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*Published in:*
Drug and Alcohol Dependence

*DOI:*
10.1016/j.drugalcdep.2021.108872

*Publication date:*
2021

*Document version:*
Final published version

Drug and Alcohol Dependence 226 (2021) 108872

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

# Distinct health-related risk profiles among middle-aged and older adults with risky alcohol use from the Danish general population

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ARTICLE INFO

*Keywords:*
Mixture modelling
Heavy drinking
Alcohol use disorder
Senior
Illness
Loneliness

ABSTRACT

*Background:* Knowledge is lacking on distinct health-related risk profiles among the substantial group of middle-aged and older adults with risky alcohol use (AU). Such profiles could inform the planning of interventions and prevention.
*Aims:* To 1) identify distinct health-related profiles based on different types of health-related functioning limitations and distress and 2) assess associations between these profiles and age, sex, and health-relevant behaviors (e.g., smoking).
*Methods:* Cross-sectional nation-wide Danish health survey with n = 6630 adults aged 55–64 and n = 7605 aged 65–74 with at least risky AU (>84 g ethanol/week in women, >168 in men). Health-related risk profiles were identified with Latent Class Analysis (LCA). Multinomial regression was applied for the association between risk profiles and auxiliary variables.
*Results:* A six-class LCA solution was found among 55–64 year-olds (classes: 'Normative' [61%], 'Distress' [6%], 'Mental health limitations [5%]', 'Pain-related distress [10%]', 'Broad limitations and pain distress [7%]', 'High overall burden' [11%]) and a five-class solution among 65–74 year-olds. Most classes were comparable across age groups. The 'Distress'-class characterized by pain-distress, tiredness-distress, and sleep-related distress (6%) only showed in the younger group. In both age groups, auxiliary covariates (high-risk AU, possible alcohol use disorder, weekly smoking) were positively associated with problematic profile membership (vs. normative class membership).
*Conclusion:* Middle-aged and older adults with risky AU have distinct health-related profiles relevant for the form and content of prevention and interventions. Despite their distinct features, almost all problematic health profiles warrant careful attention regarding high-risk AU and probable alcohol use disorder.

## 1. Introduction

Older adults (OA) constitute an especially vulnerable group regarding the detrimental health effects of alcohol use (AU) due to age related health factors, such as lean body mass reduction or pre-existing health conditions (Barry and Blow, 2016; Caputo et al., 2012). Yet, problematic AU (heavy episodic AU, drinking over recommended thresholds) is highly prevalent among OA in ageing western societies (Han et al., 2017; Seitz et al., 2019). 12-month prevalence of alcohol use disorder (AUD) is substantial (Munoz et al., 2018). Recent studies even document increases in problematic AU, AUD, and alcohol-related mortality among OA (Han et al., 2017; Marmet et al., 2016; Piontek et al., 2017). Thus, alcohol-related prevention and intervention for OA with at least problematic AU is an important public-health task. To date, prevention and intervention efforts for OA are distinctly suboptimal. AUD is undertreated in general (Grant et al., 2015) and the proportion of OA in AUD treatment is small (Danish Health Data Authority, 2016; Dauber et al., 2018). Furthermore, OA report the lowest 12-month help seeking

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https://doi.org/10.1016/j.drugalcdep.2021.108872
Received 5 March 2021; Received in revised form 1 June 2021; Accepted 3 June 2021
Available online 30 June 2021

