Alcohol use among older adults

Population perspectives on prevalence, correlates, and consequences of drinking in Swedish 70-year-olds

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ABSTRACT

Background: Alcohol consumption is a major contributor to global morbidity and mortality, as well as accidents and intentional injuries. Older adults may be particularly susceptible to these negative consequences due to age-related factors that increase vulnerability to the adverse effects of alcohol. The overall aim of this thesis was to investigate alcohol consumption patterns in population-based samples of older adults by examining the prevalence, time trends, associated factors across specific levels of consumption, and the influence of alcohol on all-cause mortality.

Method: Data were obtained from the Gothenburg H70 Birth Cohort studies, and study samples (≥70 years of age) included Birth cohorts 1906-07, 1922, 1930, and 1944, with a particular focus on Birth cohort 1944.

Results: *Paper I* outlined the methodology employed during the baseline examination of Birth cohort 1944 conducted between 2014 and 2016, serving as the foundation for all papers in this thesis. *Paper II* examined changes in alcohol consumption among four birth cohorts of 70-year-olds examined across four decades, showing a significant upward trend in consumption rates, especially among women. Risk consumption increased from 7.4% (16.1% in men, 0.5% in women) in 1976-77 to 34.0% (45.3% in men, 24.3% in women) in 2014-16. In *Paper III*, substantial discrepancies in sociodemographic, social and health-related factors across different levels of consumption were revealed, with former drinking associated with the most unfavorable set of factors. Further, characteristics varied significantly among 70-year-olds who exceeded low-risk drinking guidelines for older adults. *Paper IV* investigated the impact of alcohol on all-cause mortality in individuals with a baseline age of 70

years over an 8-year follow-up period. The study also evaluated the combined effect of lifestyle factors on mortality risk using a 7-item risk score. The findings suggested that alcohol consumption has no independent effect on all-cause mortality, but its impact was moderated by physical activity. Moreover, individuals fulfilling criteria for at least five lifestyle risk factors had up to four times higher risk of all-cause mortality.

Conclusion: Recent generations of 70-year-olds exhibited higher alcohol consumption rates, yet with few negative consequences, both cross-sectionally and longitudinally. However, consuming alcohol at rates approximately 2.5 times higher than current age-specific guidelines was associated with traditional alcohol-attributable consequences. In addition, a combination of alcohol overconsumption and several unhealthy lifestyle risk factors increased the risk of mortality. The knowledge gained from this thesis could be used to inform public health policies and interventions aimed at reducing harmful alcohol consumption in this particular age group.

Keywords: septuagenarian, aged, alcohol consumption, drinking behavior, risk consumption, cohort studies, associated factors, longitudinal studies, public health, epidemiology

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SAMMANFATTNING PÅ SVENSKA

Alkohol är en bidragande faktor till sjukdom, skador och dödsfall över hela världen. Äldre personer kan vara extra känsliga för alkoholens effekter på grund av vissa åldersrelaterade förändringar i kroppen, vilka kan påverka förmågan att hantera alkohol samt öka risken för skörhet till följd av högre förekomst av ohälsa. Mycket tyder på att dagens äldre konsumerar mer alkohol jämfört med tidigare generationer och i takt med att den äldre befolkningen ökar förväntas således även andelen personer med ett ohälsosamt alkoholbruk att öka i denna grupp, liksom de alkoholrelaterade skadorna.

Syftet med denna avhandling var att öka kunskapen kring alkoholkonsumtion bland äldre genom att använda data från de populationsbaserade H70-studierna i Göteborg. *Delarbete I* är en beskrivning av baslinjeundersökningen av 70-åringar födda 1944, vilken utgör basen för avhandlingens övriga delarbeten. *Delarbete II* undersökte skillnader i alkoholkonsumtion mellan fyra kohorter av 70-åringar från slutet av 1970-talet fram till mitten av 2010-talet. Alkoholkonsumtionen ökade drastiskt både bland män och kvinnor under studieperioden, men en kraftigare ökning observerades bland kvinnor. *Delarbete III* visade att ett antal demografiska, sociala och hälsorelaterade faktorer var associerade med olika nivåer av alkoholkonsumtion. Sammanfattningsvis visade resultaten att 70-åringar som har slutat dricka alkohol var betydligt sjukare och mindre privilegierade än sina jämnåriga i övriga konsumtions-grupper. Därtill framgick det att gruppen med riskbruk (konsumtion över 98 gram alkohol i veckan) var en mycket heterogen grupp, vilken omfattade både individer med bra socioekonomisk status och individer med högre förekomst av traditionella alkoholrelaterade skador och sjukdomar. I *Delarbete IV* undersöktes samband mellan alkoholkonsumtion och mortalitet, där inget signifikant samband kunde observeras. Däremot visade resultaten att fysisk aktivitet hade en betydelse för sambandet, där individer med högt alkoholintag och otillräcklig fysisk aktivitet hade en ökad risk för död. Vidare visade resultaten att den sammanlagda effekten av minst fem ohälsosamma livsstilsfaktorer innebar en tre till fyra gånger ökad risk att dö.

Sammanfattningsvis bidrar resultaten från denna avhandling med ökad kunskap om alkoholkonsumtion bland äldre, en grupp som historiskt sett fått lite uppmärksamhet inom alkoholforskningen. Det är särskilt viktigt att fortsätta undersöka denna grupp med tanke på de framtida utmaningar som en växande andel av befolkningen med andra alkoholvanor kan innebära. Med ökad kunskap om äldres alkoholkonsumtion kan förebyggande riktade insatser utvecklas, vilka kan minska risken för alkoholrelaterade konsekvenser i denna befolkningsgrupp.

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

I. Rydberg Sterner T* & Ahlner F*, et al. The Gothenburg H70 Birth Cohort Study 2014-16: design, methods and study population. European Journal of Epidemiology 2019; 34(2): 191-209.
*TRS and FA are joint first authors

II. Ahlner F, Sigström R, Rydberg Sterner T, Mellqvist Fässberg M, Kern S, Östling S, Waern M, Skoog I. Increased alcohol consumption among Swedish 70-year-olds 1976 to 2016: Analysis of data from The Gothenburg H70 Birth Cohort Studies, Sweden. Alcoholism: Clinical and Experimental Research 2018; 42(12): 2403-2412.

III. Ahlner F, Falk Erhag H, Johansson L, Mellqvist Fässberg M, Rydberg Sterner T, Samuelsson J, Zettergren A, Waern M, Skoog I. Patterns of alcohol consumption and associated factors in a population-based sample of 70-year-olds: Data from the Gothenburg H70 Birth Cohort Study 2014-16. International Journal of Environmental Research and Public Health 2022; 19(14): 8248.

IV. Ahlner F, Falk Erhag H, Johansson L, Samuelsson J, Wetterberg H, Mellqvist Fässberg M, Waern M, Skoog I. The effect of alcohol consumption on all-cause mortality in 70-year-olds in the context of other lifestyle risk factors: Results from The Gothenburg H70 Birth Cohort Study *(submitted)*

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Paper II © 2018 by the Research Society on Alcoholism. All rights reserved.

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ABBREVIATIONS

AHD	Alcohol dehydrogenase
AHP	Alcohol Harm Paradox
ALDH	Aldehyde dehydrogenase
APC	Alcohol per capita consumption
AUD	Alcohol use disorder
AUDIT	Alcohol Use Disorders Identification Test
AUDIT-C	Alcohol Use Disorders Identification Test - Concise
CAN	The Swedish Council for Information on Alcohol and Other Drugs
CIRS-G	Cumulative Illness Rating Scale-Geriatric
CVD	Cardiovascular disease
DSM-III-R	Diagnostic and Statistical Manual of Mental Disorders, 3rd Edition-Revised
GBD	The Global Burden of Diseases, Injuries, and Risk Factors Study
H70	The Gothenburg H70 Birth Cohort Studies
ICD	International Classification of Diseases
IQR	Interquartile Range
N	Sample size
NIAAA	National Institute on Alcohol Abuse and Alcoholism
OR	Odds Ratio
p	p-value
PEth	Phosphatidylethanol
PPSW	The Prospective Population study of Women
RCT	Randomized controlled trials
SES	Socioeconomic status
WHO	World Health Organization

DEFINITIONS IN SHORT

Abstainers	Individuals who do not consume alcohol. The term includes both former drinkers and lifetime abstainers (see specific definitions).
Alcohol	The term alcohol is a broad reference to a group of organic compounds. Ethanol, also known as ethyl alcohol, is a specific type of alcohol found in alcoholic beverages. In this thesis, the term alcohol is used to refer to beverages that contain ethanol.
Binge drinking	Consumption of a specific number of drinks (typically >5 drinks, but definitions vary among studies) on a single occasion.
Birth cohort	A group of a population born during a specified period (e.g., year)
Current drinkers	Individuals who have consumed alcohol during a specified reference period, with past-month or past-year being commonly used timeframes.
Epidemiology	The study of the distribution and determinants of health-related conditions or events within particular populations.
Former drinkers	Individuals who used to consumed alcohol, but have abstained from drinking for a period of time, typically at least several months or more.
Harmful consumption	Alcohol consumption that leads to adverse effects.
Hazardous consumption	Quantity or pattern that increases the risk of adverse effects for the individual or others.
Heavy consumption	Consuming a large amount of alcohol in a short period of time, also known as heavy episodic drinking (HED) or binge drinking.
Helsinki Declaration	A set of ethical principles that outlines guidelines for medical research involving human subjects, established by the World Medical Association in 1964.
Lifetime abstainer	An individual who never consumed alcohol

Male-to-female ratio	Expresses the degree of convergence between sexes in the indicator of interest. The ratio represents the relative difference between sexes.
Older adults	In this present thesis, the term refers to individuals aged 65 years and above (if nothing else is stated)
Oxidative stress	Occurs when the body's capacity to detoxify or repair harm caused by reactive oxygen species is insufficient, resulting in an imbalance in their production.
Per capita consumption	The sum of recorded and unrecorded amount of alcohol consumed over a calendar year in the population aged 15 and above
Risk consumption	Consumption exceeding used cut-off score for low-risk drinking. There is no universal definition of risk consumption. Within this thesis, the definition of risk consumption is more than 98 grams of pure alcohol per week.
Standard drink	A unit of measurement used to quantify the amount of pure alcohol consumed in a particular beverage.
Systematic error	Consistent deviations between the measured values and true values caused by flaws in the study design or data collection process.
Target population	A specific group of individuals that a research study aims to investigate and draw conclusions about based on the results obtained.

Introduction

1 INTRODUCTION

Alcohol consumption is a part of social gathering and events across cultures worldwide. However, the impact of alcohol is detrimental on population health, as it increases the risk for morbidity and mortality.[1] Nevertheless, the relationship between alcohol and health is complex and not yet fully understood, despite the fact that alcohol has been a part of human history for thousands of years. While chronic high alcohol consumption can cause severe harm, there is also evidence suggesting that low levels of alcohol intake might be beneficial for certain outcomes.[2-4]

Both numbers and proportions of older adults are increasing globally, and the pace of this demographic change is faster than before. By 2030, when the global Baby Boom generation born between 1946 and 1964 have reached older age (≥65 years), the global population aged 65 years and above is expected to be 997.5 million..[5,6] In Sweden, aging of the Baby Boom generation, born between 1940 and 1950, has contributed to a distinct demographic shift since the early 2000s.

Unlike previous generations of older adults, prevalence rates of alcohol consumption are suggested to remain high among Baby Boomers.[7] Increased consumption level among older adults is a major public health issue with direct and indirect effects on individuals, close relations, and society at large. Given the ongoing and progressive aging of the global population, the public health challenges associated with adverse effects of alcohol consumption are expected to become even more pronounced in the future. To anticipate future needs, it is important to gain further insights in prevalence, correlates, and consequences of alcohol consumption in older adults.

The main focus of this thesis is alcohol consumption among older adults, using a public health perspective on population-level drinking in the primary context of high-income countries. As volume and pattern of consumption do have higher impact on population health compared to the effects of alcohol use disorder,[8,9] the latter receive less attention in this thesis. The concept of 'older adults' are broadly defined as 65 years and above, if nothing else is stated.

1.1 THE EPIDEMIOLOGY OF ALCOHOL USE

Monitoring global alcohol consumption is essential for evaluating the effects of alcohol use and for capturing time trends. The two primary sources for obtaining population-level data on alcohol consumption are per capita consumption and self-reported information collected through epidemiological studies.[10,11] Information on population-level alcohol consumption can provide valuable support for practitioners, policymakers, and researchers in making informed decisions and taking relevant actions.

Epidemiological studies of alcohol consumption typically rely on two critical measures: current and lifetime drinking status, and the amount (volume) of alcohol consumed.[11] According to the World Health Organization (WHO), drinking status should be categorized into three groups: lifetime abstainer (individuals who have never consumed alcohol), former drinker (previous drinkers who have quit drinking), or current drinker (individuals who have consumed alcohol within a specific time frame).[11] Volume of alcohol intake, on the other hand, refers to the total amount consumed during a specific reference period, such as a day, week, month, or year.[11]

1.1.1 GLOBAL TRENDS IN ALCOHOL USE

Since 1999, *WHO's Global Status Reports on alcohol* have regularly provided comprehensive global estimates of alcohol consumption based on data from various surveys and alcohol sales. In the next section, prevalence rates for drinking status are from 2016, obtained from the most recent publication, referred to as WHO.[1]

WHO reports that 57.0% of the global population aged 15 years and above abstained from alcohol during the previous 12 month, with 44.5% of these being lifetime abstainers.[1] Various sociodemographic factors have been associated with alcohol abstention, including female sex, older age, lower income, lower educational level, and higher religious involvement.[1,12,13] In 2016, approximately 43.0% of the global adult population were current drinkers, with men displaying a higher prevalence (54%) than women (32%).[1] Men also tend to consume higher amounts of alcohol and engage in heavy episodic drinking (defined as ≥60 g of pure alcohol at one single occasion at least once a month) more frequently than women.[1] In the Global Burden of Disease Study 2016, the estimated average daily consumption of pure alcohol was 17 grams for men and 7.3 grams for women.[14] In Europe, the male-to-female ratio for levels of consumption is highest in older adults (4.2), and lowest in youngest age groups (minimum: 3.0).[15] Global alcohol per capita consumption (APC) was reported by WHO to have increased from 5.5 liters in 2005 to 6.4 liters in 2010 and remained stable at similar levels in 2016.[1] However, the latest data for 2019 shows a reduction in the total APC to 5.8 liters.[16] Noteworthy, trends and prevalence rates vary across

countries and regions.[1] Figure 1 displays APC data from six WHO regions between 2000 and 2005, with the WHO European Region having consistently the highest levels. However, the APC in the European Region decreased from 12.0 to 9.5 liters between 2000 and 2019.

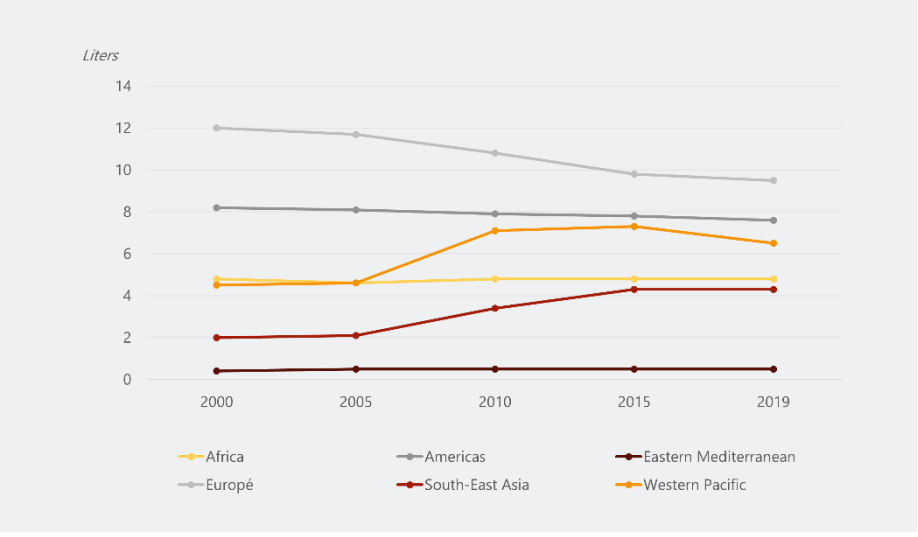


Figure 1. Total alcohol consumption per capita (aged ≥15, liters of pure alcohol) in WHO regions. Source: Original by the author based on data from the World Health Organization [Statistical Database].[16]

Globally, spirits are the most consumed alcoholic beverage, making up 44.8% of all recorded alcohol consumption, followed by beer (34.3%), wine (11.7%), and other beverages, such as fortified and fermented wines (9.3%).[1] However, there are substantial disparities in the most frequently consumed type of beverage across countries and regions. For instance, wine accounts for 29.8% of all recorded consumption in the WHO European Region, while consumption of other beverages constitutes 65.1% of the total recorded consumption in the WHO African Region.[1]

Alcohol use among older adults

Contrary to the trend observed in the general population, alcohol consumption among older adults has increased significantly during the last decades in many high-income countries.[17-20] As shown in Table 1, prevalence of alcohol consumption among middle-aged and older adults (aged ≥50) varied from 47.5% to 85.2% in studies conducted in high-income countries and published between 2013 and 2023. Prevalence rates vary substantially across studies and may be influenced by factors such as sample age, study context, timeframe, study measurements, and definitions.

Table 1. Prevalence rates across studies of alcohol consumption in middle-aged and older adults conducted in high-income countries, published 2013-2023.

Reference	Study a. Setting b. Sample size c. Sample age	Measurement & definition	Prevalence Total sample (men, women)
Bae 2022[21]	a. Switzerland b. 2,057 c. All ages (here: 60-75y)	Abstainers Moderate consumption[a] Risk consumption[a]	18.0% 23.1% 26.5%
Bye 2020[18]	a. Norway b. 34 823 c. 60-79 years	1-2 drinks/drinking day 3-4 drinks/drinking day Monthly heavy episodic drinking[b]	(53%, 64%) (23%, 15%) (~10%, ~5%)
Calvo 2021[22]	a. Data from 22 countries b. 106 180 c. ≥50 years	Lifetime abstainers Current abstainers Moderate consumption[c] Heavy consumption[c]	26.0% 20.6% 30.3% 7.3%
Calvo 2020[23]	a. 21 countries b. 179 881 c. ≥50 years	Current drinkers Moderate consumption[c] Heavy consumption[c]	52.0% 30.2% 6.0%
Cousins 2014[24]	a. Ireland b. 3 815 c. ≥60 years	Nondrinkers Current drinkers Light/moderate drinkers[d] Risk consumption[d]	37.2% 59% (70-74 y) 43.1% 19.7%
Du 2016[25]	a. Germany b. 2 508 c. 60-79 years	Weekly consumers Daily consumers Moderate consumption[e] Risk consumption[e]	51.0% 18.4% 66.9% 17.0%
Geels 2013[26]	a. The Netherlands b. 16 587 c. All ages (here: ≥65y)	Frequency of alcohol use (2-3 times/week) Frequency of alcohol use (4-5/6-7 times/week) Frequency of alcohol use (6-7 times/week) Weekly alcohol quantity (8-14 drinks) Weekly alcohol quantity (15-21 drinks) Weekly alcohol quantity (>21 drinks)	(16.8%, 21.2%) (16.0%, 12.6%) (33.7%, 23.9%) (26.4%, 25.4%) (15.1%, 11.3%) (12.5%, 3.1%)
Han 2018[27]	a. The U.S. b. 61 240 c. ≥50 years	Binge drinking[f]	14.4%
Han 2017[28]	a. The U.S. b. 61 240 c. ≥50 years	Past year alcohol use Binge drinking[f]	63.0% 14.9%
Hoeck 2013[29]	a. Belgium b. 4 825 c. ≥65 years	Non- or occasional drinkers Moderate consumption[g] Risk consumption[g]	50.4% 29.1% 20.5%
Ilomaeki 2013[30]	a. Australia b. 1 705 c. ≥70 years	Daily consumers Heavy consumption[h] Binge drinking[f]	33.7% 19.2% 13.9%
Jensen 2020[31]	a. Denmark b. 21 832 c. All ages (here: ≥60y)	Current drinkers Binge drinking[f]	85.2% 15.0%

