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Pena, Sebastian

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Measurement error as an explanation for the alcohol harm paradox: analysis of eight cohort studies

Sebastián Peña[1,2,3*], Pia Mäkelä[1], Tommi Härkänen[1], Markku Heliövaara[1], Teemu Gunnar[4], Satu Männistö,[1] Tiina Laatikainen,[1,5,6] Erkki Vartiainen,[7] Seppo Koskinen[1]

1. Department of Public Health Solutions, Finnish Institute for Health and Welfare, Mannerheimintie 166, PL 30 00271, Helsinki, Finland
2. Doctoral Programme in Population Health, University of Helsinki, Helsinki, Finland
3. Faculty of Medicine, University Diego Portales, Ejército 233, Santiago, Chile
4. Department of Government Services, Finnish Institute for Health and Welfare, Mannerheimintie 166, PL 30 00271, Helsinki, Finland
5. Institute of Public Health and Clinical Nutrition, Faculty of Medicine, University of Eastern Finland, PL 1627, 70211 Kuopio, Finland
6. Joint Municipal Authority for North Karelia Social and Health Services (Siun sote), Tikkamäentie 16, 80211 Joensuu, Finland
7. International Affairs and Research Support Office, Finnish Institute for Health and Welfare, Mannerheimintie 166, PL 30 00271, Helsinki, Finland

***Corresponding author:**

Sebastián Peña

Finnish Institute for Health and Welfare

Mannerheimintie 166

PL 30, 00271 Helsinki

FINLAND

Phone: +358 45 245 1360

Email: sebastian.penafajuri@thl.fi

Abstract

Background

Despite reporting lower levels of alcohol consumption, people with lower socioeconomic status (SES) experience greater alcohol-related harm. Whether differential biases in the measurement of alcohol use could explain this apparent paradox is unknown. Using alcohol biomarkers to account for measurement error, we examined whether differential exposure to alcohol could explain the socioeconomic differences in alcohol mortality.

Methods

Participants from eight representative health surveys (n =52,164, mean age 47.7 years) were linked to mortality data and followed up until December 2016. The primary outcome was alcohol-attributable mortality. We used income and education as proxies of SES. Exposures include self-reported alcohol use and four alcohol biomarkers (serum gamma-glutamyl transferase GGT -available in all surveys-, carbohydrate-deficient transferrin CDT, alanine aminotransferase ALT and aspartate aminotransferase AST, available in subsamples). We used shared frailty Cox proportional hazards to account for survey heterogeneity.

Results

During a mean follow-up of 20.3 years, totalling 1,056,844 person-years, there were 828 alcohol-attributable deaths. Lower SES was associated with higher alcohol mortality despite reporting lower alcohol use. Alcohol biomarkers were associated with alcohol mortality and improved the predictive ability when used in conjunction with self-reported alcohol use. Alcohol biomarkers explained a very small fraction of socioeconomic differences in alcohol mortality, since hazard ratios either slightly attenuated (percent attenuation range 1.0% to 12.1%) or increased.

Conclusions

Using alcohol biomarkers in addition to self-reported alcohol use did not explain the socioeconomic differences in alcohol mortality. Differential bias in the measurement of alcohol use is not a likely explanation of the alcohol harm paradox.

Keywords: Alcohol Drinking; Epidemiology; Socioeconomic Status; Biomarkers; Measurement error; Equity; Alcohol Mortality; Alcohol Harm Paradox

Key messages

- Bias in the measurement of self-reported alcohol use could explain the apparent discrepancy between high alcohol harm but low reported alcohol use in people with lower socioeconomic status. This hypothesis has not been tested before

- In this study, we used four biomarkers as objective indicators of alcohol use to account for measurement error in alcohol use and assess whether it explains the alcohol harm paradox

- Our study found that using alcohol biomarkers provide additional information (improve the predictive ability) but do not explain the socioeconomic differences in alcohol mortality

Measurement error as an explanation for the alcohol harm paradox: analysis of eight cohort studies

Harmful alcohol use accounts for vast health and social harm.[1] Lower socioeconomic status (SES) is consistently associated with greater alcohol-related harm.[2, 3] These socioeconomic disparities are an important contributor to overall socioeconomic inequalities in health and wellbeing.[4, 5] This is especially true in Finland, where alcohol-related deaths represent 43% and 23% of all deaths in the lowest income quintile of Finnish working-aged men and women, respectively.[6] In contrast, lower socioeconomic groups report lower or similar alcohol use than those of higher SES.[7] This discrepancy between alcohol harms and consumption is known as the "alcohol harm paradox".[8, 9]

Three factors can cause the alcohol harm paradox. First, differential biases in the measurement of exposure, where true differences in alcohol use by SES exist but are not fully captured by self-reported measures assessing alcohol consumption.[10-12] Second, differential vulnerability, where equal levels and patterns of alcohol use result in more severe consequences for lower socioeconomic groups. Differential vulnerability could arise because of differences in predisposing sociodemographic, environmental and behavioural risk factors or other protective factors,[13] or because of worse access to preventive, diagnostic and treatment services.[14] Third, reverse causality, where harmful drinkers experience a reduction in their socioeconomic status.[15]

Exposure to alcohol has been previously examined using self-reported measures of alcohol use.[13, 15, 16] However, self-report is prone to measurement error due to several types of information biases, including recall,[17] social desirability[18] and top-coding bias. Lower socioeconomic groups could be more prone to these biases.[19]

To account for differential biases in the measurement of alcohol exposure, measures of alcohol use not subject to information bias are needed.[20, 21] Alcohol biomarkers, as objective measures of chronic alcohol consumption, fulfil this requirement. Serum gamma-glutamyl transferase (GGT) is an indicator of heavy alcohol use and a marker of oxidative stress.[20, 22] Sensitivity varies between 34-85% and specificity vary between 11-85% depending on the population and measures of alcohol use.[23] Carbohydrate-deficient transferrin (CDT) is a marker of sustained heavy alcohol intake. It reverses after 14-21 days of abstinence. CDT is a more specific and sensitive measure of chronic alcohol use than GGT, with sensitivity and specificity varying between 44-94% and 82-100% respectively.[23] Alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are mitochondrial enzymes found in the liver and other tissues.[24] These enzymes are markers of abnormal liver function and heavy alcohol use. Serum ALT is more specific than AST for liver conditions.[25]

In this study, we assess the hypothesis that the alcohol harm paradox could be explained by measurement error of alcohol use, i.e. that the paradox arises because self-reported alcohol use is a biased measure of true alcohol use, and once a more objective measure (biomarkers) is used, the alcohol harm paradox would vanish. In practice, we estimate whether the systematic socioeconomic differences in alcohol mortality are accounted for by differences in alcohol use, using both self-reported measures and alcohol biomarkers. We examined the role of four alcohol biomarkers using data from eight health examination surveys in Finland linked to mortality registries. To the best of our knowledge, no study has used alcohol biomarkers as explanatory factors for the alcohol harm paradox.

Methods

The study followed the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[26] A study protocol (76/2017) was submitted and approved by the Finnish Institute for Health and Welfare Biobank. No changes in the methods occurred after the approval of the study protocol.

Design

The study design is a cohort study of eight representative health examination surveys linked to mortality data from the Causes of Death register administered by Statistics Finland. We linked data to mortality registries until December 2016 using the unique personal identifier assigned to all Finnish residents.

Participants

We used data from the Mini-Finland Survey 1978-1980 (MFS1978-1980), six rounds of the National FINRISK Study from 1982 to 2007 (FINRISK) and the Health 2000 Survey (H2000). Details on the survey procedures have been published before.[27-29]

Briefly, MFS1978-1980 and H2000 were based on a two-stage cluster sample design and represent continental Finland. FINRISK surveys were based on a stratified random sample selected from three regions in Finland in 1982 and 1987 and five regions from 1992 to 2007. Participants were drawn from the Population Register of Statistics Finland covering all residents in Finland. All participants filled in a questionnaire at home, followed by a review of the questionnaire and a health

examination by trained nurses. The age range was 30+ in MFS1978-1980 and H2000, 25-64 in FINRISK 1982-1987 and gradually extending to 25-74 by 2007. Participation rate ranged from 60 to 90% (average 74%). The analytical sample was 52,164 respondents.

All surveys comply with the Declaration of Helsinki regarding confidentiality, anonymity and data protection. Legislation requiring ethical approval and informed consents was enacted in 1996. In MFS1978-1980 and FINRISK from 1982 to 1992, agreement to participate was taken to indicate informed consent. H2000 and FINRISK from 1997 to 2007 have been approved by the respective ethical board and obtained informed consent from all participants. We obtained permission from Statistics Finland for all register data used.

Exposures

We harmonized all exposures in the eight surveys using a structured protocol as specified in the Supplementary Appendix.

Biomarker assessment

GGT was available in all surveys (n=52,164), while CDT was available in FINRISK 1997 (n=7240), ALT was available in FINRISK 2002 (n=7758) and AST was available in MFS (n=7043). In all surveys, serum GGT was determined using the kinetic method and following current international recommendations at the time of the survey. CDT was analysed using the double antibody essay.[30] ALT and AST were determined using the kinetic method. All samples were analysed at the central laboratory of the National Public Health Institute.[29, 31] More details are available elsewhere.[29, 32]

Alcohol use

Alcohol consumption was asked in a self-administered questionnaire. Participants reported the number of portions of beer, pre-mixed drinks, wine and spirits consumed during an average week. Questions were almost identical in all surveys. To adjust for secular changes in the average strength of alcoholic beverages, we estimated these annually on the basis of sales statistics and then used these to convert portions into grams of pure alcohol. We created a variable with the following categories drawing on previous studies:[13, 33] never, former and infrequent drinkers; low intake (>0 to <84 grams of ethanol per week); moderate intake (men 84 to <252 g/wk, women 84 to <168 g/wk), high intake (men 252 to <612 g/wk, women 168 to <432 g/wk) and very high intake (men ≥612 g/wk, women ≥432 g/wk).

Sociodemographic factors

We measured sociodemographic factors using sex, age and marital status. We defined marital status as those married or cohabiting versus those unmarried, widowed or divorced.

We used income as a primary proxy of SES and education as a secondary proxy. We defined income as total annual household income divided by the number of consumption units (the first adult counts as 1 unit, other adults as 0.7 and children as 0.5)[34] and divided into quintiles within surveys. We categorized education in three levels (basic, secondary, tertiary) based on the highest educational degree obtained.