rates for mental health conditions among all age groups (Choi et al., 2014; Mack et al., 2014). OA with problematic substance use and disorders experience diagnostic under-detection and suboptimal treatment referrals (Berner et al., 2007; Caputo et al., 2012; O'Connell et al., 2003). As stated above, problematic AU among OA ranges from recreational AU that exceeds health-recommendations to AUD. In addition, substantial heterogeneity in health and well-being exists among OA with problematic AU (Han et al., 2017). To provide targeted efforts for problematic AU in OA in a cost-effective manner, knowledge is needed about subgroups *within* this group that require different approaches to care. Limited functioning and distress due to pain, mental and physical health conditions, sleep problems, and loneliness are regarded as important age-specific factors and correlates of AU among OA (Brennan et al., 2011; Brennan and SooHoo, 2013; Brower and Hall, 2001; Choi et al., 2015a; Chou et al., 2011; Crowley, 2011; O'Connell et al., 2003; Satre, 2015). While these specific factors can provide crucial information about determining the need for treatment, treatment type, and what accommodations for accessibility are needed, it is unknown whether subgroups with distinct health-profiles based on these factors exist among OA with at least problematic AU in the general population. So far, studies on alcohol-related subtypes among OA have combined middle age and older adult groups; included abstainers; and/or applied AUD criteria and a range of other psychosocial factors in their typologies (Choi et al., 2015b; Jemberie et al., 2020; Roche et al., 2020; Sacco et al., 2009). It also remains unclear, whether such health-profiles are related to other health behaviors (e.g., high-risk AU, smoking). Knowledge about distinct health-profiles that are related to other health behaviors would be critical for intervention planning for the substantial group of OA who, in spite of age-related vulnerabilities, drink over the low-risk consumption threshold (Barry and Blow, 2016). Furthermore, this knowledge could guide hypothesis development on risk factors for problematic AU and AUD among OA (Behrendt, 2020). Given these gaps in the literature, we aimed to identify health-related profiles among middle-aged and older adults with the ultimate goal of identifying subgroups that may need different interventions. Among two independent groups of adults with risky AU aged 55–64 and 65–74 years, respectively, we investigated 1) the existence of subgroups (i.e., health-related profiles) defined by: a) limited functioning due to physical illness, mental health problems, and/or pain; b) loneliness; and c) distress related to pain, trouble sleeping, and/or tiredness; and 2) the association between these health-related profiles and age, sex, high-risk AU, positive CAGE-C-score, and smoking.

## 2. Methods

### 2.1. Sample and study design

The Danish National Health Survey (DNHS) is a cross-sectional health and lifestyle survey of the general population aged 16+ years residing in Denmark, including institutionalized individuals (Christensen et al., 2020). The survey has been conducted in 2010, 2013, and 2017. Only data from 2017 are used here. Data are based on six mutually exclusive samples drawn from the Danish Civil Registration System: one national random sample (conducted by the National Institute of Public Health) and five regional municipality-stratified random samples; one for each of the five Danish administrative regions (conducted by the respective region). Participants were invited by secure electronical mail service (around 90% of the sample) or by postal service.

Of all invited persons, n = 183,372 (58.7%) participated (January/February to May 2017). Among these, n = 33,552 were 55–64 years old (response rates: 66.1% among men and 72.4% among women) and n = 33,639 were 65–74 years old (response rates: 74.2% among men and 73.7% among women) (Christensen et al., 2020; Jensen et al., 2018). The two analytical samples used here consist of individuals from these two age groups with risky AU, defined as reporting current AU over the low-risk threshold (i.e., >84 g ethanol or 7 standard drinks/week for women, >168 g or 14 standard drinks for men). Risky AU occurred in 21.0% (n = 6630) of those aged 55–64 years and in 23.0% (n = 7605) of those aged 65–74 years (Danish Health Authority - National Institute of Public Health, 2018). For sociodemographic and health information on both analytical samples see Table 1.

