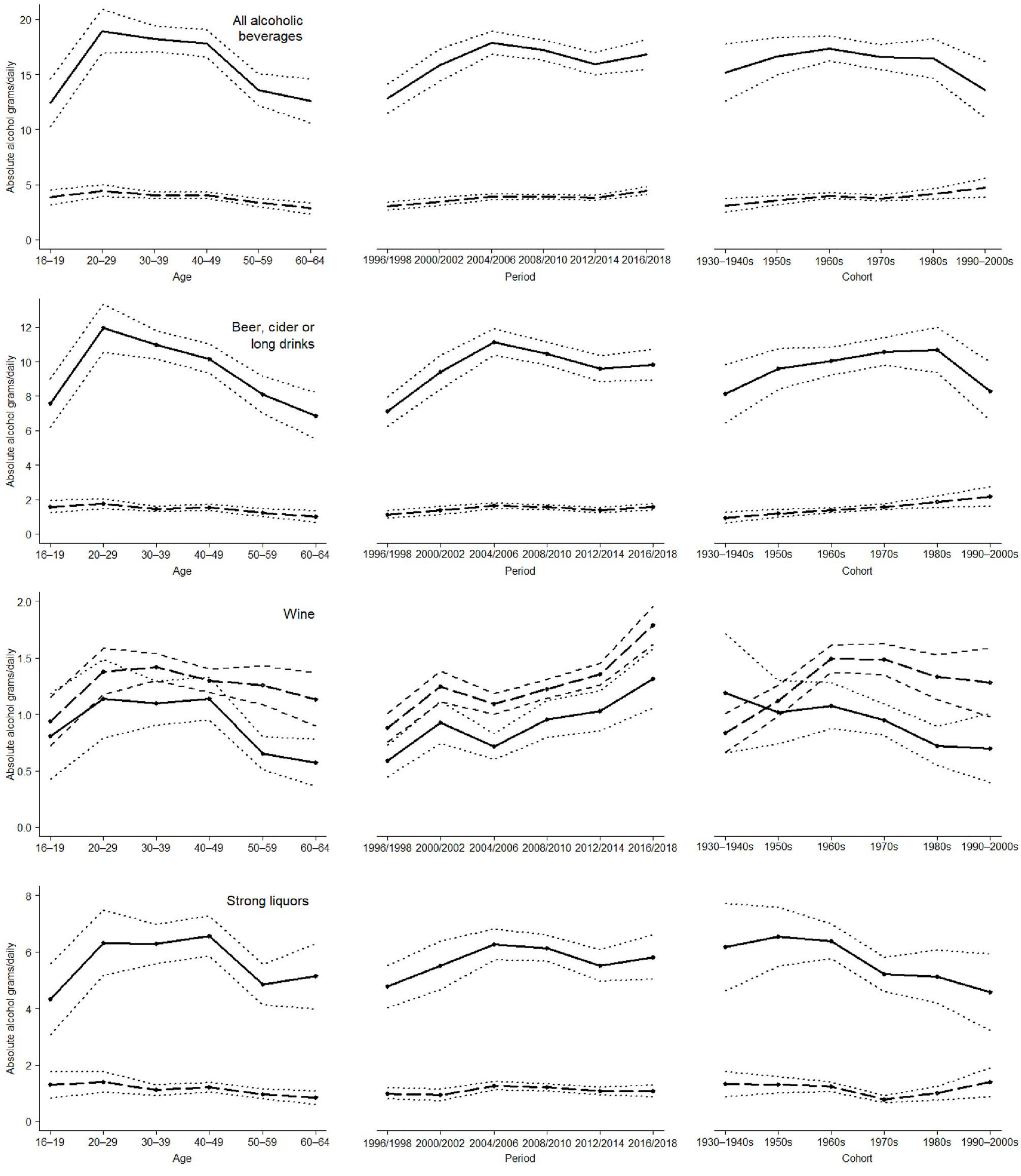

Fig. 1. Estimated mean daily alcohol consumption (grams of pure alcohol with 95% CI) by type of beverage for men (continuous line) and women (intermittent line) in Estonia.

found with alcohol consumption being highest at ages 20–29 years. The findings also suggest robust period effects indicating that total alcohol consumption and consumption of different types of beverages had increased significantly since the 1990s for both men and women. Independent from age and period, different cohort trends were found for men and women. Among men, the 1990/2000s cohort had significantly lower daily consumption compared to earlier cohorts, whereas women born in 1990s–2000s had a significantly higher total daily consumption than earlier cohorts.