Confounding factors

We controlled for smoking,[35] body mass index (BMI)[36] and baseline health conditions (diabetes, stroke, myocardial infarction, pulmonary emphysema or gallstones)[37-40] that could increase the activity of GGT as well as ALT and AST in the case of gallstones. We assessed smoking habits using structured questions and classified smoking status into never smokers, ex-smokers and current smokers. We calculated BMI as the weight (in kg) divided by height (in m) squared. Weight and height were measured by trained nurses using standard methods. We modelled BMI as a categorical variable using the classification of the World Health Organization: <18.5 underweight, 18.5–24.9 normal, 25–29.9 overweight, ≥30 obesity.[41] We defined poor self-rated health as those with poor, rather poor and moderate self-rated health versus those with good and excellent self-rated health. Participants were asked whether a physician has diagnosed them with diabetes, stroke, myocardial infarction, pulmonary emphysema or gallstones.

Outcome

The primary outcome was alcohol-attributable mortality (hereafter alcohol mortality). We included deaths where either the underlying cause or one of the contributory causes were alcohol-attributable. For this, we used the following International Classification of Disease (ICD) codes: ICD-10 F10, G312, G4051, G621, G721, I426, K292, K70, K852, K860, O354, P043, Q860 and X45 for accidental poisonings by alcohol; ICD-9: 291, 303, 3050A, 3575A, 4255A, 5353A, 5710A–5713X, 5770D–5770F, 5771C–5771D, 7607A, 7795A, 980; ICD-8: 291, 303, 5710, 577 (only for males), 980.[42] Contributory causes of death were available since 1987.

Statistical analysis

To examine whether alcohol biomarkers provided additional information, we evaluated if they were associated with the outcome and improved the predictive ability of the model. We further tested the hypothesis that alcohol biomarkers explain the association between SES and alcohol mortality using the change-in-estimation method (see below).

We modelled the time-to-event data using shared frailty Cox proportional hazards model to account for clustering of the data in survey rounds. Regression estimates are presented as hazard ratios with 95% confidence intervals. We used attained age as the time scale. Participants were right-censored due to death from other than alcohol-attributable causes or end of follow-up. We tested the proportional hazard assumption in the full model both globally and for each exposure using scaled Schoenfeld residuals.[43] The variable of alcohol use did not meet the proportional hazards assumption in some of the models and was modelled as an age-varying covariate. The follow-up time was thus split into three parts at time points 55 and 70 based on visual inspection of residual plots.[44]

We assessed linearity in the relationship between alcohol biomarkers and alcohol mortality by visual inspection of plotted martingale residuals. Since none of the biomarkers showed a linear relationship with the outcome, we used a likelihood ratio test to compare a linear model with a model using penalized smoothing splines accounting for the non-linear relationship of the biomarker.[45] Only GGT showed a significant non-linear relationship and was modelled using splines. CDT, AST and ALT were modelled as a linear relationship.

We examined whether alcohol biomarkers were associated with the outcome and improved the predictive ability of the model. In the case of GGT, we examined the association by extracting predicted values and plotted the log hazard against values of GGT (Supplementary Figure S1). For CDT, AST and ALT, we report the hazard ratios in model 4 (see below). The predictive ability was measured using Harrell's C concordance statistic (C-index).[46] We compared the C-index in models adjusted for self-reported alcohol use and/or alcohol biomarkers.

We further used the change-in-estimation method to test whether alcohol biomarkers explain the association between SES and alcohol mortality.[47, 48] For this, we estimated the percent change in the estimate (i.e. hazard ratio) of the lowest versus highest income and education group after controlling for confounders (models 1 and 2) and alcohol measures (models 3 to 5).Model 1 included sex, age (as time scale) and survey round (as the shared frailty). Model 2 was additionally adjusted for marital status, smoking, BMI, self-reported health, diabetes, myocardial infarction, gallstones, stroke and emphysema. Models 3 was further adjusted for self-reported alcohol use. Model 4 was model 2 plus self-reported alcohol use and alcohol biomarkers and Model 5 was model 2 plus only alcohol biomarkers.

If differential biases in the measurement of alcohol exposure explain the alcohol harm paradox, controlling for an alcohol biomarker in models 4 and 5 would result in an attenuation of the hazard ratio towards 1 for a given socioeconomic group. We calculated the percent change (% attenuation) in the β coefficient for income and education compared to a reference model as follows:[49]

‘‘$(\beta_{\text{Model2}} - \beta_{\text{Model3,4 or 5}})/\beta_{\text{Model2}}) * 100$’.

We carried out three sensitivity analyses: (1) stratified analysis by sex; (2) stratified analysis by duration of follow-up (less than 10, 20 and 30 years of follow-up); and (3) analyses using heavy episodic drinking (HED) and separating never, former and infrequent drinkers (both variables available in FINRISK 1987-2007 and H2000, see Supplementary Appendix for details). The complex sampling design of MFS1978-1980 and H2000 was accounted for in all calculations. We used R version 3.6.1 for all analyses. The code is available in the Supplementary Appendix II.

Results

A total of 828 alcohol-attributable deaths were observed among the 52,164 participants followed for a total of 1,056,844 person-years with a mean follow-up of 20.3 years. Baseline characteristics of participants can be found in Table 1. Participants in the lowest income group were older, more often male, single, widowed or divorced and more often current smokers and obese. Low-income participants experienced higher rates of alcohol-attributable deaths, despite reporting lower levels of alcohol use. Alcohol biomarkers showed a more equal distribution among income quintiles. Similar differences were observed by educational levels (Supplementary Table S1). Supplementary Table S2 shows characteristics of study participants by survey round.

[Table 1 here]

Alcohol biomarkers were associated with higher alcohol-attributable mortality. In fully-adjusted models (Model 4 in Table 2), the association between GGT and alcohol mortality resembled an exponential saturation curve (Supplementary Figure S1). CDT was associated with a 26% increased risk of alcohol-attributable mortality per 10-unit increase (hazard ratio 1.026, 95% confidence

interval 1.005 to 1.05). AST and ALT were associated with 3.3% and 4% increased risks per 10-unit increase, respectively (AST hazard ratio 1.003; 95% CI 1.0008 to 1.0057; ALT hazard ratio 1.004, 95% CI 1.00 to 1.01). Using alcohol biomarkers in addition to self-reported alcohol use increased the predictive ability for all biomarkers, compared to the model adjusted only for self-reported alcohol use (Table 2). However, using the alcohol biomarker instead of self-reported alcohol use increased the predictive ability only in the model with GGT and ALT (C-index change 0.025, $p = 0.028$).

[Table 2 here]

Table 3 shows the hazard ratios (HRs) for alcohol mortality in the lowest income quintile using the highest income quintile as a reference. After adjusting for self-reported alcohol use (Model 3), all HRs increased compared to model 2. Adjusting additionally for biomarkers resulted in either an increase in the HR or in a small attenuation in the case of GGT plus ALT (7.8%) compared to model 2. Adjusting for the biomarker instead of self-reported alcohol use resulted in either a small attenuation (8.6% - 12.1%) or in an increase in the HRs compared to model 2.

[Table 3 here]

We observed similar patterns when comparing the HRs for alcohol mortality in the lowest education level using the highest education level as a reference (Table 4). Adjusting for self-reported alcohol use resulted in higher HRs compared to model 2. Adjusting additionally for biomarkers resulted in increases in all HRs compared to model 2. Using the biomarker instead of self-reported alcohol use

translated into either a small attenuation (1.0% - 4.0%) or increases in the HRs compared to model 2.

[Table 4 here]

In all analyses, hazard ratios attenuated after adjusting for marital status, smoking and BMI. These attenuations appeared to be greater than the ones observed after adjusting for alcohol biomarkers.

Sensitivity analyses were consistent with the main analyses (Supplementary Tables S3-S5). Analyses stratified by sex showed similar patterns, but the effect sizes for women were much smaller. Models separating abstainers and ex-drinkers and including HED yield similar results, as well as stratified analyses by duration of follow-up.

Discussion

The study aimed to explore the role of differential exposure to alcohol use, using self-reported measures and alcohol biomarkers, in accounting for socioeconomic differences in alcohol mortality. Participants with lower SES have higher alcohol mortality even though they reported lower alcohol use; these findings demonstrate the alcohol harm paradox in this population. Alcohol biomarkers were associated with alcohol mortality and improved the predictive ability of the model when used together with self-reported alcohol use. However, adjusting for alcohol biomarkers in addition to self-reported alcohol use did not explain (or explained only a very small proportion of) the socioeconomic differences in alcohol mortality in our data. We infer from this that differential bias

in the measurement of exposure is not a likely explanation to socioeconomic differences in alcohol mortality and the alcohol harm paradox.

Comparison with previous studies

Our study confirmed the existence of the alcohol harm paradox in Finland. Majority of previous studies have either documented the socioeconomic differences in alcohol mortality[50] or socioeconomic differences in alcohol use.[9, 10] In a Swedish cohort study, unskilled workers had higher levels of abstinence and higher proportions of heavy drinkers and heavy episodic drinkers.[13] These differences, however, appear to be smaller compared to those in alcohol mortality.[13] A clearer mismatch between self-reported alcohol use and alcohol mortality was observed in our study.

The contribution of the current paper is to show that socioeconomic differences remain even after using biomarkers to account for measurement error in alcohol use. Therefore, these findings lend further credence to previous research using self-reported measures, which suggested that differential exposure to alcohol accounted for a small fraction of the socioeconomic differences in alcohol-related harm.[13, 15, 16] Together these results indicate that the reason for the alcohol harm paradox needs to be sought elsewhere than in differential exposure.

We observed a reduction in the socioeconomic differences when adjusting for marital status and behavioural risk factors (smoking and obesity). This reduction was larger than that observed for alcohol use. This is in line with previous studies showing similar reductions for smoking[13] and smoking and obesity combined.[15] Interactions between behavioural risk factors have been observed

for liver enzymes,[51] liver disease[52] and oral cancer and could result in greater alcohol harm in lower SES.[53] Smoking could also be a proxy for some unmeasured harmful drinking, as smoking and alcohol use strongly correlate.[54]

Strengths and limitations

The strengths of our study include (1) the use of a large dataset from eight health examination surveys in Finland, using comparable measures and design; (2) the use of several alcohol biomarkers as well as sensitivity analyses, which provide robustness to our conclusions; (3) a sampling frame that includes people living in institutions and the military and we were able to perform linkage to mortality data in all cases, reducing some of the risk of selection bias; and (4) reduced risk of misclassification bias in the outcome, since we did not combine alcohol mortality and morbidity. A composite endpoint might mask divergent underlying patterns and associations and be subject to different degrees of misclassification bias.[55] Moreover, death certificates in Finland have nearly 100% coverage, undergo rigorous revisions and a high proportion (about 20%) are certified with an autopsy, the highest rate among Nordic countries.[56, 57] Almost all deaths (99.3%) are covered in the Causes of Death register and, as a result, we expect a similar degree of linkage in our data.[57]

Some limitations, however, are noted. First, we examined alcohol consumption and socioeconomic status at one timepoint. However, most of our exposures change over time and we were not able to distinguish different trajectories over the life course. In our sensitivity analyses, there was no evidence that using different follow-up times would change the results, meaning that the effect of alcohol at baseline probably remained relatively constant over time. Second, heavy drinkers are less likely to participate in population health surveys, resulting in selection bias due to non-participation.

