

Economic cycles and inequalities in alcohol-related mortality in the Baltic countries and Finland in 2000–2015: a register-based study

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ABSTRACT

Aim To estimate whether large macroeconomic fluctuations in the 2000s affected inequalities in alcohol-related mortality in the Baltic countries and Finland. **Design** Longitudinal register-based follow-up study. **Setting** Estonia, Latvia, Lithuania and Finland. **Participants** General population in the 35–74 age group. **Measurements** Socioeconomic status was measured by the highest achieved educational level and was categorised using the International Standard Classification of Education 2011 as low (included categories 0–2), middle (3–4), and high (5–8). Educational inequalities in alcohol-related mortality in 2000–2003, 2004–2007, 2008–2011 and 2012–2015 were examined using census-linked longitudinal mortality data. We estimated age-standardised mortality rates and the relative and slope index of inequality. **Findings** Alcohol-related mortality increased in all countries in 2004–2007 except among Estonian women and decreased/remained the same from 2008 onward except among Latvian men. By 2012–2015 alcohol-related mortality was still higher than in 2000–2003 in Finland, Latvia and Lithuania (women only). Relative inequalities increased across the study period in all countries (significantly in Lithuania and Latvia). The 2004–2007 increase in relative inequalities was mostly driven by a larger mortality increase among the low educated, whereas in 2008–2011 and in 2012–2015 inequalities often increased because of a larger relative mortality decline among the high educated. However, these period changes in relative inequalities and between educational groups were often not statistically significant. Absolute inequalities were larger in 2012–2015 versus 2000–2003 in all countries except Estonia (decrease). **Conclusion** In the Baltic countries and Finland, alcohol-related mortality tended to increase faster among the low educated during a period of economic expansion (2004–2007) and decrease more among the high educated during a period of economic recession (2008–2011).

Keywords Alcohol-related mortality, economic expansion, education, inequalities, recession, register-based.

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INTRODUCTION

Research has linked macroeconomic fluctuations to both changes in mortality and socioeconomic inequalities in mortality [1,2]. In particular, economic change has been associated with variations in alcohol-related mortality [3]. An earlier study covering 26 European Union (EU) countries found that a large rise in unemployment ($\geq 3\%$)

was associated with a significant increase in deaths from alcohol abuse [4].

Despite this research, there are still important gaps in the literature concerning the association between macroeconomic fluctuations and changes in alcohol-related mortality. For example, until now there has been an absence of cross-country research on the effects of macroeconomic fluctuations on social inequalities in

alcohol-related mortality. Rather, studies that have examined across-time changes in socioeconomic differences in alcohol mortality have either ignored the economic context [5], focused primarily on alcohol affordability [6], or examined the effects of macroeconomic change within a single country [7], even though relative and absolute inequalities in alcohol-related mortality vary within and between countries over time [8]. Moreover, two studies that have been undertaken to date have suggested that there may be differences in the association between countries and/or time periods. Specifically, recent research from Spain concluded that the effects of the great recession on alcohol-attributable mortality were not worse among those in lower socioeconomic positions in 2008–2011 [9], whereas an earlier study from Finland highlighted the greater growth and then smaller decrease in alcohol-related mortality among (unspecialised) blue-collar workers in a period of economic boom and then recession (1987–1995) [3]. Given this, understanding how economic cycles might be linked to socioeconomic inequalities in alcohol mortality might be important for future efforts to reduce alcohol-related harm, which has recently been described as a public health imperative by the World Health Organisation [10].

The current study examines the association between macroeconomic fluctuations and educational inequalities in alcohol-related mortality in the Baltic countries (Estonia, Latvia and Lithuania) and Finland in 2000–2015. These countries provide a potentially informative setting to examine these associations. The Baltic countries experienced huge macroeconomic changes in the 2000s: *per capita* gross domestic product (GDP) increased more than 4-fold between 2000 and 2008, while in Finland, *per capita* GDP more than doubled in the same period (see Supporting information Fig. S1). In all countries, the annual growth rate accelerated in the second half of this period. Subsequently, *per capita* GDP decreased sharply following the global financial crisis. With >20% average reduction in *per capita* GDP from 2008 to 2009, the Baltic countries were among the most affected in Europe. In Finland the decrease was ~12%. *Per capita* GDP had surpassed its pre-recession levels by 2013 in Estonia and Lithuania but pre-recession levels had still not been attained in Finland and Latvia by 2015 [11]. A focus on education as a measure of socioeconomic inequality is warranted given that previous research in these countries has suggested that educational differences may exist in both harmful alcohol consumption [12] and alcohol-related mortality [13]. Research from earlier periods has shown that alcohol-related mortality is an important component of total mortality in these countries and that relative and absolute educational inequalities in alcohol-related deaths

have increased over time [8], with alcohol-related mortality now making an important contribution to socioeconomic differences in life expectancy [14].

The aim of this study was to examine changes in alcohol-related mortality in the Baltic countries and Finland in the context of large macroeconomic fluctuations in 2000–2015. We first assessed the changes in overall alcohol-related mortality and its contribution to all-cause mortality. We evaluated how alcohol-related mortality changed in different educational groups and how these changes affected both absolute and relative inequalities in alcohol-related mortality and their contribution to inequalities in total mortality.

