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Research paper

Socioeconomic inequalities in the incidence of alcohol-related liver disease: A nationwide Danish study

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SUMMARY

Background: There is socio-economic inequality in total alcohol-related harm, but knowledge of inequality in the incidence of specific alcohol-related diseases would be beneficial for prevention. Registry-based studies with nationwide coverage may reveal the full burden of socioeconomic inequality compared to what can be captured in questionnaire-based studies. We examined the incidence of alcohol-related liver disease (ALD) according to socioeconomic status and age.

Methods: We used national registries to identify patients with an incident diagnosis of ALD and their socio-economic status in 2009–2018 in Denmark. We computed ALD incidence rates by socioeconomic status (education and employment status) and age-group (30–39, 40–49, 50–59, 60–69 years) and quantified the inequalities as the absolute and relative difference in incidence rates between low and high socioeconomic status.

Findings: Of 17,473 patients with newly diagnosed ALD, 78% of whom had cirrhosis, 86% had a low or medium-low educational level and only 20% were employed. ALD patients were less likely to be employed in the 10 years prior to diagnosis than controls. The incidence rate of ALD correlated inversely with educational level, from 181 (95% CI, 167–197) to 910 (95% CI, 764–1086) per million person-years from the highest to the lowest educational level. By employment status, the incidence rate per million person-years was 211 (95% CI, 189–236) for employed and 3449 (95% CI, 2785–4271) for unemployed. Incidence rates increased gradually with age leading to larger inequalities in absolute numbers for older age-groups. Although ALD was rare in the younger age-groups, the relative differences in incidence rates between high and low socio-economic status were large for these ages. The pattern of socioeconomic inequality in ALD incidence was similar for men and women.

Interpretation: This study showed substantial socioeconomic inequalities in ALD incidence for people aged 30–69 years.

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Research in context

Evidence before this study

We initially searched MEDLINE in April, 2020, using keywords including "liver", "cirrhosis", "alcohol", "socioeconomic status", "socioeconomic position", "deprivation", and "inequalities". Previous studies found a socioeconomic gradient in total alcohol-related morbidity and mortality. A systematic review published in 2015 on the relation between socioeconomic status and alcohol-attributable harms concluded that few studies had investigated the socioeconomic pattern of single alcohol-related diseases and that such knowledge would be beneficial for prevention purposes. For instance, prevention programs of liver disease that develops after chronic heavy drinking would be different than prevention programs of alcohol-related accidents resulting from acute alcohol poisoning. Moreover, application of both an absolute and relative measure of inequality in disease is recommended by the World Health Organization.

Added value of this study

This nationwide study, based on a population with access to universal healthcare, social security benefits, and free education, showed substantial inequalities in the incidence of alcohol-related liver disease in ages 30–69 years. This is the first study of socioeconomic inequality in alcohol-related liver disease incidence applying both an absolute and relative measure of inequality. Application of the absolute measure of inequality showed a huge burden of alcohol-related liver disease incidence for people of low socioeconomic status after the age of 40 years. This follows the increasing incidence of alcohol-related liver disease with age until 60–70 years. Application of the relative measure of inequality revealed that the inequality was present already in the age-group of 30–39 years. Moreover, the study showed that the difference in employment status between alcohol-related liver disease patients and controls was evident several years before the ALD diagnosis pointing to a window of opportunity for prevention.

Implications of all the available evidence

The huge socioeconomic inequality in alcohol-related disease should make governments and healthcare institutions consider alcohol control policies such as minimum unit pricing which has greater impact among groups of lower socioeconomic status. On the individual level, research is needed to investigate an effect of liver-specific prevention programs. For example, non-invasive screening for liver disease followed by treatment of the underlying cause may be offered at the social security offices to people who are unemployed or receiving disability pension.

1. Introduction

Reducing health inequalities is a key strategic objective of the World Health Organization and individual governments [1–3]. Alcohol-related causes are important contributors to inequality in mortality in several European countries [4–6]. Groups of low socioeconomic status are much more likely to die from alcohol-related causes than groups of high socioeconomic status [7]. The socioeconomic pattern in the incidence of specific alcohol-related diseases is less studied and may provide disease-specific targets of prevention [4,8]. Alcohol-related liver disease (ALD) results from chronic heavy alcohol drinking, usually for several years [9]. Worldwide, ALD is responsible for more than 20 million disability-adjusted life years (DALY), accounting for 25% of all DALYs lost due to alcohol [10].