Some limitations regarding the data and methods used need to be considered for interpretation of the findings. First, alcohol consumption is based on self-reports and could potentially be underreported. Although self-administered postal surveys have smaller social desirability bias than other survey modes (Bowling, 2005), the difference

Table 2. IRRs with 95% CIs for estimated age, period and cohort effects on daily alcohol consumption among men

	Total consumption		Beer and other light drinks		Wine		Liquor	
	Model 1[a]	Model 2[b]	Model 1[a]	Model 2[b]	Model 1[a]	Model 2[b]	Model 1[a]	Model 2[b]
Age								
16–19	1.03 (0.77–1.38)	0.99 (0.74–1.32)	1.13 (0.81–1.58)	1.10 (0.79–1.55)	0.92 (0.44–1.91)	1.41 (0.67–2.98)	0.91 (0.57–1.45)	0.84 (0.53–1.32)
20–29	1.53 (1.20–1.95)	1.50 (1.18–1.91)	1.74 (1.31–2.31)	1.74 (1.31–2.31)	1.52 (0.84–2.77)	2.00 (1.08–3.70)	1.27 (0.86–1.86)	1.23 (0.84–1.79)
30–39	1.46 (1.20–1.77)	1.44 (1.19–1.75)	1.60 (1.26–2.02)	1.60 (1.26–2.02)	1.76 (1.11–2.80)	1.93 (1.19–3.13)	1.26 (0.93–1.70)	1.22 (0.91–1.64)
40–49	1.43 (1.22–1.67)	1.41 (1.21–1.65)	1.49 (1.23–1.81)	1.48 (1.22–1.79)	1.72 (1.19–2.49)	2.00 (1.36–2.95)	1.32 (1.04–1.68)	1.27 (1.01–1.61)
50–59	1.09 (0.97–1.22)	1.08 (0.96–1.21)	1.19 (1.02–1.38)	1.18 (1.01–1.37)	1.16 (0.89–1.51)	1.15 (0.86–1.53)	0.97 (0.82–1.14)	0.94 (0.80–1.11)
60–64	1	1	1	1	1	1	1	1
Period								
2016/2018	1.32 (1.14–1.54)	1.31 (1.13–1.53)	1.41 (1.18–1.68)	1.38 (1.16–1.64)	2.46 (1.72–3.50)	2.24 (1.54–3.26)	1.13 (0.88–1.44)	1.22 (0.96–1.54)
2012/2014	1.27 (1.11–1.46)	1.24 (1.09–1.43)	1.40 (1.20–1.64)	1.35 (1.15–1.58)	1.84 (1.32–2.56)	1.76 (1.26–2.45)	1.10 (0.89–1.36)	1.16 (0.94–1.42)
2008/2010	1.37 (1.22–1.54)	1.34 (1.19–1.51)	1.52 (1.33–1.74)	1.47 (1.29–1.69)	1.65 (1.25–2.17)	1.63 (1.22–2.19)	1.22 (1.02–1.47)	1.29 (1.08–1.53)
2004/2006	1.42 (1.28–1.58)	1.40 (1.25–1.56)	1.61 (1.42–1.82)	1.57 (1.39–1.78)	1.32 (1.03–1.69)	1.22 (0.95–1.56)	1.27 (1.07–1.50)	1.31 (1.12–1.54)
2000/2002	1.25 (1.10–1.41)	1.24 (1.09–1.40)	1.37 (1.19–1.57)	1.32 (1.15–1.52)	1.59 (1.23–2.05)	1.58 (1.21–2.06)	1.09 (0.90–1.34)	1.15 (0.95–1.40)
1996/1998	1	1	1	1	1	1	1	1
Cohort								
1930–1940s	1.08 (0.79–1.49)	1.11 (0.81–1.53)	0.92 (0.64–1.33)	0.98 (0.68–1.42)	1.49 (0.67–3.30)	1.70 (0.76–3.79)	1.31 (0.80–2.16)	1.35 (0.83–2.21)
1950s	1.20 (0.92–1.55)	1.22 (0.94–1.59)	1.08 (0.81–1.45)	1.16 (0.86–1.55)	1.39 (0.73–2.64)	1.46 (0.76–2.79)	1.40 (0.93–2.13)	1.43 (0.95–2.16)
1960s	1.25 (1.01–1.56)	1.27 (1.02–1.59)	1.16 (0.91–1.49)	1.21 (0.95–1.55)	1.56 (0.90–2.72)	1.54 (0.89–2.65)	1.39 (0.98–1.97)	1.40 (0.99–1.97)
1970s	1.19 (1.00–1.43)	1.22 (1.02–1.46)	1.22 (1.00–1.48)	1.28 (1.05–1.55)	1.42 (0.95–2.12)	1.36 (0.89–2.07)	1.14 (0.86–1.50)	1.14 (0.87–1.51)
1980s	1.18 (1.02–1.37)	1.21 (1.04–1.40)	1.23 (1.05–1.44)	1.29 (1.10–1.51)	1.11 (0.80–1.55)	1.03 (0.73–1.45)	1.09 (0.86–1.39)	1.12 (0.89–1.42)
1990–2000s	1	1	1	1	1	1	1	1