METHODS

Data

Data for Estonia, Latvia and Lithuania come from longitudinal mortality follow-up studies of population censuses in 2000 (2001 in Lithuania) and 2011, encompassing all permanent residents. The censuses in the Baltic countries combined traditional survey-based enumeration (the share of coverage varied from 91% in Latvia to 98% in Estonia) and register-based enumeration [15]. The register-based data did not include information about socioeconomic status and were therefore excluded from the analysis. All individuals were followed from the census date until the date of death or emigration or until the end of the follow-up period. The date and cause of death were linked from national mortality registries with 95%–98% of deaths being successfully matched to census records. All data linkages were performed by National Statistical Offices. Data for Finland were obtained from the longitudinal register-based population data file of Statistics Finland covering the total population during the study period. Data were organised into four sub-periods to capture periods of distinct macroeconomic development: 2000–2003 (moderate economic growth), 2004–2007 (economic expansion), 2008–2011 (recession) and 2012–2015 (stabilisation). The population exposures were calculated by adding up the number of person years lived by each individual within each 5-year age interval during a given period. Deaths were allocated to age intervals using the age at death. Data were anonymised and aggregated into multidimensional frequency tables combining deaths and population exposures split by study periods and sociodemographic variables before they were delivered for research purposes. This study included persons in the 35–74 age group to achieve optimal accuracy in determining socioeconomic status and in causes of death classification.

Variables

Causes of death were classified using the 10th revision of the International Classification of Diseases (ICD-10). Alcohol-related mortality was measured by a combined group of directly alcohol attributable causes of death including mental disorders because of alcohol (ICD-10 code F10), alcohol-related diseases of the nervous system (G31.2, G62.1, G72.1), alcoholic cardiomyopathy (I42.6), alcoholic cirrhosis of the liver (K70), alcohol induced pancreatitis (K85.2, K86.0) and accidental poisoning by alcohol (X45). We also included non-alcoholic liver cirrhosis (K74) because a large proportion of these deaths can be alcohol-related [16]. Detailed mortality data for selected alcohol-related causes of death are presented in Supporting information Tables S1 and S2.

Demographic and socioeconomic data were retrieved from census records and were coded by Statistical Offices following a common study protocol. Socioeconomic status was measured by the highest achieved educational level categorised using the International Standard Classification of Education (ISCED) 2011 [17]. Low education refers to primary and lower secondary education corresponding to ISCED categories 0–2, middle education includes upper secondary and post-secondary non-tertiary education (categories 3–4), and high education covers tertiary education (categories 5–8).

Analysis

Changes in overall and education-specific alcohol-related mortality were examined using age-standardised mortality rates per 100 000 person years (ASMRs), calculated by using the European Standard Population [18]. Percentage differences were calculated between consecutive study periods and between the first and the last period to assess overall change. Interaction tests were performed between period and education to assess whether the period effect differed by educational level, using Poisson regression. Relative and absolute inequalities in alcohol-related mortality were measured using the relative index of inequality (RII) and slope index of inequality (SII) [19]. The RII and SII are regression-based measures that adjust the relative position of each educational group to its share in the population, therefore, taking into account differences between countries or time-periods in the population distribution by educational level. The relative position is assessed with educational rank, a cumulative proportion of each educational group within the educational hierarchy, with 0 (for the highest educated) and 1 (for the lowest educated) as the extreme values on the rank order. The age-adjusted RIIs were calculated with Poisson regression with educational rank as an independent variable. The RII can be interpreted as a mortality rate ratio comparing those with

the very lowest educational level to those with the very highest educational level. The SII per 100 000 person years measures the absolute mortality rate differences between the lowest and highest end of the educational hierarchy. The SIIs were calculated from the RIIs and the overall ASMRs by using the formula $SII = 2 * ASMR * (RII - 1) / (RII + 1)$. To assess the magnitude and direction of the potential bias relating to the exclusion of register-based data from census records in the Baltic countries we performed a sensitivity analysis for Latvia comparing overall mortality estimates while excluding and including register-based data.

All analyses were performed separately for men and women as an interaction test between gender and the predictor variables (education and period) indicated that there was a differential gender effect on the associations between the predictor variables and alcohol-related mortality (data not shown). Statistical testing of differences between study periods was performed for all measurements and exact *P* values were added to the tables; the level of statistical significance was set at $P < 0.05$. Statistical analyses were conducted using SPSS Statistics for Windows, version 26.0 (IBM Corp. 2019) and STATA 14.2 (StataCorp). The full study protocol was not pre-registered on a publicly available platform and therefore, the results should be considered exploratory.

RESULTS

Characteristics of the study populations are presented in Tables 1 and 2. In total, the study covered nearly 65 000 alcohol-related deaths and 92 million person years. The percentage of missing education data was between 0% and 0.7% and all cases with missing values were excluded from the analysis. In all countries, the percentage of the highly educated increased in 2000–2015 and was higher among women.

In 2000–2003, the ASMRs per 100 000 person years for alcohol-related mortality ranged from 86.0–149.9 among men to 22.7–49.0 among women and were highest in Estonia (Tables 1 and 2). Between 2000–2003 and 2004–2007, alcohol-related mortality increased substantially in all countries, except for Estonian women; the increase was largest in Lithuania (61% among men; 78% among women). From 2004–2007 to 2008–2011, alcohol-related mortality declined in Finland (men only), Estonia and Lithuania, but increased among Latvian men. From 2008–2011 to 2012–2015, alcohol-related mortality continued to decline in Finland, Estonia and Lithuania. Despite these positive changes, the alcohol-related ASMRs remained higher in 2012–2015 compared with 2000–2003 in Finland, Latvia and Lithuania (women only); the ASMRs had declined in Estonia. In all countries, the percentage of alcohol-related deaths among

Table 1 Characteristics of the study populations and changes in alcohol-related mortality in 2000–2015 among men in the 35–74 age group.