Socioeconomic status is related to numerous exposures, resources, and susceptibilities that may affect health. No single indicator of socioeconomic status captures its full effect on health during the whole course of life, thus the assessment of several indicators may help to identify vulnerable groups [11]. Education, used as one marker of socioeconomic status, is obtained in early adulthood and is usually fixed hereafter [11]. In Danish health surveys, heavy drinking is reported twice as frequently in men of low education until the age of 65 years [12]. Employment status may change during a lifetime and can reflect the current socioeconomic status. In Danish and international health surveys, individuals who are unemployed or outside the labor force are more likely to be heavy drinkers than employed ones [13,14].

For public health purposes, identifying socioeconomic groups with a high risk of developing ALD could enable targeted preventive interventions for liver disease and alcohol use disorders. Registry-based studies with complete coverage may reveal the full burden of socioeconomic inequality in alcohol-related disease, compared to that which can be captured in questionnaire-based studies. Heavy drinkers of low socioeconomic status are less likely to participate in questionnaire-based studies than are heavy drinkers of high socioeconomic status [15–17]. Therefore, we carried out a nationwide, registry-based study aiming to describe the inequality in ALD incidence by education and employment status.

2. Methods

All 5.8 million Danish citizens have access to universal, tax-financed healthcare and social security benefits, regardless of labor market history. We used healthcare and socioeconomic registries to identify newly diagnosed patients with ALD and their socioeconomic status. Registries were linked by a personal identification number: a unique identifier assigned to all Danish residents since 1968 [18]. We obtained aggregated data on the socioeconomic status of the general population to calculate incidence rates of ALD in Denmark 2008–2019 by socioeconomic status and age.

2.1. Alcohol-related Liver Disease

We identified patients in the National Patient Registry and Cause of Death Registry with an incident diagnosis of ALD between 2009 and 2018. Only patients at least 30 years old were included since final educational attainment was assumed to be acquired at this age. Only patients up to age 70 were included since population data for comparison above 70 years were not available. The National Patient Registry was established in 1977 and contains data on all somatic admissions, with emergency and outpatient contacts added in 1995 [19]. The Cause of Death Registry has recorded causes of death among all Danish citizens since 1970 [20]. In both registries, diagnoses are selected by physicians and coded according to the 8th and, since 1994, the 10th edition of the International Classification of Diseases (ICD). We defined ALD in The National Patient Registry by 1) a diagnostic code specifying ALD, or 2) the combination of a diagnostic code with liver disease of unknown etiology and a diagnostic code indicating alcohol use disorder, where these codes were recorded within one year in the National Patient Registry. The year when the liver diagnosis of unknown etiology was registered counted as the year of ALD diagnosis. We defined ALD in the Cause of Death Registry by 1) a diagnostic code specifying ALD, or 2) the combination of a diagnostic code with liver disease of unknown etiology and a diagnostic code indicating alcohol use disorder among the causes of death registered. Patients with the combination of codes for liver disease of unknown etiology and alcohol use disorder accounted for 7% of the total cohort (Supplemental Table S1). See Supplemental Table S2 for diagnostic codes used in this study and Supplemental Figure S1 for the flowchart of the cohort selection. We excluded patients with a diagnostic code indicating liver disease from 1977 to 2009 to exclude prevalent cases of ALD.

The severity of ALD was defined according to the incident diagnosis of ALD as either cirrhosis or non-cirrhotic liver disease (all other codes that defined the liver disease). ALD was also classified as cirrhosis if a procedure or diagnostic code indicated variceal bleed or ascites up to and including the day of diagnosis.

2.2. Socio-economic status

The indicators of socioeconomic status used in this study were educational level and employment status. We chose not to use income as part of the definition of socioeconomic status since low income could represent both unemployment with the receiving of social benefits and low paid occupations, since the difference in payments for these are small in Denmark. Highest educational attainment was obtained from the Population Education Registry [21]. About 3% of the population have unknown educational status, either because they are immigrants to Denmark or because their education is not acknowledged by Danish authorities. We grouped educational level according to the International Standard Classification of Education (ISCED), noting that Denmark has no educational program that corresponds to ISCED level 4, post-secondary non-tertiary education [22]. See Supplementary Figure S2 for an overview of the Danish education system. The following four educational levels are used in this study: 1) 'low': unknown education, early childhood education, primary education, and lower secondary education (ISCED levels 0–2 and 9); 2) 'medium-low': high school programs, vocational training, and education preparing for a career in a specific trade or industry (ISCED level 3); 3) 'medium-high': short-cycle tertiary education, bachelor or equivalent (ISCED level 5–6); and 4) 'high': long second-cycle programs, master's or equivalent, doctoral, Ph.D. programs or equivalent (ISCED levels 7–8).