[a]Model 1—unadjusted.
[b]Model 2—adjusted for ethnicity and education.

Table 3. IRRs with 95% CIs for estimated age, period and cohort effects on daily alcohol consumption among women

	Total consumption		Beer and other light drinks		Wine		Liquor	
	Model 1[a]	Model 2[b]	Model 1[a]	Model 2[b]	Model 1[a]	Model 2[b]	Model 1[a]	Model 2[b]
Age								
16–19	1.35 (0.99–1.84)	1.35 (0.99–1.84)	1.67 (1.01–2.75)	1.56 (0.94–2.59)	0.78 (0.53–1.14)	0.83 (0.57–1.20)	1.62 (0.91–2.90)	1.54 (0.86–2.77)
20–29	1.59 (1.22–2.08)	1.56 (1.19–2.05)	1.81 (1.15–2.84)	1.74 (1.10–2.77)	1.32 (0.96–1.82)	1.22 (0.89–1.67)	1.68 (1.02–2.78)	1.66 (1.00–2.77)
30–39	1.43 (1.15–1.79)	1.42 (1.13–1.77)	1.50 (1.02–2.21)	1.46 (0.98–2.17)	1.36 (1.06–1.75)	1.25 (0.97–1.61)	1.32 (0.89–1.96)	1.33 (0.89–1.99)
40–49	1.43 (1.19–1.71)	1.42 (1.18–1.70)	1.56 (1.13–2.16)	1.52 (1.09–2.12)	1.21 (0.99–1.48)	1.15 (0.94–1.40)	1.45 (1.07–1.96)	1.43 (1.05–1.95)
50–59	1.19 (1.04–1.37)	1.19 (1.04–1.37)	1.26 (0.97–1.63)	1.22 (0.94–1.59)	1.13 (0.96–1.31)	1.11 (0.95–1.30)	1.17 (0.94–1.46)	1.15 (0.92–1.45)
60–64	1	1	1	1	1	1	1	1
Period								
2016/2018	1.50 (1.28–1.76)	1.46 (1.24–1.72)	1.40 (1.09–1.80)	1.39 (1.08–1.80)	2.26 (1.86–2.76)	2.03 (1.67–2.48)	1.02 (0.75–1.39)	1.08 (0.78–1.48)
2012/2014	1.28 (1.11–1.47)	1.25 (1.09–1.44)	1.22 (0.98–1.52)	1.21 (0.97–1.52)	1.68 (1.41–2.00)	1.54 (1.29–1.83)	1.04 (0.80–1.35)	1.08 (0.83–1.40)
2008/2010	1.31 (1.15–1.48)	1.28 (1.13–1.46)	1.38 (1.14–1.69)	1.37 (1.12–1.67)	1.47 (1.25–1.72)	1.39 (1.19–1.64)	1.17 (0.93–1.46)	1.22 (0.97–1.52)
2004/2006	1.31 (1.16–1.47)	1.29 (1.14–1.45)	1.46 (1.21–1.76)	1.44 (1.19–1.74)	1.28 (1.10–1.50)	1.24 (1.06–1.45)	1.26 (1.03–1.55)	1.28 (1.04–1.57)
2000/2002	1.16 (1.01–1.32)	1.14 (1.00–1.31)	1.22 (1.00–1.49)	1.21 (0.99–1.49)	1.42 (1.22–1.66)	1.42 (1.21–1.66)	0.92 (0.70–1.20)	0.94 (0.72–1.24)
1996/1998	1	1	1	1	1	1	1	1
Cohort								
1930–1940s	0.68 (0.48–0.95)	0.66 (0.47–0.93)	0.44 (0.26–0.74)	0.44 (0.26–0.74)	0.73 (0.48–1.09)	0.65 (0.44–0.97)	0.96 (0.51–1.82)	0.95 (0.50–1.81)
1950s	0.77 (0.59–1.01)	0.76 (0.58–0.99)	0.55 (0.37–0.83)	0.55 (0.37–0.83)	0.94 (0.68–1.31)	0.87 (0.63–1.21)	0.97 (0.57–1.65)	0.93 (0.54–1.60)
1960s	0.86 (0.69–1.07)	0.85 (0.68–1.05)	0.63 (0.46–0.86)	0.63 (0.46–0.86)	1.25 (0.94–1.65)	1.17 (0.89–1.54)	0.91 (0.58–1.41)	0.88 (0.57–1.37)
1970s	0.81 (0.68–0.96)	0.80 (0.67–0.95)	0.73 (0.57–0.92)	0.73 (0.57–0.93)	1.22 (0.97–1.53)	1.16 (0.93–1.45)	0.59 (0.42–0.84)	0.56 (0.39–0.80)
1980s	0.89 (0.78–1.02)	0.88 (0.77–1.01)	0.85 (0.71–1.01)	0.86 (0.73–1.03)	1.10 (0.93–1.31)	1.04 (0.88–1.23)	0.72 (0.55–0.94)	0.72 (0.55–0.94)
1990–2000s	1	1	1	1	1	1	1	1