This would impact the results if heavy drinkers from lower SES were less likely to participate than heavy drinkers from higher SES. While possible, we estimate the risk of selection bias to be small given the relatively high participation rate (74% on average) in the surveys in this study. Third, the use of a short recall period (average week) has the advantage of being less sensitive to recall bias, but it is subject to within-person variations and might overlook infrequent drinkers.[58] Our sensitivity analyses separated never, former and infrequent drinkers and the results were consistent with the main analyses.

Conclusions

Lower socioeconomic groups experienced higher alcohol mortality, despite reporting lower levels of alcohol use. Differential exposure to alcohol, measured with alcohol biomarkers, did not explain the alcohol harm paradox. Further research should explore the role of differential vulnerability due to behavioural risk factors and access to health care. Universal and targeted alcohol policies benefiting people with lower SES are needed to reduce their disproportionate share of alcohol-attributable mortality.

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Conflicts of interest

None declared

References

1. GBD Alcohol Collaborators. Alcohol use and burden for 195 countries and territories, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2018; **392**: 1015-35.
2. Probst C, Roerecke M, Behrendt S, Rehm J. Gender differences in socioeconomic inequality of alcohol-attributable mortality: A systematic review and meta-analysis. *Drug Alcohol Rev* 2015; **34**: 267-77.
3. Mackenbach JP, Kulhanova I, Bopp M, et al. Inequalities in Alcohol-Related Mortality in 17 European Countries: A Retrospective Analysis of Mortality Registers. *PLoS Med* 2015; **12**: e1001909.
4. Mäkelä P, Valkonen T, Martelin T. Contribution of deaths related to alcohol use to socioeconomic variation in mortality: register based follow up study. *BMJ* 1997; **315**: 211-6.
5. Hemström O. Alcohol-related deaths contribute to socioeconomic differentials in mortality in Sweden. *Eur J Public Health* 2002; **12**: 254-62.
6. Tarkiainen L, Martikainen P, Laaksonen M. The contribution of education, social class and economic activity to the income-mortality association in alcohol-related and other mortality in Finland in 1988-2012. *Addiction* 2016; **111**: 456-64.
7. Peña S, Mäkelä P, Valdivia G, et al. Socioeconomic inequalities in alcohol consumption in Chile and Finland. *Drug Alcohol Depend* 2017; **173**: 24-30.
8. Beard E, Brown J, West R, et al. Deconstructing the Alcohol Harm Paradox: A Population Based Survey of Adults in England. *PLOS ONE* 2016; **11**: e0160666.

9. Lewer D, Meier P, Beard E, Boniface S, Kaner E. Unravelling the alcohol harm paradox: a population-based study of social gradients across very heavy drinking thresholds. *BMC Public Health* 2016; **16**: 599.
10. Bellis MA, Hughes K, Nicholls J, Sheron N, Gilmore I, Jones L. The alcohol harm paradox: using a national survey to explore how alcohol may disproportionately impact health in deprived individuals. *BMC Public Health* 2016; **16**: 111.
11. Bloomfield K, Grittner U, Kramer S, Gmel G. Social inequalities in alcohol consumption and alcohol-related problems in the study countries of the EU concerted action 'Gender, Culture and Alcohol Problems: a Multi-national Study'. *Alcohol Alcohol Suppl* 2006; **41**: i26-36.
12. Bobak M, Malyutina S, Horvat P, et al. Alcohol, drinking pattern and all-cause, cardiovascular and alcohol-related mortality in Eastern Europe. *Eur J Epidemiol* 2016; **31**: 21-30.
13. Sydén L, Sidorchuk A, Mäkelä P, Landberg J. The contribution of alcohol use and other behavioural, material and social factors to socio-economic differences in alcohol-related disorders in a Swedish cohort. *Addiction* 2017; **112**: 1920-30.
14. Mäkelä P, Keskimäki I, Koskinen S. What underlies the high alcohol related mortality of the disadvantaged: high morbidity or poor survival? *J Epidemiol Community Health* 2003; **57**: 981-6.
15. Katikireddi SV, Whitley E, Lewsey J, Gray L, Leyland AH. Socioeconomic status as an effect modifier of alcohol consumption and harm: analysis of linked cohort data. *Lancet Public Health* 2017; **2**: e267-e76.
16. Mäkelä P, Paljärvi T. Do consequences of a given pattern of drinking vary by socioeconomic status? A mortality and hospitalisation follow-up for alcohol-related causes of the Finnish Drinking Habits Surveys. *J Epidemiol Community Health* 2008; **62**: 728-33.
17. Cherpitel CJ, Ye Y, Stockwell T, Vallance K, Chow C. Recall bias across 7 days in self-reported alcohol consumption prior to injury among emergency department patients. *Drug and Alcohol Review* 2018; **37**: 382-8.
18. Davis CG, Thake J, Vilhena N. Social desirability biases in self-reported alcohol consumption and harms. *Addictive Behaviors* 2010; **35**: 302-11.
19. Devaux M, Sassi F. Social disparities in hazardous alcohol use: self-report bias may lead to incorrect estimates. *Eur J Public Health* 2016; **26**: 129-34.
20. Niemelä O. Biomarker-Based Approaches for Assessing Alcohol Use Disorders. *Int J Environ Res Public Health* 2016; **13**: 166.
21. Dolman JM, Hawkes ND. Combining the audit questionnaire and biochemical markers to assess alcohol use and risk of alcohol withdrawal in medical inpatients. *Alcohol Alcohol* 2005; **40**: 515-9.
22. Litten RZ, Bradley AM, Moss HB. Alcohol biomarkers in applied settings: recent advances and future research opportunities. *Alcohol Clin Exp Res* 2010; **34**: 955-67.
23. Montalto NJ, Bean P. Use of contemporary biomarkers in the detection of chronic alcohol use. *Med Sci Monit* 2003; **9**: RA285-90.
24. Tavakoli HR, Hull M, Michael Okasinski L. Review of current clinical biomarkers for the detection of alcohol dependence. *Innov Clin Neurosci* 2011; **8**: 26-33.
25. Niemelä O, Alatalo P. Biomarkers of alcohol consumption and related liver disease. *Scand J Clin Lab Invest* 2010; **70**: 305-12.
26. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin Epidemiol* 2008; **61**: 344-9.
27. Knekt P, Rissanen H, Järvinen R, Heliövaara M. Cohort Profile: The Finnish Mobile Clinic Health Surveys FMC, FMCF and MFS. *Int J Epidemiol* 2017; **46**: 1760-1i.
28. Borodulin K, Tolonen H, Jousilahti P, et al. Cohort Profile: The National FINRISK Study. *Int J Epidemiol* 2017.

29. Heistaro S, editor. *Methodology Report: Health 2000 Survey*. Helsinki, Finland: National Public Health Institute; 2008.
30. Sillanaukee P, Massot N, Jousilahti P, et al. Dose response of laboratory markers to alcohol consumption in a general population. *Am J Epidemiol* 2000; **152**: 747-51.
31. Jousilahti P, Rastenyte D, Tuomilehto J. Serum Gamma-Glutamyl Transferase, Self-Reported Alcohol Drinking, and the Risk of Stroke. *Stroke* 2000; **31**: 1851-5.
32. Järvisalo J, Maatela J, Mäki J, Marniemi J, Reunanen A. Health-based reference values of the Mini-Finland Health Survey: 1. Serum gamma-glutamyltransferase, aspartate aminotransferase and alkaline phosphatase. *Scand J Clin Lab Invest* 1989; **49**: 623-32.
33. Smyth A, Teo KK, Rangarajan S, et al. Alcohol consumption and cardiovascular disease, cancer, injury, admission to hospital, and mortality: a prospective cohort study. *The Lancet*; **386**: 1945-54.
34. OECD. *OECD list of social indicators*. Paris: OECD Publications and Information Center; 1982.
35. Wannamethee SG, Shaper AG. Cigarette smoking and serum liver enzymes: the role of alcohol and inflammation. *Ann Clin Biochem* 2010; **47**: 321-6.
36. Danielsson J, Kangastupa P, Laatikainen T, Aalto M, Niemelä O. Impacts of common factors of life style on serum liver enzymes. *World J Gastroenterol* 2014; **20**: 11743-52.
37. Alatalo PI, Koivisto HM, Hietala JP, Puukka KS, Bloigu R, Niemelä OJ. Effect of moderate alcohol consumption on liver enzymes increases with increasing body mass index. *Am J Clin Nutr* 2008; **88**: 1097-103.
38. Lee DH, Ha MH, Christiani DC. Body weight, alcohol consumption and liver enzyme activity--a 4-year follow-up study. *Int J Epidemiol* 2001; **30**: 766-70.
39. Du G, Song Z, Zhang Q. Gamma-glutamyltransferase is associated with cardiovascular and all-cause mortality: a meta-analysis of prospective cohort studies. *Prev Med* 2013; **57**: 31-7.
40. Kunutsor SK, Apekey TA, Cheung BM. Gamma-glutamyltransferase and risk of hypertension: a systematic review and dose-response meta-analysis of prospective evidence. *J Hypertens* 2015; **33**: 2373-81.
41. World Health Organization. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser* 1995; **854**: 1-452.
42. Statistics Finland. *The key between the short list in the time series of the causes of death since 1969 and the earlier classifications*. 2005 [cited 27 April 2018]; Available from: http://www.stat.fi/til/ksyyt/2005/ksyyt_2005_2006-10-31_luo_002_en.html
43. Grambsch PM, Therneau TM. Proportional hazards tests and diagnostics based on weighted residuals. *Biometrika* 1994; **81**: 515-26.
44. Zhang Z, Reinikainen J, Adeleke KA, Pieterse ME, Groothuis-Oudshoorn CGM. Time-varying covariates and coefficients in Cox regression models. *Ann Transl Med* 2018; **6**: 121.
45. Ramsay JO, Heckman N, Silverman BW. Spline smoothing with model-based penalties. *Behavior Research Methods, Instruments, & Computers* 1997; **29**: 99-106.
46. Therneau TM, Atkinson E. Concordance. 2019.
47. Baron RM, Kenny DA. The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology* 1986; **51**: 1173-82.
48. MacKinnon DP, Krull JL, Lockwood CM. Equivalence of the Mediation, Confounding and Suppression Effect. *Prevention Science* 2000; **1**: 173-81.
49. Stringhini S, Zaninotto P, Kumari M, Kivimäki M, Lassale C, Batty GD. Socio-economic trajectories and cardiovascular disease mortality in older people: the English Longitudinal Study of Ageing. *International Journal of Epidemiology* 2017; **47**: 36-46.