Employment status was obtained from the Registry-based Labor Force Statistics the year before the ALD diagnosis. The register holds information on the type of labor market attachment at the end of November every year with the population divided into three main groups according to the International Labor Organization: employed, unemployed, and persons outside the labor force [23]. In this study, individuals outside the labor force were split into groups receiving 'health benefits' implying a temporary situation of sick or maternity leave, etc., and 'disability pension' and 'retirement' implying being permanently outside the labor force. Employed individuals were divided according to their specific occupation with the following hierarchy mentioning the lowest first: 'self-employed', 'other workers', 'skilled workers', 'intermediates', and 'professionals', since professionals and managers were collapsed to one group in this study. See Supplemental Figure S3 for a detailed presentation of the classification of employment status.

2.3. Aggregated general population data

In calculations of ALD incidence, we used publicly available data on the demographics of the Danish population provided by Statistics Denmark. Data on education and employment status were aggregated by sex, five-year age-groups, and individual calendar years. Supplementary Table S3 presents the number of individuals in Denmark by socioeconomic status of 30–69 years.

2.4. Main analysis: ALD incidence according to socioeconomic status

The incidence rate of ALD was calculated for each calendar year between 2009 and 2018, for five-year age groups, sex, and indicators of socioeconomic status (educational level and employment status). For example, the incidence rate for low educational level in 2009 was calculated as the number of newly diagnosed ALD patients in 2009 of low educational level divided by the total number of person-years observed among people of low educational level in 2009.

Socioeconomic inequality in disease incidence can be defined as the difference in disease incidence between low and high socioeconomic status [24]. We followed the recommendation of the World Health Organization and calculated both absolute and relative quantifications of socioeconomic inequality in disease [25,26]. Educational level and employment status were analyzed separately. The absolute measure of socioeconomic inequality was the absolute rate difference in ALD incidence between low and high educational levels [26]. The relative measure of socioeconomic inequality was the incidence rate ratio (IRR) of low compared to high educational level. Incidences were estimated with negative binomial model and the absolute rate differences and IRR were adjusted for calendar-year and sex. We stratified analyses of IRRs of ALD by 10-year age groups (30–39, 40–49, 50–59, and 60–69) to investigate the influence of educational level in each age group. We tested for interaction between the effects of age and educational level on ALD incidence by including an interaction term in the IRR model. We used the nested log likelihood to test whether this interaction term increased the model fit. Finally, we estimated population attributable fractions of educational level on ALD incidence [27]. The population attributable fraction is the proportional reduction in ALD in the hypothetical situation where all in the population had the same risk of ALD as the high educational level. It is calculated as the difference between the incidence of ALD in the population and the incidence of ALD in individuals of the highest category of educational level.

All analyses were repeated with employment status replacing educational level. Unemployment was considered the lowest socioeconomic status, and the highest rank of employment (professionals) was considered the highest.

2.5. Employment status in the 10 years before ALD diagnosis

To provide context for our findings, we performed a case-control study of educational level and employment status in the years *before* the ALD diagnosis for patients with ALD and population controls. For each included patient with ALD, Statistics Denmark randomly identified four or five population controls without ALD and matched on sex, age, and birth-year according to the date of ALD diagnosis. Sociodemographic characteristics of controls are found in Supplemental Table S4. We examined employment status in each of the 10 years prior to the diagnosis of ALD, excluding 331 (2%) patients with ALD and 3469 (5%) population controls without complete information for all 10 years.

2.6. Sex-stratified analysis

ALD develops about twice as frequently in men than in women [28]. We ran all analyses stratified by sex to assess whether the pattern of ALD incidence according to socioeconomic status was different for men and women.

2.7. Role of funding source

GA and PJ were supported by a grant from the Novo Nordisk Foundation (NNF18OC0054612). GA was supported by a grant from the Research Fund of Bispebjerg Hospital. The funders had no role in

Table 1
Number and incidence rate (95% confidence intervals) according to demographic and socioeconomic characteristics of newly diagnosed patients with alcohol-related liver disease (ALD) in Denmark, 2009–2018