[a]Model 1—unadjusted.
[b]Model 2—adjusted for ethnicity and education.

between the actual and reported consumption cannot be controlled for in our data. However, the standardized survey methodology and only minor changes in the wording of alcohol questions could ensure that the reporting bias is comparable across study waves. The overall response rates have been declining throughout the survey years, but as the additional analysis (data not shown) using weighted data did not alter the results, unweighted crude data were used for the final analysis. Another set of considerations relate to the APC methodology. More specifically, the estimation of independent effects of age, period and cohort is complicated by the linear association between the variables that results in non-unique regression coefficients. We used a common solution to this 'identification problem' by grouping the items into time intervals of different lengths to allow fitting fixed-effects regression models. Additional sensitivity analyses were carried out using both negative binomial regression in generalized linear model procedure and classified random-effects models (CCREMs) with age-squared specified (along with ethnicity and education) as fixed-effects and period and cohort variables were estimated as random-effects in SAS Studio 3.8. As the results of unadjusted models proved to be generally robust, initial modelling strategy was deemed to be suitable for the study.

Similarly to previous APC studies (Kerr *et al*., 2009; Meng *et al*., 2014; Kraus *et al*., 2015), we found distinct age pattern in alcohol consumption. For men, the total alcohol consumption peaked at ages 20–29 after which the daily amounts declined. Similar pattern was found also for beer, whereas for wine and liquor, the consumption remained high up to age 50. For women, higher consumption was also found at younger ages, yet the age differences were subtler and consumed quantities were substantially smaller than for men. The exception was wine that constituted nearly half of women's total alcohol consumption with women consistently demonstrating higher levels of drinking. This beverage specific pattern is well known as wine is generally preferred over beer or strong liquor by women and by those with higher income and education (Heckley *et al*., 2017). In general, age effects on alcohol consumption reflect the life course patterns, with alcohol use increasing as people enter adolescence and adulthood, followed by a decline as they get older. An encouraging trend in this respect is the increase of abstainers among male respondents in the youngest age groups (data not shown).

Period effects indicate that total alcohol consumption for both men and women has generally increased over the study period. The trend has not been linear as total alcohol consumption declined between 2004/2006 and 2012/2014 but increased in 2016/2018, particularly markedly among women. This roughly corresponds to official sales trends that have increased from 1990s onwards with a peak in 2007 at 14.8 l of pure alcohol per capita (Estonian Institute of Economic Research, 2008) and with a gradual decline afterwards (Estonian Institute of Economic Research, 2018). Estonian anti-alcohol policy since 2005 has been characterized by a rapid increase of alcohol excise duties, resulting in increase in retail prices. Excise tax on alcohol was increased on four occasions since 2005 for all alcoholic beverages. The highest tax increase (30% altogether) was implemented in 2008 and coincided with the beginning of the economic crisis. Both tax increase and collapsing economy resulted in substantial decrease in alcohol affordability (Lai and Habicht, 2011). Subsequent tax increases have resulted in doubling of alcohol retail prices between 2006 and 2017 (Parna, 2019). In 2017, the increase in alcohol retail prices exceeded both the increase of general consumer prices and increase of average net salary (Estonian Institute of Economic Research, 2018). The changes in alcohol sales and affordability are also reflected in our individual-level period data, especially in the case of men whose higher overall alcohol consumption makes them more sensitive to affordability. Although period effects in alcohol consumption are often dependent on the national alcohol policy, alcohol consumption has decreased in majority of CEE countries (Trias-Llimos *et al*., 2018). This is also reported in an APC study from Russia (Radaev and Roshchina, 2018), where changes in alcohol preferences (substitution of strong liquors with beer) and also increasingly restrictive alcohol policy were attributable to period effects in alcohol consumption.