### 2.2. Assessment

The self-administered survey-questionnaire[1] included 53 core questions (between 88 and 109 total in the six samples) and covered, among others, the topics: health and well-being, illness, smoking, AU, physical activity, nutrition, weight, social relationships, and contact with a general medical practitioner. An English translation of the questions of interest is provided in Appendix A. Some face-valid questions were created specifically for the survey, and some were based on established instruments. Information on age and sex was extracted from the Civil Registration Number, which contains this information for all citizens. The amount of alcohol typically consumed on each day of the week was assessed in standard drinks of 12 g ethanol. Explanatory examples of standard drinks in common alcoholic beverages were provided. For

**Table 1**
Sociodemographic and health-related sample characteristics[1].

| | 55–64 years (n = 6630)[2] | 65–74 years (n = 7605)[2] |
|---|---|---|
| Sex (female) | 50.7 | 50.4 |
| Age (mean, SD) | 59.8 (2.9) | 69.4 (2.8) |
| Education (n = 6454[3], n = 7349[4]) | | |
| Long-cycle higher education (>4 years) | 10.8 | 11.3 |
| Short or medium-cycle higher education (< = 4 years) | 35.3 | 33.7 |
| Vocational education | 40.3 | 38.9 |
| Other (e.g. military) or ongoing education | 5.8 | 6.1 |
| No (vocational or higher) education | 7.8[8] | 10.0 |
| Currently working (n = 6501[3], n = 7465[4]) | 65.0[7] | 12.0 |
| 12-month contact to GP (n = 6503[3], n = 7445[4]) | 78.9 | 84.1[6] |
| Current physical illness (n = 6329[3], n = 7292[4])[5] | 40.8 | 53.2[6] |
| Limited ability to function | | |
| Physical health limitations (n = 6462[3], n = 7282[4]) | 30.7 | 31.7 |
| Mental health limitations (n = 6545[3], n = 7419[4]) | 23.7[7] | 20.8 |
| Pain limitations (n = 6602[3], n = 7569[4]) | 25.1 | 24.2 |
| Distress | | |
| Sleep distress (n = 6589[3], n = 7522[4]) | 15.4[7] | 10.7 |
| Pain distress (n = 6499[3], n = 7401[4]) | 33.5[7] | 27.5 |
| Tiredness distress (n = 6580[3], n = 7510[4]) | 14.2[7] | 8.6 |
| Loneliness (n = 6514[3], n = 7492[4]) | 27.2[7] | 22.9 |
| CAGE-C > = 2 (n = 6592[3], n = 7551[4]) | 23.4[7] | 14.4 |
| Weekly smoking (n = 6607[3], n = 7556[4]) | 29.6[7] | 19.4 |
| High-risk drinking (n = 6630[3], n = 7605[4]) | 40.2 | 40.7 |

[1] Weighted.
[2] Case numbers can vary due to missings.
[3] Number of cases with information in the younger sample.
[4] Number of cases with information in the older sample.
[5] Current physical illness defined as diabetes, high blood pressure, heart or brain thrombosis, angina pectoris, stroke, lung disease (chronic bronchitis, enlarged lungs, emphysema, chronic obstructive pulmonary disease), osteoporosis, or cancer. Percentage given for those with current physical illness in the entire sample.
[6] Greater odds in older compared to younger age group ($p < 0.05$; logistic regression by age group).
[7] Smaller odds in older compared to younger age group ($p < 0.05$; logistic regression by age group).
[8] Significant difference, compared to vocational education ($p < 0.05$; nominal logistic regression by age group).

[1] Available at: www.danskernessundhed.dk/Spoergeskema (Danish Health Authority - National Institute of Public Health, 2018)

indication of past 12-month AUD, the first four questions of the Danish CAGE-C (Zierau et al., 2005) were applied which are very similar to the CAGE questions (Ewing, 1984). Questions on limited functioning were based on the Short Form-12 questionnaire (Shah and Brown, 2020).

### 2.3. Statistical analysis

The DNHS survey weights were applied to account for sampling procedure and non-response, taking into account (e.g.) sex, age, education, occupational status, ethnic background, and hospital stays (Christensen et al., 2020).