	ALD patients, number (%)	Incidence rate per million person-years (95%CI)
Overall	17,473 (100)	529 (466–601)
Men	12,092 (69)	720 (610–850)
Women	5381 (31)	337 (283–403)
Data source of diagnosis		
Cause of death registry	3003 (17)	
Hospital registry	14,470 (83)	
Age at diagnosis		
30–39 years	581 (3)	76 (59–97)
40–49 years	2982 (17)	318 (255–395)
50–59 years	6804 (39)	782 (669–915)
60–69 years	7106 (41)	963 (866–1071)
Median age (IQR) in years	58 (51–64)	-
Liver diagnosis		
Cirrhosis	13,609 (78)	-
Non-cirrhotic	3864 (22)	-
Educational level (duration)		
High (≥16 years)	534 (3)	181 (167–197)
Medium-high (14–15 years)	2006 (11)	295 (202–308)
Medium-low (12 years)	6907 (40)	586 (471–728)
Low (≤10 years)	8026 (46)	910 (764–1086)
Employment status		
Employed (overall)	3523 (20)	211 (189–236)
Professionals	474 (3)	101 (78–132)
Intermediate	325 (2)	153 (117–200)
Skilled workers	1287 (7)	203 (164–252)
Other workers	849 (5)	298 (243–365)
Self-employed	588 (3)	308 (248–383)
Unemployed	3686 (21)	3449 (2785–4271)
Outside labour force (overall)	10,250 (59)	1706 (1494–1947)
Disability pension	5507 (32)	2516 (2118–2987)
Health benefits	2311 (13)	1081 (886–1318)
Retirement	2432 (14)	992 (807–1220)
Missing data	14 (0)	-

study design, data collection and analysis, decision to publish, or preparation of the manuscript.

2.8. Patient and public involvement

No patients were involved in the design or conduct of the study.

3. Results

In all, 17,473 patients had a first-time diagnosis of ALD in Denmark in 2009–2018, of whom 12,092 (69%) were men (Table 1). The median age was 58 years (IQR: 51–64) and 80% of patients were 50–69 years old. Overall 78% of ALD patients had cirrhosis and this proportion were roughly similar according to educational level (Supplemental Table S5). Low level of education was the most common (46%), followed by medium-low (40%), medium-high (11%), and high education level (3%). In controls, 30% had a low level of education, 41% had a medium-low, 21% had a medium-higher, and 8% had a high educational level (Supplemental Table S4). For employment status, 59% of ALD patients were outside the labor force on November 30th of the year before their diagnosis, 21% were unemployed, and 20% were employed. For controls, 25% were outside the labor force, 8% were unemployed, and 67% were employed.

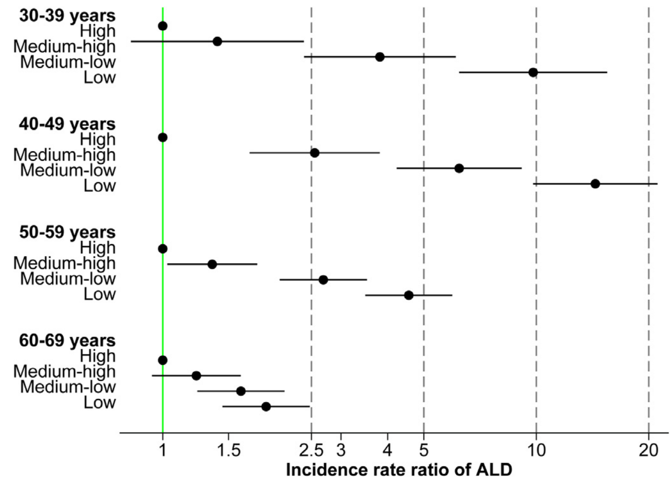

Fig. 1. Relative inequality in alcohol-related liver disease (ALD) incidence by educational level. Incidence rate ratios showed on a logarithmic scale of ALD according to educational level and age in Denmark 2009–2018, adjusted for calendar-year and sex. Incidence rate ratios measure the relative inequality of alcohol-related liver disease incidence according to educational level, with high educational level as the reference.

3.1. Overall ALD incidence rates

The overall incidence rate of ALD was 529 (95% CI, 466–601) per million person-years in the Danish population aged 30–69 years, 720 (95% CI,610–850) in men and 337 (95% CI, 283–403) in women (Table 1). Incidence rates increased gradually with age from 76 (95% CI, 59–97) per million person-years for 30–39 years to 963 (95% CI, 866–1071) per million person-years for 60–69 years.

3.2. ALD incidence by educational level

ALD incidence rates correlated inversely with education ranging from 181 (95% CI, 167–197) per million person-years for high educational level to 910 (95% CI, 764–1086) per million person-years for low educational level (Table 1). The inverse correlation of the incidence rate with educational level was observed in all age-groups (Fig. 1). The absolute rate difference in incidence between low and high educational level gradually increased with age from 165 (95%CI, 142–188) per million person-years for 30–39 years to 1149 (95%CI, 1083–1217) per million person-years for 50–59 years, and then decreased to 590 (95%CI, 320–859) per million person-years for 60–69 years.

The relative difference in incidence rates between high and low educational level was larger in younger than in older age groups (p for interaction < 0.0001) (Table 2). For example, the IRR for low compared to high educational level was 9.8 (95%CI, 6.2–15) for 30–39 years and 2.0 (95%CI, 1.8–2.3) for 60–69 years.