Independent from age and period, different cohort patterns were found for both men and women. Among men, consumption was highest for those born in the 1960s and was lower in subsequent cohorts, especially among those born in the 1990s and the 2000s. Among women, the daily alcohol use was highest among the youngest cohort compared to other birth cohorts. The converging gap in alcohol consumption between men and women found in this study accords with earlier research. For example, the systematic review by Slade *et al*. (2016) revealed that although traditionally women drink less alcohol than men, the difference is narrowing mainly due to increased consumption among women in the youngest cohorts (born between the 1980s and the 2000s). Despite of the converging trends, the difference in daily alcohol amounts between men and women was 3-fold. While consumption of wine and strong liquor among men has declined in birth cohorts born after the 1960s, the consumption of beer was at highest in the 1980s cohort. It is plausible that lighter alcohol (especially beer) has substituted strong liquor in the 1980s birth cohort among men. For women, every following birth cohort has increased consumption of beer, while wine consumption increased considerably in the 1960s cohort and has not declined significantly afterwards. After being at the lowest in the cohort of 1970s, the consumption of strong liquor among women has started to increase in younger cohorts. While the latter supports the finding from Keyes *et al*. (2011) that younger birth cohorts are engaged in more episodic and problem drinking, the overall cohort trends seem to be comparable to earlier studies (Bratberg *et al*., 2016; Radaev and Roshchina, 2018).

Substantial sex differences in consumed alcohol amounts found in this study are also reflected in the temporal patterns of alcohol-related harm in Estonia. The predicted average consumption of total alcohol during the survey period for men was more than 16 g of pure alcohol per day, whereas the amount consumed by women was about four times smaller. Although the gender gap in life expectancy has decreased from 11.3 years in 1996 to 8.5 years in 2018 (Statistics Estonia, 2019), the alcohol-attributable mortality contributed to more than 17% of this difference in 2012 (Trias-Llimos *et al*., 2018). Our results also indicated that although total alcohol consumption was lower for non-Estonians (did not differ among women), they consumed more strong liquors than Estonians. It is possible that higher consumption of strong liquors among non-Estonians indicates more hazardous drinking patterns (Rochelle *et al*., 2015). A study in Wales found that an increase in unit of spirits consumed was positively associated with a higher risk of alcohol-related hospital admission and the risk was higher compared to other beverages (Gartner *et al*., 2019). This may also explain why non-Estonian men and women have a higher level of alcohol-related mortality compared to Estonians (Baburin *et al*., 2011). We also found that those with lower than tertiary education had a higher overall daily consumption and were more likely to drink strong liquors. A higher mortality risk from alcohol-attributable causes is associated with lower education status, especially in Eastern Europe, with Estonia displaying extensive mortality gap by education in both men and women (Mackenbach *et al*., 2015). This pattern is similar to recent analysis from USA (Lui *et al*., 2018), where volume of consumed alcohol increases with the level of education while heavier drinking was associated with lower education. Although these sociodemographic factors clearly contribute to the alcohol consumption pattern at population level, the independent effects of age, period and cohort persisted after taking account the effect of these factors in our data.

While the age-related effects in the total amounts and beverage preferences are aligned with life course stages, the alcohol consumption has increased over the study period with a temporary decline during the economic recession. Independent from age and period, the cohort trends suggest convergence of alcohol consumption patterns for men and women. This is also **one of** the main policy implications of the study as increasing consumption among women—visible as both period and cohort effects—is a potential public health challenge for the near future. Encouraging example of successful intervention policies comes from Lithuania, where alcohol-related and all-cause mortality along with alcohol-attributable burden of disease has substantially declined after the implementation of broad-scale measures to reduce alcohol consumption, more recently including all WHO 'best buy' policies (Rehm et al., 2019).

DATA AVAILABILITY

Data available on request.

CONFLICTS OF INTEREST STATEMENT

None declared.

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