Jiang 2020[32]	a. Australia b. 7 976 c. ≥60 years	Risk consumption[d] Binge drinking[f, i]	32.5% 27%
Laberge 2021[33]	a. Canada b. 2 274 c. ≥65 years	Current drinkers Risk consumption[j]	70% (4.5%, 6.8%)
Listabarth 2020[34]	a. 12 European countries b. 13 351 c. ≥50 years	Not at all in past 3 month Frequency of consumption (1-4 times/week) Frequency of consumption (≥5 times/week)	79.4% 3.7% 2.7%
Qato 2015[35]	a. The U.S. b. 2 975 c. 57-85 years	Frequency of consumption (≥1 drinks/week) Moderate consumption[k] Heavy or binge consumption[k]	41% 20% <5%
Raninen 2020[20]	a. Sweden b. 225 134 c. 60-79 years (here: 70-74y)	Current drinkers (past 30 days) Frequency of consumption (≥2 times/week) Binge drinking[f]	(83.2%, 70.2%) (38.5%, 25.4%) (14.4%, 4.2%)
Rossow 2020[36]	a. Norway (1), Denmark (2), Belgium (3), Portugal (4) b. 3 814 c. 60-75 years	Abstainers Risk consumption[d]	(1) 23.3%, (2) 15.3%, (3) 23.9%, (4) 39.7% (1) 34.5%, (2) 50.0%, (3) 47.6%, (4) 38.2%
Stelander 2022[37]	a. Norway b. 8 616 c. 66-99 years	Risk consumption[l]	(46%, 44%)
Stelander 2021[38]	a. Norway b. 20 939 c. ≥60 years (here: ≥70y)	Frequent drinker (≥2-3 times/week) Moderate consumption[m] Risk consumption[m]	(33.6%, 26.9%) (75.7%, 92.6%) (24.3%, 7.4%)
Tevik 2019[39]	a. Norway b. 10 656 c. ≥54 years	Frequent of consumption (≥4 times/week)	3.0%
Towers 2019[40]	a. New Zealand b. 3 673 c. 55-89 years	Lifetime abstainers Current abstainers Risk consumption[l]	4.3% 12.7% 56.5%
Tyrovolas 2020[41]	a. 17 studies b. 135 440 c. ≥65 years	Current drinkers Frequency of consumption (≥1 drink/week)	47.5% 22.0%
van Gils 2019[42]	a. The Netherlands b. 1 366 c. ≥65 years	Current drinkers Risk consumption[d] Binge drinking[f]	84.4% 26.6% 14.8%

[a] Moderate consumption: <12 g/day for men,<24 g/day for women, Risk consumption: >12 g/day for men, >24 g/day for women; [b] Monthly heavy episodic drinking: ≥6 drinks/occasion; [c] Moderate consumption: Frequency ≥1 days/week or ≤3 drinks/day for men, ≤2 drinks/day for women, and no binging in a single day, [c] Heavy consumption: >3 drinks/day for men, >2 drinks/day for women or binge >5 drinks in a single day for men, >4 for women; [d] Risk consumption: >3 drinks/day or >7 drinks/week; [e] Moderate consumption: >0 to <20 g/day for men, >0 to <10 g/day for women; Risk consumption: ≥20 g/day for men, ≥10 g/day for women; [f] Binge drinking: >5 drinks/occasion once a month; [g] Moderate consumption: 1-7 drinks/week, Risk consumption: ≥8 drinks/week; [h] Heavy consumption: >2 drinks/day for men, >1 drinks/day for women; [i] Binge drinking: >2 drinks/day in the last 12 month; [j] Risk consumption: ≥15 drinks/week for men, ≥10 drinks/week for women; [k] Moderate consumption: 2-3 drinks/day, Heavy or binge consumption: ≥4 drinks/day; [l] Risk consumption: AUDIT-C score ≥4 for men, ≥3 for women; [m] Moderate consumption: ≤24 g/day, Risk consumption: ≥36 g/day

Older adults tend to drink more frequently than younger adults but are less likely to exceed low-risk drinking guidelines.[26,43] Typically, the quantity of alcohol consumed per occasion and the prevalence of heavy episodic drinking is lower among older adults.[26,44] However, contrary phenomena exists in some regions. In the WHO regions of South-East Asia and Africa, prevalence of heavy episodic drinking is higher among older age groups, or at similar levels as for young people.[44]

Drinking patterns among older adults are a combination of established behaviors from younger- and mid-adulthood, as well as adaptations to age-related changes and associated life transitions.[45] Compared to younger adults, older adults have a more established alcohol consumption pattern, suggested to reduce motivation, self-efficacy, and threshold to resist alcohol temptation among hazardous drinkers.[46] Moreover, past failures of alcohol behavior change may impact the individuals' incentives and attitudes toward further attempts at discontinuation.[47]

1.1.2 TRENDS IN ALCOHOL USE IN SWEDEN

In Sweden, national data on alcohol consumption are regularly contributed by *the Monitor study*[48] and *the Swedish National Public Health Survey*[49]. These studies have provided information on self-reported alcohol consumption since the early 2000's. Reports indicate a decline in overall alcohol consumption among the Swedish adult population during the last decades,[48,49] defined respectively as those aged 17-84 and 15 or older. In contrast, there are increasing trends for total alcohol consumption and deaths explicit due to alcohol diagnoses among older adults during the same period.[48,49] Figure 2 displays self-reported alcohol consumption among Swedish 65-84-year-olds in 2004-2020. In this age group, an increase in total alcohol consumption was observed during the study period which included 2020, the first year of the COVID-19 pandemic.[48] Despite this, the average alcohol consumption among older adults was still lower than that of younger adults (aged ≤49).[48]

Beyond increasing trend of average consumption level, individuals who exceed the Swedish national drinking guidelines administrated by the National Board of Health and Welfare (≥168 g/week for men, ≥108 g/week for women) have increased among individuals aged 50 years and above, but not among younger adults (aged 17-29), as illustrated in Figure 3. In line with these findings, the prevalence of risk consumption, as measured by scores from the Alcohol Use Disorders Identification Test (AUDIT; ≥6 for men, ≥5 for women), increased among middle-aged and older adults (aged 45-84), while it decreased in younger adults (aged 16-29).[49] Trends of self-reported alcohol consumption are consistent with the figures obtained from total alcohol purchasing patterns during the same period.[50,51]

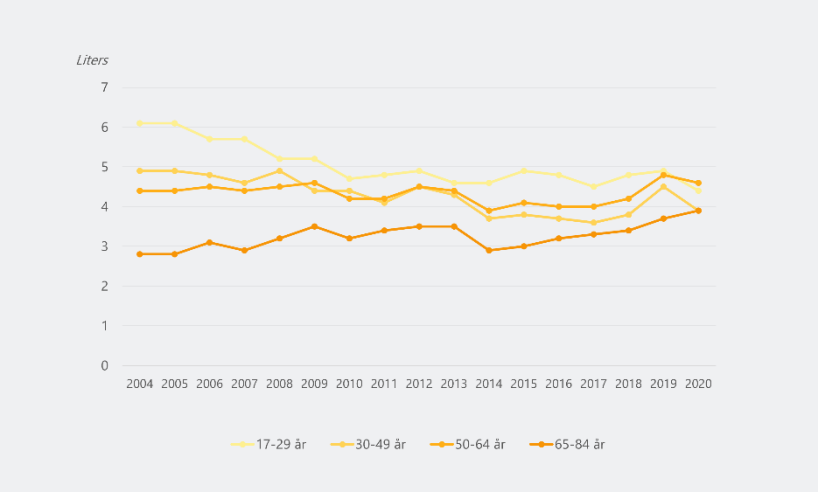


Figure 2. Self-reported alcohol consumption (liters of pure alcohol) among individuals aged 65-84 in Sweden 2004-2020. Note: The upper age limit was 80 years in 2004-2013. Source: Original by the author based on data from appendix to Self-reported alcohol habits in Sweden 2004-2020, CAN Report 204.[48]

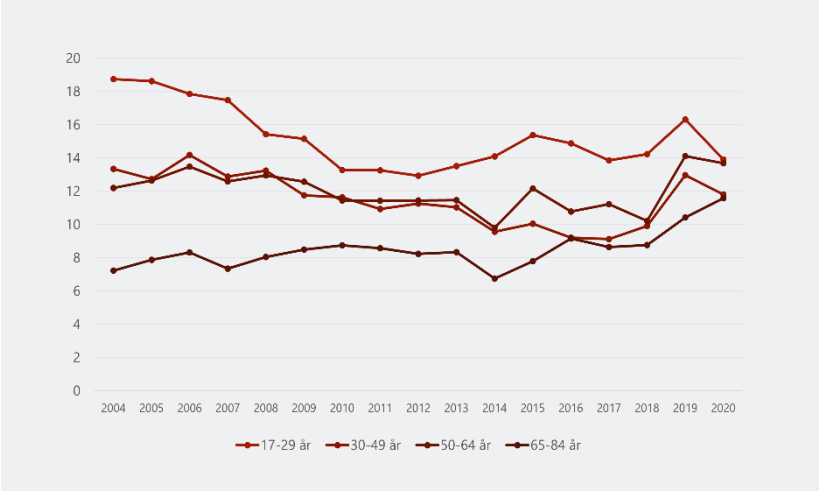


Figure 3. Prevalence (%) of individuals exceeding Swedish low-risk drinking guidelines[a] once every week during the past 30 days in the Swedish population aged 17-84 by age 2004-2020. Note: The upper age limit was 80 years in 2004-2013 [a] ≥168 g/week for men, ≥108 g/week for women. Source: Original by author based on data from appendix to Self-reported alcohol habits in Sweden 2004-2020, CAN Report 204.[48]

1.2 GUIDELINES ON ALCOHOL CONSUMPTION

In recent years, increasing epidemiological research suggest that there is no safe level of alcohol consumption, and that non-consumption is the safest level for minimizing adverse effects of alcohol, particularly for older adults.[14] Nevertheless, low-risk drinking guidelines still exists at national levels, with considerable variation across countries, as demonstrated in Table 2.

Table 2. An overview of nationally defined standard drinks and low-risk drinking guidelines in grams of pure alcohol in a selection of high-income countries.

Country	Standard Drink (g)	Daily (g)		Weekly (g)	
		Men	Women	Men	Women
Australia	10	20	20	—	—
Austria	20	24	16	—	—
Canada	13.45	40.35	26.9	201.75	134.5
Denmark	12	—	—	168	84
Finland	12	20	10	—	—
France	10	30	20	210	140
Germany	12	24	12	—	—
Hong Kong	10	20	10	—	—
Iceland	12	24	12	168	84
Italy	12	36	24	—	—
Ireland	10	40	30	210	140
The Netherlands	10	30	20	—	—
Portugal	10	20	20	—	—
Spain	10	30	20	210	140
Switzerland	10	40	20	—	—
Sweden	12	—	—	168	108
The United Kingdom	8	32	24	—	—
The United States	14	56	42	196	98

Source: Based on Table 1 in Furtwaengler et al. 2013[52] and Table 1 in Kolinsowski et al. 2016,[53] adapted by the author.

Attempts have been made to establish a universal definition of a low-risk drinking threshold, but inconsistencies in the scientific evidence have made it difficult to put such measures into practice.[54-56] As a result, each country is left to create its own rough estimates of what constitutes low-risk drinking.[55,56] Most guidelines are expressed in terms of average amount per day or week that should not to be exceeded,[53,57] often accompanied by textual information with a general recommendation to avoid alcohol.[58] Thresholds are generally higher for men than for women.[53,54,57,58] Age-specific recommendations are rare, but do exist in some countries. In the United States, the National Institute on Alcohol Abuse and Alcoholism (NIAAA) has established guidelines for individuals aged 65 years and

above, indicating a maximum consumption limit of 42 grams per day or 98 grams per week.[59] Public awareness of existing drinking guidelines has increased over time, but little is known about the extent to which such awareness influences drinking behavior.[60-64]

As alcohol content, which is indicated in alcohol percentage by volume (i.e., milliliters of pure ethanol per 100 milliliter), varies by beverage type, the concept of a "standard drink" has been introduced to facilitate reporting and estimation of drinking patterns and levels consumed. A standard drink, or standard unit, is a standardized measure of alcohol consumption referring to a specific amount of pure alcohol regardless of beverage type or container size.

Standard drink is commonly used on the national level when expressing drinking guidelines and providing general public health information. However, there is no international consensus on the definition of a standard drink, leading to cross-country variation in alcohol content.[65] As displayed in Table 2, the alcohol content ranges from 8 to 20 grams of pure alcohol per unit. In Sweden, a standard drink consists of 12 grams of pure alcohol, as illustrated by beverage type in Figure 4.

Figure 4. Swedish Definition of a standard drink. The figure shows the Swedish definition of a standard drink, which contains 12 grams of pure alcohol. This amount is found in 33 cl of >3.5% strong beer, 50 cl of ≤3.5% light beer, 10-15 cl of table wine (red or white), 8 cl of fortified wine (e.g. port or sherry), and 4 cl shot of distilled spirits (e.g. whiskey, rum, or vodka). Illustration: Julius Nord.

1.3 DETERMINANTS OF ALCOHOL CONSUMPTION

The concentration of alcohol in the blood is influenced by multiple factors, including the amount of alcohol consumed, as well as several individual factors such as body composition and temporary factors such as recent food intake. These factors may result in varying blood alcohol concentrations among individuals who have consumed the same amount of alcohol.[66]

There are various factors that can influence alcohol consumption by impacting alcohol tolerance, alcohol drinking behavior, and social and physical availability and accessibility to alcohol. These factors can be categorized into determinants at the individual, community, and societal levels, as illustrated in Figure 5. Determinants may be of varying importance among individuals, and associations with alcohol consumption must be interpreted with caution, as strength and direction of associations may vary depending on factors such as age, region, and historical time period.[67]

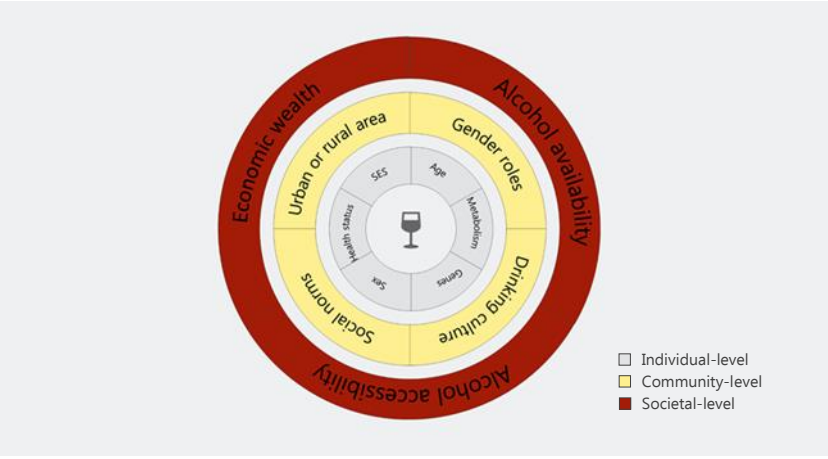


Figure 5. Individual-, community, and societal-level determinants of alcohol consumption. The figure uses different colors to illustrate examples of potential predictors of alcohol consumption, with grey representing individual-level determinants, yellow representing community-level determinants, and red representing societal-level determinants. Source: Original by the author.

Understanding determinants of alcohol consumption is essential for designing effective prevention efforts to reduce harmful alcohol consumption. The composition of individual-level factors in study samples and the structure of factors at the community and societal levels can influence findings in epidemiological studies

of alcohol consumption. The following chapter briefly describes some of the most common determinants at the individual, community, and societal level.

1.3.1 INDIVIDUAL-LEVEL DETERMINANTS

Age

Biological aging is associated with various changes in body composition, such as decreased body water and lean body mass as well as reduced liver mass and function.[17,68-70] These changes reduce the body's ability to process and eliminate alcohol, which leads to higher blood alcohol concentrations after consumption.[71,72] Older adults may also experience impaired abilities such as balance and coordination, which further increases the risk of adverse effects associated with being under the influence of alcohol (e.g. injurious falls).[17,71-73] Older adults with chronic medical conditions are particularly vulnerable to alcohol-related harm due to potential negative effects of prescribed medications, including contraindications, side effects, or interactions.[17,74,75] Alcohol consumption levels generally decline with age,[22,29,34,42,76-78] but the rate of decline has been slower in more recent cohorts.[76] However, there are substantial variations in drinking patterns among older adults due to age-related health heterogeneity.[79]

Sex

Men consume more alcohol than women, a phenomenon which is apparent in all ages and most geographical areas across time (alcohol per capita male-to-female ratio 1.3-3.8).[1] Social and biological factors contribute to differences in alcohol consumption between sexes, such as variations in social sanctions, expectancies, genetic risk, and alcohol metabolism pace.[80,81] However, the isolated effect of biological differences is suggested to be small.[82] There is a closing gap between men and women shown in later born cohorts of both younger and older adults,[83-85] indicating other explanations beyond biological mechanisms. This narrowing gap is a result of higher increases in alcohol consumption in women than in men, and the convergence has been more pronounced among individuals of higher ages (aged ≥50) than among younger indiviudals.[84,86] Sex differences in consumption patterns can be attributed to expectations surrounding gender and age roles,[82] and may also be influenced by country-level gender equality.[36] The effects of gender roles on alcohol consumption level are presented in more detail below.

Genes

Genetics contribute to the level of alcohol consumption and the risk of alcohol use disorder (AUD) and alcohol-related diseases.[87] The risk of developing AUD is influenced by a combination of genetic risk and environmental risk factors, of which

genetic predisposition accounts for approximately half of the variance.[88] Various genes have also been linked to metabolic rate,[87,89,90] alcohol consumption level, and harmful drinking.[91-93] Moreover, studies have demonstrated that genetic factors can influence sensitivity to sweet and bitter tastes, which may have implications for an individual's preferences for various food and beverages, including alcohol consumption.[94,95]

Metabolism

Alcohol metabolism in humans occurs primarily in the liver, where it is converted into acetaldehyde and then into acetate by the key enzymes alcohol dehydrogenase (AHD) and aldehyde dehydrogenase (ALDH). The rate of metabolism varies based on individual factors such as age, weight, genes, and liver function.[89,90,96] Older adults have been found to exhibit higher levels of intoxication with lower amount of alcohol consumption, and this has been hypothesized to be due to reduced metabolic capacity.[69] Chronic high alcohol consumption can lead to liver damage and dysfunction of the metabolic process which may cause a more rapid onset and increased severity of symptoms (e.g., nausea, vomiting, rapid heartbeat) of alcohol intoxication.[90,96]

Personality

Certain personality traits are associated with increased alcohol consumption and related negative consequences. Impulsivity and sensation seeking are the most frequently studied traits in relation to binge drinking, with impulsivity involving risk-taking and poor planning- and concentration ability and sensation seeking characterized by a desire for novel experiences.[97] Alcohol consumption has been positively associated with higher levels of extraversion, which includes sociable, warm, and assertive traits, as well as higher levels of neuroticism, which includes emotionally instability, anxiety, and impulsivity, in various populations.[34,98-101] Some studies suggest that alcohol use may also contribute to changes in personality traits over time.[102-104]

Health status

In older adults, alcohol use is strongly linked to health status. Good health status is associated with continuation of drinking, while disease onset and poor health status are reported to reduce levels of alcohol consumption.[105-109] Based on the assumption that changes in health and disease onset entail cessation of alcohol consumption, the phenomenon "sick quitter effect" was established in the late 1980's.[110] Underlying explanatory factors for cessation of alcohol due to worsened health status include risk of adverse interactions with prescribed medications, reduced social contacts, and changes in ability to access alcohol. Contrastingly, poor mental or physical health has

also been associated with higher levels of alcohol consumption (e.g., binge drinking, hazardous drinking, AUD) in adults aged 50 and above.[27,28,40,78,111]

Socioeconomic status

Alcohol consumption is influenced by an individual's socioeconomic status (SES), which is determined by a combination of social and economic factors including income, educational level, and occupation. Evidence suggests that higher SES are associated with higher levels of alcohol use.[29,78,112-115] Simultaneously, higher levels of consumption have also been observed among current drinkers with lower SES.[116] Additionally, there is evidence of variations due to cultural context, such as opposite directions of correlations between educational attainment and alcohol consumption levels among older adults in Norway and China (i.e., higher education - higher consumption vs higher education - lower consumption).[117]

Lifestyle factors

Various behavioral lifestyle factors are associated with alcohol consumption. However, the magnitude of the association depends on the factors studied, and findings have shown varying directionality. For example, studies on the influence of sleep problems[47,118,119] and physical activity[120,121] on alcohol consumption have shown conflicting results. In general, older adults with an active and sociable lifestyle are more likely to consume higher levels of alcohol.[122] Among several lifestyle risk behaviors, smoking is a strong and well-established predictor of alcohol consumption.[123] Alcohol and nicotine are suggested to increase both cravings and the rewarding effects of both substances, and the risk of dependence is greater when both alcohol and nicotine are used together.[124-126]

Social relationships

In general, social relationships have been found to promote health and encourage healthy behavior.[127] However, the influence of social relationships on alcohol use is complex. Older adults who engage in more social activities generally have higher levels of alcohol consumption.[128] Reasons for this include the integration of alcohol into various forms of social activities, which generates more opportunities for drinking.[128] Moreover, research has found that having friends with permissive attitudes towards alcohol increases levels of consumption in adults aged 55-65 years.[129]