3.3. Incidence by employment status

For employment status, the ALD incidence rate per million person-years was 211 (95% CI, 189–236) in employed, 3449 (95% CI, 2785–4271) in unemployed, and 1,706 (95% CI, 1494–1947) in individuals outside the labor force (Table 1). Among the employed, incidence rates correlated inversely with employment rank: The incidence rate was 101 (95% CI, 78–132) per million person-years in the highest employment rank (professionals) and it increased gradually to 308 (95% CI, 248–383) per million person-years in the lowest employment rank (self-employed). For individuals outside the labor force, individuals receiving disability pension had the highest incidence rate of 2516 (95% CI, 2118–2987) per million person-years. The incidence rate was 1081 (95% CI, 886–1318) per million person-

Table 2
Incidence of alcohol-related liver disease (95% confidence intervals) per million person-years and absolute inequality according to educational level and age in Denmark 2009−2018

	30−39 years	40−49 years	50−59 years	60−69 years
High	18 (10−33)	50 (37−68)	320 (256−398)	670 (574−783)
Medium-high	24 (17−34)	134 (106−166)	443 (361−544)	814 (674−983)
Medium-low	73 (55−96)	324 (259−406)	870 (702−1080)	1078 (886−1311)
Low	186 (148−233)	749 (624−890)	1460 (1212−1759)	1249 (1026−1521)
Absolute rate difference (low− high) per million person-years	165 (142−188)	697 (650−744)	1149 (1083−1217)	624 (532−716)
Population attributable fraction	0.77 (0.65−0.85)	0.86 (0.81−0.89)	0.66 (0.61−0.71)	0.41 (0.34−0.48)

The absolute rate difference measures the absolute inequality of alcohol-related liver disease incidence between low and high educational levels.The population attributable fraction is the proportional reduction in ALD in the hypothetical situation where all in the population had the same ALD incidence as the high educational level.

years for individuals receiving health benefits and 992 (95% CI, 807−1220) per million person-years for the retired. The pattern of incidence rates according to employment status was similar in all age-groups (Table 3). The absolute rate difference in incidence between unemployed and highest employment rank (professionals) gradually increased with age from 468 (95% CI, 408−529) per million person-years for 30−39 years to 6988 (95% CI, 6324−7652) for 60-69 years.

The relative difference in incidence rates tended to be higher in younger than in older age groups, although this trend was not as pronounced as it was for educational level (p for interaction < 0.0001) (Supplemental Figure S4).

3.4. Employment status in the 10 years before ALD diagnosis

Patients with ALD were less likely to be employed than controls in the 10 years prior to ALD diagnosis (Fig. 2). For instance, only 59% of patients with ALD were employed on November 30th of the year that was 10 years before their time of ALD diagnosis, compared with 87% of controls. At five years before the time of ALD diagnosis, 40% of ALD patients were employed compared with 78% of controls.

3.5. Sex-stratified analysis

The sex-stratified analyses showed a similar pattern of socioeconomic inequality in ALD incidence for men and women (Supplementary Figures S5-9).

4. Discussion

This nationwide study, based on a population with access to universal healthcare and social security benefits, showed huge inequalities in the incidence of ALD by educational level and employment status in ages 30−69 years. ALD incidence rates increased with age and with the decrease of educational level and employment rank, and were very high in people who were unemployed or receiving disability pension. With respect to absolute differences in incidence rates, the socioeconomic gradient was higher in people aged 40−69 years than in people aged 30−39 years. With respect to relative differences in incidence rates, the socioeconomic gradient was higher in younger people. The difference in employment status between ALD patients and controls was evident several years before the ALD diagnosis.

Coverage was nearly complete for data on hospital care and socioeconomic status [19,21,23]. The validity of the ALD diagnosis is high: diagnostic codes for non-specified liver disease and alcoholic cirrhosis in the National Patient Registry had a positive predictive value of 80-100% when compared with discharge summaries and medical records [29−31]. The accuracy of educational level and employment status from Danish registries is also high [21,23], although there may be some misclassification of employment status. For instance, unemployed who are not receiving social benefits are wrongly classified as employed [32]. This misclassification is most likely to be independent of ALD occurrence, thus less likely to influence our findings. In conclusion, this study is likely to represent valid population-based estimates of the ALD incidence by socioeconomic status in Denmark.