50. Probst C, Roerecke M, Behrendt S, Rehm J. Socioeconomic differences in alcohol-attributable mortality compared with all-cause mortality: a systematic review and meta-analysis. *Int J Epidemiol* 2014; **43**: 1314-27.
51. Park EY, Lim MK, Oh JK, et al. Independent and supra-additive effects of alcohol consumption, cigarette smoking, and metabolic syndrome on the elevation of serum liver enzyme levels. *PLoS One* 2013; **8**: e63439.
52. Hart CL, Morrison DS, Batty GD, Mitchell RJ, Davey Smith G. Effect of body mass index and alcohol consumption on liver disease: analysis of data from two prospective cohort studies. *BMJ* 2010; **340**: c1240.
53. Ferreira Antunes JL, Toporcov TN, Biazevic MG, Boing AF, Scully C, Petti S. Joint and independent effects of alcohol drinking and tobacco smoking on oral cancer: a large case-control study. *PLoS One* 2013; **8**: e68132.
54. Härkönen J, Aalto M, Suvisaari J, et al. Predictors of Persistence of Risky Drinking in Adults: An 11-Year Follow-Up Study. *Eur Addict Res* 2017; **23**: 231-7.
55. Goldberg R, Gore JM, Barton B, Gurwitz J. Individual and Composite Study Endpoints: Separating the Wheat from the Chaff. *The American journal of medicine* 2014; **127**: 379-84.
56. Lehti V, Gissler M, Markkula N, Suvisaari J. Mortality and causes of death among the migrant population of Finland in 2011-13. *Eur J Public Health* 2017; **27**: 117-23.
57. Statistics Finland. *Quality Description: Causes of death 2015*. 2015 [cited 10 May 2018]; Available from: https://www.stat.fi/til/ksyyt/2015/ksyyt_2015_2016-12-30_laa_001_en.html
58. Gmel G, Rehm J. Measuring alcohol consumption. *Contemporary Drug Problems* 2004; **31**: 467-540.

Supplementary Appendix for the article:

Measurement error as an explanation for the alcohol harm paradox: analysis of eight cohort studies

Sebastián Peña, Pia Mäkelä, Tommi Härkänen, Markku Heliövaara, Teemu Gunnar, Satu Männistö, Tiina Laatikainen, Erkki Vartiainen, Seppo Koskinen

Corresponding author

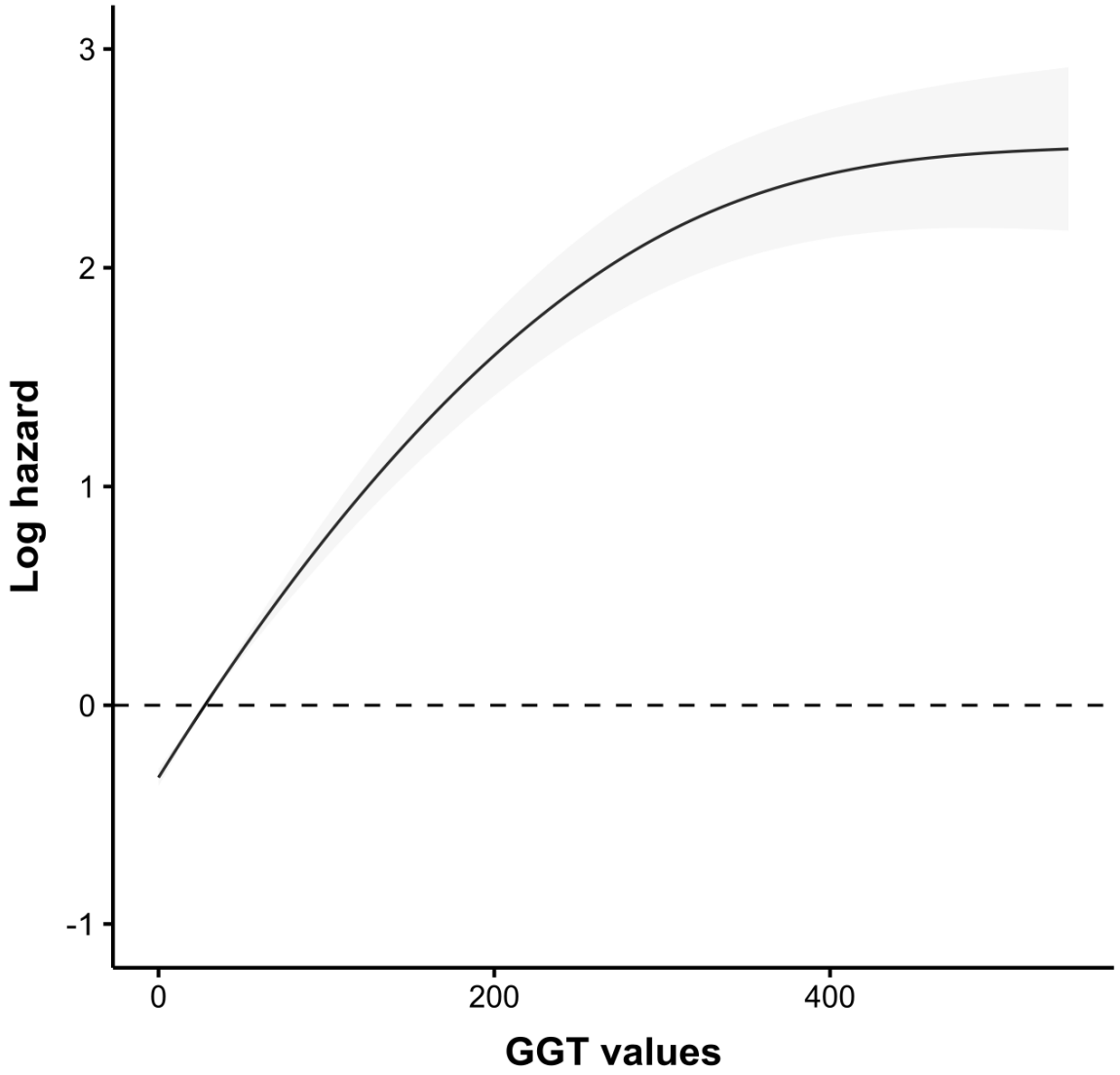
Sebastián Peña
Finnish Institute for Health and Welfare
Mannerheimintie 166
PL 30, 00271 Helsinki
FINLAND
Email: sebastian.penafajuri@thl.fi

Table of Contents

An R markdown file and the STROBE checklist for observational studies have been attached separately during the submission process.

1. Functional form of gamma-glutamyl transferase (GGT) with alcohol mortality (Supplementary Figure S1)

Supplementary Figure S1. Functional form of GGT with alcohol mortality as outcome in 52,164 participants in eight cohort studies in Finland (1978-2007)



Figures are based on predicted probabilities of a Cox model adjusting for age (as timescale), sex, income, marital status, smoking status, body mass index, baseline health conditions, self-reported alcohol use and survey round (as frailty). To prevent overrepresentation of extreme values, percentiles 0-99% of biomarker values are plotted. GGT gamma-glutamyl transferase

2. Baseline characteristics of participants by educational level (Supplementary Table S1)

Supplementary Table S1. Baseline characteristics of participants by educational level

	Educational levels		
	Basic	**Intermediate**	**High**
Total participants	24752	19395	9971
Mean follow-up	21.1	21.1	16.3
Person-years	523434	410005	162555
Deaths, %	475	305	78
Death rate	9.1	7.4	4.8
Age (SD)	52.70 (12.84)	42.88 (12.39)	44.73 (12.45)
Male, %	47.5	49.9	42.3
Alcohol intake			
Mean grams per week	43.14 (94.43)	60.78 (100.95)	67.83 (98.79)
Never and former drinkers	51	35.8	26.3
Low intake	33.8	41	46.6
Moderate intake	11.6	17.9	21.4
High intake	3.1	4.8	5.2
Very high intake	0.5	0.5	0.5
GGT	30.69 (51.73)	29.66 (44.48)	29.79 (37.77)
CDT	15.40 (7.71)	14.86 (7.89)	9.91 (9.66)
AST	23.89 (14.67)	23.27 (8.85)	23.27 (13.01)
ALT	26.28 (16.87)	28.50 (27.05)	25.30 (16.59)
Smoking			
Never smoker	51.5	51	61.7
Ex-smoker	21.9	21.2	19.6
Current smoker	26.7	27.9	18.7
Body mass index			
Underweight	0.6	1	1.1
Normal weight	34	45.2	49.5
Overweight	42.3	37.7	36.2
Obese	23	16	13.3
Marital status			

Single, divorced or widowed	28.7	25.4	23.5

Data are mean (SD) or number (%). Even rates are rates per 10,000 person-years

Data on alcohol use and GGT available for full sample. Data on CDT was available from the full sample of FINRISK 1997 and a subsample of FINRISK 2007. Data on AST was available from MFS 1978-1980. Data on ALT was available from FINRISK 2002.