Country	Period	Alcohol-related deaths		Person		Educational level			Alcohol-related mortality			ASMR in total mortality	
		<i>n</i>	<i>n</i>	<i>n</i>	<i>years</i>	High %	Middle %	Low %	Missing %	ASMR (95% CI)	Diff. %	<i>P</i> value	%
Finland	2000–2003	4420	5 119 923	26.0	36.0	37.9	0.0	86.0 (83.5–88.6)	–	–	–	–	9.0
	2004–2007	5902	5 192 099	27.6	38.9	33.6	0.0	110.4 (107.6–113.3)	28.4	<0.001	28.4	<0.001	12.4
	2008–2011	5890	5 214 194	28.2	41.9	29.9	0.0	106.3 (103.6–109.1)	–3.7	0.042	–3.7	0.042	13.1
	2012–2015	5376	5 404 134	31.5	42.8	25.7	0.0	91.6 (89.1–94.1)	–13.8	<0.001	–13.8	<0.001	12.9
	Diff. 2012–2015 vs 2000–2003								6.5	0.002	6.5	0.002	<i>P</i> value (0.016)
Estonia	2000–2003	1582	1 068 749	26.2	44.7	29.2	0.7	149.9 (142.6–157.5)	–	–	–	–	7.8
	2004–2007	1892	1 127 925	26.7	49.0	24.3	0.7	169.3 (161.7–177.1)	12.9	<0.001	12.9	<0.001	9.5
	2008–2011	1487	1 124 020	26.7	52.2	21.0	0.7	132.4 (125.8–139.3)	–21.8	<0.001	–21.8	<0.001	9.1
	2012–2015	1320	1 155 961	31.6	49.9	18.6	0.3	113.4 (107.4–119.7)	–14.4	<0.001	–14.4	<0.001	9.1
	Diff. 2012–2015 vs 2000–2003								–24.3	<0.001	–24.3	<0.001	<i>P</i> value (0.238)
Latvia	2000–2003	1521	1 690 418	15.9	54.8	29.3	0.6	90.5 (86.0–95.2)	–	–	–	–	4.5
	2004–2007	1927	1 766 037	16.1	59.4	24.5	0.6	110.5 (105.6–115.5)	22.0	<0.001	22.0	<0.001	5.4
	2008–2011	2044	1 749 112	16.0	62.4	21.6	0.5	117.7 (112.6–122.9)	6.6	0.047	6.6	0.047	6.7
	2012–2015	1906	1 660 547	21.5	65.4	13.1	0.1	113.7 (108.7–119.0)	–3.4	0.285	–3.4	0.285	7.3
	Diff. 2012–2015 vs 2000–2003								25.6	<0.001	25.6	<0.001	<i>P</i> value (<0.001)
Lithuania	2001–2003	1788	2 065 146	16.9	56.4	26.7	0.5	89.6 (85.4–93.9)	–	–	–	–	5.6
	2004–2007	4142	2 944 194	16.9	60.4	22.6	0.5	144.4 (140.0–148.9)	61.2	<0.001	61.2	<0.001	7.5
	2008–2011	3687	2 947 743	17.2	63.9	18.9	0.5	127.1 (123.0–131.3)	–12.0	<0.001	–12.0	<0.001	7.5
	2012–2015	2541	2 710 316	21.2	62.1	16.6	0.0	93.1 (89.5–96.8)	–26.8	<0.001	–26.8	<0.001	6.4
	Diff. 2012–2015 vs 2001–2003								3.9	0.215	3.9	0.215	<i>P</i> value (0.407)

The follow-up in the 1st period started from the census date in the Baltic countries (i.e. 31/03/2000 in Estonia, 1/03/2000 in Latvia, and 6/04/2001 in Lithuania), and on all other occasions, the follow-up started on 1 January and ended on 31 December in respective periods. ASMR = age-standardised mortality rate per 100 000 person years; CI = confidence interval; Diff. = differences; Diff. and *P* values of the differences are calculated in comparison with the preceding period or between the last and the first period.

Table 2 Characteristics of the study populations and changes in alcohol-related mortality in 2000–2015 among women in the 35–74 age group.