A socioeconomic gradient of total alcohol-related disease and mortality is observed in many countries [6]. The socio-economic pattern in the incidence of specific alcohol-related diseases such as ALD

Table 3
Incidence of alcohol-related liver disease (95% confidence intervals) per million person-years and absolute inequality according to employment status and age in Denmark 2009−2018

		30−39 years	40−49 years	50−59 years	60−69 years
Employed	Professionals	9 (5−16)	35 (28−46)	145 (115−184)	229 (186−283)
	Intermediate	18 (10−33)	62 (43−90)	223 (179−279)	342 (252−465)
	Skilled workers	32 (24−43)	125 (97−160)	302 (239−382)	372 (300−461)
	Other workers	60 (39−86)	198 (151−260)	426 (347−523)	548 (455−661)
	Self-employed	47 (28−80)	183 (139−240)	475 (376−601)	572 (469−698)
Not employed	Unemployed	484 (368−630)	2140 (1732−2042)	3975 (3278−4819)	7421 (5974−9218)
	Health benefits	185 (135−252)	823 (644−1052)	2041 (1627−2561)	1258 (1009−1569)
	Disability pension	637 (495−820)	2190 (1706−2814)	3715 (2932−4706)	3429 (2682−4304)
Absolute rate difference (unemployed − professionals) per million person-years		468 (408−529)	2102 (1932−2273)	3770 (3583−3950)	6988 (6324−7652)
Population attributable fraction		0.69 (0.65−0.74)	0.72 (0.68−0.75)	0.68 (0.66−0.71)	0.65 (0.62−0.68)

The absolute rate difference measures the absolute inequality of alcohol-related liver disease incidence between unemployed and highest employment rank (professionals).
The population attributable fraction is the proportional reduction in ALD in the hypothetical situation where all in the population had the same ALD incidence as the highest employment rank (professionals).