GGT gamma-glutamyl transferase, CDT carbohydrate-deficient transferrin, AST alanine aminotransferase, ALT aspartate aminotransferase

3. Baseline characteristics of participants by survey round (Supplementary Table S2)

Supplementary Table S2. Baseline characteristics of participants by survey round

	MFS 1978-80	**FINRISK 1982**	**FINRISK 1987**	**FINRISK 1992**	**FINRISK 1997**	**Health 2000**	**FINRISK 2002**	**FINRISK 2007**
Age range	30+	25-64	25-64	25-74	25-74	30+	25-74	25-74
Total participants	7045	8147	4825	5349	7438	6058	7782	5520
Mean follow-up	25.8	29.3	26.6	23.0	18.4	13.7	14.3	9.6
Person-years	181947	238907	128454	122984	136733	83106	111546	53165
Events, %	131	206	94	117	103	71	78	28
Incidence rate	7.2	8.6	7.3	9.5	7.5	8.5	7.0	5.3
Age (SD)	51.33 (14.05)	43.78 (11.23)	43.72 (11.23)	44.41 (11.39)	47.69 (13.36)	53.36 (14.85)	47.15 (13.03)	49.79 (13.90)
Male, %	46.3	50.1	49	47.9	50.1	45.5	46.2	47.1
Alcohol intake								
Mean (g/week)	45.8 (97.1)	41.4 (86.0)	40.6 (78.5)	56.3 (96.1)	56.0 (94.6)	74.9 (127.8)	62.5 (99.8)	61.0 (97.4)
Never and former drinkers	45.2	53.4	49.4	38	36.6	31.2	33.6	34.5
Low intake	40.4	30.6	34	40.9	41.6	43.1	42	40.4
Moderate intake	10	13	14.1	16.6	17.3	17.2	19.5	19.8
High intake	3.8	2.6	2.3	4.2	4.1	7.2	4.4	4.9
Very high intake	0.6	0.3	0.2	0.4	0.3	1.4	0.4	0.4
GGT	27.31 (44.13)	22.70 (32.95)	22.25 (27.67)	28.05 (41.01)	35.96 (60.18)	36.80 (48.68)	34.23 (52.20)	33.96 (56.43)
CDT					16.60 (6.82)			
AST	23.71 (13.51)							
ALT							26.57 (20.54)	
Smoking								
Never smoker	55.3	52.2	54	52.2	53	51.6	52.1	54.1

Ex-smoker	21	19.2	19.5	19.7	23.1	21.8	21.5	25.1
Current smoker	23.8	28.6	26.5	28.1	23.9	26.6	26.4	20.9
Body mass index								
Underweight	1.1	0.8	1	1.1	0.8	0.7	0.7	0.6
Normal weight	44.7	44.8	42.2	44.2	39.4	36.7	38.5	36.9
Overweight	39	39	39.8	37.2	40.9	40.3	39.8	40.3
Obese	15.2	15.4	17.1	17.5	18.9	22.3	20.9	22.1
Marital status								
Single, divorced or widowed	26.9	26	22	24.8	26.6	30.2	25.1	27.8

GGT gamma-glutamyl transferase, CDT carbohydrate-deficient transferrin, AST alanine aminotransferase, ALT aspartate aminotransferase

4. Stratified analysis by sex (Supplementary Table 3)

Supplementary Table 3 shows the hazard ratios of lowest versus highest income quintile stratified by sex. The results in men are consistent with the main analyses. In the case of women, there are no income differences in alcohol mortality. Adjusting for self-reported alcohol use and further by GGT leads to an increase in the hazard ratio, although confidence intervals overlap with 1.

It should be noted that the beta coefficient in model 2 is negative (HR 0.97, 95% CI 0.57; 1.65), which results in a positive percent attenuation (while it should be negative). We omitted the percent attenuation in this case to avoid confusion.

Supplementary Table 3. Hazard ratios of lowest vs. highest income quintile and percent attenuation after adjusting for covariates by sex

	Men		Women	
	HR (95% CI)	% attenuation	HR (95% CI)	% attenuation
Model 1: Adjusted for sex, age and survey round	2.32 (1.84; 2.93)		1.06 (0.63; 1.80)	
Model 2: model 1 and marital status, smoking, obesity and baseline health conditions	1.85 (1.47; 2.34)	reference	0.97 (0.57; 1.65)	reference
Model 3: model 2 and self-reported alcohol use	2.41 (1.89; 3.07)	-42.8	1.47 (0.85; 2.54)	-
Model 4: model 2 and self-reported alcohol use and GGT	2.27 (1.77; 2.90)	-33.2	1.40 (0.81; 2.42)	-
Model 5: model 2 and GGT	1.88 (1.48; 2.38)	-2.2	1.06 (0.62; 1.81)	-

HR hazard ratio, CI confidence interval. HR is for the lowest income compared to highest income. GGT gamma-glutamyl transferase

Baseline health conditions include poor self-rated health, self-reported history of diabetes, myocardial infarction, stroke, emphysema and gallstones

Model in men: n =24949, 698 events. Model in women: n = 27215, 130 events

5. Stratified analysis by duration of follow-up (Supplementary Table 4)

Supplementary Table 4 shows the hazard ratios of lowest versus highest income quintile stratified by duration of follow-up: less than 10 years, less than 20 years and less than 30 years. For simplicity and technical feasibility, we report analyses using all surveys and GGT as alcohol biomarker.

We observed a lower initial hazard ratio compared to Table 3. This is more prominent in the analysis with duration of follow-up less than 10 years. However, the results are consistent with the main analyses.

Supplementary Table 4. Hazard ratios of lowest vs. highest income quintile and percent attenuation after adjusting for covariates by duration of follow-up

	Less than 10 years		Less than 20 years		Less than 30 years	
	HR (95% CI)	% attenuation	HR (95% CI)	% attenuation	HR (95% CI)	% attenuation
Model 1: Adjusted for sex, age and survey round	1.26 (0.89; 1.79)		1.62 (1.26; 2.08)		1.74 (1.39; 2.18)	
Model 2: model 1 and marital status, smoking, obesity and baseline health conditions	1.16 (0.82; 1.66	reference	1.35 (1.05; 1.74)	reference	1.47 (1.17; 1.84)	reference
Model 3: model 2 and self-reported alcohol use	1.39 (0.97; 1.98)	-117.0	1.66 (1.28; 2.14)	-66.8	1.86 (1.47; 2.36)	-62.6)
Model 4: model 2 and self-reported alcohol use and GGT	1.35 (0.94; 1.93)	-99.5	1.56 (1.21; 2.02)	-47.7	1.81 (1.43; 2.29)	-54.6
Model 5: model 2 and GGT	1.21 (0.84; 1.72	--25.2	1.38 (1.07; 1.78)	-6.6	1.53 (1.22; 1.93)	-11.6

HR hazard ratio, CI confidence interval. HR is for the lowest income compared to highest income. GGT gamma-glutamyl transferase

Baseline health conditions include poor self-rated health, self-reported history of diabetes, myocardial infarction, stroke, emphysema and gallstones

Model with follow-up less than 10 years: n = 9217, 314 events. Model with follow-up less than 20 years: n = 31822, 609 events. Model with Model with follow-up less than 30 years: n = 43086, 783 events.

6. Analyses using an alternative measure of alcohol use (Supplementary Table 5)

Supplementary Table 5 shows the hazard ratios of lowest versus highest income quintile using different measures of alcohol use. The main analyses use a categorical variable of volume of alcohol consumption. The category never or former drinkers includes three types of drinkers: people who have never drunk alcohol in their life (never drinkers), people who used to drink but quit (former drinkers) and people who reported to have drank alcohol in the past 12 months but not in the last week (infrequent drinkers). The surveys FINRISK 1987-2007 and Health 2000 include a question to differentiate these three groups. Alcohol biomarkers GGT, CDT and ALT are available in those surveys.

We built a new variable with seven categories: 1 = never drinker, 2 = former drinker, 3 = infrequent drinker, 4 = low intake, 5 = moderate intake, 6 = high intake and 7 = very high intake. Additionally, we constructed a heavy episodic drinking (HED) variable with three categories: 0 = HED less than once a month, 1 = HED once a month or more but less than once a week, 2 = HED once a week or more. HED was defined as drinking more than 5 standard drinks per occasion (~60 grams of pure alcohol).

The results are very similar to the analyses in Table 3. Adjusting for self-reported alcohol use and HED resulted in an increase in the HR. Adjusting for both self-reported and alcohol biomarkers resulted in a small attenuation (3.0%-3.8%) or in an increase in the HR compared to model 2. Adjusting for biomarkers only resulted in small attenuations ranging from 1.2% to 11.0%.

Supplementary Table 5. Hazard ratios of lowest vs. highest income quintile and percent attenuation after adjusting for covariates using alternative measures of alcohol use

	GGT		GGT+CDT		GGT+ALT	
	HR (95% CI)	% attenuation	HR (95% CI)	% attenuation	HR (95% CI)	% attenuation
Model 1: Adjusted for sex, age and survey round	3.35 (2.52; 4.44)		3.26 (1.71; 6.24)		6.64 (2.70; 16.34)	
Model 2: model 1 and marital status, smoking, obesity and baseline health conditions	2.51 (1.89; 3.35)	reference	2.52 (1.31; 4.85)	reference	3.69 (1.47; 9.26)	reference
Model 3: model 2 and expanded self-reported volume and HED in alcohol use	2.98 (2.23; 3.98)	-18.4	2.87 (1.48; 5.60)	-14.2	4.09 (1.62; 10.33)	-7.8
Model 4: model 2 and self-reported volume and HED in alcohol use and alcohol biomarker	2.71 (2.03; 3.63)	-8.3	2.43 (1.23; 4.82)	3.8	3.55 (1.41; 8.97)	3.0
Model 5: model 2 and alcohol biomarker	2.49 (1.86; 3.31)	1.2	2.28 (1.17; 4.44)	11.0	3.34 (1.32; 8.44)	7.8

Expanded self-reported has seven categories: never drinker, former drinker, current drinker but not in the past 7 days, low intake, moderate intake, high intake and very high intake. GGT gamma-glutamyl transferase, CDT carbohydrate-deficient transferrin, ALT aspartate aminotransferase

Model with GGT has data from FINRISK 1987-2002 and H2000 (n = 32,738, events = 472). Model with GGT+CDT: n = 6318, events = 97. Model with GGT+ALT: n = 6833, events = 71

7. Data harmonization protocol

1.1 Alcohol variables

1.1.1 GRWEEK7D – Weekly consumption of alcohol

Name: grweek7d

Type: Decimal, [0, ∞]

Description:

Weekly consumption of alcohol in grams is estimated by adding the consumption of alcohol in grams from beverage-specific questions. See beverage-specific variables for more details on the conversion of frequencies, quantities and grams from each survey. Quantity measures were estimated by multiplying the volume in each question by a standard % of pure alcohol for a beer, long drink, cider or light wine and by the alcohol density of 1 ml (0.789 gr/m3). The standard alcohol content was calculated using the yearly average strength of medium and strong beer, long drinks, light and fortified wines and spirits using sales data on volume and 100% alcohol volume provided by the Finnish Institute for Health and Welfare. For each survey, an average strength for each alcohol beverage was calculated. In case of questions including more than one alcohol beverage, we calculated the average alcohol strength.

Weekly alcohol consumption is calculated using the following formula:

(a) $Weekly\ use\ alcohol_{beer} = Volume\ consumed * Average\ strength * 0.789$

Example:

$$Weekly\ consumption\ of\ 3\ bottles\ of\ beer\ in\ FINRISK\ 1982 = 3 * 330 * 0.045 * 0.789$$
$$= 35.1\ \text{grams/week}$$

The average weekly consumption of alcohol is used to create a categorical variable (ALCOHOL7D_5): abstainers (including never and former drinkers), low intake (0.1 to 84 grams of ethanol per week), moderate intake (men 84-252 gr/w); women 84-168 gr/w), high intake (men 252-611 gr/w; women 168-431 gr/w) and very high intake (men ≥612 gr/w; women ≥432 gr/wk). These cut-offs are based on previous research.

Comparability. All instruments had a similar structure. MFS78 and H2000 asked about the average weekly consumption during the past month. The type of beverages included in the

questionnaire is not constant. Annex 1 describes the survey questions and exact coding strategy.