Findings regarding the association between marital or cohabitation status and harmful alcohol consumption in older adults are inconclusive.[33,40,42,113,122,130,131] Inconsistencies in studies may be due to divergent patterns between men and women, as older non-cohabiting men are more likely to consume high levels of alcohol, while

the opposite has been shown for women.[132,133] Being single, whether due to being unmarried, divorced, separated, or widowed, has been suggested as a predictor of harmful alcohol consumption,[78] particularly among men.[130,134] However, there is also evidence for spousal influence on alcohol consumption habits between middle-aged and older partners over time, with high consumption by one spouse potentially leading to increased consumption by the other.[135,136] Moreover, relationship dysfunction or dissolution may increase the risk of harmful alcohol consumption as a coping strategy for past or current conflicts.[127,137]

Loneliness

Loneliness is an important factor influencing alcohol consumption patterns across all age groups. It does not necessarily become more potent with increasing age.[47] However, involuntary loneliness is prevalent among older adults and has been identified as a risk factor for harmful drinking.[138,139] Despite this association, the relationship between loneliness and alcohol use remains unclear.[140] Some evidence suggests that loneliness is associated with lower frequency of alcohol use.[141]

Religion

Studies have shown that religious activity and involvement, encompassing religious beliefs, religious service attendance, commitment, and affiliation, are associated with abstention, lower alcohol consumption rates, fewer drinks per occasion, and lower rates of AUD symtoms.[142-147] It should be noted that most of these studies were conducted in general population samples in the United States, where the religious context differs markedly from that of Sweden and other Scandinavian countries. Still, similar findings have been found in a Norwegian sample aged 40-80 years.[13] This suggests that religion influences alcohol behavior even in secular societies and among older individuals. However, with increasing secularization worldwide, there is reason to believe that religion will have less influence on alcohol-related behavior in the future.[148]

Early life circumstances

Lifetime prevalence of binge drinking generally peaks in young adulthood (≤30 years),[149] but the age of peak has increased among recent cohorts.[150,151] Young adulthood is a key period of development which will set stage for later adult alcohol use. There is consistent evidence that early onset drinking and high adolescent alcohol consumption are associated with higher risk of harmful consumption habits, including AUD, later in life.[152-159] In addition, there is evidence that alcohol consumption patterns established during late adolescence and early adulthood persist over the life course.[135,157,158] Other potential adolescent predictors of alcohol consumption in adulthood are impaired parent-child relationship,[160] family drinking

culture,[137,161] family history of AUD,[161-163] experience of adverse childhood events (e.g., abuse, parental divorce or death),[164] and low childhood SES.[165,166]

Life events and social transitions

Major life changes in later life include retirement, loss of spouse and friends, and disease onset, among others. Retirement implies changes in everyday life, daily routines, social interactions, and income, with varying impact among individuals. Consequently, results are mixed.[135,167-171] The effect of retirement may be moderated by individual attributes such as sex and SES.[168-170] Also, some studies fail to find a clear effect of retirement on alcohol consumption habits.[170-172]

Negative life events are associated with increased alcohol consumption in population-based studies, suggesting that alcohol might serve as a coping strategy.[173-175] However, the influence of major life changes may differ among individuals and may also vary with age. For example, changes in partnership status due to divorce, separation or death of partner have been shown to be associated with a steeper decline in both frequency and quantity of alcohol consumption in older women but not in men.[45] These findings are suggested to be influenced by the fact that older women experience widowhood to a higher extent than older men. On the other hand, participants aged 50-95 in a qualitative study considered widowhood a causal factor for drinking.[176] However, studies of late middle-age populations found no clear change in alcohol consumption associated with negative life events (e.g., divorce, death or illness).[177,178] Still, one of the studies noted an increase in consumption levels several years before the occurrence of any such event.[177]

1.3.2 COMMUNITY-LEVEL DETERMINANTS

Gender roles

Normative views of masculinity and femininity may affect alcohol consumption [148,179] Expected roles vary across time, and women have historically been responsible for most of the unpaid work (e.g., childcare, domestic labor), leading to higher social barriers for drinking among women than among men. In contrast, alcohol consumption has historically been associated with stereotypical masculinity.[148,180] According to the Gender Development Index published by the United Nations Development Programme, Sweden holds a prominent position as being one of the most egalitarian countries globally.[181] Converging gender roles are associated with diminishing sex differences in alcohol consumption.[148] Moreover, normative views have been challenged by the use of alcohol as a symbol of independence and self-reliance in female gender identity.[182] Specifically, among middle-aged women, increases in alcohol consumption were predominantly apparent among individuals with high educational level, occupational prestige, and high income. These changes

suggest that female alcohol consumption patterns are approaching those of the traditional patterns of alcohol consumption observed in men.[183]

Culture and social norms

Cultural influences, including social norms regarding drinking and attitudes towards aging and older adults, play a crucial role for population drinking. Societal norms tend to have a greater impact on drinking behavior, than beliefs regarding alcohol shared by family and friends.[184] Cultures with greater acceptance of alcohol are associated with higher rates of and more frequent heavy consumption,[184] particularly in cultures premiering traditional masculine traits.[184] In contrast, cultures with restrictive drinking norms have lower consumption and higher abstention rates.[184] Alcohol is used for various social purposes across cultures, such as expressing hospitality, respect, self-affirmation, friendship, and social interaction in some,[185] and predominately for celebration and enjoyment in others.[117] Social stigma associated with drinking is more pronounced in certain cultures and can also influence population-level drinking, particularly for women and older adults who historically have experienced greater alcohol-related social stigma and harsher judgement.[184,186,187] However, recent increases in alcohol consumption among women and older adults may reflect changing societal attitudes towards drinking in these groups.

Urban or rural area

Several studies conducted in high-income countries have shown that urban residency is associated with higher levels of consumption compared to rural residency.[36,117] These results are probably influenced by the greater accessibility of alcohol in urban areas, attributable to the presence of liquor stores, pubs and restaurants, among other factors.[188]

1.3.3 SOCIETAL-LEVEL DETERMINANTS

Alcohol availability

Alcohol availability refers to the accessibility of alcohol in a given area and is influenced by various factors such as pricing and taxation of alcohol, density and opening hours of liquor stores, age restrictions for purchasing and consuming alcohol, as well as governmental control over the production, sale, and distribution of alcohol.[189,190] Several studies have demonstrated that higher alcohol prices can reduce harmful alcohol consumption and alcohol-related problems, particularly among younger adults.[191-193] However, the effect of price depends on the type of beverage and context and may vary over time.[192] National data from the Public Health Agency of Sweden indicate that alcoholic beverages have become more affordable in recent years, which is also the case in the European Union.[194,195] In 2019, the economic

accessibility for alcoholic beverages, calculated by dividing the disposable median income by price per liter of pure alcohol, was 288 liters among older adults in Sweden.[196]

Beyond direct effects of alcohol availability, there is evidence for long-term health consequences of the same.[197-199] Being young during restrictive alcohol periods is associated with lower consumption rates later in life.[198] Conversely, increased alcohol availability during adolescence increases the risk of receiving disability pension decades later.[199]

Economic wealth and other country characteristics

Economic wealth is commonly associated with higher levels of APC and higher prevalence of current drinkers.[1] A multi-national study including data from 22 countries found that variation in alcohol consumption levels and age declines in drinking across countries were partly explained by development level and alcohol prices.[22] Middle-aged adults ranging from 50 to 60 years of age residing in high-income countries with lower alcohol prices tend to drink more than same aged in lower-income countries where alcohol prices are comparatively higher. The strength of this association became weaker with age, and was not fully attributed to development level and alcohol prices; cultural beliefs regarding drinking, gender roles, and religious engagement suggested as additional factors.[22]

1.3.4 AGE, PERIOD, AND COHORT EFFECT

Despite variations in population composition and context, levels of alcohol consumption also vary substantially across time. Age, period, and cohort effects help to explain this.[183,200-202] These concepts are important for understanding the direction and magnitude of changes in alcohol use within populations.[183]

Age effect

Age effect refers to variations due to the consequences of aging, without the influence of time period or birth cohort.[183] For alcohol use, age effects may include a decreased ability to metabolize alcohol, which can contribute to changes in alcohol consumption habits. Evidence suggests a general pattern of drinking onset during adolescence or early adulthood, reaching a peak during young adulthood, and thereafter declining consumption during mid- and late life.[203,204] Factors contributing to declining rates of alcohol consumption in older age include changes in life circumstances, attitudes, and the onset of disease.

Period effect

Period effects refer to factors that have an equal impact on individuals in all age groups during a specific time period (i.e., a year or set of years). Period effect variations may arise from changes at the community- or societal-level. For alcohol use, these changes may include policy or law regulations, and cultural norms and attitudes.[183]

Cohort effect

Cohort effects refer to unique characteristics of a group due to shared life experience across time as an effect of being born during a certain time or period. Cohort effects arise when period effects affect age groups differently (i.e., age-by-period interaction).[183,205] For alcohol use, it could be manifested when alcohol policy changes results in an overall increase in population drinking, but with different rates for different age groups or cohorts born in specific years (birth cohorts).[183] For example, evidence shows that individuals who were young adults during historical periods of greater levels of general population drinking will establish and maintain higher consumption levels compared to others.[200]

1.4 MOTIVATIONS FOR ALCOHOL ABSTENTION AND CONSUMPTION IN OLDER ADULTS

Abstinence is primarily motivated by expectancies or experience of decreased positive effects of alcohol or increased negative effects of the same.[206] There are reasons to believe that lifetime abstainers and former drinkers may have different motivations for abstaining from alcohol. As presented previously, health constraints strongly predict reduction and cessation of alcohol in older age,[45,207] but may not be as important for lifetime abstention. In a German sample of adults aged 50-64 years, the main motives for lifetime abstainers were their dislike of the taste or smell, followed by loss of control and family disapproval. For late middle-aged 12-month abstainers, loss of control was the most cited motivator for abstention, followed by medical conditions worsened by alcohol and dislike of the taste or smell.[12] These findings are consistent with previous research.[208,209]

There are several reasons for alcohol drinking, and motives vary among individuals. The literature suggests a four-dimensional structure of drinking motives based on the combinations of valence (positive or negative reinforcement) and source of motivation, either from the individual (internal) or from the social environment (external).[206,210] Based on these considerations, a drinking motivation model has been developed, which includes four categories: enhancement, social, coping, and conformity. The model is illustrated in Figure 6. Support for a three-item structure including enhancement, social motives, and coping has been found to be valid in older adults.[211] Among these, enhancement and social motives are suggested to be associated with a higher frequency of drinking in older adults, while coping has been associated with high levels of consumption.[211]

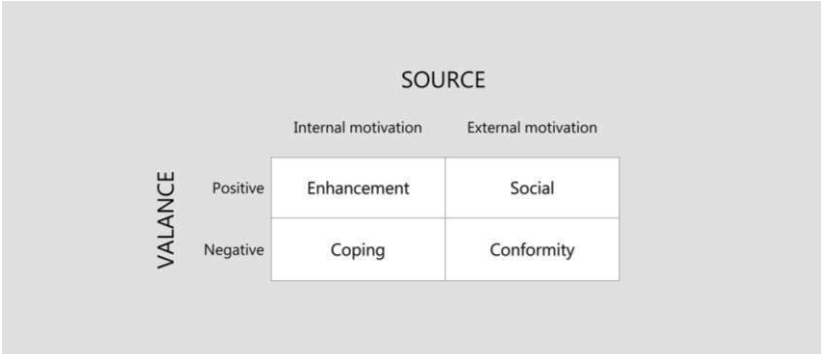


Figure 6. Model of drinking motivations. Source: Original by the author.

According to a systematic review of qualitative studies, the most common reasons for drinking among adults aged 55 years and above are for enhancement (e.g., relaxation, fun, celebration) and for social reasons.[135] Consumption of alcohol has been described as a part of a regular routine, established during the life course.[212] Alcohol is also commonly raised as a health-promoting strategy to decrease the risk for disease or as a coping strategy to deal with difficulties in life, including physical symptoms and illness, anxiety, bereavement, disability, and losses.[122,135] In line with these findings, enjoyment and social reasons were the most common motives for drinking, followed by drinking for health benefits, among 65-85 year-olds in Sweden in 2015.[213]

1.5 ALCOHOL AND POPULATION HEALTH

The relationship between alcohol use and health is complex.[1,15] Alcohol-related harm may arise through multiple mechanisms. These mechanisms include a cumulative effect of alcohol on organs and tissues, acute intoxication increasing the risk of various injuries or poisoning, chronic high consumption causing impairments and risk of dependence with associated consequences.[14,214] Risk for alcohol-related harm is dependent on dose and consumption pattern.[14] Moreover, there is a potential influence of the quality and type of alcoholic beverages, although their impact appears to be less significant compared to the overall volume consumed and consumption patterns.[215,216] Figure 7 displays a conceptual model of the causal impact of alcohol on the risk of adverse health effects influenced by several external factors.

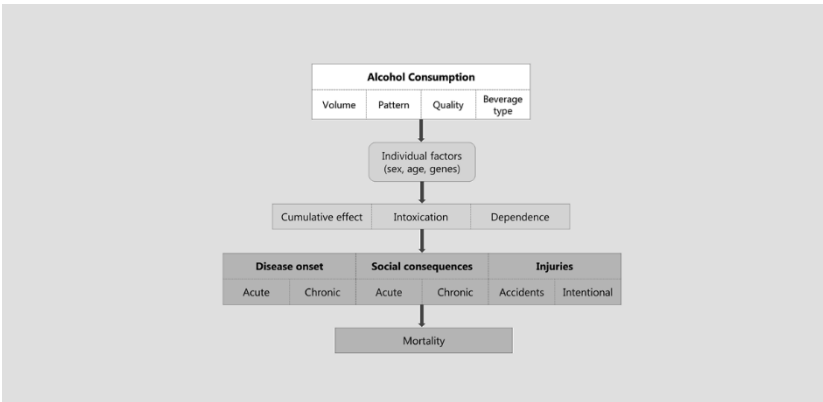


Figure 7. Causal model of the impact of alcohol consumption. Source: Based on Figure 1 in Rehm et al. 2010[9] and Figure 1 in Minzer et al. 2020,[217] adapted by the author.

For most diseases, risk increases with increasing level of alcohol consumption. However, consumption at any level increases the risk substantially for some conditions, such as liver disease and breast cancer.[1,14,58] Older adults are at a particular risk due to increased vulnerability associated with biological aging and the cumulative consequences of lifetime alcohol consumption.[218] At the same time, it has been suggested that the adverse effects of low-level drinking may be less pronounced in older adults compared to younger.[58]

At a population-level, small increases in APC are associated with substantial increases in alcohol-related harm.[86] However, the burden of alcohol-related diseases and injuries varies by geographical context due to differences in disease rates and demographic composition, such as age and sex.[58,219,220] The highest age-standardized alcohol-attributable burden of disease and injuries is found in Eastern Europe and in western, southern, and central sub-Saharan African regions.[1,220]

1.5.1 ALCOHOL-RELATED MORTALITY AND MORBIDITY

Alcohol use is a large contributor to various non-communicable and communicable diseases, conditions, and injuries, leading to a substaintial burden of disability and mortality.[1,14,221] In 2016, alcohol use was the seventh leading risk factor for global disability and mortality,[14] and it accounted for 5.3% of all deaths.[1] Figure 8 (page 22) illustrates major diseases and bodily damage attributed to alcohol consumption. Generally, the alcohol-attributable mortality rate mirrors trends in APC.[220] Increased consumption rates among older adults have led to higher rates of alcohol-related hospital admissions and deaths in this age group.[43,223,224] In 2019, alcohol contributed to 720 005 global deaths among individuals aged 70 years and above.[225] The majority (absolute numbers) of alcohol-attributable deaths occur in older adults.[15,226]

The health burden related to alcohol consumption varies by diseases and types of injury.[1] The following sections provide a brief introduction to some harm attributable to alcohol consumption, focusing on five major categories of non-communicable diseases and injuries that account for the overwhelming majority of alcohol-related mortality and morbidity worldwide; AUD, cancers, cardiovascular diseases (CVD), liver disease, and injuries. In addition, the sections cover the impact of alcohol consumption on brain damage, dementia, and type 2 diabetes.[15,220,221]

Alcohol Use Disorders (AUD)

AUD is a disease category that is 100% attributable to alcohol.[1] Genetic predisposition can increase the likelihood of developing the disorder.[66,227] Severe forms of AUD are associated with a 3- to 4-fold increased risk of mortality.[66] The prevalence of AUD is generally lower among older adults compared to younger adults, likely due to age-related declines in alcohol consumption levels.[228]

Liver disease

Chronic heavy alcohol consumption increases the risk of developing liver diseases, such as liver cirrhosis.[229] In 2007, alcoholic liver cirrhosis was introduced as a specific category in ICD-10 due to strong evidence for a causal inference of alcohol.[230] Individuals with AUD are at higher risk (10-15%) for liver cirrhosis,[231] caused by alcohol-induced liver damage via metabolites and byproducts during alcohol metabolism.[66] However, individual-level risk factors such as genetics, sex, and weight may also influence the development of the full disease spectrum.[66]

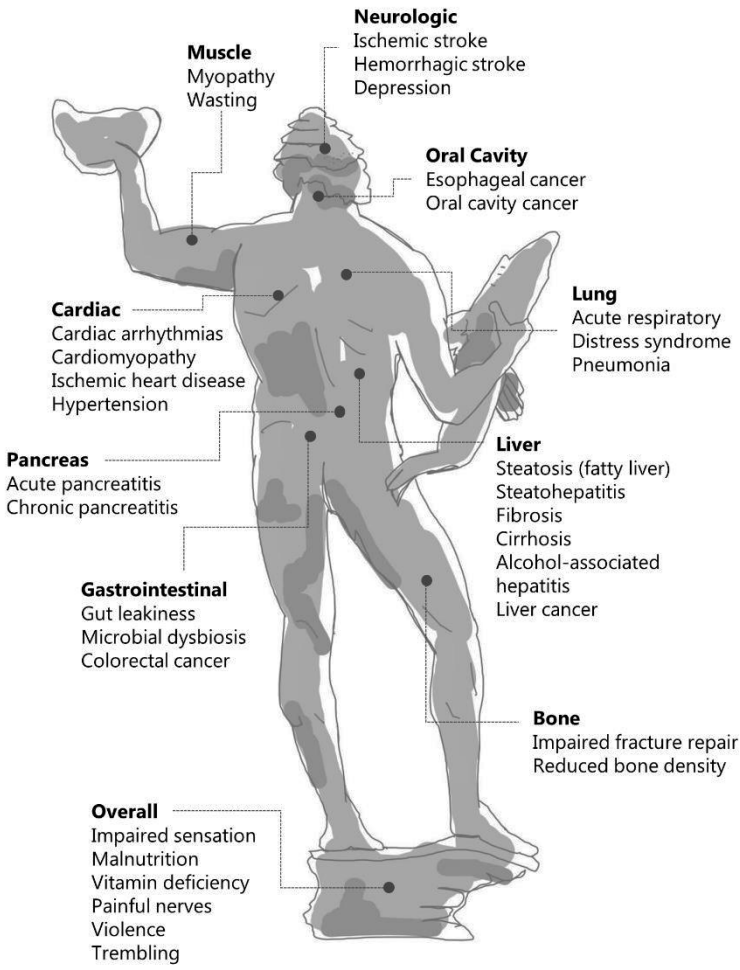


Figure 8. Effects of chronic high alcohol consumption. The figure displays a selection of long-term health consequences associated with excessive alcohol intake, including increased risk of disease onset and organ damage. Source: Original by the author, inspired by figures in a publication by WHO[222] and by the NIAAA at https://www.niaaa.nih.gov/alcohols-effects-health/alcohols-effects-body (accessed March 26, 2023). Illustration of Poseidon: Julius Nord.