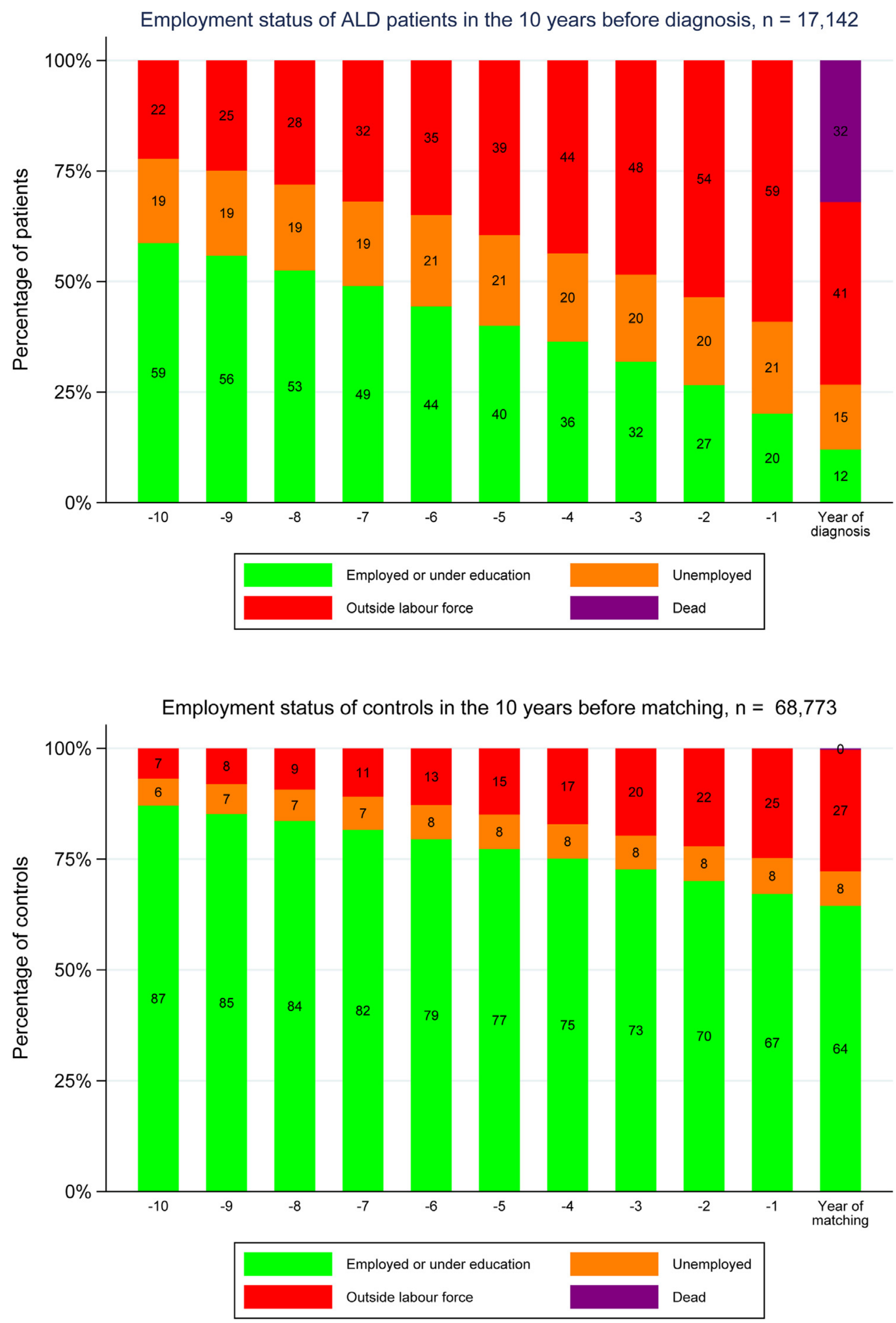

Fig. 2. Prior employment status in patients (above) with alcohol-related liver disease (ALD) between 2009–2018 and controls (below), 30–69 years of age at time of diagnosis or matchingNote: Employment status was the employment status held on November 30th that year.

is less studied and may provide disease-specific targets of prevention [4,8]. A nationwide UK study found a nearly three-fold increase in the rate of variceal bleeding in the most deprived quintile compared with the least deprived [33]. A Hungarian case-control study found an increasing likelihood of chronic liver disease with decreasing educational level [34]. A Chinese case-control study had the same observation for education, but, contrary to our results, ALD was positively associated with employment compared to unemployment, which the authors suggested was due to social drinking after work [35].

4.1. *Why is there a socioeconomic gradient in ALD incidence?*

First, biases in coding could produce the socio-economic gradient in ALD. It is a limitation of our study that we do not have data on coding practice. There is, however, nothing in our clinical experience to suggest that clinicians are more likely to give a diagnosis code of *alcohol-related* liver disease to a person of low socio-economic status when in fact the etiology of liver disease is uncertain. The available data suggests that low socioeconomic status may also be an independent risk factor in nonalcoholic liver disease [36]. Thus, we believe that bias in coding is an unlikely contributor to our findings.

Second, we believe that differences in the prevalence of hazardous alcohol consumption between socio-economic groups contribute to the observed inequality in ALD incidence seen in this study. It is a limitation of our study that we could not clarify the causal mechanisms, since we lacked data on alcohol consumption and other lifestyle factors. Heavy drinking was reported more frequently in men of low socioeconomic status compared to high socioeconomic status up to the age of 65 years in the Danish National Health Survey 2017 [12]. After the age of 65 years, the picture was the opposite with men of high socioeconomic status being more likely to be heavy drinkers than people of low socio-economic status. This change may partly be explained by a high mortality of people of low socio-economic status who are heavy drinkers [7]. For women, heavy drinking according to socioeconomic status in the Danish National Health Surveys was similar up to the age of 65 years, but after 65 years women of high socio-economic status were more likely to be heavy drinkers than those of low [12]. The true proportion of heavy drinkers in groups of lower socio-economic status may be even higher than reported in health surveys. People of low socio-economic status who are heavy drinkers are less likely to participate in questionnaire-based studies than heavy drinkers of high socioeconomic status. For example, for both men and women, alcohol-related mortality was three times higher in low education non-participants of a health survey compared with non-participants of a high educational level [17]. A study from the UK indicates that individuals of lower socio-economic status were more likely to be extreme drinkers (>24 units per day) than those of high socio-economic status [37]. Whether alcohol drinking patterns contribute to the observed socio-economic inequality in ALD incidence needs further investigation. A recent systematic review suggested that heavy episodic drinking explained more of the socio-economic inequality than alcohol use in general [38]. However, for ALD, prior studies suggest that daily rather than episodic drinking increased the risk [39,40]. Future studies should evaluate whether inequality of ALD incidence is different according to specific alcohol use disorders. Early socio-economic disadvantage leads to an increased likelihood of alcohol use disorders in adolescence [41]. Heavy drinking in adolescence diminishes educational attainment and is associated with higher unemployment risk [42]. Low educational attainment is in general associated with higher unemployment risk [43]. Unemployment may lead to an increase in drinking, with chronic heavy drinking common among unemployed and individuals outside the labor force, which is also known to reduce the likelihood of transition back to employment [13,14]. On the other hand, heavy drinking decreases employment performance and increases the risk of job loss, sick leave and ultimately a permanent exit from the labor market and receipt of disability pension [13]. In line with this, we found that patients with ALD, compared with controls, were less likely to be employed, and more likely to be either unemployed or outside the labor market in the 10 years before the diagnosis of ALD, presumably reflecting the influence of heavy drinking on employment performance prior to the ALD diagnosis. The lower ALD incidence for ‘persons outside the labor force’ than for those unemployed could be due to fact that individuals who drink heavily may be unable to work, but they will not receive disability pension until they develop organ disease (such as ALD), whereas patients with more obvious conditions, such as severe neurologic or psychiatric diseases, who do not drink heavily will more easily get a disability pension [44]. It is therefore plausible that heavy alcohol drinking would lead to unemployment in several years before it led to manifest organ disease and access to disability pension. Alcohol is also a risk factor for several other diseases associated with a high mortality such as chronic pancreatitis, cancer, and heart disease, that we were not able to address in this study.