1.1.2 GRBEER7D – Weekly consumption of beer and similar beverages

Name: grbeer7d

Type: Decimal, [0, ∞]

Description:

Weekly grams of alcohol consumption were calculated as described above. There was variation in the types of beverages asked in each survey. This is primarily due to the fact that consumption of cider was very low in the 1970s and 1980s. More recent surveys introduced questions about medium and strong beer and cider, but the average alcohol strength remains relatively constant over the study period.

Average strength and types of beverages examined in each cohort

Cohort	Type of beverage	Average strength
MFS 1978-1980	Beer or long drink	4.5%
FINRISK 1982	Beer III or IV or long drinks	4.8%
FINRISK 1987 and 1992	Beer III or IV or long drinks	4.8%
FINRISK 1992	Beer III or IV or long drinks	4.6%
FINRISK 1997	Beer III or IV, long drinks, cider or light wine	4.6%
H2000	Beer, cider or long drinks	4.7%
FINRISK 2002-2007	Beer III, strong beer IV, strong cider or long drinks	4.7
FINRISK 2007	Beer III, strong beer IV, strong cider or long drinks	4.6%

1.1.3 GRWINE7D – Average daily consumption of wine and other similar beverages

Name: grwine7d

Type: Decimal, [0, ∞]

Description:

Weekly grams of alcohol consumption were calculated as described above. The types of beverage are consistent over time, except for FINRISK 2002 and 2007 which had separate questions for red wine and other wines. Consumption of fortified wines (wines with added spirits, such as sherry and vermouth) was greater in the 1980s, which leads to a higher average strength in the MFS1978 and FINRISK 1982 and 1987.

Average strength and types of beverages examined in each cohort

Cohort	Type of beverage	Average strength
MFS 1978-1980	Wine	15.5%
FINRISK 1982	Wine	15.3%
FINRISK 1987	Wine	14.0%
FINRISK 1992	Wine	12.5%
FINRISK 1997	Wine	12.1%
H2000	Wine	12.2%
FINRISK 2002	Red wine and other wines	12.3%
FINRISK 2007	Red wine and other wines	12.8%

1.1.4 GRSPIRITS7D – Average daily consumption of spirits

Name: grspirits7d

Type: Decimal, [0, ∞]

Description:

Weekly grams of alcohol consumption were calculated as described above. The types of beverages are consistent over time. The average strength experienced a decline over the study period.

Average strength and types of beverages examined in each cohort

Cohort	Type of beverage	Average strength
MFS 1978-1980	Spirits	38.0%
FINRISK 1982	Spirits	37.7%
FINRISK 1987	Spirits	37.4%
FINRISK 1992	Spirits	36.6%
FINRISK 1997	Spirits	36.9%
H2000	Spirits	36.2%
FINRISK 2002-2007	Spirits	36.0%
FINRISK 2007	Spirits	35.1%

1.1.5 HED_DIC - Heavy episodic drinking

Name: hed_dic

Type: Categorical

Description:

Heavy episodic drinking was defined as the consumption of more than 5 drinks at a single occasion. A categorical variable was constructed: 0 for those who drank 5 drinks less than once a month; 1 for those who drank 5 drinks once a month or more but less than once a week; 2 for those who drank 5 drinks once a week or more.

1 = HED once a month or more but less than once a week, 2 = HED once a week or more

MFS does not have specific questions for HED. In H2000, respondents were asked how often they consumed 5 or more portions during the past year. A sum of the frequencies greater than 12 (proxy for once per month) of 5 or more portions was considered HED. In FINRISK, the QF measure was used to identify drinkers who consumed more than 5 drinks (1 bottle of beer, 12cl of wine or 4cl of spirits) more than once a month.

1.1.6 DRINKSTATUS – Drinking status

Name: drinkstatus

Type: Categorical

Description: The category never or former drinkers includes three types of drinkers: people who have never drunk alcohol in their life (never drinkers), people who used to drink but quit (former drinkers) and people who reported to have drank alcohol in the past 12 months but not in the last week (infrequent drinkers). The surveys FINRISK 1987-2007 and Health 2000 include a question to differentiate these three groups

1.2 Sociodemographic variables

1.2.1 INCOME_5 – Income quintiles

Name: income_5

Type: Categorical

Description:

Income was defined as total household income per year adjusted to household composition. The OECD equivalence scale was used, dividing the total household income by the number of consumption, where the first member over 17 years old was weighted as 1-unit, other members > 17 years old as 0.7 and children aged under 18 years old as 0.5.

All surveys included a categorical variable either in FIM (Finnish marks) or euros. Arithmetic mid-points were considered for frequencies including a range (e.g. 10000-20000 euros was coded as 15000). Higher summary frequencies were coded as the lowest possible value (e.g. 80000 euros was coded 80000). In MFS, the cut-off for children was under 16 years (15 years or less). Income was finally converted into quintiles within each survey.

1.2.2 EDULEVEL_3 – Educational level

Name: edulevel_3

Type: Categorical

Description:

Level of education was divided in three categories based on the highest grade achieved. Basic education (corresponds to ISCED 1-2) was defined as those without matriculation examination and at most with a vocational course or on the job training. Intermediate

education included high school or completed vocational school. High education was defined as having higher vocational institution, polytechnic or university.

In H2000 and MFS, the variable is derived from two questions on the highest degree completed and what further education the respondent had. In FINRISK, the variable is based on one question about the highest educational degree achieved (with a varying number of alternatives).

Annex 2 has a detailed description of how the socioeconomic variables variables were created.

1.2 MARITALSTATUS – Marital status

Name: maritalstatus

Type: Binary

Description:

All datasets provide comparable questions on marital status. Married or cohabiting were coded 0 and single, widowed or divorced were coded 1.

1.3 Confounders

1.3.1 SMOKSTATUS – Smoking status

Name: smokstatus

Type: Categorical

Description:

Smoking was constructed based on whether respondents ever smoked, whether they smoked at least 100 times, whether they smoked daily for at least one year and the last time they smoked (or when did they quit). The Appendix 3 has more information on each of the questions from each survey. A categorical variable of never-smoker, former-smoker and current smoker was constructed with all datasets.

1.3.2 BODY MASS INDEX – Body Mass Index

Name: bmi

Type: Decimal

Description:

Body mass index was measured by trained health professionals during the health examination in all surveys. Body mass index was calculated using the weight in kilograms divided by the squared height in centimetres. We checked non-linearity by plotting BMI against martingale residuals. The functional form was clearly non-linear, thus a categorical variable was constructed based on WHO classification: underweight (<18.50), normal (18.5-24.99), overweight (25-29.99) and obese (>30). Normal weight was used as the reference level.

1.3.3 Poor self-rated health

Name: selfhealth

Type: Binary

Description:

Poor self-rated health was measured using a question that asked about the participant's present state of health. The formulation was very similar in all surveys. The Appendix 3 has more information on each of the questions from each survey. A binary variable of poor/rather poor and good/rather good/average was constructed with all datasets.

1.3.3 Baseline health conditions

Name: diabetes, mi, stroke, gallstones, emphysema

Type: Binary

Description:

All surveys asked about whether the participant has been diagnosed with certain baseline health conditions. The formulation was very similar in all surveys. The Appendix 3 has more information on each of the questions from each survey. We constructed a binary variable (yes/no) based on the questions.

1.4 *Questions in each survey and exact coding patterns*[1]

1.4.1 Alcohol variables

Quantity of alcohol use - Beer

Survey	Question	Answers	Equivalence
MFS 1978-1980	V3391. What has your average weekly consumption of alcohol been during the past month: Beer and long drinks altogether	None Bottles a week: ____	(bottles per week) Count*330 ml
FINRISK 1982-1992	How many bottles did you drink during the last week (last 7 days) of the following: Q130a. Beer (IV A or III) Q130b. Long drink	_ bottles	(bottles per week) Count*330 ml
FINRISK 1997	ky141_1. How many glasses (restaurant measures) or bottles did you drink during the last week (last 7 days) of the following: Beer (IV A or III) (bottle = 1/3 litre) ky141_2. How many bottles did you drink during the last week (last 7 days) of the following: Long drinks ky141_5. How many glasses (restaurant measures) or bottles did you drink during the last week (last 7 days) of the following: Cider or light wine (1 glass = c. 12 cl, alcohol over 5%)	_ bottles	(bottles per week) Count*330 ml
H2000	K1_K42. On an average how much of these drinks did you drink a week during the past month? [refers to K1_K41 "beer, cider or long drinks"]	0 None at all 1 ___ bottles a week	(330 ml bottles) Count*330
FINRISK 2002-2007	How many glasses (restaurant measures) or bottles did you drink during the last week (last 7 days) of the following:	_ glasses or bottles	(glasses or bottles per week) Count*333.3 ml

[1] All FINRISK surveys have a skip pattern for non-drinkers (Q129 in FINRISK 1982-1992, ky140 in FINRISK 1997 and Q128a and Q129 in FINRISK 2002-2007). H2000 has a similar skip pattern (kys1_k38).

	fr02_145a. Beer (class III) or medium strong cider (sold in markets, alcohol content 2.9-4.7%) bottles (1/3 litre) fr02_145b. Beer (class IV, alcohol content over 4.7%) bottles (1/3 litre) fr02_145c. Strong cider or long drinks (sold only in the ALKO stores, alcohol content over 4.7%) bottles (1/3 litre)		

Quantity of alcohol use – Wine

Survey	**Question**	**Answers**	**Equivalence**
MFS 1978-1980	V3392. What has your average weekly consumption of alcohol been during the past month: Wine (e.g. red wine, white wine, sherry, vermouth) a week [Note: 1 bottle = 3/4 litre bottle]	0 None 1 Less than a glass (8 cl) a week 2 1-4 glasses a week 3 1/2 - less than 3 full size bottles 4 3-less than 5 full size bottles 5 5 full size bottles or more	0 0 1 80 2 300 3 1312.5 4 3000 5 3750
FINRISK 1982-1992	Q130d. How many glasses did you drink during the last week (last 7 days) of the following: Wine or equivalent	_ glasses	(glasses per week) Count*120 ml
FINRISK 1997	KY141_4. How many glasses (restaurant measures) or bottles did you drink during the last week (last 7 days) of the following: Wine or equivalent (1 glass = c. 12 cl, alcohol over 5%)	_ glasses	(glasses per week) Count*120 ml
H2000	Kys1_k45. How much wine did you drink on an average per day during the days when you drank any wine?	1 two big bottles or more. How many bottles? __bottles 2 one and a half big bottles 3 about one big bottle 4 about half a litre 5 about one small bottle 6 about two glasses 7 about one glass 8 less than one glass	(in ml) 1 count 2 1250 3 750 4 500 5 375 6 300 7 150 8 100
FINRISK 2002-2007	How many glasses (restaurant measures) or bottles did you drink during the last week (last 7 days) of the following:	_ glasses	(glasses per week) Count*120 ml

	fr02_145e. Red wine glasses (1 glass = c. 12 cl) fr02_145f. Other kind of wine glasses (1 glass = c. 12 cl)		