Country	Period	Alcohol-related deaths		Person years		Educational level			Alcohol-related mortality			ASMR in total mortality	
		n	n	n	n	High %	Middle %	Low %	Missing %	ASMR (95% CI)	Diff. %	P value	%
Finland	2000–2003	1209	5 283 508	28.3	34.3	37.4	0.0	22.7 (21.4–24.0)	–	–	–	–	5.4
	2004–2007	1695	5 322 211	31.7	36.3	32.0	0.0	30.6 (29.1–32.1)	34.8	<0.001	–	<0.001	7.8
	2008–2011	1686	5 330 776	34.1	38.3	27.6	0.0	29.3 (27.9–30.8)	–4.2	0.238	–	0.238	8.0
	2012–2015	1639	5 506 591	40.0	38.4	21.6	0.0	26.5 (25.2–27.9)	–9.6	0.004	–	0.004	7.8
	Diff. 2012–2015 vs 2000–2003								16.7	<0.001	–	<0.001	P value (0.229)
Estonia	2000–2003	659	1 358 776	33.6	42.4	24.1	0.5	49.0 (45.3–53.0)	–	–	–	–	6.9
	2004–2007	711	1 426 376	36.0	45.2	18.8	0.5	49.5 (45.9–53.3)	1.0	0.865	–	0.865	8.1
	2008–2011	564	1 404 552	37.5	47.7	14.8	0.5	38.8 (35.6–42.2)	–21.6	<0.001	–	<0.001	7.6
	2012–2015	454	1 380 875	44.5	43.4	12.0	0.2	31.6 (28.7–34.7)	–18.6	0.001	–	0.001	7.0
	Diff. 2012–2015 vs 2000–2003								–35.5	<0.001	–	<0.001	P value (1.000)
Latvia	2000–2003	659	2 218 112	18.4	55.5	26.1	0.4	28.9 (26.7–31.3)	–	–	–	–	3.8
	2004–2007	879	2 303 910	19.6	59.8	20.6	0.4	37.9 (35.4–40.5)	31.1	<0.001	–	<0.001	5.0
	2008–2011	794	2 252 541	20.4	63.1	16.5	0.3	34.7 (32.3–37.2)	–8.4	0.073	–	0.073	5.3
	2012–2015	716	2 092 289	31.5	58.6	9.9	0.0	33.2 (30.8–35.8)	–4.3	0.418	–	0.418	5.6
	Diff. 2012–2015 vs 2000–2003								14.9	0.012	–	0.012	P value (0.128)
Lithuania	2001–2003	724	2 578 589	18.6	55.6	25.8	0.4	28.5 (26.5–30.7)	–	–	–	–	5.0
	2004–2007	1804	3 596 069	19.6	59.7	20.8	0.5	50.8 (48.4–53.2)	78.2	<0.001	–	<0.001	7.5
	2008–2011	1549	3 578 538	20.4	64.0	15.6	0.5	43.6 (41.4–45.8)	–14.2	<0.001	–	<0.001	7.1
	2012–2015	1134	3 302 820	27.9	59.3	12.7	0.0	33.5 (31.6–35.6)	–23.2	<0.001	–	<0.001	6.4
	Diff. 2012–2015 vs 2001–2003								17.5	<0.001	–	<0.001	P value (0.399)

The follow-up in the 1st period started from the census date in the Baltic countries (i.e. 31/03/2000 in Estonia, 1/03/2000 in Latvia, and 6/04/2001 in Lithuania) on all other occasions the follow-up started on 1 January and ended on 31 December in respective periods. ASMR = age-standardised mortality rate per 100 000 person years; CI = confidence interval; Diff. = differences; Diff. and P values of the differences are calculated in comparison with the preceding period or between the last and the first period.

all deaths slightly increased from 2000–2003 to 2012–2015, although the increase was statistically significant only among men in Finland and Latvia.

Among men, alcohol-related mortality increased from 2000–2003 to 2004–2007 in all educational groups in Finland and Lithuania, whereas in Latvia it increased among the middle and low educated, and in Estonia among high and middle educated individuals (Table 3). In Finland, Latvia and Lithuania, the percentage increase was largest among low educated men; in Estonia the increase was largest among the middle educated. Between 2004–2007 and 2008–2011, alcohol-related mortality decreased among all educational groups in Estonia, among the high and middle educated in Lithuania, among the high educated in Finland, whereas it increased among middle educated men in Latvia. In Finland and Lithuania, the decline was largest among the high educated; in Estonia it was largest among the middle and high educated. From 2008–2011 to 2012–2015, alcohol-related mortality declined in all educational groups in Lithuania, among the middle and low educated in Finland and among the middle educated in Estonia. Across the whole study period, the low educated had a less favourable mortality trend compared to the high and middle educated in all countries except in Latvia. Interaction tests showed that differential period effects were often not statistically significant (Supporting information Table S3).

Among women, alcohol-related mortality increased between 2000–2003 and 2004–2007 in all educational groups in Finland and Lithuania, and among the middle and low educated in Latvia (Table 4). In Finland, the mortality increase was largest among the low educated, in Lithuania it was largest among the high educated, and in Latvia among the middle educated. From 2004–2007 to 2008–2011, alcohol-related mortality decreased significantly among middle educated women in Estonia and Lithuania. Although the mortality changes in all other groups were not statistically significant, a small increase in mortality was observed among low educated women in Finland, Latvia and Lithuania that was in contrast to the mortality decline seen among the high and middle educated in these countries. After 2008–2011, alcohol-related mortality declined in Lithuania in all educational groups, with the largest decline observed among high educated women. At the same time, alcohol-related mortality increased among middle educated women in Latvia. Across the whole study period, high educated women had a more favourable mortality trend in all countries but Estonia. With few exceptions, the differential period effects were not statistically significant (Supporting information Table S4).

A strong educational gradient in alcohol-related mortality was found in all countries (Table 5). The RIIs, measuring the relative inequalities in mortality between the

very lowest and the very highest educational level, increased in all countries between 2000–2003 and 2012–2015, although statistically significantly only in Lithuania and Latvia (among women). In 2012–2015 the RIIs ranged from 4.1–4.2 (among men) to 7.6–8.8 (among women) in the Baltic countries. In Finland, the RIIs among men and women were 3.6 and 5.4, respectively. The upward trend was interrupted on a few occasions when RIIs declined in 2004–2007 in Estonia and Latvia (women only), in 2008–2011 in Latvia (men only) and in 2012–2015 in Finland. Excepting Latvian and Lithuanian men in 2008–2011, the changes between periods were not statistically significant. Absolute inequalities increased between 2000–2003 and 2012–2015 in all countries but Estonia, where SIIs gradually decreased. In Finland, Latvia and Lithuania, most of the SIIs increase occurred in 2004–2007; In Finland and Lithuania they remained approximately the same in 2008–2011 and fell thereafter. In 2012–2015, SIIs per 100 000 person years ranged from 49–53 (among women) to 115–139 (among men) in the Baltic countries. In Finland, the respective SIIs were 36 and 103. In 2012–2015, alcohol-related deaths contributed 7% to 15% (among men) and 8% to 11% (among women) to inequalities in total mortality.