Cancers

Alcohol use is a leading preventable risk factor for cancer,[66] with causal links established for several types of cancers, including lip and oral cavity, pharynx, esophagus, larynx, colon and rectum, liver, and female breast cancer.[1,232] Ethanol is the carcinogenic ingredient causing cancer,[233] and for these subtypes, risk increases at any level of use.[232] However, there are also findings showing no association between lower levels of alcohol consumption and incidence of most common cancers.[234] In addition to those with clear dose-response relationship, associations with alcohol use have also been found for other subtypes of cancers, such as gastric, lung, pancreatic, and prostate cancer.[190] During the last two decades, the alcohol-attributable age-adjusted cancer rates have decreased in Europe, following the trends of overall population-level consumption.[232]

Cardiovascular diseases

The effect of alcohol on cardiovascular conditions is strongly modulated by the dose and pattern of consumption.[216] High levels of consumption can cause several cardiovascular outcomes, such as cardiac arrhythmias, hypertension, ischemic heart disease, and stroke.[1,9,14,216,219,235] Some cardiovascular conditions are associated with aging, leaving older adults at a higher risk.[228] Long-term high blood pressure, cellular changes, oxidative stress, and hormones are suggested pathways for detrimental effects.[216] Low levels of consumption may have a protective effect on specific CVDs such as ischemic stroke and myocardial infarction,[2,235-237] particularly in older populations,[238-240] by triggering physiological mechanisms that positively affects nitric oxide signaling.[216] The complex alcohol-cardiovascular health relationship, with detrimental levels differing for various cardiovascular conditions, hinders the establishment of clear relationships.[9,216,235]

Type 2 diabetes

High alcohol consumption is a preventable risk factor associated with type 2 diabetes,[217] as it increases insulin resistance.[1] Low to moderate alcohol consumption may have a protective effect,[1,3,66,217,241] particularly among those aged 60 years and above.[1] Underlying mechanisms for the potential protective effect include decreased blood sugar, insulin levels, and inflammation.[66] Nevertheless, some studies have found no or limited effects of alcohol on the risk of developing type 2 diabetes.[14,242,243]

Injuries

Alcohol use contributes to the global burden of injuries, which includes intentional events such as interpersonal violence and self-harm, as well as unintentional events like burns, drownings, falls, poisoning, and road traffic injuries. In 2016, alcohol was estimated to account for 0.9 million estimated injuries, with road injuries, self-harm,

and interpersonal violence being the most common.[1] At the population-level, increases in APC is associated with an escalation in road traffic injuries, suicide, and homicide.[244] Males and younger individuals are at higher risk of injury death,[244] particularly within six hours of alcohol consumption.[228] The burden of alcohol-attributable injuries varies substantially by region,[1] with high-income countries having a higher impact than low-income countries.[244] For older adults, physiological changes and reduced abilities increase the risk and severity of injuries.[228]

Brain damage

Chronic high alcohol consumption causes brain atrophy through various mechanisms, including cell death, oxidative stress, and thiamine deficiency. Additionally, chronic exposure is associated with liver dysfunction, which can lead to higher concentrations of neurotoxic substances in the blood and contribute to brain damage.[245]

Dementia and cognitive decline

Chronic high alcohol consumption is associated with an increased risk of dementia and cognitive decline.[66,245] However, the effect of lower levels is less clear. Several epidemiological studies and meta-analyses suggest that low to moderate alcohol consumption may reduce the risk of dementia,[246-250] while others fail to replicate these findings.[251]

1.5.2 THE ALCOHOL HARM PARADOX

Disadvantaged groups in high-income countries exhibit higher rates of alcohol-related morbidity and mortality than those of advantaged groups, despite similar or lower levels of alcohol consumption.[252-256] This phenomenon, called the Alcohol Harm Paradox (AHP), contributes to health inequalities across population groups. There is no consensus about the mechanisms underpinning the AHP, and there is no simple explanation.[257] Several underlying theories suggest that a combined effect of several risk behaviors is the most likely.[257] Other explanations include a higher overall burden of disease,[1] higher levels of both current and past consumption (such as fewer but heavier drinking occasions),[180,258] unfavorable drinking and living environments,[1] limited access to health care and alcohol support services,[259,260] disproportionate under-reporting among groups,[261,262] and a potential reversed causal relationship where disadvantageous circumstances are caused by alcohol consumption.[253] Additionally, it has been hypothesized that AHP findings may be attributed to several systematic errors during data collection, including selection bias and recall bias.[258] However, artefactual explanations for the AHP were recently disproved in a systematic review.[257] Still, the AHP seems to be dependent on variables used for measuring level of disadvantage.[256]

Aim

2 AIM

The overarching aim of this thesis was to study alcohol consumption in population-based samples of older adults focusing on prevalence and time trends of consumption, associated factors across specific levels of intake, and the potential impact of alcohol on premature mortality. The thesis comprises four papers based on data from the Gothenburg H70 Birth Cohort studies (the H70 studies), specially focusing on Birth cohort 1944 examined in 2014-16.

Specific aims of *Paper I-IV*:

Paper I To describe the study procedures utilized during the baseline examination of Birth cohort 1944, which was conducted in 2014-16.

Paper II To investigate potential shifts in alcohol consumption patterns across four distinct birth cohorts of 70-year-olds born in 1906-07, 1922, 1930, and 1944, examined across four decades.

Paper III To examine factors that may be associated with different levels of alcohol consumption in 70-year-olds born in 1944.

Paper IV To investigate the impact of alcohol consumption, as well as the combined effect of seven different unhealthy lifestyle factors, on all-cause mortality in 70-year-olds born in 1944.

Methods

3 METHODS

3.1 THE GOTHEBURG H70 BIRTH COHORT STUDIES

The H70 studies are multidisciplinary epidemiological studies aimed at examining the impact of mental, somatic, and social health on functional capacity and overall well-being among older adults. An overview of birth cohorts and examination years within the H70 studies is displayed in Figure 9.

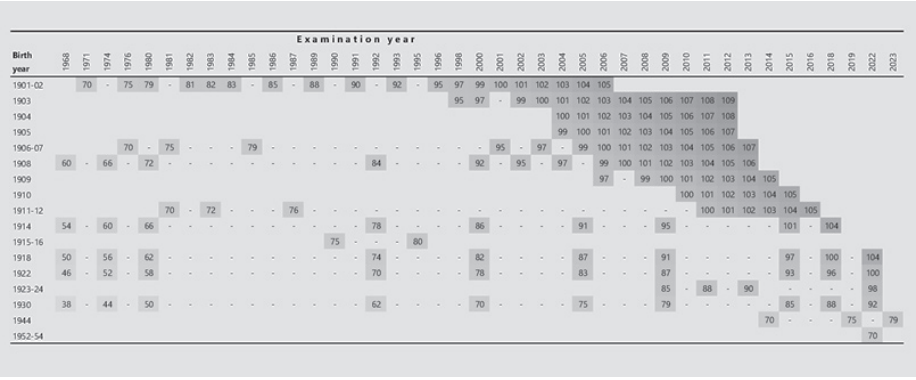


Figure 9. The Gothenburg H70 Birth Cohort studies – an overview of birth cohorts and examination years included in the H70 studies, a longitudinal study of aging and health. Source: Original figure created by Thomas Marlow, modified and published by Mellqvist Fässberg and Vanaelst et al. 2019[263] and Rydberg Sterner 2020,[264] and further adapted by the author.

Participants are systematically selected from the Swedish Tax Agency based on birth dates. Inclusion and exclusion criteria for the H70 studies are shown in Table 3. After study entry, participants are followed longitudinally with repeated examinations until dropout or death.

Table 3. Inclusion and exclusion criteria in the Gothenburg H70 Birth Cohort Studies.

Criteria	Description
Inclusion criteria	• Swedish citizenship • Born on specific birth dates • Residing in Gothenburg at time of recruitment
Exclusion criteria	• Emigration before first examination • Inability to communicate in Swedish • No contact

Sampled individuals got an invitation letter containing study information and consent form by postal mail, followed by a telephone call. The research staff members responsible for participant recruitment were well-informed about the study and were available to provide additional information if needed.

On the examination day, participants underwent a comprehensive set of general examinations at the study clinic, which lasted for approximately eight hours. When necessary, the examination could be spread across several days or conducted in the participant's home, including residential care facilities. In the case of home visits, a less extensive set of examinations was performed as compared to the general examination conducted at the study clinic. Upon completion of the general examination, participants were invited to take part in several additional examinations.

3.2 STUDY SAMPLES AND STUDY DESIGN

The initial H70 study was conducted in 1971-72, examining individuals born in 1901 and 1902 at age 70. Since then, six birth cohorts have been examined at the age of 70, and followed longitudinally. The primary data source for this thesis is the baseline examination of Birth cohort 1944, conducted between 2014 and 2016. All papers included in this thesis are based on this examination. Owing to the birth cohort comparisons conducted in *Paper II*, the present thesis also incorporates data for three additional birth cohorts at age 70. Sample flowchart for study samples in *Papers I-IV* is displayed in Figure 10 and additional information regarding study design and sampling information for each examination and paper is found in Table 4 and Table 5.

Table 4. Sampling information for examination of included birth cohorts at age 70.

Birth cohort	Examination year	Birth dates	Total sample	Response rate, %
1906-07	1976-77	2, 5, 8, 12, 15, 18, 22, 25, 28	1 036	80.8
1922	1992-93	6, 12, 18, 24, 30	299[a]	63.2
1930	2000-02	3, 6, 12, 18, 21, 24, 30	524	69.6
1944	2014-16	2, 5, 8, 10, 12, 15, 18, 20, 22, 25, 28, 30	1 203	72.2

[a] women only

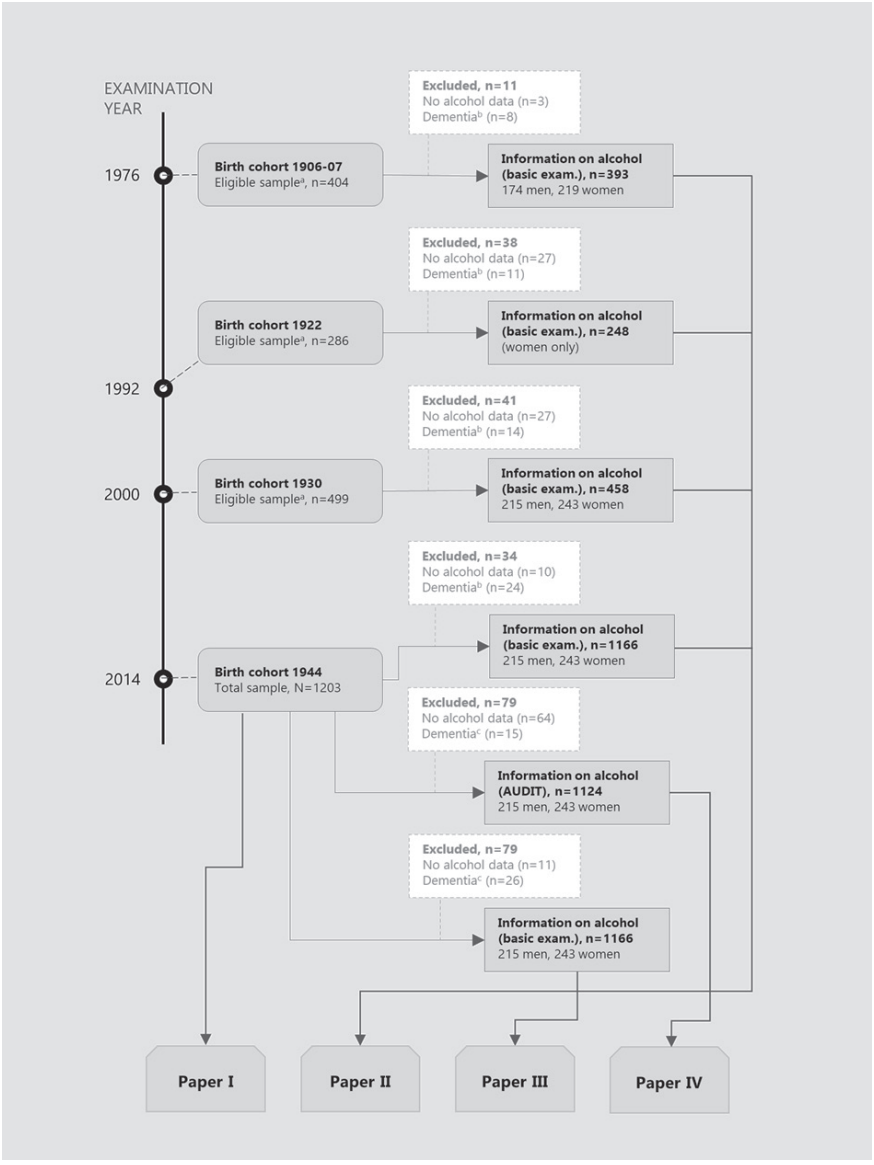


Figure 10. Overview of birth cohorts included in this thesis. [a] Eligible sample: number of participants who took part in examination in which questions on alcohol use were included; [b] Dementia diagnoses according to Kay et al.[265]; [c] Dementia diagnosis according to DSM-III-R. Source: Original by the author.

Table 5. Study design and samples of *Paper I-IV*.

Paper	Design	Birth cohort	Study sample, N (men, women)	Completion rate[a], %	Age, mean
I	Cross-sectional	Birth cohort 1944	1203 (559, 644)	72.2	70.5
II	Cross-sectional	Birth cohort 1906-07	393 (174, 219)	97.3	70.3
		Birth cohort 1922	248[b]	86.7	70.6
		Birth cohort 1930	458 (215, 243)	91.8	70.5
		Birth cohort 1944	1169 (543, 626)	97.2	70.6
III	Cross-sectional	Birth cohort 1944	1156 (539, 617)	96.1	70.5
IV	Longitudinal	Birth cohort 1944	1124 (517, 607)	93.4	70.6

[a] Completion rate = Number of completed answers on main alcohol questions / Number of participants conducted the interview in which alcohol questions where a part of; [b] women only

In short, samples included in *Paper I-IV* were:

Paper I The total sample of Birth cohort 1944 (n=1 203) examined in 2014-16.

Paper II Includes 2 268 dementia-free individuals examined at age 70 from four different birth cohorts in the H70 study: Birth cohorts 1906-07, 1922, 1930, and 1944. The 1922 birth cohort was merged with the Prospective Population study of Women in Gothenburg (PPSW), described elsewhere.[266] Data from examinations of Birth cohorts 1901-02 and 1911-12 at age 70 in the H70 study were not included in *Paper II* due to lack of alcohol data.

Paper III Includes 1 156 dementia-free individuals with alcohol data from semi-structured interview during the baseline examination of Birth cohort 1944 in 2014-16. Individuals who had quit drinking within the past five years were not included.

Paper IV Includes 1 124 dementia-free participants with alcohol data from the semi-structured interview and the self-administrated questionnaire AUDIT.

3.3 DATA COLLECTION

Over the years, the H70 study protocol has undergone several updates and extensions integrating new diagnostic criteria, instruments, and examinations. As a consequence, the baseline protocol of Birth cohort 1944 represents the most extensive examination to date. Information was collected through semi-structured face-to-face interviews, self-administrated questionnaires, clinical examinations, and tests, primarily carried out by research nurses.

3.3.1 ASSESSMENT OF ALCOHOL CONSUMPTION

Although the essential alcohol-related data has been maintained, the inclusion of amendments to the existing alcohol questions has resulted in minor disparities among the baseline assessments of Birth cohorts 1906-07, 1922, 1930, and 1944 (Appendix 1-4). In the baseline examination of Birth cohort 1944, information on alcohol consumption was collected through a semi-structured interview and the AUDIT. The AUDIT questionnaire was self-administered and was one of several additions in the examination conducted in 2014-16 (Appendix 5).

Alcohol intake

Alcohol consumption habits were assessed as part of a semi-structured general health interview that covered medical status, dental health, hearing and visual function, reproductive history, and other lifestyle behaviors such as cigarette smoking and sexual behavior. Participants reported their average weekly consumption of light beer (alcohol content ≤3.5%), beer (alcohol constent >3.5%), wine (red, white, fortified wine), and spirits separately in centiliters, during the previous month. Total weekly alcohol consumption in grams of pure alcohol was calculated by converting the reported amounts of alcohol consumption using specific conversion factors based on the average alcohol by volume of the corresponding beverage type. These conversion factors have been revised over the years to account for changes in average alcohol content for each beverage type. For Birth cohort 1944, total intake (grams of alcohol) was calculated as follows:

Light beer ≤3.5% (amount /4) + Beer >3.5% (amount /2.75) + Red/white wine (amount /1.25) + Fortified wine (amount * 1.5) + Spirits (amount * 3)

For Birth cohorts 1906-07, 1922, and 1930, conversion factors were as follows:

Light beer ≤3.5% (amount /5) + Beer >3.5% (amount /3) + Red/white wine (amount /1.00) + Fortified wine (amount * 1.5) + Spirits (amount * 3)

However, to facilitate birth cohort comparisons in *Paper II*, weekly total grams for Birth cohort 1944 was calculated using the same conversion factors as for Birth cohorts 1906-07, 1922, and 1930.

Participants answering "Yes" to the question *"Are you abstaining from alcohol"* (1 = Yes, since 0-5 years, 2 = Yes, since 6-10 years, 3 = Yes, since >10 years, 4 = Yes, always) and reporting no alcohol consumption during the past month were defined as alcohol abstainers. Based on reported years of abstaining alcohol, abstainers were further classified as former drinkers (response category 1-3) and lifetime abstainers (never drinkers, response category 4). Of the 1 166 participants in the baseline examination of Birth cohort 1944 who responded to questions about alcohol and did not have dementia, 74 individuals (30 men, 44 women) reported abstaining from alcohol. Of these, 42 individiuals (20 men, 22 women) were former drinkers, while 32 individuals (10 men, 22 women) reported a lifetime history of abstaining from alcohol.

In addition to questions on quantity, participants reported frequency of beer, wine, and spirits consumption in the past month. Moreover, there are questions on lifetime and past month prevalence of alcohol-related blackouts, inability to stop drinking, and need of a restorative drink. Neither frequency of beverage-specific consumption nor participants' control of their alcohol use have been analyzed in the papers included in this thesis.

Alcohol consumption categories

Information on total weekly consumption was used to identify harmful alcohol consumption. This corresponds to guidelines for individuals aged 65 and above recommended by the NIAAA in the United States.[59] Cut-offs for risk consumption in *Paper II* (≥100 g/week) and *Papers III-IV* (>98 g/week) were similar, but not identical. Discrepancies are due to lack of continuous alcohol data for Birth cohorts 1906-07 and 1922. To enable birth cohort comparisons in *Paper II*, a cut-off of 100 grams per week was used.

3.3.2 DEMENTIA DIAGNOSIS

The H70 studies have included information on symptoms of dementia since the first baseline examination in 1971-72, and since 2000-02 dementia is classified using criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R). Dementia diagnoses are established using a combination of information from face-to-face interviews, global assessments of symptoms, psychometric testing, and close informant interviews, with computerized algorithms used to identify participants meeting specific criteria (Appendix 6). The diagnoses are then reviewed by psychiatrists and discussed further during consensus conferences when necessary.

In Birth cohort 1944, a total of 30 participants (2.5%) were diagnosed with dementia, one of which was identified as being attributed to alcohol consumption. For birth cohort comparisons including cohorts examined before 2000, criteria described by Kay et al.[265] was utilized (Appendix 6).

3.4 DATA ANALYSES

Data was analyzed using SPSS Statistics for Windows, version 24-28 (IBM Corp., Armonk, N.Y., USA). Statistical tests were two-tailed and p values ≤ 0.05 were considered statistically significant.

Paper I Sample characteristics were presented as numbers and percentages.

Paper II Participant characteristics was presented as numbers, median values, and percentages. Differences in proportions using Pearson's Chi-squared test for categorical data and Mann Whitney U test for continuous measures.

Paper III Sample characteristics was presented as numbers, median values, minimum and maximum values, and percentages. Differences in proportions were analyzed using Pearson's Chi-squared test for categorical data. Mann Whitney U test and Kruskal-Wallis test were used for continuous measures. Logistic regression models were used to examine associations between independent variables and alcohol consumption categories. Model 1 included sex as a covariate. Model 2 included sex and educational level. Potential effect modifications of sex were tested using logistic regression to explore potential interactions between sex and other independent variables.

Paper IV Participant characteristics were presented as numbers and percentages. Proportions were compared using Pearson's Chi-squared test. Cox regression models were used to examine the effect of baseline alcohol consumption and unhealthy lifestyle risk score on mortality risk during 8 years of follow-up. Covariates included demographic and health-related factors and were sequentially included in models. Cox regression models were also used to explore potential interactions between alcohol consumption and demographic and lifestyle factors by including the interaction term alcohol*(sex/education/smoking/BMI/physical activity/sedentary time/sleep/dietary pattern).

3.5 ETHICAL CONSIDERATIONS

The Regional Ethics Review Board in Gothenburg has approved all studies in this thesis (*Paper I-IV*: Approval number 869-13; *Paper II*: Additional approval numbers 52/76, 179-92, S227-00). Written informed consent was obtained prior to the general and additional examinations. In cases in which the participant was not able to give informed consent (e.g., due to major cognitive impairment), permission was obtained from a close relative. Participants had the right to withdraw their consent at any time and individual data was deleted upon request.

All studies were conducted according to the Helsinki Declaration. As stated in the declaration, participant welfare was a central concern. There were no risks or harms associated with participation. Examination outline could be adjusted for individual needs and as participation was entirely voluntary participants were permitted to decline participation in specific tests or parts of the examination. In the event that any clinically relevant pathologies or undiagnosed medical conditions were identified, the participants were referred to a suitable health facility for additional evaluation and treatment.