Quantity of alcohol use - Spirits

Survey	**Question**	**Answers**	**Equivalence**
MFS 1978-1980	V3393. What has your average weekly consumption of alcohol been during the past month: Spirits or other strong alcoholic beverages (spirits, vodka, brandy, whisky, gin, liqueur) a week. [Note: 1 glass = 4cl. 1 bottle = 1/2 little bottle]	0 None 1 Less than a glass (4 cl) a week 2 1-6 glasses a week 3 1/2 - less than 2 bottles (7-24 glasses) 4 2 - less than 4 bottles 5 4 bottles or more	0 0 1 40 2 140 3 625 4 1500 5 2000
H2000	kys1_k48. How much spirits a day did you usually drink on the days when you drank them?	1 more than two half litre bottles, how many whole bottles? ___bottles 2 approx. two half litre bottles (or one litre bottle) 3 approx. one whole bottle (0.75 litres) 4 approx. one half litre bottle 5 approx. one small bottle (0.37 litres) 6 a little less than one small bottle (approx. 0.30 litres) 7 approx. five restaurant portions (approx. 20 cl) 8 approx. four restaurant portions (approx. 16 cl) 9 a couple restaurant portions (approx. 8 cl) 10 approx. one restaurant portion (approx. 4 cl)	(in ml) 1 count 2 1000 3 750 4 500 5 375 6 300 7 200 8 160 9 80 10 40
FINRISK 1982-1992	Q130c. How many restaurant measures did you drink during the last week (last 7 days) of the following: Spirits (restaurant measures, c. 4 cl)	_ glasses	(glasses per week) Count*40 ml
FINRISK 1997	Ky141_3. How many glasses (restaurant measures) or bottles did you drink during the last week (last 7 days) of the	_ glasses	(glasses per week) Count*40 ml

	following: Spirits (restaurant measures, c. 4 cl)		
FINRISK 2002-2007	fr02_145e. How many glasses (restaurant measures) or bottles did you drink during the last week (last 7 days) of the following: Spirits or other strong alcohol restaurant measures (c. 4 cl)	_ glasses	(glasses per week) Count*40 ml

Heavy episodic drinking

Survey	**Question**	**Answers**	**Equivalence**
MFS	No specific question for HED		
H2000	50. How often during the past 12 months did you consume alcohol	1 15 or more portions of alcohol a day? _____times 2 from 13 to 14 portions a day? _____times 3 from 11 to12 portions a day? _____times 4 from 9 to 10 portions a day? _____times 5 from 7 to 8 portions a day? _____times 6 from 5 to 6 portions a day? _____times 7 from 3 to 4 portions a day? _____times 8 from 1 to 2 portions a day? _____times	Q50 Sum of 1+2+3+4+5+6 higher than 12
FINRISK 1982-1992	How often do you usually drink beer (III or IV A)? How much do you usually drink beer at a time? (1 bottle = 1/3 litres.) How often do you usually drink wine (light or strong, also homemade)? How much do you usually drink wine at a time?	Frequency (identical for all beverages) 0 never 1 daily 2 a few times a week 3 about once a week 4 few times a month 5 about once a month 6 about once in a few months 7 3- 4 times a year 8 twice a year 9 once a year or more seldom Beer 1 less than one bottle 2 1bottle 3 2bottle 4 3bottles 5 4- 5 bottles	Frequency Beer: 1-5 AND Quantity Beer (5-8) OR Frequency Wine: 1-5 AND Quantity Wine (5-8) OR Frequency Spirits: 1-5 AND Quantity Spirits (5-8)

		6 6- 9 bottles 7 10 - 14 bottles 8 15 bottles or more 9 I do not drink beer Wine 1 half a glass (1 glass = c. 12 cl() 2 one glass 3 two glasses 4 about half a bottle(1 bottle = 0,75 l) 5 a little less than one bottle 6 about one bottle 7 from one to two bottles 8 more than two bottles 9 I do not drink wine Spirts 1 less than one restaurant measure (less than 4 cl) 2 one restaurant measure (about 4 cl) 3 two restaurant measures 4 3- 4 restaurant measures 5 5- 6 restaurant measures 6 7- 10 restaurant measures 7 about a half litre bottle 8 more than a half litre bottle 9 I do not drink spirits	
FINRISK 1997	How often do you usually drink beer (III or IV A)? How much do you usually drink beer at a time? (1 bottle = 1/3 litres.) How often do you usually drink wine (light or strong, also homemade)? How much do you usually drink wine at a time?	Frequency (identical for all beverages) 0 never 1 daily 2 a few times a week 3 about once a week 4 few times a month 5 about once a month 6 about once in a few months 7 3- 4 times a year 8 twice a year 9 once a year or more seldom Beer 1 less than one bottle 2 1bottle 3 2bottle 4 3bottles 5 4- 5 bottles 6 6- 9 bottles 7 10 - 14 bottles 8 15 bottles or more 9 I do not drink beer Cider or light wine 1 half a glass (1 glass = c. 12 cl() 2 one glass	Frequency Beer: 1-5 AND Quantity Beer (5-8) OR Frequency Cider: 1-5 AND Quantity Cider (5-8) OR Frequency Wine: 1-5 AND Quantity Wine (5-8) OR Frequency Spirits: 1-5 AND Quantity Spirits (5-8)

		3 two glasses 4 about half a bottle(1 bottle = 0,75 l) 5 a little less than one bottle 6 about one bottle 7 from one to two bottles 8 more than two bottles 9 I do not drink wine Wine 1 half a glass (1 glass = c. 12 cl() 2 one glass 3 two glasses 4 about half a bottle(1 bottle = 0,75 l) 5 alittle less than one bottle 6 about one bottle 7 from one to two bottles 8 more than two bottles 9 I do not drink wine Spirts 1 less than one restaurant measure (less than 4 cl) 2 one restaurant measure (about 4 cl) 3 two restaurant measures 4 3- 4 restaurant measures 5 5- 6 restaurant measures 6 7- 10 restaurant measures 7 about a half litre bottle 8 more than a half litre bottle 9 I do not drink spirits	
FINRISK 2002-2007	How often did you drink the following amounts daily during the last 12 months? 5-7 doses How often did you drink the following amounts daily during the last 12 months? 8-12 doses How often did you drink the following amounts daily during the last 12 months? 13-17 doses How often did you drink the following amounts daily during the last 12 months? 18 or more doses	1 at least 4 times a week 2 2-3 times a week 3 once a week 4 1-2 times a month 5 3-10 times a year 6 1-2 times a year 7 never	Frequency 1-4 on any of the previous questions

Drinking status

Survey	Question	Answers	Equivalence
MFS	Not available		
H2000	38. Describe your use of alcohol; circle the alternative best describing your own alcohol use	1. I have been a non-drinker all my life (or tasted alcohol not more than 10 times during my life). 2. I used previously to drink from year 19___ but I stopped drinking___ years ago. 3. I have been drinking alcoholic drinks since year 19___ and continue to do so	Never drinker: Q38 1 Former drinker Q38 2 Infrequent drinker Q38 3 AND ALCOHOL7D_5 0
FINRISK 1987-2007	Q128A. Do you use any alcoholic drinks, even ocasionally (for example beer, wine or spirits)?	1. Yes, at least once a month 2. Yes, less than once a month 3. No, because I quit using alcohol __ years ago 4. I have never used alcohol	Never drinker: Q128A 4 Former drinker Q128A 3 Infrequent drinker: Q128A 1 or 2 AND ALCOHOL7D_5 0

Socioeconomic variables

Income

Survey	Question	Answers	Equivalence
MFS 1978-1980	V5285. What was the total income of your family last year without deducting income-related expenditure (i.e. taxable income) HOW MANY MEMBERS ARE THERE IN YOUR FAMILY? (The family includes the head with spouse and their parents and any unmarried children if permanently residing in this dwelling and sharing board. Brothers and sisters of the parents or grandparents are not reckoned herein as members of the family) V5264. HOW MANY MEMBERS OF THE FAMILY ARE CHILDREN UNDER 15? V5265. HOW MANY MEMBERS OF THE FAMILY ARE 15-64 YEARS OLD? V5266. HOW MANY MEMBERS OF THE FAMILY ARE 65 OR OLDER?	<9000 MK 9-11000 11-16000 16-22000 22-28000 28-35000 35-42000 42-50000 50-61000 61-81000 81-106 T >106000	Mid-point range divided for household members (1 for first adult, 0.7 for other adults and 0.5 for children under 15 years old 9000 10000 13500 19000 26000 31500 38500 46000 55500 71000 93000 106000
H2000	AJ01. On this card income groups are indicated with numbers. Give the number corresponding to the monthly income of your family (with taxes)? _____ Adjusted to household members by question	1 under 2500 FIM 2 2500 – 5000 3 5001 – 7500 4 7501 – 10 000 5 10 001 – 12 500 6 12 501 – 15 000	Mid-point range divided for household members (1 for first adult, 0.7 for other adults and 0.5 for children under 17

	AB02. How many persons in your household are aged: AB02a a. under 7? _____ AB02b b. from 7 to 17? _____ AB02c c. from 18 to 24? _____ AB02d d. from 25 to 64 _____ AB02e e. 65 or over? _____	7 15 001 – 17 500 8 17 501 – 20 000 9 20 001 – 25000 10 25 001 – 30 000 11 30 001 – 40 000 12 40 001 – 50 000 13 OVER 50 000 FIM	years old 9000 10000 13500 19000 26000 31500 38500 46000 55500 71000 93000 106000
FINRISK 1982	TULOT. How large was your household's income last year (before tax deduction)? RKAIKM. Are there any other persons (including spouse, children, pensioners, etc.) who are 16 years of age or older with your household LASTM. How many of your household members are under 16 years old?	1 <10000 mk 2 10000-20000 mk 3 20001-40000 mk 4 40001-60000 mk 5 60001-80000 mk 6 80001-100000 mk 7 100001-120000 mk 8 120001-140000 mk 9 >140000 mk	Mid-point range divided for household members (1 for first adult, 0.7 for other adults and 0.5 for children under 15 years old) 10000 15000 30000 50000 70000 90000 110000 130000 140000
FINRISK 1987	TULOT. How large was your household's income last year (before tax deduction)? RKAIKM. Are there any other persons (including spouse, children, pensioners, etc.) who are 16 years of age or older with your household LASTM. How many of your household members are under 16 years old?	1 <15000 mk 2 15000-30000 mk 3 30001-60000 mk 4 60001-90000 mk 5 90001-120000 mk 6 120001-150000 mk 7 150001-180000 mk 8 180001-210000 mk 9 >210000 mk	Mid-point range divided for household members (1 for first adult, 0.7 for other adults and 0.5 for children under 15 years old) 15000 22500 45000 75000 105000 135000 165000 195000 210000
FINRISK 1992	TULOT. How large was your household's income last year (before tax deduction)? RKAIK. How many members are presently included in your household? RKAIKM. How many of your household members are under 7 years LASTM. How many of your household members are 7-16 years old	1 <20000 mk 2 20000-40000 mk 3 40001-80000 mk 4 80001-120000 mk 5 120001-160000 mk 6 160001-200000 mk 7 200001-240000 mk 8 240001-280000 mk 9 >280000 mk	Mid-point range divided for household members (1 for first adult, 0.7 for other adults and 0.5 for children under 15 years old) 20000 30000 60000 100000 140000 180000