The results from the sensitivity analyses showed that by excluding register-based records we somewhat underestimated alcohol-related mortality in Latvia with a larger effect observed among women (Supporting information Table S5). At the same time, the effect on changes between periods was minimal.

DISCUSSION

This study examined changes and inequalities in alcohol-related mortality in the Baltic countries and Finland in a period of rapid economic change. When the economy was expanding alcohol-related mortality increased considerably in most countries in 2004–2007, whereas it decreased or remained the same during recession/stabilisation from 2008 onward. Relative educational inequalities in alcohol-related mortality increased from 2000–2003 to 2012–2015 in all countries (significantly in Lithuania and Latvia). The increase in relative inequalities in 2004–2007 was mostly driven by a larger mortality increase among the low educated, whereas in 2008–2011 and in 2012–2015 inequalities often increased because of a larger relative mortality decline among the high educated. However, the period changes in relative inequalities and between educational groups were often not statistically significant. Absolute inequalities increased by 2012–2015 in all countries except Estonia where they had gradually decreased.

Before discussing the main findings of this study, several limitations need to be considered. First, although our

Table 3 Alcohol-related mortality by educational level in 2000–2015 among men in the 35–74 age group.

Country	Period	Educational level					
		High			Middle		
		ASMR (95% CI)	Diff., %	P value	ASMR (95% CI)	Diff., %	P value
Finland	2000–2003	45.5 (41.8–49.5)	–	–	90.1 (85.4–95.0)	–	–
	2004–2007	56.7 (52.9–60.8)	24.6	<0.001	116.8 (111.9–121.9)	29.6	<0.001
	2008–2011	51.0 (47.5–54.7)	–10.1	0.033	115.0 (110.5–119.6)	–1.5	0.589
	2012–2015	47.5 (44.4–50.8)	–6.9	0.153	99.5 (95.6–103.6)	–13.5	<0.001
	Diff. 2012–2015 vs 2000–2003		4.4	0.435		10.4	0.003
Estonia	2000–2003	77.9 (67.8–89.1)	–	–	147.7 (136.3–159.7)	–	–
	2004–2007	93.0 (82.4–104.5)	19.4	0.049	181.6 (169.8–193.9)	23.0	<0.001
	2008–2011	71.0 (62.0–80.9)	–23.7	0.003	138.0 (128.3–148.4)	–24.0	<0.001
	2012–2015	67.6 (59.5–76.6)	–4.8	0.603	113.4 (104.8–122.5)	–17.8	<0.001
	Diff. 2012–2015 vs 2000–2003		–13.2	0.136		–23.2	<0.001
Latvia	2000–2003	37.7 (30.6–45.9)	–	–	87.4 (81.1–94.1)	–	–
	2004–2007	48.6 (40.9–57.4)	28.9	0.052	100.9 (94.6–107.5)	15.4	0.004
	2008–2011	57.1 (48.7–66.5)	17.5	0.165	115.0 (108.6–121.8)	14.0	0.002
	2012–2015	53.1 (45.8–61.2)	–7.2	0.497	120.9 (114.5–127.6)	5.1	0.211
	Diff. 2012–2015 vs 2000–2003		40.6	0.005		38.3	<0.001
Lithuania	2001–2003	45.0 (38.0–52.9)	–	–	91.8 (85.6–98.4)	–	–
	2004–2007	71.5 (64.2–79.5)	58.9	<0.001	145.8 (139.8–152.1)	58.8	<0.001
	2008–2011	55.4 (49.2–62.2)	–22.5	0.001	126.4 (121.1–131.8)	–13.4	<0.001
	2012–2015	40.3 (35.2–45.9)	–27.3	<0.001	98.3 (93.6–103.2)	–22.2	<0.001
	Diff. 2012–2015 vs 2001–2003		–10.4	0.303		7.1	0.107
	2000–2003	114.7 (109.7–119.9)	–	–	114.7 (109.7–119.9)	–	–
	2004–2007	157.9 (151.6–164.5)	37.7	<0.001	157.9 (151.6–164.5)	37.7	<0.001
	2008–2011	154.9 (148.3–161.8)	–1.9	0.529	154.9 (148.3–161.8)	–1.9	0.529
	2012–2015	141.8 (135.0–148.8)	–8.5	0.007	141.8 (135.0–148.8)	–8.5	0.007
	Diff. 2012–2015 vs 2000–2003		23.6	<0.001		23.6	<0.001
	2000–2003	222.2 (203.9–241.8)	–	–	222.2 (203.9–241.8)	–	–
	2004–2007	248.4 (227.4–270.9)	11.8	0.072	248.4 (227.4–270.9)	11.8	0.072
	2008–2011	207.5 (187.4–229.3)	–16.5	0.007	207.5 (187.4–229.3)	–16.5	0.007
	2012–2015	200.9 (179.6–223.9)	–3.2	0.667	200.9 (179.6–223.9)	–3.2	0.667
	Diff. 2012–2015 vs 2000–2003		–9.6	0.147		–9.6	0.147
	2000–2003	130.8 (119.5–143.0)	–	–	130.8 (119.5–143.0)	–	–
	2004–2007	185.9 (171.3–201.3)	42.1	<0.001	185.9 (171.3–201.3)	42.1	<0.001
	2008–2011	173.9 (159.2–189.5)	–6.5	0.267	173.9 (159.2–189.5)	–6.5	0.267
	2012–2015	181.4 (160.6–204.0)	4.3	0.575	181.4 (160.6–204.0)	4.3	0.575
	Diff. 2012–2015 vs 2000–2003		38.7	<0.001		38.7	<0.001
	2001–2003	127.3 (115.6–139.8)	–	–	127.3 (115.6–139.8)	–	–
	2004–2007	221.3 (207.0–236.2)	73.8	<0.001	221.3 (207.0–236.2)	73.8	<0.001
	2008–2011	209.9 (195.5–225.1)	–5.1	0.285	209.9 (195.5–225.1)	–5.1	0.285
	2012–2015	147.0 (134.1–160.7)	–30.0	<0.001	147.0 (134.1–160.7)	–30.0	<0.001
	Diff. 2012–2015 vs 2001–2003		15.5	0.031		15.5	0.031