No incentives were used to motivate participation. However, participants received compensation for expenses related to participation (e.g., transportation), and meals and snacks were provided during the general examination day at the study clinic.

Perspectives on participating in the H70 studies have been examined in a qualitative study using focus group methodology.[267] Overall, the positive experiences preponderate over the time and effort spent. In addition, response rates in follow-up examinations have historically been high among individuals participating in the H70 baseline examinations, indicating that participation is perceived to be worthwhile.

In addition to ethical considerations in research design, there are some core ethical principles that must be applied during data collection and handling. All staff within the H70 studies have a duty of confidentiality. Participants' confidentiality and anonymity is maintained by responsible data management. Individual data is protected from unauthorized access by pseudonymization and appropriate storing.

Results

4 RESULTS

In this chapter, main results for *Paper I-IV* are summarized. Details can be found in the separate papers at the end of this thesis.

4.1 PAPER I

Rydberg Sterner T & Ahlner F, et al. The Gothenburg H70 Birth Cohort Study 2014-16: design, methods, and study population. *European Journal of Epidemiology* 2019; 34(2): 191-209.[268]

Paper I describes the methodology used in the baseline examination of Birth cohort 1944 in 2014-16. An overview of included examinations, instruments, and tests is displayed in Figure 11. A total of 1203 individuals participated (response rate 72.2%; 559 men, 644 women).

Analyses of non-participants (n=464) were not performed due to lack of individual-level data. In order to increase knowledge regarding composition of the baseline sample, additional results including general population data from Statistics Sweden are shown in Tables 6 and 7.

Table 6. Characteristics of 70-year-olds in the H70 Birth cohort 1944, in Gothenburg, and in Sweden 2014.

	H70 study (n=1 203)	**Gothenburg (n=4 658)**	**Sweden (n=115 197)**
	% (no. cases/total)	% (no. cases)	% (no. cases)
Women	53.5 (644/1 203)	52.3 (2 434)	50.5 (58 208)
Residential care[a]	2.1 (25/1 203)	0.8 (39)	0.8 (875)
Born in Sweden	84.5 (1 010/1 195)	80.5 (3 751)	89.2 (102 764)
Married	57.3 (685/1 196)	52.5 (2 447)	60.2 (69 352)
≤Primary education	14.7 (176/1 196)	25.1 (1 170)	29.4 (33 880)
Secondary education	52.8 (632/1 196)	39.0 (1 818)	42.4 (48 884)
Higher education	32.4 (388/1 196)	33.9 (1 580)	26.9 (30 983)

[a] Residing in long term care facility. Source: Based on data from H70 2014-16 and Statistics Sweden (for Gothenburg and Sweden) in Table 5 in Rydberg Sterner[264], adapted by the author.

As demonstrated in Table 6, some differences were observed between 70-year-olds in the H70 Birth cohort 1944 and the general populations of Gothenburg and Sweden.

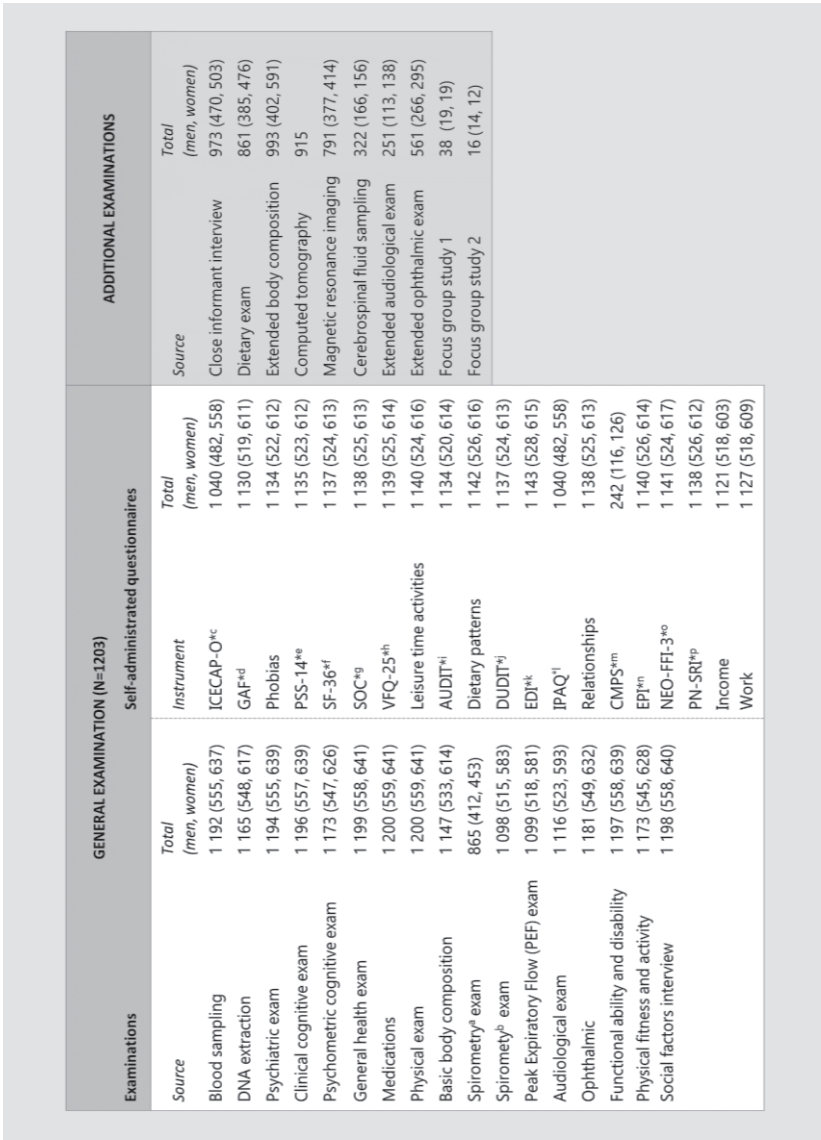
Table 7. Drinking status of 70-year-olds without dementia in the H70 Birth cohort 1944.

	Total (n=1 166)	**Men (n=545)**	**Women (n=621)**	
	% (no. cases/total)	% (no. cases/total)	% (no. cases/total)	*p*
Drinking status				
Lifetime abstainer	2.7 (32/1 166)	1.8 (10/545)	3.5 (22/621)	.155
Former drinker	3.6 (42/1 166)	3.7 (20/545)	3.5 (22/621)	.155
Current drinker	93.7 (1 092/1 166)	94.5 (515/545)	92.9 (577/621)	.269
Cut-offs based on NIAAA[a] drinking guidelines				<.001*
Low-risk consumption	68.2 (745/1 092)	55.0 (283/515)	80.1 (462/577)	
Risk consumption	31.8 (347/1 092)	45.0 (232/515)	19.9 (115/577)	
Cut-offs based on Swedish drinking Guidelines[b]				.160
Low-risk consumption	79.5 (868/1 092)	77.7 (400/515)	81.1 (468/577)	
Risk consumption	20.5 (224/1 092)	22.3 (115/515)	18.9 (109/577)	
Cut-offs based on AUDIT-C score[c]				.189
Non-hazardous consumption	72.3 (761/1 052)	70.3 (343/488)	74.1 (418/564)	
Hazardous consumption	27.7 (291/1 052)	29.7 (145/488)	25.9 (146/564)	

Sex differences tested with Pearson Chi-square test; *=statistical significant differences between groups (*p*-value<.05); [a] NIAAA: the US National Institute on Alcohol Abuse and Alcoholism, cut-off for risk consumption: >98 g/week (age-specific, both sexes); [b] Cut-off for risk consumption: >168 g/week for men, >108 g/week for women (all ages, sex-specific); [c] The Alcohol Use Identification Test – Consumption, cut-off for hazardous drinking: ≥5 for men, ≥4 for women (age- and sex-specific)

Out of 1 203 participants in the baseline examination of Birth cohort 1944, 1 166 participants (545 men, 621 women; response rate 97.1%) without dementia responded to the alcohol questions in the semi-structured interview (Table 7). Among the 1 092 current drinkers, the median (Interquartile Range, IQR) weekly consumption was 60.0 (IQR ± 104) centiliters of pure alcohol. A total of 347 participants (31.8%; 232 men, 115 women) were risk consumers (cut-off >98 g/week). Compared to women (19.9%), there was a higher proportion of risk consumers in men (45.0%; X^2: p<.001).

A total of 1 052 (488 men, 564 women; response rate 95.8%) among current drinkers without dementia responded to the AUDIT questionnaire. The median AUDIT-C score was 3.0 (IQR ± 2). A sex difference in the prevalence of risk consumers was apparent when using age-specific cut-offs in accordance with the NIAAA guidelines, which are for both sexes. No differences were observed when applying the sex-specific cut-offs based on Swedish national guidelines or the sex- and age-specific AUDIT-C score cut-offs.



Examinations	GENERAL EXAMINATION (N=1203) Self-administrated questionnaires			ADDITIONAL EXAMINATIONS	
Source	*Total (men, women)*	*Instrument*	*Total (men, women)*	*Source*	*Total (men, women)*
Blood sampling	1 192 (555, 637)	ICECAP-O*[c]	1 040 (482, 558)	Close informant interview	973 (470, 503)
DNA extraction	1 165 (548, 617)	GAF*[d]	1 130 (519, 611)	Dietary exam	861 (385, 476)
Psychiatric exam	1 194 (555, 639)	Phobias	1 134 (522, 612)	Extended body composition	993 (402, 591)
Clinical cognitive exam	1 196 (557, 639)	PSS-14*[e]	1 135 (523, 612)	Computed tomography	915
Psychometric cognitive exam	1 173 (547, 626)	SF-36*[f]	1 137 (524, 613)	Magnetic resonance imaging	791 (377, 414)
General health exam	1 199 (558, 641)	SOC*[g]	1 138 (525, 613)	Cerebrospinal fluid sampling	322 (166, 156)
Medications	1 200 (559, 641)	VFQ-25*[h]	1 139 (525, 614)	Extended audiological exam	251 (113, 138)
Physical exam	1 200 (559, 641)	Leisure time activities	1 140 (524, 616)	Extended ophthalmic exam	561 (266, 295)
Basic body composition	1 147 (533, 614)	AUDIT*[i]	1 134 (520, 614)	Focus group study 1	38 (19, 19)
Spirometry[a] exam	865 (412, 453)	Dietary patterns	1 142 (526, 616)	Focus group study 2	16 (14, 12)
Spirometry[b] exam	1 098 (515, 583)	DUDIT*[j]	1 137 (524, 613)		
Peak Expiratory Flow (PEF) exam	1 099 (518, 581)	EDI*[k]	1 143 (528, 615)		
Audiological exam	1 116 (523, 593)	IPAQ*[l]	1 040 (482, 558)		
Ophthalmic	1 181 (549, 632)	Relationships	1 138 (525, 613)		
Functional ability and disability	1 197 (558, 639)	CMPS*[m]	242 (116, 126)		
Physical fitness and activity	1 173 (545, 628)	EPI*[n]	1 140 (526, 614)		
Social factors interview	1 198 (558, 640)	NEO-FFI-3*[o]	1 141 (524, 617)		
		PN-SRI*[p]	1 138 (526, 612)		
		Income	1 121 (518, 603)		
		Work	1 127 (518, 609)		

Figure 11. Overview of examinations and participants in the general and additional examination of Birth cohort 1944 in 2014-16. *: validated instruments; [a] Spirometry, Spriare 3; [b] Spirometry, micro medical; [c] The ICEpop CAPability measure for Older people; [d] The Global Assessment of Functioning; [e] The Perceived Stress Scale; [f] The Short-Form Health Survey; [g] The Scence of Coherence; [h] The Visual Function Questionnaire; [i] The Alcohol Use Disorders Identification Test; [j] The Drug Use Identification Test; [k] Eating Disorder Inventory; [l] The International Physical Activity status Questionnaire; [m] The Cesarec Marke Personality Scheme; [n] The Eysenck Personality Inventory; [o] The NEO Five Factor Inventory; [p] The Positive-Negative Sex-Role Inventory. Source: Original by the author, based on the results published in *Paper I*.[268]

4.2 PAPER II

Ahlner F, et al. Increased alcohol consumption among Swedish 70-year-olds 1976 to 2016: Analysis of data from The Gothenburg H70 Birth Cohort Studies, Sweden. *Alcoholism: Clinical and Experimental Research* 2018; 42(12): 2403-2412.[269]

Paper II investigated the prevalence of alcohol consumption in four birth cohorts of 70-year-olds examined over a period of almost 40 years. The main results are summarized in Figure 12. The observed changes in alcohol consumption level over time were statistically significant ($p<.05$). The male-to-female ratio of risk consumption (>100 g/week) decreased from 32.2 in Birth cohort 1906-07 to 1.9 in Birth cohort 1944. Furthermore, there were changes in beverage preference over time, with a decrease in consumption of spirits among men and an increase in wine consumption among both sexes.

As demonstrated previously in Table 4 and Table 5, response and completion rates varied among the included birth cohorts. Further examination of potential differences, supported by additional information from Statistics Sweden, shows that the remaining life expectancy at age 70 has increased for both men and women throughout the study period, from an average of 10.9 for men and 13.7 years for women in 1976-77, to 15.3 for women in 1992, to 13.1 for men and 16.0 for women in 2000, and to 15.0 for men and 17.3 for women in 2014.[270] Additional information also reveals that the population of 70-year-olds in Gothenburg has fluctuated over time, from an average of 4 334 during the examination of Birth cohort 1906-07 (1976-77), to 2 436 (women only) during the examination of Birth cohort 1922 (1992-93), 3 420 during the examination of Birth cohort 1930 (2000-02), and 4 867 during the examination of Birth cohort 1944 (2014-16).[271] Accordingly, alcohol data were provided by 9.1% of all 70-year-olds in Gothenburg in the examination of Birth cohort 1976-77. The corresponding figures for Birth cohorts 1922, 1930, and 1944 were 10.2%, 13.4%, and 24.0%, respectively.

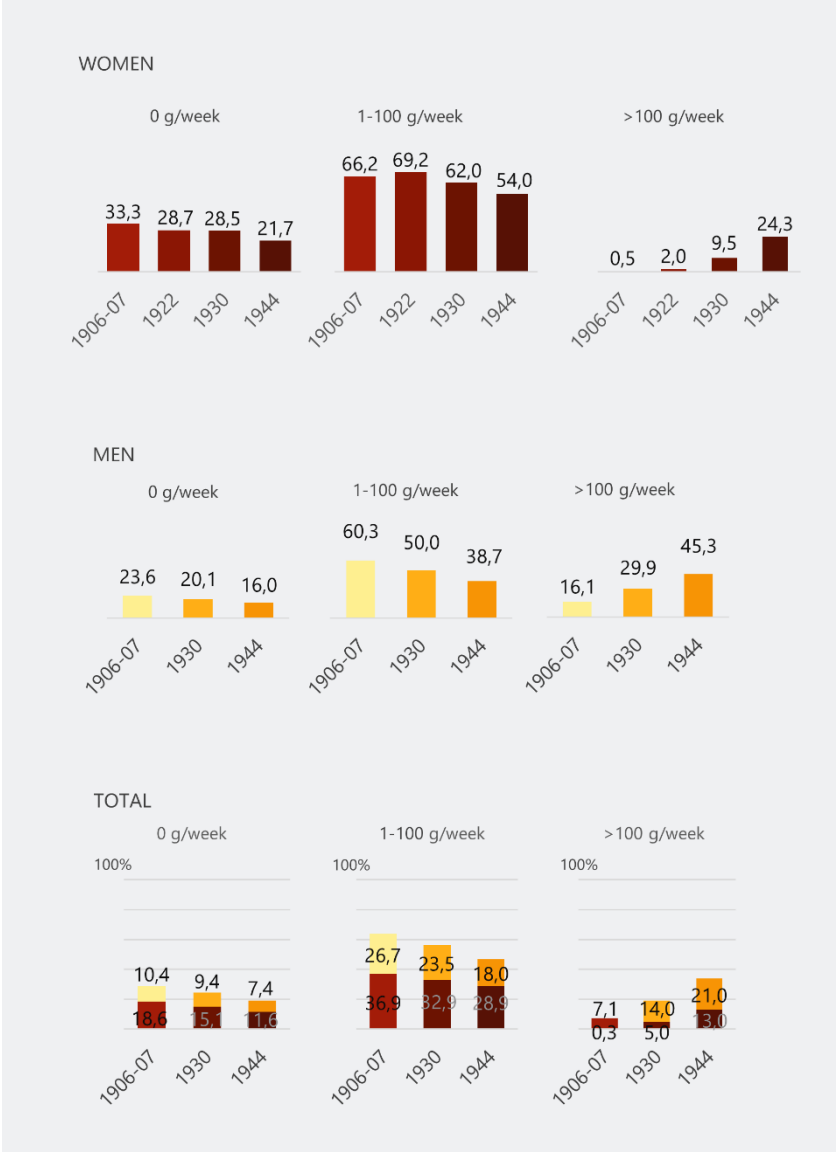


Figure 12. An overview of main findings in *Paper II*. The bars represent the prevalence (%) of 70-year-olds with a weekly consumption of 0 grams, 1-100 grams, and >100 grams by sex. Abstainers are included in the group of individuals consuming 0 grams per week. The total study sample was 392 in the Birth cohort 1906-07 (174 men, 219 women), 248 in the Birth cohort 1922 (women only), 458 in the Birth cohort 1930 (215 men, 243 women), and 1169 in the Birth cohort 1944 (543 men, 626 women). Source: Original by the author, based on the results in *Paper II*.[269]

4.3 PAPER III

Ahlner F, et al. Patterns of alcohol consumption and associated factors in a population-based sample of 70-year-olds: Data from the Gothenburg H70 Birth Cohort Study 2014-16. *International Journal of Environmental Research and Public Health* 2022; 19(14): 8248.[272]

Paper III examined factors associated with different levels of alcohol consumption among participants in Birth cohort 1944 examined in 2014-16. The main results are summarized in Figure 13. In short, findings indicated that former drinking was associated with most unfavorable factors, while few differences regarding health-related factors were found between lifetime abstention or risk drinking (>98 g/week) and those who reported moderate consumption (≤98 g/week). However, when analyzing different levels of risk drinking, significant variation emerged. Individuals with lower risk consumption (98-195 g/week) showed more favorable demographics and health-related factors, whereas those with higher risk consumption (≥350 g/week) displayed greater medical and psychiatric impairment (as reflected by higher Cumulative Illness Rating Scale-Geriatric score), and a higher prevalence of liver disease and minor depression.

Table 8 provides supplementary information on the characteristics of individuals who were included in the study sample (n=1 156) and those who were excluded from the analyses due to missing data or dementia (n=47).

Table 8. Characteristics of study sample (n=1 156) and those excluded from analyses (n=47) in *Paper III*.