			220000 260000 280000
FINRISK 1997	TULOT. How large was your household's income last year (before tax deduction)? K13. How many members are presently included in your household? K14a. How many of your household members are under 7 years K14b. How many of your household members are 7-16 years old	1 <40000 mk 2 40001-80000 mk 3 80001-120000 mk 4 120001-160000 mk 5 160001-200000 mk 6 200001-240000 mk 7 240001-280000 mk 8 280001-320000 mk 9 >320000 mk	Mid-point range divided for household members (1 for first adult, 0.7 for other adults and 0.5 for children under 15 years old 40000 60000 100000 140000 180000 220000 260000 300000 320000
FINRISK 2002-2007	TULOT. How large was your household's income last year (before tax deduction)? K13. How many members are presently included in your household? K14a. How many of your household members are under 7 years k14b. How many of your household members are 7-16 years old	1 <10000 2 10001 - 20000 3 20001 - 30000 4 30001 - 40000 5 40001 - 50000 6 50001 - 60000 7 60001 - 70000 8 70001 - 80000 9 >80000	Mid-point range divided for household members (1 for first adult, 0.7 for other adults and 0.5 for children under 15 years old 10000 15000 25000 35000 45000 55000 65000 75000 80000

Educational level

Survey	**Question**	**Answers**	**Equivalence**
MFS	V5273. What education have you had? V5274. How much further education have you had?	1. Less than primary education 2. Primary school 3. Part of secondary school 4. Secondary school 5. Part of senior secondary school 6. Matriculated 1. No further education 2. Only courses or on-the-job training 3. No more than 2 years of institutional studies 4. Over 2 years of institutional studies 5. University degree	Basic: Q14 1 to 5 AND Q15 1 or 2 Intermediate: Q14 1 to 6 AND Q14 3 or 4 High: Q14 1 to 6 AND Q15 5

H2000	AC01. Is your basic education: AC02. What is the highest completed education or examination after your basic education:	1 less than primary school 2 primary school 3 secondary school 4 part of grammar school or part of comprehensive school (less than 9 years) 5 grammar school 6 comprehensive school 7 high school (upper secondary school) or part of it 8 matriculation examination? 1 no vocational education at all 2 training or technical certificate for courses completed 3 vocational school certificate, apprenticeship contract 4 vocational school (e.g. technical school) 5 a technical college qualification 6 a special vocational qualification (e.g. a mastership examination) 7 a degree of higher vocational qualification 8 a lower university qualification 9 a higher university qualification 10 licentiate examination 11 doctor's degree?	Basic: AC01 1 to 7 AND AC02 1 and 2 Intermediate: AC01 1 to 8 AND AC02 3, 4 and 6 High: AC01 1 to 8 AND AC02 5, 7-11 This produces variable name: MKOULU_3 (renamed edulevel_3)
FINRISK 1982-1992	PKOUL. What is your education?	1 elementary school, basic education, lower secondary education 2 vocational school or equivalent 3 upper secondary education or high school 4 university education	Basic: KY3 1 Intermediate: KY3 2 and 3 High: KY3 4
FINRISK 1997	Ky3. What is your education?	1 elementary school, basic education 2 lower secondary education 3 vocational school or equivalent 4 upper secondary education or high school 5 university education	Basic: KY3 1 OR 2 Intermediate: KY3 3 OR 4 High: KY3 5
FINRISK 2002-2007	FR02_3. What is your education? Mark your highest educational degree.	1 elementary school, basic education 2 lower secondary education 3 vocational school or equivalent 4 upper secondary education or high school 5 non-university lower education 6 non-university higher education 7 university education	Basic: FR02_3 1 OR 2 Intermediate: FR02_3 3 OR 4 High: FR02_3 5 TO 7

Confounders

Smoking

Survey	Question	Answers	Equivalence
MFS	HAVE YOU EVER BEEN A REGULAR SMOKER FOR A TOTAL OF AT LEAST ONE YEAR? (Regular smoking means smoking at least one cigarette, cigar, cigarillo or pipe every day or almost every day) DO YOU SMOKE CIGARETTES REGULARLY NOW? (Cigarettes include "home rolled") HAVE YOU SMOKED CIGARETTES REGULARLY AT SOME EARLIER PERIOD (and quit)?	Summary variable: V9021 0. never smoked 1. quit smoking 2. Cigars/pipe 3. 1-9 cigarretes 4. 10-19 cigarretes 5. 20-29 cigarretes 6. 30 cigarretes or more	1. current smoker 2. former smoker 3. never smoker
H2000	FB01. Have you ever smoked during your life time? FB02. Have you smoked at least 100 times during your life time (cigarettes, cigars or pipe tobacco)? FB03. Have you ever smoked daily for at least one year? FB06. When did you smoke last? FB05. Do you smoke nowadays (cigarettes, cigars or pipe):	Summary variable[2] M_TUPAKKA4 1. smokes daily 2. smokes occasionally 3. quit smoking 4. doesn't smoke/never smoked	1. current smoker 2. former smoker 3. never smoker
FINRISK 1992-2007	Have you ever smoked? Have you ever smoked regularly (almost every day for at least a year)? When was the last time you smoked? If you smoke continuously, mark alternative number 1.	Summary variable: TUPI3 1 Non-smoking 2 Quit smoking over 1/2 years ago 3 Quit smoking less than 1/2 years ago 4 smoking	1. current smoker 2. former smoker 3. never smoker

Poor self-rated health

Survey	Question	Answers	Equivalence
MFS	V2742. DO YOU CONSIDER YOUR	1. Good	Poor self-rated health:

[2] See Heikinen 2008 for details on the calculation https://academic.oup.com/ntr/article-abstract/10/7/1199/1096858?redirectedFrom=fulltext

	PRESENT HEALTH	2. Fairly good 3. Moderate 4. Rather poor 5. Poor 6. Can´t say	V2472 4 or 5 Goor, fairly good or medium: V2472 1, 2 or 3
H2000	BA01. I would next like to inquire about matters concerning your health and illnesses. Is your present state of health:	1. good 2. rather good 3. moderate 4. rather poor 5. poor	Poor self-rated health: BA01 4 or 5 Goor, fairly good or medium: BA01 1, 2 or 3
FINRISK 1982-2007	Q40. What do you think about your current state of health?	1. excellent 2. quite good 3. average 4. quite bad 5. very bad	Poor self-rated health: Q40 4 or 5 Goor, fairly good or medium: Q40 1, 2 or 3

Baseline health conditions

Survey	**Question**	**Answers**	**Equivalence**
MFS	Have you had, according to a physician's diagnosis V2915. Diabetes V2778. Myocardial infarction (thrombosis of coronary artery) V2818. Cerebral stroke (cerebral bleeding, cerebral thrombosis) V2943. Gallstones V2756. Pulmonary emphysema V2761. Chronic bronchitis	0. no 1. yes	Diabetes: V2915 1 Myocardial infarction: V2778 1 Stroke: V2818 1 Gallstones V2943 1 Emphysema V2756 or V2761 1
H2000	Has a doctor ever diagnosed you with any of the following illnesses: BA26. Diabetes? BA08. Coronary thrombosis i.e. myocardial infarction? BA14. Stroke (cerebral haemorrhage, cerebral thrombosis)? BA29. Bilestones or gallbladder inflammation (cholecystitis) BA05. Chronic obstructive pulmonary disease (COPD)	1. yes 2. no	Diabetes: BA26 1 Myocardial infarction: BA08 1 Stroke: BA14 1 Gallstones BA29 1 Emphysema BA05 or BA06 1

	BA06. Chronic bronchitis		
FINRISK 1982	S18. Do you have diabetes as diagnosed by your doctor? Q15a. Has a doctor ever diagnosed you for myocardial infarction? Q16a. Has a doctor ever diagnosed you with stroke or cerebral hemorrhage? Has a doctor diagnosed or treater you for any of the following diseases during the past year (last 12 months) Q17g. Gallstones, gallbladder inflammation Q17f. Pulmonary emphysema, bronchitis, chronic bronchial catarrh	1. No 2. Yes, I get insulin treatment 3. yes, I take diabetes medicines (in tablets) 4. Yes, diet only 1. no 2. yes	Diabetes: S18 2, 3 or 4 Myocardial infarction: Q15a 1 Stroke: Q16a 1 Gallstones Q17g 1 Emphysema Q17f. 1
FINRISK 1987-2002	Q34. Have you even been diagnosed for diabetes or latent diabetes? Q15a. Has a doctor ever diagnosed you for myocardial infarction? Q16a. Has a doctor ever diagnosed you with stroke or cerebral hemorrhage? Has a doctor diagnosed or treater you for any of the following diseases during the past year (last 12 months) Q17g. Gallstones, gallbladder inflammation Q17f. Pulmonary emphysema, bronchitis, chronic bronchial catarrh	1. no 2. latent diabetes 3. diabetes 1. no 2. yes	Diabetes: Q34 2 or 3 Myocardial infarction: Q15a 1 Stroke: Q16a 1 Gallstones Q17g 1 Emphysema Q17f. 1
FINRISK 2007	Has a doctor diagnosed or treater you for any of the following diseases during the past year (last 12 months) FR07_26D. Diabetes Q15a. Has a doctor ever diagnosed you for myocardial infarction? Q16a. Has a doctor ever diagnosed you with	1. no 2. yes	Diabetes: FR07_26D 1 Myocardial infarction: Q15a 1 Stroke: Q16a 1 Gallstones Q17g 1

	stroke or cerebral hemorrhage? Has a doctor diagnosed or treater you for any of the following diseases during the past year (last 12 months) Q17g. Gallstones, gallbladder inflammation Q17f. Pulmonary emphysema, bronchitis, chronic bronchial catarrh		Emphysema Q17f. 1