Third, obesity, smoking, inactivity, and poor nutrition may contribute to the socioeconomic inequality in ALD incidence observed in this study. Multiple additional risky health behaviors cluster in heavy drinkers of low socio-economic status, whereas heavy drinkers of high socio-economic status seem to lead a less unhealthy lifestyle besides drinking heavily [45]. Obesity and smoking are both risk factors for chronic liver disease and are unevenly distributed across socio-economic strata [46,47]. For instance, obesity is three times as common in individuals of low compared to high education [12]. We regard the influence of viral hepatitis as negligible in this study since the prevalence of hepatitis B and C in Denmark is below 0.5% [48,49].

Fourth, unknown factors may contribute to the socio-economic gradient in ALD. For example, prospective cohort studies of total alcohol-related harm found that alcohol and other lifestyle factors had only a minor role in mediating the socio-economic inequality of alcohol-related harm [4,8]. Similarly, in the Hungarian case-control study of chronic liver disease, socio-economic inequality in chronic liver disease persisted after adjustments for alcohol and other lifestyle factors [34]. These unknown factors may include peri- and prenatal factors such as maternal smoking, infections, psychosocial stressors due to poor material circumstances, and diet, that each could increase the vulnerability to ALD in people of low socioeconomic status [50].

This is the first study of socio-economic inequality in ALD incidence applying both an absolute and relative measure of inequality [24–26]. Application of the absolute measure of inequality showed the huge burden of ALD incidence for people of low socio-economic status compared to high socio-economic status after the age of 40 years. This follows the previously observed increase in the incidence of ALD with age until 60–70 years [51]. Application of the relative measure of inequality in this study contributed with the finding that the inequality of ALD incidence was present already in the young age-group of 30–39 years. Similarly, a Finnish nationwide study of total alcohol-related mortality found a higher relative inequality according to educational level and employment status for younger than for older ages [16]. The stronger influence of employment status compared with educational level on ALD incidence is in line with employment status reflecting the current socio-economic status, whereas educational level is fixed after early adulthood [16]. This downward social mobility due to heavy drinking is termed social drift [16]. Heavy drinking in the twenties could negatively impact the ability to attain an education, but if heavy drinking begins later in life, the impact is mainly observed for employment status, that is high incidence rates of ALD for unemployment.

4.2. Implications

In 2021 we are facing a substantial economic downturn with high unemployment rates already seen in the US and Latin American countries [52–54]. As a consequence, a rise in heavy drinking and alcohol-related disease may be expected [14]. For instance, alcohol-related cirrhosis mortality increased remarkably in the US after the financial crisis in 2008 [55]. Governments and healthcare institutions should act now and consider alcohol control policies such as minimum unit pricing which has greater impact among groups of lower socioeconomic status [56,57]. Limiting the availability of alcohol by restricting licenses to sell alcohol in deprived areas may be another promising approach [58]. On the individual level, we hope that our results will motivate research and implementation of liver-specific prevention programs. The finding from this study that patients with ALD were more likely to be unemployed several years before the diagnosis indicates a window of opportunity for such preventive interventions. For example, non-invasive screening for liver disease followed by treatment of the underlying cause may be offered to people who are unemployed when attending social security offices [59]. Systematic liver screening programs may also be delivered to patients hospitalized with alcohol problems or seeking alcohol abuse treatment, who are more likely to have a low educational level than the background population [60,61].

In conclusion, this study showed substantial inequality in ALD incidence by educational level and employment status in Denmark for the ages of 30−69 years. Further research is needed to understand the contribution of heavy drinking, drinking patterns, and other lifestyle factors on the socioeconomic inequality in ALD incidence. Alcohol prevention programs should target groups of low socioeconomic status, in all ages, and may be combined with liver-specific prevention programs.

Data availability

Data used in this study are not publicly available, but can be applied for at the Danish Health Data Authorities.

Author contributions

All authors contributed to the design of the study. GA and CBJ analyzed the data and GA wrote the first draft of the manuscript. All authors contributed to critically revising the paper.

Declaration of Competing Interests

All authors state that they have nothing to disclose regarding conflicts of interests.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.lanepe.2021.100172.

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