ASMR = age-standardised mortality rate per 100 000 person years; CI = confidence interval; Diff. = differences; Diff. and P values of the differences are calculated in comparison with the preceding period or between the last and the first period.

Table 4 Alcohol-related mortality by educational level in 2000–2015 among women in the 35–74 age group.

Country	Period	Educational level					
		High			Middle		
		ASMR (95% CI)	Diff., %	P value	ASMR (95% CI)	Diff., %	P value
Finland	2000–2003	12.5 (10.5–14.8)	–	–	20.8 (18.7–23.1)	–	–
	2004–2007	15.6 (13.6–17.8)	24.8	0.038	28.6 (26.2–31.0)	37.0	<0.001
	2008–2011	15.5 (13.7–17.4)	–0.6	0.912	28.2 (26.0–30.6)	–1.1	0.841
	2012–2015	14.1 (12.6–15.8)	–9.0	0.293	27.9 (25.8–30.2)	–1.1	0.857
	Diff. 2012–2015 vs 2000–2003		12.8	0.222		34.1	<0.001
Estonia	2000–2003	23.1 (18.8–28.1)	–	–	51.8 (46.0–58.1)	–	–
	2004–2007	26.2 (22.0–31.1)	13.4	0.342	54.8 (49.2–60.9)	5.8	0.478
	2008–2011	20.4 (16.8–24.6)	–22.1	0.054	45.2 (40.2–50.6)	–17.5	0.014
	2012–2015	15.8 (12.8–19.2)	–22.5	0.066	39.9 (35.0–45.3)	–11.7	0.152
	Diff. 2012–2015 vs 2000–2003		–31.6	0.009		–23.0	0.003
Latvia	2000–2003	13.4 (10.0–17.6)	–	–	25.5 (22.7–28.5)	–	–
	2004–2007	17.0 (13.5–21.3)	26.9	0.184	37.8 (34.6–41.2)	48.2	<0.001
	2008–2011	15.3 (12.0–19.3)	–10.0	0.516	34.9 (31.9–38.1)	–7.7	0.201
	2012–2015	12.4 (9.8–15.4)	–19.0	0.201	40.2 (36.7–43.9)	15.2	0.026
	Diff. 2012–2015 vs 2000–2003		–7.5	0.667		57.6	<0.001
Lithuania	2001–2003	10.6 (7.7–14.2)	–	–	28.1 (25.3–31.2)	–	–
	2004–2007	21.5 (18.1–25.3)	102.8	<0.001	50.9 (47.8–54.1)	81.1	<0.001
	2008–2011	18.0 (15.1–21.3)	–16.3	0.147	44.4 (41.7–47.2)	–12.8	0.002
	2012–2015	11.7 (9.6–14.2)	–35.0	0.001	38.0 (35.4–40.9)	–14.4	0.001
	Diff. 2012–2015 vs 2001–2003		10.4	0.569		35.2	<0.001
	2000–2003	36.3 (33.2–39.6)	–	–	102.9 (86.3–121.6)	–	–
	2004–2007	53.4 (49.3–57.8)	47.1	<0.001	93.1 (77.8–110.5)	–9.5	0.418
	2008–2011	57.6 (52.8–62.6)	7.9	0.204	72.0 (57.2–89.3)	–22.7	0.066
	2012–2015	54.4 (49.3–59.9)	–5.6	0.379	66.0 (51.0–83.9)	–8.3	0.603
	Diff. 2012–2015 vs 2000–2003		49.9	<0.001		–35.9	0.002
	2000–2003	51.3 (43.4–60.3)	–	–	51.3 (43.4–60.3)	–	–
	2004–2007	65.6 (55.4–77.1)	27.9	0.038	65.6 (55.4–77.1)	27.9	0.038
	2008–2011	66.0 (54.9–78.5)	0.6	0.960	66.0 (54.9–78.5)	0.6	0.960
	2012–2015	68.6 (53.2–86.7)	3.8	0.803	68.6 (53.2–86.7)	3.8	0.803
	Diff. 2012–2015 vs 2000–2003		33.5	0.066		33.5	0.066
	2001–2003	51.0 (42.0–61.4)	–	–	51.0 (42.0–61.4)	–	–
	2004–2007	95.8 (84.2–108.7)	87.8	<0.001	95.8 (84.2–108.7)	87.8	<0.001
	2008–2011	97.3 (84.6–111.4)	1.6	0.873	97.3 (84.6–111.4)	1.6	0.873
	2012–2015	68.3 (57.9–80.0)	–29.8	<0.001	68.3 (57.9–80.0)	–29.8	<0.001
	Diff. 2012–2015 vs 2001–2003		33.9	0.019		33.9	0.019

ASMR = age-standardised mortality rate per 100 000 person years; CI = confidence interval; Diff. = differences. Diff. and P values of the differences are calculated in comparison with the preceding period or between the last and the first period.