	Study sample (n=1 156)	**Excluded (n=47)**	
	% (no. cases/total)	% (no. cases/total)	*p*
Women	53.4 (617/1 156)	57.4 (27/47)	.583
Primary education	14.3 (165/1 154)	29.3 (12/41)	<.001*
Employed	21.6 (248/1 147)	6.8 (3/44)	.033
Born in Sweden	85.3 (983/1 153)	65.1 (28/43)	<.001*
Residential care[a]	1.4 (16/1 145)	20.9 (9/43)	<.001*
Having partner	73.3 (846/1 154)	45.5 (20/44)	<.001*
Living alone	36.0 (416/1 154)	63.6 (28/44)	<.001*
Being religious	24.7 (273/1 104)	30.8 (8/26)	.481
Lifetime smoker	61.9 (715/1 155)	69.4 (25/36)	.358

Differences between groups tested by Pearson Chi-square test; *=statistically significant differences (*p*-value<.05); [a] Residing in long term care facility

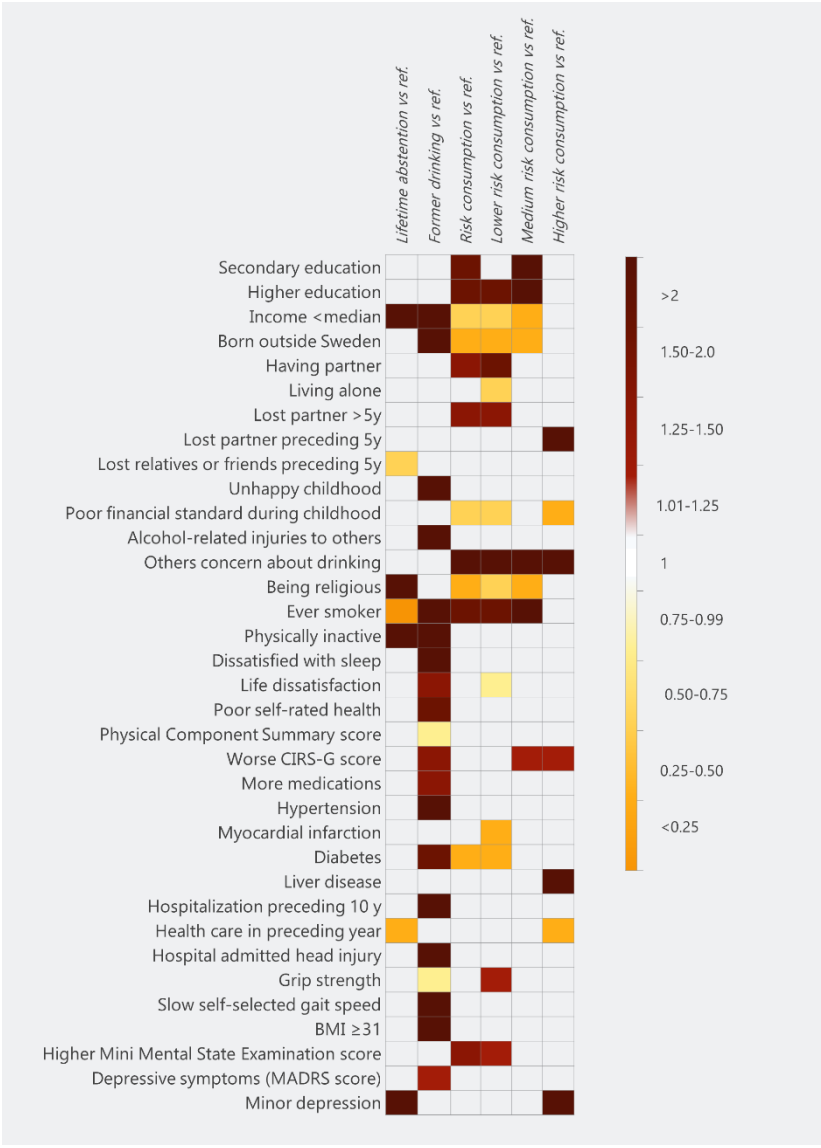


Figure 13. Overview of sociodemographic, social, and health-related factors associated with lifetime abstention, former drinking, risk consumption (>98 g/week), lower risk consumption (98-195 g/week), medium risk consumption (196-349 g/week), and higher risk consumption (≥350 g/week). Based on logistic regression models adjusted for sex, with moderate consumption ≤98 g/week as reference. Cells shaded in yellow indicate an odds ratio (OR) less than 1, with darker shades indicating lower odds of having the attribute. Red cells represent an OR larger than 1, with darker shades indicating higher odds of having the attribute. Cells with no color indicate no statistically significant associations (p>.05). Source: Original by the author, based on the results in *Paper III*.[272]

4.4 PAPER IV

Ahlner F, et al. The effect of alcohol consumption on all-cause mortality in 70-year-olds in the context of other lifestyle risk factors: Results from The Gothenburg H70 Birth Cohort Study *(submitted)*

Given that *Paper IV* is yet unpublished, this section provides a brief overview of the results. In summary, while there was no independent effect of alcohol consumption on all-cause mortality, an observed interaction was noted between alcohol consumption and physical activity (data not shown). Additionally, the combined effect of at least five lifestyle factors, including alcohol consumption, was associated with a 3-4 times higher risk of mortality in comparison to individuals with less than two lifestyle risk factors, as illustrated in Figure 14.

Table 9 displays supplementary information on the characteristics of individuals identified with risk or hazardous consumption, as well as those identified with harmful alcohol consumption according to both the risk and hazardous consumption definitions. As shown in Table 9, some differences were identified among the groups (X^2; $p<.05$).

Table 9. Baseline characteristics of individuals with harmful alcohol consumption levels according to three different definitions (>98g/week, AUDIT-C score ≥5 for men, ≥4 for women, or both in the study sample of *Paper IV*.

	>98 g/week (n=135)	**AUDIT-C score beyond cut-off (n=86)**	**Both (n=204)**
	% (no. cases/total)	% (no. cases/total)	% (no. cases/total)
Men	80.7 (109/135)*	31.4 (27/86)*	57.4 (117/204)*
Born outside Sweden	8.9 (12/135)	9.3 (8/86)	7.8 (16/204)
≥Secondary education	88.9 (120/135)	86.0 (74/86)	89.2 (182/204)
Lifetime smoker	64.4 (87/135)*	74.4 (64/86)	75.4 (153/203)*
Being religious	16.3 (22/135)	18.8 (16/85)	13.4 (27/202)
Somatic disease [a], median (± IQR)	1.0 (± 0)	1.0 (± 1)	1.0 (± 0)
Any depression (yes)	5.9 (8/135)	10.5 (9/86)	11.3 (23/204)
Functional dependent [b]	13.3 (18/135)	13.3 (11/83)	10.9 (22/202)
Poor self-rated health	9.6 (13/135)	16.3 (14/86)	14.2 (29/204)

Pearson Chi-square test (X^2), *=statistically significant pairwise differences between groups (p-value<.05)
[a] Somatic disease score including four chronic non-communicable diseases (cardiovascular disease, liver disease, cancer, and diabetes) ranging from 0 to 4, where a higher score indicate higher burden; [b] Based on Activities of Daily Living (ADL) using the Barthel Index for Activities of Daily Living, where scores <100 were considered as being functional dependent in this functional independent sample.

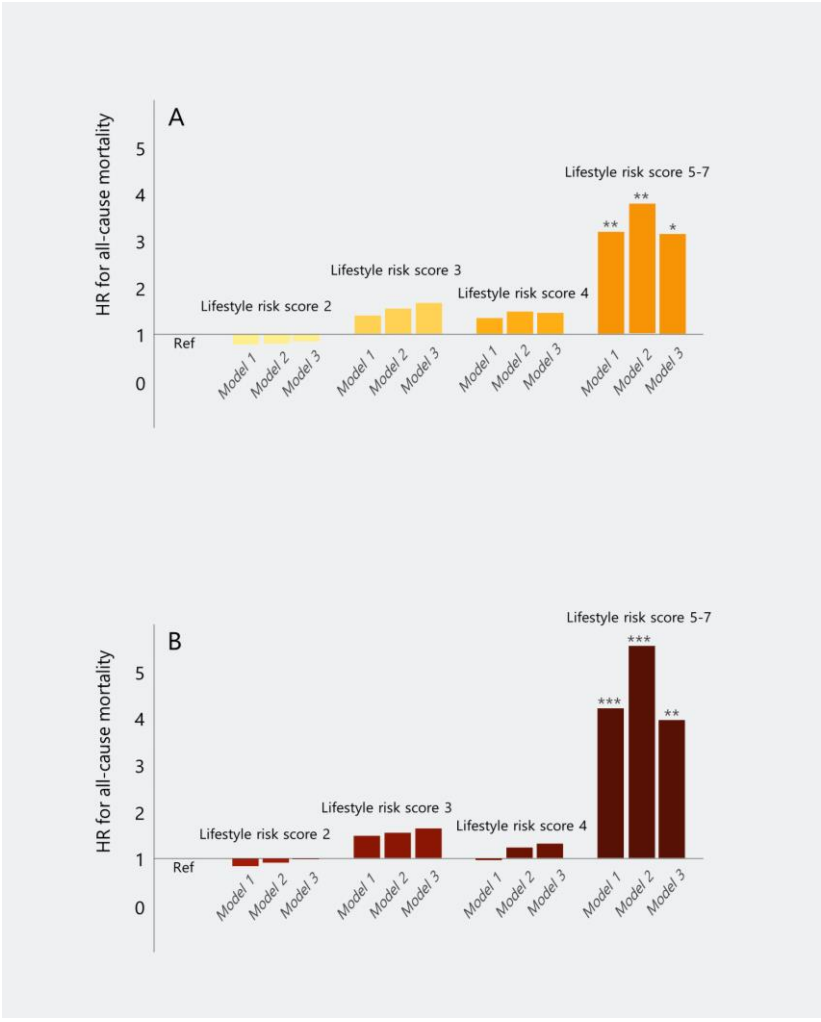


Figure 14. Associations of lifestyle risk score with all-cause mortality. (A) Lifestyle risk score based on high alcohol consumption (>98 g/week), smoking status (lifetime), Body Mass Index (<23 or ≥31), insufficient physical activity (<150 min/week of moderate activities or <75 min of vigorous activity), sedentary behavior (>7h/day), insufficient/prolonged sleep (<7 or ≥9 hours/night), and unhealthy dietary pattern (score ≤4), (B) Lifestyle risk score based on hazardous drinking (AUDIT-C score ≥5 for men, ≥4 for women), smoking status (lifetime), Body Mass Index (<23 or ≥31), insufficient physical activity (<150 min/week of moderate activities or <75 min of vigorous activity), sedentary behavior (>7h/day), insufficient/prolonged sleep (<7 or ≥9 hours/night), and unhealthy dietary pattern (score ≤4). Model 1: Adjusted for sex, Model 2: Adjusted for sex, county of birth, education, and religion, Model 3: Adjusted for sex, county of birth, education, religion, somatic disease, depression, self-rated health, and functional dependence. *=p-value <.05, **=p-value <.01, ***=p-value <.001. Source: Original by the author, based on the results in *Paper IV*.

Discussion

5 DISCUSSION

The papers included in this thesis are based on data from observational cohort studies. In the hierarchy of scientific evidence, randomized controlled trials (RCTs) are referred to as the gold standard of research designs to establish causal inference.[273] However, RCTs are associated with practical and ethical challenges in alcohol research in humans.[228] Consequently, observational studies play a crucial role in alcohol research as they provide valuable insights to the impact of alcohol consumption on health-related outcomes in natural settings. However, observational studies, particularly those concerning alcohol consumption in older adults, entail several methodological challenges that necessitate careful consideration.

5.1 METHODOLOGICAL CHALLENGES IN ALCOHOL RESEARCH

Observational studies of alcohol consumption may be subject to several systematic errors (bias). During the procedure of sample selection, non-response bias and healthy user bias can occur and impact the ability to capture true variations in alcohol consumption in the target population. While current drinking is less prevalent among non-participants,[274] non-participants who do consume alcohol tend to exhibit higher levels of alcohol consumption compared to current drinkers among participants.[274,275] Nevertheless, the overall impact of non-response on alcohol consumption findings has been suggested to be limited.[276-278] Healthy user bias arises when study participants are healthier than the target population, either because they are more health-conscious or because they are less likely to have pre-existing health conditions. In alcohol research, this may lead to overestimations of alcohol consumption rates and underestimation of its consequences due to better overall health status among participants.

Efforts have been made to minimize the impact of selection bias in the H70 studies, including offering individual examination arrangements and inviting individuals regardless of their place of residence. Non-native Swedish speakers with acceptable communication skills were offered a downsized examination with linguistic assistance provided by a relative if needed, without challenging the confidentiality of the participant. Moreover, individually adapted examinations (i.e., divided into two or several days or conducted at participants' place of living) were offered. While the impact may be limited in *Paper I-IV* due to a low percentage of participants living in residential care facilities, it remains crucial to include individuals living in such facilities to capture the true variation in health and alcohol consumption within older populations.[279] Despite this, both non-response bias and healthy user bias may have

influenced study findings in *Paper II-IV*, leading to a potential overestimation of risk consumers and underestimation of risks associated with alcohol consumption.

Response bias refers to a tendency of reporting untruthfully, either consciously or unconsciously, thereby affecting the validity and reliability of the data collected. Response bias manifests in several forms, such as recall and social desirability bias. Recall bias can result from memory loss or challenges in estimating the correct amount of alcohol consumed. The influence of recall bias varies with the reference period of reporting, with longer reference period increasing the risk of bias.[280,281] In the H70 studies, recall bias was minimized due to the one month recall period,[282] which is suggested as a good indicator of alcohol consumption in older adults.[283] Shorter reference periods are more suitable in studies of older adults due to potential age-related changes in memory and cognitive ability.[130,284,285] Recall bias was further reduced with face-to-face interview approach, as the interviewer can assist participants in completing the questionnaires and recalling the number of drinks consumed.[282]

Social desirability bias occurs when participants underreport socially negative attributes or behaviors, such as alcohol consumption, and over report positive traits and behaviors, such as physical activity.[286,287] Alcohol-related stigma, and fear of being judged or criticized influence how comfortable participants feel about withholding truthful responses. Moreover, the impact of social desirability bias on self-reported data can vary across demographic and consumption-based subgroups of the population.[262] For example, research has shown that underreporting is generally more pronounced among heavy drinkers.[122,288] In the context of the H70 studies, efforts were made to create a pleasant and positive experience for participants during the examination. To facilitate this, the same research nurse was assigned to examine participants throughout the entire general examination day, whenever possible, in order to establish a good respondent-interviewer relationship. A stronger relationship could increase participants' willingness to provide more conscientious reports and disclosure of more information, particularly for sensitive questions.[289] Additionally, the data collection process was characterized by a non-judgmental approach to promote a comfortable and trusting atmosphere for the participants.

Bias is suggested to be more pronounced in studies involving older adults.[228,290,291] This can be attributed to the stronger relationship between health status and alcohol consumption among older adults, which may magnify the impact of health on participation in research. Consequently, the greater influence of healthy user bias may result in spurious conclusions regarding the potential benefits of moderate alcohol consumption in older individuals.[291]

Older populations are to a higher extent influenced by survival bias than younger populations. There is reason to believe that many of those with chronic high exposure of alcohol consumption have died at younger ages,[292,293] influencing risk estimates associated with different levels of consumption and the generalizability of findings to other age groups. It is worth noting that survival rates have improved in recent years due to medical advances and better access to healthcare. As reported previously,[264] the five-year mortality rate has declined in recent cohorts of 70-year-olds in the H70 studies (i.e., 11.9% in Birth cohort 1906-07; 8.1% in Birth cohort 1922; 5.0% in Birth cohort 1930, 4.7% in Birth cohort 1944). Moreover, additional results of *Paper II* in this thesis showed that the remaining life expectancy at age 70 has increased for both men and women over the last four decades. Higher survival rate may indicate less influence of survival bias in later born birth cohorts.

Self-report data

In most epidemiological studies, information on alcohol use is primarily based on self-reports.[1,10,282] The quality of self-report data is strongly influenced by several factors, including content and structure of questions, response options, and wording.[294,295] Consistent evidence suggest that self-reported volumes underestimate actual consumption.[65,296-298] Self-reported volumes account for only 39-56% of total alcohol sales.[298] On the other hand, sales data alone probably overestimate population-level drinking due to stockpiling and purchases made by non-residents.[11]

Despite certain limitations, self-reports are considered to be reliable and valid measurements of alcohol use.[284,299] In addition, AUDIT-C has been applied among older adults in various settings and has demonstrated an ability to accurately identify older individuals with harmful drinking habits.[300,301] Objective measures, such as biomarkers including Phosphatidylethanol (PEth), have been proposed as an alternative to subjective measures. Although less prone to bias, objective measures have limitations for use in observational studies. Specifically, PEth can be more invasive, expensive, and less sensitive in detecting low levels of consumption and single drinking episodes.[302,303]

5.1.1 DISCREPANCIES AMONG STUDIES

In addition to various impacts of bias among studies, inconsistencies in results may arise due to various factors related to study design, sample characteristics, and study context.[298]

The lack of a universally recognized methodology for the assessment and categorization of alcohol data results in disparities in findings across studies. This can be primarily attributed to the instruments used, thresholds applied, confounding

factors considered, and length of recall period.[65,66,282] A recent systematic review established and validated definitions of risk consumption and heavy episodic drinking in older adults.[282] If universally accepted, these definitions would improve comparisons among future studies. In this thesis, the definition of risk consumption was based on drinking guidelines for individuals aged 65 years and above recommended by the NIAAA in the United States.[59] This threshold is commonly used in studies of older adults[282] and is roughly in line with current Swedish national drinking guidelines provided by the National Board of Health and Welfare for women of all ages (i.e., <108 g/week), but considerably lower than those for men of all ages (i.e., <168 g/week). When applying cut-offs based on Swedish national drinking in the total sample of Birth cohort 1944, about one-fifth were considered being risk consumers, compared to approximately one-third when using the NIAAA thresholds. These findings underscore the impact of threshold selection on study findings.

Sample characteristics and intended target population will also influence study findings. For example, disease rates vary among different populations, which in turn will influence levels of alcohol consumption and the proportional risk of all-cause mortality in these populations.[219,304] Moreover, studies examining only community-dwelling older adults will find higher prevalence rates of alcohol consumption than studies which also include individuals living in residential care facilities, representing the general older population.[279] Given substantial differences in sample characteristics, meta-analyses that use multinational data may have limited applicability as estimates are not generalizable to any particular population.[304] The average age of study samples in this thesis is lower than that of most studies involving older adults. This lower sample age may have influenced study findings by generating higher consumption rates, and this could limit comparability with previous research.

Differences in aspects of study context, such as urban or rural location, alcohol availability, societal norms and attitudes may explain disparities among studies. Apart from drinking culture,[22] studies have also indicated that countries with greater financial stability, better healthcare and welfare systems, greater gender equality, and less inequality tend to have higher levels of population drinking.[36-38] Findings from this thesis may thus be influenced by being conducted in a high-income country.

5.2 MAIN FINDINGS

In this thesis, the prevalence, correlates, time trends, and consequences of alcohol consumption in population-based samples of 70-year-olds were investigated. The upcoming chapters provide a broader perspective of the main findings enriching the discussion of each paper. Paper-specific findings and concerns are to be found in the individual papers included at the end of this thesis.

5.2.1 PREVALENCE AND CORRELATES OF ALCOHOL CONSUMPTION

There was a significant increase in alcohol consumption among 70-year-olds since the late 1970s. Increasing alcohol consumption rates among later born cohorts of older adults have repeatedly been confirmed in previous studies from various high-income countries.[17-20,38,305] Research indicate that this could be partially attributed to cohort effects; older adults of today could maintain alcohol consumption habits up to older ages than previous generations.[306] One possible explanation for this is that older adults of today experience less impact of health-related conditions on their everyday life, possibly due to improved care and better medical treatments with lower risk of potential side effects.

Findings from *Paper II* revealed that the prevalence of current drinkers and risk consumers (>100 g/week) among 70-year-olds examined in 2014-16 was 93.2% and 34.0%, respectively. These figures were relatively high compared to previous studies of older adults aged 60-75 years[21] and 60-79 years.[25] However, similar or higher rates of risk consumption have been reported in individuals aged 60-75 years in Norway (34.5%), Denmark (50.0%), Belgium (47.6%) and Portugal (38.2).[36] As suggested previously, regional or cross-country differences in prevalence rates are to be expected in both general as well as older populations.[1,32,36] In line with previous research,[1,24,28,29,32,36,37,82,113,117,122,130,307-309] alcohol consumption rates were consistently higher among men than among women. However, the sex gap in alcohol consumption narrowed over the study period, a trend also found in previous studies.[83-85]

The main objective of *Paper III* was to identify potential predictors of alcohol consumption in the youngest-old by analyzing factors associated with different alcohol consumption categories. This knowledge is essential in recognizing older adults with harmful alcohol consumption habits and guiding public health policy and interventions. Associations were found between several factors and varying levels of alcohol consumption. Specifically, former drinking was associated with unfavorable demographic, social, and health-related factors. The findings were consistent with the

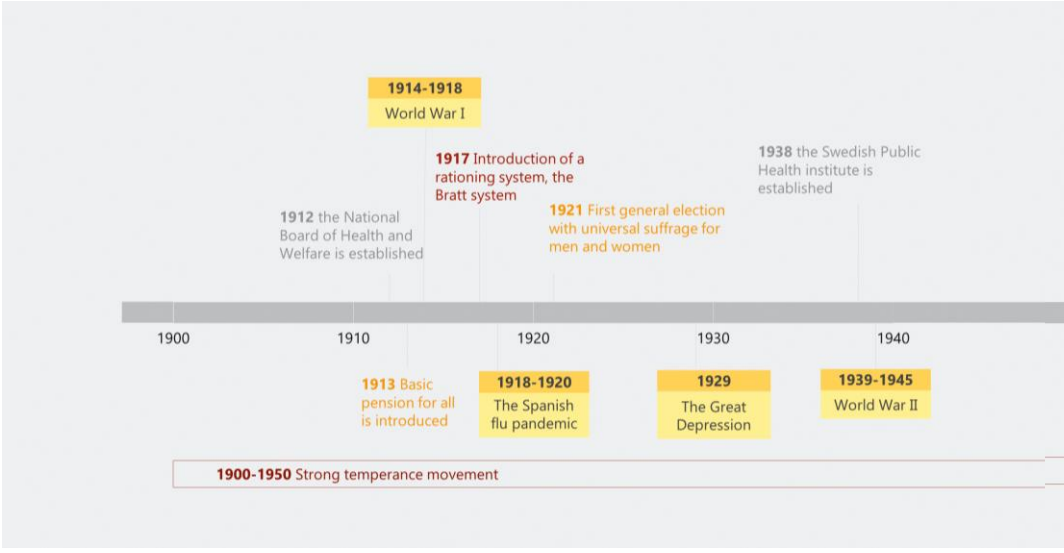
sick quitter effect, which suggests that individuals with poor health tend to abstain from alcohol more frequently than those in good health.[45,110,310-312]

Factors associated with risk consumption in our study are in line with correlates of high alcohol intake identified in various contexts in middle-aged and older adults (aged ≥40) including male sex,[24,28,29,32,36,37,113,117,122,130,308,309] younger age,[24,29,34,37,39,113,117,122,130,313] higher SES or indicators of high SES (e.g., higher education, income, and social status),[24,32,34,36,39,45,111,113,308,309,313] smoking,[24,28,29,32,37,39,111,113,130,313] and better health status.[78,111,313] It is important to note that the associations observed in *Paper III* are cross-sectional, which limits the possibility to draw conclusions about causality.[314]

5.2.2 TIME TRENDS IN ALCOHOL CONSUMPTION

Improvements in population health may be one out of several factors that could explain the increase in alcohol consumption in older adults.[17-20,38,305] Health status is an important predictor of alcohol consumption,[105-109] influenced by past and current exposures to physical, environmental, and psychosocial factors. Figure 15 (page 54-56) displays significant dates in the Swedish public health history throughout the 20th century, impacting the life course of included birth cohorts.