To empirically identify subgroups with different health-related risk profiles (i.e., different probabilities of the health-indicators), we conducted a latent class analysis (LCA). LCA is a mixture model. Its core assumptions are that, based on the indicator variables, at least two latent subgroups exist in a population and that the indicator variables used in the analysis are independent from one another within the latent subgroups ("local independence") (Muthén and Muthén, 1998-2007; Nylund et al., 2007). Models with two through eight classes were fit. Up to 12,000 random sets of starting values were generated in the initial stage, and up to 120 optimizations were carried out in the final stage. The most common fit indices were used (Bayesian information criterion [BIC], sample size adjusted BIC [ABIC], Akaike's information criterion [AIC]). These reveal a compromise between model fit and parsimony. Lower values indicate a better model fit. In addition, model fit was assessed with the Vuong-Lo-Mendell-Rubin Likelihood Ratio Test (LRT) and the Lo-Mendell-Rubin adjusted LRT. Clinical meaning of the model was also considered. Maximum posterior probabilities were applied to estimate class membership. For the chosen latent class solutions, standardized residual z-scores were obtained to gain information on possible violations of the local independence assumption (standardized z-score in excess of $|1.96|$). To investigate the association between the categorical latent class variable and the dichotomous auxiliary health-behavior variables not included in the LCA-model, we applied the R3STEP-procedure (Asparouhov and Muthén, 2014a, b), in which we implemented a multinomial logistic regression analysis using the latent class variable as outcome. While this may seem counter-intuitive, it is appropriate for our cross-sectional data and exploits advantages of R3STEP (e.g., allowing sampling weights and accounting for the uncertainty in class assignment). The Stata Software package 16.0 was used for descriptive analyses, Mplus version 8.4 for LCA with the R3STEP-procedure.

#### 2.3.1. Variables

LCA indicators were:

Limited ability to function

a) 'Physical health limitations': defined as health problems leading to significant (vs. minor or no) limitations in simple activities (e.g., vacuuming) or past four weeks physical health problems leading to limitations in the type of work or regular activities that are possible in daily life or to accomplishing less than one would like for at least 'some' of the time (vs. 'rarely' or 'never').
b) 'Mental health limitations': defined as emotional problems leading to accomplishing less than one would like or to doing work or regular activities less carefully for at least 'some' of the time (vs. 'rarely' or 'never') in the past four weeks.
c) 'Pain limitations': defined as the extend of pain interfering with daily work or household chores rated as 'some', 'quite a bit', or 'very much' (vs. 'a little' or 'not at all') in the past four weeks.

Distress (past 14 days)

a) Pain distress: 'a lot of' (vs. 'little' and 'no') distress due to headache or pain in shoulders, neck, back, extremities, joints, or haunches.
b) Sleep distress: 'a lot of' (vs. 'little' and 'no') distress due to trouble sleeping.
c) Tiredness distress: 'a lot of' (vs. 'little' and 'no') distress due to tiredness.

Loneliness

defined as being alone when one would rather have had company ('sometimes' and 'often' vs. 'rarely' and 'not') or 'sometimes' or 'almost never or never' having somebody to talk to in case one had problems or needed support (vs. 'most times' and 'always').

Auxiliary covariates were:

Sex, age (continuous), current high-risk drinking (>168 g ethanol per week in women, >252 g in men), positive CAGE-C-score (here: ≥2 positive answers on questions 1–4), and current smoking (at least weekly). For the dichotomous CAGE-C variable, 0.6% (younger sample) and 0.7% (older sample) had missing information.[2] To avoid listwise deletion of these cases in the R3STEP procedure, values for these cases were imputed with the median sum-score of zero of all subjects with complete CAGE-C information. This may make the test for an elevated risk of a positive CAGE-C more conservative. For the same reasons, missing on smoking (0.4% in younger, 0.6% in older sample) was set to zero.