Table 5 Educational inequalities in alcohol-related mortality in 2000–2015 in the 35–74 age group.

Country	Period	Men				Women				SII in total mortality			
		RII (95% CI)	P value	SII (95% CI)	P value	%	RII (95% CI)	P value	SII (95% CI)	P value	%	SII in total mortality	%
Finland	2000–2003	3.21 (2.85–3.62)	–	90.3 (82.7–97.5)	–	10.7	5.00 (3.92–6.38)	–	30.2 (26.9–33.0)	–	9.0		
	2004–2007	3.45 (3.12–3.82)	0.367	121.5 (113.6–129.1)	<0.001	15.0	5.53 (4.52–6.76)	0.532	42.4 (39.0–45.4)	<0.001	12.7		
	2008–2011	3.60 (3.26–3.98)	0.557	120.3 (112.9–127.3)	0.824	15.8	5.67 (4.65–6.90)	0.862	41.1 (37.9–43.8)	0.561	13.2		
	2012–2015	3.56 (3.20–3.94)	0.879	102.8 (96.1–109.1)	<0.001	15.3	5.41 (4.43–6.60)	0.743	36.4 (33.5–39.1)	0.025	10.9		
	Diff. 2012–2015 vs 2000–2003		0.201		0.014	P value (0.009)		0.624		0.004	P value (0.472)		
Estonia	2000–2003	3.93 (3.22–4.79)	–	178.2 (157.8–196.2)	–	9.7	6.52 (4.71–9.02)	–	71.9 (63.7–78.4)	–	10.9		
	2004–2007	3.19 (2.67–3.80)	0.124	176.9 (154.3–197.6)	0.931	10.1	5.24 (3.87–7.09)	0.335	67.2 (58.3–74.5)	0.410	12.1		
	2008–2011	3.67 (3.00–4.47)	0.302	151.3 (132.5–168.0)	0.074	10.9	5.27 (3.76–7.38)	0.980	52.8 (45.0–59.1)	0.010	11.5		
	2012–2015	4.14 (3.34–5.13)	0.420	138.6 (122.3–152.9)	0.292	11.1	7.60 (5.17–11.16)	0.161	48.5 (42.7–52.8)	0.335	11.3		
	Diff. 2012–2015 vs 2000–2003		0.727		0.002	P value (0.610)		0.549		<0.001	P value (0.913)		
Latvia	2000–2003	3.42 (2.79–4.20)	–	99.1 (85.4–111.4)	–	5.4	5.08 (3.66–7.06)	–	38.8 (33.0–43.5)	–	5.7		
	2004–2007	4.44 (3.69–5.33)	0.063	139.6 (126.7–151.1)	<0.001	7.3	4.48 (3.37–5.96)	0.571	48.1 (41.1–54.0)	0.030	7.2		
	2008–2011	3.25 (2.72–3.88)	0.017	124.6 (108.9–138.9)	0.138	7.5	5.28 (3.90–7.15)	0.439	47.3 (41.0–52.3)	0.857	7.3		
	2012–2015	4.07 (3.34–4.95)	0.096	137.7 (122.7–151.1)	0.221	8.7	8.23 (5.86–11.56)	0.056	52.0 (47.1–55.9)	0.212	8.2		
	Diff. 2012–2015 vs 2000–2003		0.229		<0.001	P value (<0.001)		0.045		<0.001	P value (0.082)		
Lithuania	2001–2003	2.87 (2.35–3.49)	–	86.5 (72.3–99.4)	–	6.0	4.72 (3.39–6.55)	–	37.1 (31.1–42.0)	–	8.4		
	2004–2007	3.30 (2.90–3.77)	0.249	154.6 (140.6–167.6)	<0.001	8.3	4.92 (3.99–6.06)	0.835	67.2 (60.8–72.8)	<0.001	10.6		
	2008–2011	4.16 (3.62–4.78)	0.018	155.7 (144.2–166.3)	0.902	9.2	6.43 (5.11–8.10)	0.092	63.7 (58.6–68.0)	0.369	10.7		
	2012–2015	4.23 (3.58–5.01)	0.881	115.0 (104.9–124.2)	<0.001	7.4	8.80 (6.71–11.55)	0.084	53.3 (49.6–56.3)	<0.001	9.5		
	Diff. 2012–2015 vs 2001–2003		0.003		0.002	P value (0.155)		0.004		<0.001	P value (0.642)		

RII = relative index of inequality; SII = slope index of inequality per 100 000 person years; CI = confidence interval. P values are calculated for the differences with the preceding period or between the last and the first period.

sensitivity analyses showed that the effect of excluding register-based records from the analysis had only a minimal impact on overall alcohol-related mortality in Latvia we cannot exclude the possibility that the effect differed by educational level. Second, in this study alcohol-related mortality was measured by causes that are directly attributable to alcohol and therefore, cover only part of all alcohol-related deaths. Differences in certification practices of single alcohol-related causes of death may not only hamper cross-country comparisons [20] but they may also be crucial for assessing mortality changes over time [21]. By combining directly alcohol-attributable causes and including non-alcoholic cirrhosis we improved comparability between countries and over time. Finally, although macroeconomic changes are likely to affect people's living standards and alcohol affordability, we cannot exclude confounding because of other temporal changes.