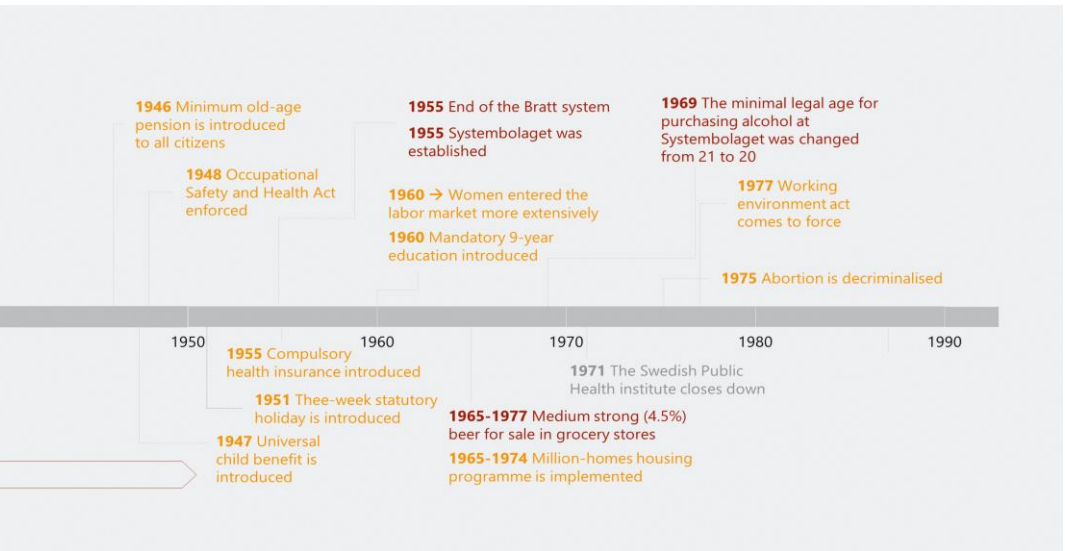
Figure 15. Timeline of dates in public health history in Sweden 1900-2020. Source: Sundin and Willner 2007,[315] Figure 2 in Rydberg Sterner et al. 2019,[316] and Figure 2 in *Paper II*, adapted by the author.



In addition, improvements in population health are attributed to several other factors, including democratization, economic growth, welfare state emergence, declining mortality rates, greater healthcare accessibility, improved living standards, enhanced occupational health, and medical advancements.[315] Variation in societal development during the 20th century have contributed to health disparities among different birth cohorts and have significant implications for healthy aging opportunities.

Age, period, or cohort effect?

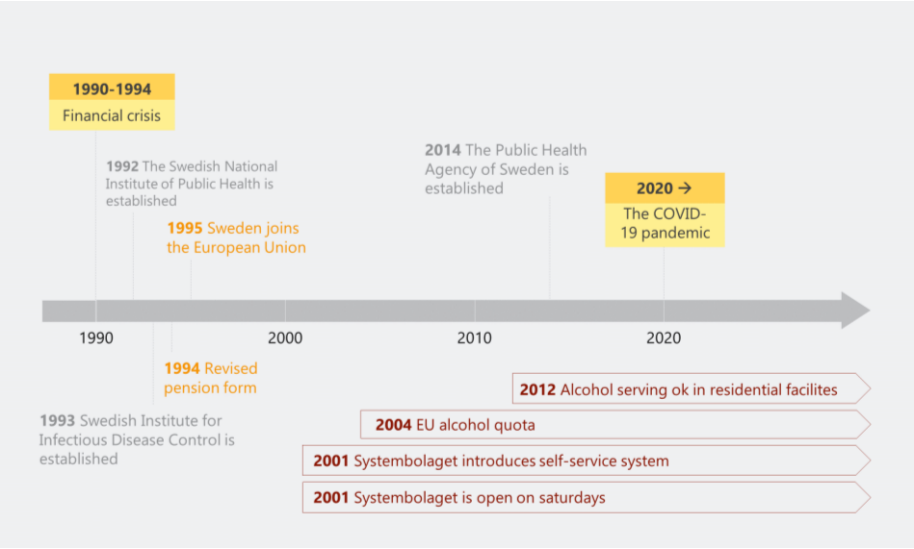
Increased consumption rates in older adults are influenced by multiple factors beyond better health status, and their impact may vary over time due to age, period, and cohort effects. The existing evidence argues for a decreasing influence of age on alcohol consumption in recent years.[76] A declining effect of age over time may explain some of the observed disparities in alcohol consumption in *Paper II*, as the impact of age was likely to be greater in earlier born cohorts (Birth cohort 1906-07 and Birth cohort 1992) than in later born cohorts (Birth cohort 1930 and Birth cohort 1944).Over the 40-year study period, there have been several changes that have impacted alcohol availability. For instance, Sweden's accession to the European Union (EU) in 1995 resulted in increased availability and reduced alcohol prices. As these changes are suggested to affect all ages similarly, they could be classified as period effects. However, changes associated with EU membership occurred after the examinations of Birth cohort 1906-07 (examined in 1976-77) and Birth cohort 1922 (examined in 1992-93), meaning that differences in alcohol consumption level between earlier and later born cohorts may partly be explained by differences in alcohol availability at time of examination. There are indications that Sweden's EU



membership led to an increase in population-level drinking.[317-319] However, others have found no or marginal effects of reduced taxation and relaxed boarder restrictions on overall alcohol consumption.[320-322] Policy changes may have had differential effects on different age groups, and it has been suggested that any potential effects may be more pronounced in the older segment of the population.[321,322]

Cohort effects may also account for the increased alcohol consumption shown among older adults of today. Various factors contribute to the development of cohort-specific characteristics that influence alcohol consumption habits. Members of the same birth cohort experience period changes simultaneously during their life course, and these exposures may introduce cohort-specific characteristics. In addition to societal development, variation in the availability of alcohol may have different effect across birth cohorts due to varying ages at the time of policy change. Moreover, temporary policies affecting alcohol availability have been found to have long term effects on individual alcohol consumption habits.[197-199]

During the early adulthood of Birth cohorts 1906-07 and 1922, between 1917 and 1955, an alcohol rationing system called "the Bratt system" was implemented in Sweden. The Bratt system aimed to regulate population-level drinking though registration and limits on purchasing. Restrictions varied based on the sex and socioeconomic status of the purchaser, with a maximum volume of three liters of liquor per month.[315] The Bratt system may have entailed a more restrictive attitude towards alcohol among individuals in the earlier born cohorts compared to the two later born birth cohorts. Growing up with restrictive alcohol policies has previously



been found to be associated with lower current consumption rates.[198] However, Swedes born between 1930 and 1950 have previously been referred to as "high-risk birth cohorts" due to a higher risk of alcohol-related mortality compared to later born cohorts.[202]

Paper II did not include statistical evaluations of age, period, and cohort effects due to methodological inadequacies.[323] However, the presence of age effect can be eliminated as analyses included birth cohorts of the same age. The effect of time period is estimated to be limited based on the existing literature of a reversed trend among younger adults.[48,49] Therefore, cohort effects are deemed the most applicable explanatory force of the observed variations. Previous studies establishing an influence of cohort effect on alcohol consumption levels in general and older Swedish populations support this assumption.[201,202,279] In addition, the likelihood of cohort effects is suggested to be greater in birth cohorts of older age, as these individuals have led longer lives, increasing the likelihood of potential exposures and cumulative effects.[279]

5.2.3 CONSEQUENCES OF ALCOHOL CONSUMPTION

Consistent evidence shows that high alcohol consumption is associated with an increased risk of long-term adverse health effects.[1,14,58] However, findings regarding the effect of alcohol consumption on risk of all-cause mortality are inconsistent. In *Paper* IV, there was no evidence for an increased risk of all-cause mortality with elevated alcohol consumption in the study sample with a baseline age of 70 followed for 8 years. Lack of association has also been reported in a Norwegian sample of individuals aged 65 years and above.[324] There are however several studies conducted in high-income countries with follow-up periods ranging from 2 to 20 years that have demonstrated a higher risk of all-cause mortality in middle-aged and older adults who engage in harmful alcohol consumption.[132,218,325-330] There is also evidence for a curvilinear (i.e., J- or U-shaped) association,[109,331] as well as decreased risk associated with low-to-moderate drinking.[332-334] The majority of these studies were conducted during the early 2000's, and have been strongly criticized in recent years due to methodological issues.

Taken together, findings of *Paper III* and *Paper IV* indicate that harmful alcohol consumption among older adults is associated with levels exceeding the current low-risk drinking guidelines set by the NIAAA with a substantial margin. Specifically, cross-sectional associations with traditional alcohol conditions such as liver disease were only evident among those with the highest levels of consumption (≥350 g/week), whereas lower levels were associated with few adverse health effects. These results suggest that harmful alcohol consumption among older adults is associated with a high threshold, beyond which significant health risks become evident.

A potential explanation for our results may entail having all-cause mortality as outcome variable, previously problematized by the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2020 Alcohol Collaborators.[58] Causal pathways for different alcohol-related outcomes may vary significantly, which can introduce various confounding factors that are challenging to account for when analyzing the impact of alcohol use on all-cause mortality.[58] However, potential confounding factors in *Paper IV* were selected a priori based on established confounding factors and additional adjustments for general health variables and four major alcohol-attributable diseases or categories of diseases. Given this, finding may have been different if evaluating the effect of alcohol use on cause-specific mortality, or other potential alcohol-related consequences such as development of specific types of cancer. Noteworthy, even though no significant associations were established between alcohol consumption levels and risk of all-cause mortality in *Paper IV*, alcohol may be associated with various other negative health consequences apart from death in this study sample. Risk of death may also be largely influenced by level of overall health at baseline.[109] Although several covariates were carefully considered, there is still a risk that not all variables influencing the relationship were accounted for in analyses.

Findings of *Paper IV* suggest that physical activity may moderate the association between hazardous alcohol consumption and all-cause mortality risk. Research on the relationship between alcohol consumption and physical activity in older adults is limited. However, a study conducted in the United Kingdom on individuals aged 40 years and above demonstrated that sufficient physical activity was associated with a reduced risk of all-cause mortality among those who consumed alcohol below hazardous levels.[335] There is reason to believe that both alcohol consumption and physical activity are indicators of better overall health status in older adults,[336,337] rather than direct causes of reduced mortality risk.

In *Paper IV*, a combination of five or more lifestyle risk factors were associated with a 3- to 4-fold increase in the risk of all-cause mortality, compared to individuals who had less than two such risk factors. These results align with previous studies of older adults, which have demonstrated that an increased number of unhealthy lifestyle factors are associated with greater risk of all-cause mortality,[338] while a higher number of healthy lifestyle behaviors are associated with a decreased risk of all-cause mortality.[339] These findings indicate that the burden of having several unhealthy behaviors is of greater importance rather than the isolated effect of one risk factor.

5.3 ALCOHOL USE AMONG OLDER ADULTS – A MATTER OF CONCERN?

In contrast to trends among young adults, alcohol consumption levels are increasing among older adults, a trend which has also been confirmed in this thesis. Together with projected population aging the prevalence of alcohol-related conditions is an increasing public health issue. Increased alcohol consumption in older adults may result in increased alcohol-related harm including higher prevalence of chronic diseases, mental health problems, accidents and injuries, medication interactions, social consequences, and increased healthcare expenditures.[340] Broad scale evidence-based prevention and intervention initiatives can improve public health outcomes,[23,189,340-344] particularly actions that focus on price and availability.[189,191,344] Changes in price and availability of alcohol have proven effective even in older adults.[17] Empirically supported interventions aimed at a reduced consumption have shown effectiveness in this age group, even among individuals with chronic use.[345-347]

As discussed previously, the existing literature presents inconclusive findings regarding the relationship between alcohol consumption and survival. Although some studies indicate a dose-response relationship between alcohol intake and mortality risk,[132,218,325-330] other studies,[324] including *Paper IV*, find no such association or even a decreased risk for mortality with low-to-moderate consumption.[109,331-334] In addition to potential methodological errors, it is also plausible that moderate consumption may not have significant negative effect on survival in older adults. Consistent with this, recent evidence suggests that the health risks associated with lower levels of alcohol consumption are less significant for older populations compared to younger populations.[58] One possible explanation for the attenuated risk is that individuals who have survived until the age of 70 may be more resilient than those who have not.

According to several qualitative studies, many older adults of today are skeptical about the health risks associated with drinking.[176,345,348-350] One possible explanation for this skepticism may be a more liberal view on alcohol generated by growing up during a historical period when alcohol was more socially accepted. Moreover, the absence of personal experience or observations of any negative effect throughout life also result in questioning of harm caused by alcohol and the related advice.[351] Some studies suggest that older adults are ill-informed about drinking guidelines and risks related to drinking,[135,176,352] which in combination with observed skepticism can make it challenging to motivate behavior changes in alcohol related behavior.

5.3.1 AGE-SPECIFIC LOW-RISK DRINKING GUIDELINES

The majority of high-income countries have current guidelines for alcohol consumption, but the recommended level of consumption varies markedly across countries, and the effectiveness as public health interventions have been debated.[353-358] Moreover, recent evidence suggests that there is no safe limit for alcohol consumption,[14,359] and some argue that low-risk drinking guidelines gives a misleading impression of safe levels of alcohol consumption.[360]

There is an ongoing discussion about the definition of a risk-threshold and whether a lower threshold should be applied to older adults. Given the potential cumulative effect, age-related biological changes resulting in lower tolerance, and the increased burden of medical conditions in this particular segment of the population, there is evidence arguing for the increasingly adequacy of adopting lower thresholds for older adults.[27,41,54,55,361-365] However, Skovenborg argues in response to the BMJ editorial *"Alcohol complicates multi-morbidity in older adults"* that the idea of an increased vulnerability due to reduced metabolic efficiency in older adults is a misconception due to limited studies in humans.[366] At the same time, a recent multi-national study using data of individuals aged 15 years and above in 204 countries and territories, found that existing guidelines are too high for the younger populations in all regions.[58] In accordance with this finding, a study utilizing combined data from individuals of varying ages across 19 high-income countries demonstrated that the risks associated with alcohol consumption on all-cause mortality increased beyond a weekly threshold of 100 grams,[54] corresponding to the maximum drinking limit recommended by NIAAA.[59] Additionally, the authors concluded that recommendations for alcohol consumption should vary by country due to substantial differences within all-cause mortality across populations. Moreover, these variations limit the applicability of using multinational observational data for establishing a universal definition of low-risk drinking guidelines.[58]

5.4 STRENGTHS AND LIMITATIONS

In this chapter, general methodological strengths and limitations of this thesis are discussed. Paper specific strengths and limitations are acknowledged in the discussion section of each paper.

General strengths

This thesis has several strengths. First, the overall findings of this thesis gives a broad perspective based on observational data based on a variety of study designs and analyses. The findings provide new insights on a particular segment of the population that has become increasingly important due to rapid aging of the global population.

Second, the included papers are based on data from systematically selected samples from the prospective population-based H70 studies. Systematic sampling reduces the risk for bias, and the comprehensive examination covers high-quality data that has the potential to capture diverse aspects of aging and to test for associations with alcohol consumption.

Third, response rates of included study populations were high (63.2-80.8%). In recent years, declining response rates have become an increasing challenge in research.[367] Surveys with response rates below 50% are often used to estimate national trends in alcohol consumption,[279] although survey method textbooks recommend response rates of at least 70%.[368,369] Lower response rates increase the risk of obtaining study population that is less representative, thereby potentially excluding certain subgroups from the target population, which may generate skewed results.[370] While high response rate can help to mitigate the potential risk for response bias, it should be noted that high response rates cannot fully eliminate the risk of bias.

Fourth, all papers included in this thesis are based on samples of individuals of the same age. Findings may serve as a complement to previous surveys of alcohol consumption in the Swedish population aged 65 years and above. A wide age range can present challenges, especially it when it spans from the youngest to the oldest old. Substantial diversity and inequality in both health and alcohol consumption within this group may influence findings and potentially result in incorrect conclusions that are not applicable to subgroups within the broad age category.[115] The generalizability of findings in this thesis is limited to 70-year-olds living in similar urban contexts. With some caution, the findings may apply to baby boomers in other high-income countries in the Western world. However, studying same-aged individuals precludes the ability to examine the effect of age on alcohol consumption habits.

Fifth, categorizations of drinking status suggested by the WHO (i.e., lifetime abstainers, former drinkers, and lifetime abstainers) were followed in data analyses,[11] and definitions of risk consumptions were in line with existing drinking guidelines for individuals aged 65 years and above.[59] Adopting a lower threshold for risk drinking in older adults may be perceived as less conservative than using cut-offs for all ages.[32] As discussed previously, the applicability of age-specific thresholds is under debate and the cut-off applied in *Papers III-IV* may have been too low to detect adverse health effects of alcohol consumption in our study sample. However, this threshold is widely used in studies of older adults, which facilitates comparisons to previous findings.

Sixth, several actions have been taken to improve the quality of alcohol data collected within the H70 studies. Beyond actions for minimizing the influence of recall and social desirability bias discussed previously, information on alcohol consumption was obtained as just one part of a comprehensive health examination, found to be appropriate for capturing actual consumption rates.[122]

General limitations

There are several limitations that should be acknowledged. First, limited sample size reduced the statistical power, particularly when conducting subgroup analyses.

Second, findings may be susceptible to residual confounding, as adjustments made for known potential confounders do not preclude the possibility of unknown factors influencing the observed associations. Moreover, a smaller sample size limits the ability to include a larger number of covariates in analyses, which can affect the accuracy of results. Thus, interpretation of findings should be done with some caution.

Third, despite several efforts to increase the quality of alcohol data, some limitations still exist. While utilizing a reference period of the previous month can mitigate the risk of recall bias in studies of older adults,[282] it is associated with some limitations. Past month reporting does not capture seasonal variations or periods with deviant consumption patterns and further, infrequent drinkers may be missed or misclassified.[10,282,294,371] However, the risk of misclassifying infrequent drinkers as abstainers was limited in the H70 studies as classifications of abstainers and current drinkers was based on a specific question regarding alcohol abstention. Average alcohol consumption was a major focus, without regard to drinking pattern (e.g. binge drinking, typical day drinking) or context (e.g., drinking alone or in social settings). Past research suggests that a focus on average consumption may underestimate the risk for harmful alcohol consumption among older adults.[372-374] Apart from past month consumption, there was no available information on lifetime consumption or previous drinking patterns. However, findings from prior studies indicate a

longitudinal stability of consumption levels throughout adulthood.[375,376] Moreover, reasons for alcohol consumption are unknown, and these probably vary substantially among study participants due to demographic, social, and behavioral influences. Additionally, the overall impact of incorrect alcohol consumption levels cannot be excluded due to the influence of several factors such as healthy user bias, recall bias, and social desirability bias.

Another consideration is that self-reported data were not corroborated by objective measurements, such as PEth. However, previous research suggests a strong correlation between self-reported alcohol consumption (e.g., AUDIT-C and amount consumed) and PEth in middle-aged (35-59 years) and older adults (aged ≥60).[377] Moreover, the percentage of individuals identified as risk consumers based on their alcohol consumption levels reported during the face-to-face interview (31.8%, using the NIAAA cut-off) and through the self-administrated AUDIT questionnaire (27.7%) suggests that the responses were truthful, or at least robust. Noteworthy, these methods are not entirely comparable, due to variations in cut-offs and reference period, which may explain variations in the prevalence of risk consumers.

Despite several efforts to obtain accurate responses, the influence of underreporting cannot be completely discounted, as the sensitive nature of the questions may discourage some individuals from disclosing their true drinking behavior. Systematic underestimation of alcohol consumption may lead to an underestimation of associated risks. However, the consistency found between reported amounts during interviews and in the self-administrated questionnaire suggest that underreporting was not a major concern. Also, it should be noted that levels of alcohol consumption were higher in Birth cohort 1944 compared to previous studies of older adults. This may imply that participants were comfortable in reporting their true alcohol intake. Moreover, underestimation is less pronounced among older females,[262] and the phenomenon of underreporting it is not necessarily applicable to all individual reports of consumption.[296]

Fourth, no imputation was conducted for missing data. Imputation would have maintained sample size and increased statistical power of analyses to some extent. However, even if missing alcohol data was prevalent, the magnitude was limited (i.e., 37 of 1203 in baseline examination of Birth cohort 1944), resulting in limited potential effect of imputation. Moreover, differences among those included in analytic sample and those excluded were presented. For papers with no such comparisons (*Paper I-III*), supplementary information on samples were provided as additional results in this thesis.

Finally, although an extensive evaluation of potential associations was conducted, no correction for multiple analyses was performed. Without multiple correction, the

probability of falsely rejecting the null hypothesis increases with each test, which increases the risk of type I errors and spurious associations. However, performing multiple corrections may increase the risk of type II errors, where true associations are missed due to reduced statistical power. Given the relatively small sample size and limited statistical power, multiple testing was deemed unsuitable. Nevertheless, *p*-values are provided allowing readers to apply multiple correction methods such as Bonferroni post-hoc test if considered necessary.[378]

In summary, errors and limitations are inevitable in scientific research regardless of study design,[379] and dismissing studies solely on these issues is unreasonable. Measures can be taken to minimize and control for their influence. Transparent disclosure of potential errors and limitations that may affect findings is crucial for scientific research, and even with minor limitations findings can contribute to improved scientific knowledge. Furthermore, insights about errors and limitations from previous studies can refine research methods and improve future research.

Concluding remarks

6 CONCLUDING REMARKS

This thesis presents new research findings on alcohol consumption among older adults in Sweden. Findings adds to the existing body of literature on this topic by focusing specifically on a group of urban-based 70-year-olds, thereby providing new insights and expanding the current understanding of alcohol use in younger older adults.

In essence, findings suggest that alcohol consumption has increased among older adults during the past four decades. In 2014-16, more than two-fifth of 70-year-old men and approximately one-fourth of 70-year-old women exceeded existing low-risk drinking guidelines adjusted for individuals aged 65 years and above. However, these individuals did not exhibit any obvious cross-sectional indications of unfavorable social status or ill health. Findings did not provide conclusive evidence of an independent negative effect of alcohol consumption at levels exceeding drinking guidelines on all-cause mortality. Still, a combination of at least five lifestyle risk behaviors (high alcohol consumption, lifetime smoking, unhealthy BMI, insufficient physical activity, sedentary behavior, insufficient/prolonged sleep, or unhealthy dietary pattern), was associated with a 3- to 4-fold increase in mortality risk.

The findings have implications for initiatives aimed to promote reasonable alcohol consumption levels among older adults, as they indicate that attributes typically associated with healthy aging to a large extent also are linked to exceeding low-risk drinking guidelines.[45] Moreover, these findings indicate that the identification of harmful alcohol consumption habits in older adults can pose challenges due to their non-typical manifestations and the potential for masking effects arising from favorable social position, good functional status and overall well-being. Identification of older adults with harmful alcohol consumption is essential to provide proper advice and care. Findings indicate that intervention targeting older drinkers should extend beyond disadvantaged groups, which are typically the focus of health promoting efforts.[32]

Although findings did not support a higher risk of adverse health effects or mortality among older adults with high alcohol intake, it is important to consider the potential influences of specific sample characteristics and low statistical power when interpreting the results. It would be inaccurate to draw conclusions that high alcohol consumption is not associated with adverse effects based solely on these results. Instead, frequent and high alcohol consumption in older adults may serve as an indicator of health status rather than being a causative factor of the health status itself.[37,380,381]

Consuming alcohol at rates approximately 2.5 times higher than current age-specific guidelines was associated with adverse health effects. From a public health perspective, these findings support the existing low-risk drinking guidelines for individuals aged 65 and above by the NIAAA. In order to promote population health, low-risk drinking guidelines should be applied a margin to limits where adverse health effects have been observed.

However, it is important to acknowledge the existence of individual variations, and recognize that alcohol consumption can lead to adverse effects that extend beyond the individual consumer, as previously demonstrated.[382,383] Thesis findings are generalizable to populations of younger older adults with similar sample composition in similar contexts and may have implications for the design of future public health interventions aiming at influencing alcohol consumption habits in younger older adults. Moreover, findings emphasize the importance of considering sex-specific changes in alcohol consumption patterns across different generations of older adults over time.

6.1 FUTURE PERSPECTIVES

This thesis contributes to the existing literature by providing new insights that are relevant for the population of younger older adults in high-income countries. Findings from this thesis need to be corroborated in studies using large population-based samples of same-aged individuals from different contexts.

Regular repeated studies are necessary to monitor changes at the population-level, as the conditions among different groups, the surrounding environment, and the historical context are constantly evolving. Cohort effects may have impacted the findings of this thesis, as associations with alcohol consumption could vary across subsequent cohorts of older adults. Future research can determine whether observed increases in alcohol consumption are a temporary peak that will diminish with future cohort replacement, or a permanent increase related to improved health status among older adults today. The prospective design of the H70 studies permits longitudinal analyses of the same birth cohort as they age, enabling examinations of the long-term effects of high alcohol consumption. This allows for an exploration of whether persistent consumption levels increase the risk of adverse health outcomes in older age. Furthermore, future baseline examinations of subsequent birth cohorts of 70-year-olds can be compared to the observed findings in this thesis, which primarily focused on invidiuals born in 1944.

The impact of alcohol consumption on healthy aging remains unclear, and knowledge gaps exist that require further investigation. In order to optimize the health and well-

being of older adults, it is necessary to clarify the effects of various patterns and levels of alcohol consumption on specific health outcomes. While recent research indicates that low-to-moderate consumption may have less harmful effects on older adults,[58] more studies are needed to determine whether this can be attributed to higher resilience to adverse effects among individuals with greater survival. Additionally, there is a need for more studies investigating the complex interplay of individual-, community-, and societal-level factors that influence alcohol consumption in older adults. The role of genetics in shaping alcohol consumption habits and resilience is also not fully understood and warrants further investigation. Such studies have the potential to facilitate the development of effective interventions aimed at promoting healthy aging and preventing alcohol-related harm.

The development of standardized measures worldwide and the adoption of identical definitions would facilitate future research in establishing valid comparisons of alcohol consumption and health outcomes. Future research would further benefit from distinguishing between subgroups of various ages (e.g. 65-74, 75-84, and ≥85) to capture the true diversity within the broad category of older adults aged 65 years and above.

Given the demographic shift toward an aging population, and the substantial evidence for the adverse health effects of chronic high alcohol intake, increasing alcohol consumption among older adults could lead to a considerable burden on healthcare systems worldwide.[137] Public health campaigns have the potential to drive positive behavior change by providing updated information on the effects of alcohol consumption on the risk for morbidity and mortality.[360,384] Awareness of associated risks with alcohol consumption is crucial for individuals to make informed decisions regarding own alcohol consumption habits based on individual tolerance and circumstances. Additionally, healthcare providers must be vigilant in screening older adults for harmful alcohol consumption and providing appropriate treatment and support when necessary. Recommendations for older adults should focus on maintaining a balanced lifestyle that involves reducing overall alcohol consumption and maintaining healthy lifestyle behaviors.

Although there is consistent evidence of an increase in alcohol consumption among older adults in high-income countries, the absolute numbers of current drinkers in older age groups remain small compared to younger age groups. However, as more individuals have the opportunity to maintain lifestyle habits even at advanced ages,[115] it is likely that the number of older adults consuming alcohol will continue to rise. As social attitudes toward alcohol consumption evolve, the potential for early help-seeking behaviors may increase, which could help prevent some of the harm associated with this growing public health issue.

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APPENDIX 1

Questions on alcohol consumption in the baseline examination of Birth cohort 1906-07 in 1976-77.

	Question	Response categories
1.	Are you an abstainer now?	0 = No 1 = Yes, since 0-1 year 2 = Yes, since 1-2 years 3 = Yes, since 2-5 years 4 = Yes, since 6-10 years 5 = Yes, since 11-15 years 6 = Yes, for more than 15 years but not always 7 = Yes, always
2.	Frequency of beer consumption during the last month	0 = Abstainer 1 = No consumption 2 = 1-2 times per week or less 3 = 3-5 times per week 4 = Daily or almost daily light beer or pilsner (≤3.5%), less than one bottle 5 = Daily or almost daily medium-strength beer, less than one bottle 6 = Daily or almost daily light beer or pilsner (≤3.5%), more than one bottle 7 = Daily or almost daily medium-strength beer, more than one bottle
3.	Frequency of wine consumption during the last month	0 = Abstainer 1 = No consumption 2 = 1-2 times per week or less 3 = 3-5 times per week 4 = Daily 5 = Sometimes, as medication 6 = 3-5 times per week, as medication 7 = Daily, as medication
4.	Frequency of spirit consumption during the last month	0 = Abstainer 1 = No consumption 2 = Less than 1 time per week 3 = 1-2 times per week 4 = 3-5 times per week 5 = Daily or almost daily 6 = Sometimes, as medication 7 = 3-5 times per week, as medication 8 = Daily, as medication
5.	Amount of spirits in the last month	0 = Not applicable 1 = Less than 37 cl 2 = 37-75 cl 3 = 75-150 cl 4 = 150-200 cl 5 = More than 200 cl

6.	Estimated total alcohol consumption per week converted to grams of alcohol per week	0 = 0 1 = 0-20 2 = 20-40 3 = 40-60 4 = 60-100 5 = 100-150 6 = 150-250 7 = 250-500 8 = More than 500
7.	Current presence of symptoms; need for a recovery drink, blackout, trigger mechanism	0 = Lifetime abstainer 1 = No symptoms 2 = Recovery drink 3 = Blackout 4 = Trigger mechanism 5 = Recovery drink + Blackout 6 = Recovery drink + Trigger mechanism 7 = Blackout + Trigger mechanism 8 = Recovery drink + Blackout + Trigger mechanism
8.	Contact with sobriety committee, driving license revocation, institutionalization (applies for life)	0 = Lifetime abstainer 1 = None of these 2 = Drunk driving offense 3 = Contact with sobriety committee 4 = Driving license revocation 5 = Institutionalization 6 = Sobriety committee + Driving license revocation 7 = Sobriety committee + Institutionalization 8 = Driving license revocation + Institutionalization

APPENDIX 2

Questions on alcohol consumption in the baseline examination of Birth cohort 1922 in 1992.

	Question	Response categories
1.	Are you an abstainer now?	0 = No 1 = Yes, since 0-1 year 2 = Yes, since 1-2 years 3 = Yes, since 2-5 years 4 = Yes, since 6-10 years 5 = Yes, since 11-15 years 6 = Yes, for more than 15 years but not always 7 = Yes, always
2.	Frequency of beer consumption during the last month	0 = Abstainer 1 = No consumption 2 = 1-2 times per week or less 3 = 3-5 times per week 4 = Daily or almost daily light beer or pilsner (≤3.5%), less than one bottle 5 = Daily or almost daily strong beer (>3.5%), less than one bottle 6 = Daily or almost daily light beer or pilsner (≤3.5%), more than one bottle 7 = Daily or almost daily strong beer (>3.5%), more than one bottle
3.	Frequency of wine consumption during the last month	0 = Abstainer 1 = No consumption 2 = Less than 1 time per week 3 = 1-2 times per week 4 = 3-5 times per week 5 = Daily or almost daily
4.	Frequency of spirit consumption during the last month	0 = Abstainer 1 = No consumption 2 = Less than 1 time per week 3 = 1-2 times per week 4 = 3-5 times per week 5 = Daily or almost daily
5.	Amount of spirits in the last month	0 = Not applicable 1 = Less than 37 cl 2 = 37-75 cl 3 = 75-150 cl 4 = 150-200 cl 5 = More than 200 cl
6.	Estimated total alcohol consumption per week converted to grams of alcohol per week	0 = 0 1 = 0-20 2 = 20-40 3 = 40-60 4 = 60-100 5 = 100-150

		6 = 150-250 7 = 250-500 8 = More than 500
7.	How often do you consume alcohol?	_____ times per year
8.	Current presence of symptoms (last month); need for a recovery drink, blackout, trigger mechanism	0 = Lifetime abstainer 1 = No 2 = Recovery drink 3 = Blackout 4 = Trigger mechanism 5 = Recovery drink + Blackout 6 = Recovery drink + Trigger mechanism 7 = Blackout + Trigger mechanism 8 = Recovery drink + Blackout + Trigger mechanism
9.	Need for a recovery drink, blackout, trigger mechanism (first appearance)	0 = Lifetime abstainer 1 = No 2 = Before the age of 20 3 = 20-60 years 4 = 60 years and older

APPENDIX 3

Questions on alcohol consumption in the baseline examination of Birth cohort 1930 in 2000.

	Question	Response categories
1.	Are you an abstainer now?	0 = No 1 = Yes, since 0-1 year 2 = Yes, since 1-2 years 3 = Yes, since 2-5 years 4 = Yes, since 6-10 years 5 = Yes, since 11-15 years 6 = Yes, for more than 15 years but not always 7 = Yes, always
2.	Frequency of beer consumption during the last month	0 = Abstainer 1 = No consumption 2 = 1-2 times per week or less 3 = 3-5 times per week 4 = Daily or almost daily light beer (≤3.5%), less than one bottle 5 = Daily or almost daily strong beer (>3.5%), less than one bottle 6 = Daily or almost daily light beer (≤3.5%), more than one bottle 7 = Daily or almost daily strong beer (>3.5%), more than one bottle
3.	Amount of light beer (≤3.5%) per week	_____ cl
4.	Amount of strong beer (>3.5%) per week	_____ cl
5.	Frequency of wine consumption during the last month	0 = Abstainer 1 = No consumption 2 = Less than 1 time per week 3 = 1 time per week 4 = 2 times per week 5 = 3-5 times per week 6 = Daily or almost daily
6.	Amount of red wine per week	_____ cl
7.	Amount of white wine per week	_____ cl
8.	Amount of fortified wine per week	_____ cl
9.	Frequency of spirit consumption during the last month	0 = Abstainer 1 = No consumption 2 = Less than 1 time per week 3 = 1 time per week 4 = 2 times per week 5 = 3-5 times per week 6 = Daily or almost daily
10.	Amount of spirits per week	_____ cl

11.	Amount of spirits in the last month	0 = Not applicable 1 = Less than 37 cl 2 = 37-75 cl 3 = 75-150 cl 4 = 150-200 cl 5 = More than 200 cl
12.	Estimated total alcohol consumption per week converted to grams of alcohol per week	0 = 0 1 = 0-20 2 = 20-40 3 = 40-60 4 = 60-100 5 = 100-150 6 = 150-250 7 = 250-500 8 = More than 500
13.	Amount of pure alcohol consumption per week	_____ cl
14.	How often do you consume alcohol?	_____ times per year
15.	Need for a recovery drink, blackout, trigger mechanism (first appearance)	0 = Lifetime abstainer 1 = No 2 = Before the age of 20 3 = 20-60 years 4 = 60 years and older
16.	Current presence of symptoms (last month); need for a recovery drink, blackout, trigger mechanism	0 = Lifetime abstainer 1 = No 2 = Recovery drink 3 = Blackout 4 = Trigger mechanism 5 = Recovery drink + Blackout 6 = Recovery drink + Trigger mechanism 7 = Blackout + Trigger mechanism 8 = Recovery drink + Blackout + Trigger mechanism

APPENDIX 4

Questions on alcohol consumption in the baseline examination of Birth cohort 1944 in 2014-16.

	Question	Response categories
1.	Are you an abstainer now?	0 = No 1 = Yes, since 0-5 years 2 = Yes, since 6-10 years 3 = Yes, for more than 10 years 4 = Yes, always
2.	Frequency of beer consumption during the last month	0 = No consumption 1 = Daily or almost daily strong beer (>3.5%), less than one bottle 2 = Daily or almost daily strong beer (>3.5%), more than one bottle
3.	Amount of light beer (≤3.5%) per week	_____ cl
4.	Amount of strong beer (>3.5%) per week	_____ cl
5.	Frequency of wine consumption during the last month	0 = No consumption 1 = Less than 1 time per week 2 = 1-2 times per week 3 = 3-5 times per week 4 = Daily or almost daily
6.	Amount of red wine per week	_____ cl
7.	Amount of white wine per week	_____ cl
8.	Amount of fortified wine per week	_____ cl
9.	Frequency of spirit consumption during the last month	0 = No consumption 1 = Less than 1 time per week 2 = 1-2 times per week 3 = 3-5 times per week 4 = Daily or almost daily
10.	Amount of spirits per week	_____ cl
11.	Amount of spirits in the last month	0 = Not applicable 1 = Less than 37 cl 2 = 37-75 cl 3 = 75-150 cl 4 = 150-200 cl 5 = More than 200 cl
12.	Estimated total alcohol consumption per week converted to grams of alcohol per week	0 = 0 1 = 0-20 2 = 20-40 3 = 40-60 4 = 60-100 5 = 100-150

		6 = 150-250 7 = 250-500 8 = More than 500
13.	Amount of pure alcohol consumption per week	_____ cl
14.	Current presence of symptoms (last month); need for a recovery drink, blackout, trigger mechanism	0 = No 1 = Yes
15.	Need for a recovery drink, blackout, trigger mechanism (first appearance)	0 = No 1 = Before the age of 20 2 = 20-60 years 3 = 60 years and older

APPENDIX 5

The Alcohol Use Disorders Identification Test

	Question	Response categories
1.	How often do you have a drink containing alcohol?	0 = Never 1 = Monthly or less 2 = 2-4 times a month 3 = 3-4 times a week 4 = 4 or more times a week
2.	How many drinks containing alcohol do you have on a typical day when you are drinking?	0 = 1 or 2 1 = 3 or 4 2 = 5 or 6 3 = 7 or 9 4 = 10 or more
3.	How often do you have six or more drinks on one occasion?	0 = Never 1 = Less than monthly 2 = Monthly 3 = Weekly 4 = Daily or almost daily
4.	How often during the last year have you found that you were not able to stop drinking once you have started?	0 = Never 1 = Less than monthly 2 = Monthly 3 = Weekly 4 = Daily or almost daily
5.	How often during the last year have you failed to do what was normally expected of you because of drinking?	0 = Never 1 = Less than monthly 2 = Monthly 3 = Weekly 4 = Daily or almost daily
6.	How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?	0 = Never 1 = Less than monthly 2 = Monthly 3 = Weekly 4 = Daily or almost daily
7.	How often during the last year have you had a feeling of quilt or remorse after drinking?	0 = Never 1 = Less than monthly 2 = Monthly 3 = Weekly 4 = Daily or almost daily
8.	How often during the last year have you been unable to remember what happened in the night before because of your drinking?	0 = Never 1 = Less than monthly 2 = Monthly 3 = Weekly 4 = Daily or almost daily

9.	Have you or someone else been injured because of your drinking?	0 = No 2 = Yes, but not in the last year 4 = Yes, during the last year
10.	Has a relative, friend, doctor, or other health care worker been concerned about your drinking or suggested you cut down?	0 = No 2 = Yes, but not in the last year 4 = Yes, during the last year

APPENDIX 6

Criteria for dementia according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R) and criteria described by Kay et al. Old Age Mental Disorders in Newcastle upon Tyne. II. A study of possible Social and Medical Causes. British journal of psychiatry. 1964;110:668-682.

DSM-III-R

A. Impairment in short- and long-term memory
B. At least one of the following:
    1. Impairment in abstract thinking
    2. Impaired judgement
    3. Other disturbances of higher cortical functions
    4. Personality change
C. The disturbance in criteria (A) and (B) significantly interferes with work or usual social activities or relationship with others
D. Not occurring exclusively during the course of delirium
E. Either 1 or 2:
    1. Evidence of a specific factor (or factors) judged to be etiologically
    2. An etiologic organic factor can be presumed if the disturbance cannot be accounted for by any non-organic mental disorder

Criteria by Kay et al.

Either A or B:
A. Presence of severe disorientation in time or place
B. Severe memory impairment