The finding that alcohol-related mortality increased in a period of strong economic growth and reduced when the economy was in recession accords with earlier research showing a pro-cyclical pattern between economic fluctuations and alcohol-related mortality [3]. Although different factors might underpin these variations in alcohol-related harm [22], it is possible that alcohol control policies and changes in the affordability of alcohol had a major impact on the observed changes in national and group-specific mortality. For example, strong economic growth in the early-mid 2000s [11] and a corresponding growth in salaries [23], increased alcohol affordability markedly in all of these countries [14,24], and was accompanied by a large increase in alcohol consumption [24,25]. In some cases, the growth in affordability of alcohol occurred in the context of the liberalisation of alcohol policies (Lithuania) [24,26] and reduction in taxes (Finland) [14]. Similarly, the effects of economic downturn during the 2008 global financial crisis on affordability and consumption of alcohol should also be understood in the context of more restrictive national alcohol policies [24,27–29].

The effects of economic fluctuations on alcohol-related mortality seemed to be especially detrimental for the low educated. Specifically, in the period of economic growth the increase in alcohol-related mortality was often larger among the low educated, whereas in the recessionary/economic stabilisation period the low educated more often experienced a smaller decline in mortality compared to their high educated counterparts, with both of these phenomena contributing to increasing inequalities in mortality. It is possible that various mechanisms were underlying these period-specific effects. For example, there is some evidence that alcohol consumption not only increased more among the lower educated in the 2000s [30], but that the socioeconomic (educational) gradient that exists in risky drinking in these countries [12,31] may have widened for some groups during the period of

economic growth [31,32]. This might have contributed to the growth in inequality in alcohol-related deaths. It has also been shown that lower socioeconomic status is associated with more detrimental alcohol-related health outcomes (hospitalisation/death) even when the volume/pattern of drinking is the same as in higher socioeconomic groups [33], with factors such as poverty [34] and other adverse health behaviours [35] possibly helping to explain 'excess' alcohol-related mortality/harm in lower socioeconomic groups.

Despite the overall improvement after 2008 our results showed that the mortality decline was often less pronounced or mortality did not decrease in the least educated. It can only be speculated what underlies this socioeconomic difference, although various factors might be involved. For instance, although the recession was marked by a substantial growth in unemployment in the Baltic states [11], there is evidence that the least educated were disproportionately affected by falling employment [36]. This may have been important because research from elsewhere has linked unemployment to a significantly increased risk of binge drinking during the recession [37]. Moreover, although reduced affordability may have had a positive impact on alcohol-related mortality among the low educated, some of this effect may have been counterbalanced by other factors. For example, the recession might have also resulted in increased drinking as a result of a deteriorating work situation. In particular, wage cuts and reduced working hours, which were more prevalent in industries such as construction and hotels and catering [38], may have led to psychological distress and the use of alcohol to self-medicate [22], with previous research showing that binge drinking is more common in lower socioeconomic groups as a response to stress accumulation [39]. Austerity measures in response to the recession might have also played a role in the Baltic countries leading to a fragmentation of the labour market while placing a disproportionately high burden on lower-skilled employees [40]. Austerity also impacted overall and equitable access to health care. Unmet medical need was higher among the lower educated in Latvia [41], where there was a decrease in the funding of public addiction treatment facilities during this period [24], which might help explain why alcohol-related mortality increased (men) or decreased little (women) after 2007.

CONCLUSION

This study showed that both economic growth and recession can increase relative educational inequalities in alcohol-related mortality, but specific mechanisms may vary between economic cycles and across countries. In prosperous times mortality tends to increase more among the low educated whereas in periods of economic turmoil

the low educated experience a lower reduction in alcohol-related mortality. Following a sharp increase in absolute educational inequalities in alcohol-related mortality during economic expansion (excepting Estonia), absolute inequalities have since declined (except in Latvia). Alcohol-related mortality is still exceedingly high in these countries and is playing an important role in overall inequalities in mortality. The high and increasing level of inequalities suggest that policies directed at reducing factors underpinning excess alcohol-related mortality among socioeconomically disadvantaged groups are necessary to further reduce alcohol mortality and its socioeconomic gradient.

Declaration of interests

None.

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Author contributions

Andrew Stickley: Conceptualization; writing - original draft; writing - review & editing. **Aleksei Baburin:** Formal analysis; methodology; writing - review & editing. **Domantas Jasilionis:** Data curation; formal analysis; methodology; writing - review & editing. **Juris Krumins:** Data curation; writing - review & editing. **Pekka Martikainen:** Data curation; formal analysis; methodology; writing - review & editing. **Naoki Kondo:** Writing - review & editing. **Mall Leinsalu:** Conceptualization; data curation; formal analysis; funding acquisition; project administration; writing - original draft; writing - review & editing.

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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 Mortality from alcohol-related causes of death among men in the 35–74 age group.

Table S2 Mortality from alcohol-related causes of death among women in the 35–74 age group.

Table S3 Changes in alcohol-related mortality between periods by educational level among men in the 35–74 age group.

Table S4 Changes in alcohol-related mortality between periods by educational level among women in the 35–74 age group.

Table S5 Impact of excluding register-based census records on total and alcohol-related mortality in the 35–74 age group in Latvia, 2000–2015.

Figure S1 Macroeconomic changes between 2000 and 2015. Source: The World Bank Open Data 2019.