## 3. Results

### 3.1. Latent class solution

55–64 years: The smallest BIC occurred for the six-class solution, which was also supported by both LRT-tests. Entropy was 0.83 (see Table 2). As a disadvantage, posterior class-membership probabilities were low (mean = 0.58) for those individuals most likely in class 2 (detailed results available upon request). 65–74 years: The smallest BIC occurred for the five-class solution, which was also supported by both LRT-tests. Entropy was 0.80. As a disadvantage, posterior class-membership probabilities were low (mean = 0.55) for those individuals most likely in class 3.

### 3.2. Latent class characteristics among 55–64 year-olds

Class 1 "Normative" (60.9%): this class had low probabilities for all indicators. Class 2 "Distress" (5.8%): this class had elevated probabilities for all types of distress (0.53 – 0.57). Class 3 "Mental health limitations" (5.3%): this class had a high probability for mental health limitations (0.88) and elevated probabilities for loneliness (0.53) and physical health limitations (0.64). Class 4 "Pain-related limitations and distress" (9.9%): this class had high probabilities for pain-related limitations (0.81) and distress (0.85). Class 5 "Broad limitations and pain distress" (7.2%): this class had high probabilities for all types of limitations (0.88 – 0.96) and pain distress (0.77), but low probabilities of other distress types (< = 0.10). Class 6 "High overall burden" (10.8%): this class was characterized by all types of limitations (0.79 – 0.97), all types of distress (pain-related [0.90], tiredness-related [0.66] and sleep-related [0.67]), and loneliness (0.59) (Tables 3 and 4; Fig. 1).

### 3.3. Latent class characteristics among 65–74 year-olds

Class 1 "Normative" (63.1%): this class had low probabilities for all indicators. Class 2 "Mental health limitations" (8.1%): this class had a high probability of mental health limitations (0.72) and an elevated probability of physical health limitations (0.63). Class 3 "Pain distress"

[2] Missing information does not permit conclusions about the CAGE-C status. Note that persons with a CAGE-C sum score >=2 were considered positive regardless of missing values, just as persons with a CAGE-C sum score of 0 and one missing value were considered negative.

**Table 2**
Model fit information for the different latent class solutions.

| Age group 55–64 years (n = 6630) | Two classes | Three classes | Four classes | Five classes | Six classes | Seven classes | Eight classes |
|---|---|---|---|---|---|---|---|
| Loglikelihood | −20503.708 | −20191.490 | −19974.776 | −19867.897 | **−19804.823** | −19772.134 | −19760.251 |
| Number of free parameters | 15 | 23 | 31 | 39 | **47** | 55 | 63 |
| Akaikes Information Criterion (AIC)[1] | 41037.416 | 40428.980 | 40011.552 | 39813.795 | **39703.646** | 39654.268 | 39646.503 |
| Bayesian Information Criterion (BIC)[1] | 41139.406 | 40585.366 | 40222.332 | 40078.970 | **40023.216** | 40028.232 | 40074.863 |
| Sample-size adjusted Bayesian Information Criterion (ABIC)[1] | 41091.740 | 40512.277 | 40123.822 | 39955.037 | **39873.862** | 39853.456 | 39874.664 |
| Vuong-Lo-Mendell-Rubin Likelihood Ratio Test | | | | | | | |
| H0 Loglikelihood Value | −24740.356 | −20503.708 | −20191.490 | −19974.776 | **−19867.897** | −19804.823 | −19772.134 |
| P-value | <0.0001 | <0.0001 | 0.0001 | 0.0001 | **0.0030** | 0.0557 | 0.7048 |
| Lo-Mendell-Rubin Adjusted Likelihood Ratio Test | | | | | | | |
| Value | 8354.614 | 615.690 | 427.358 | 210.763 | **124.381** | 64.463 | 23.432 |
| P-value | <0.0001 | <0.0001 | 0.0001 | 0.0001 | **0.0034** | 0.0586 | 0.7056 |
| Entropy | 0.857 | 0.863 | 0.819 | 0.793 | **0.826** | 0.801 | 0.794 |

| Age group 65–74 years (n = 7603)[2] | Two classes | Three classes | Four classes | Five classes | Six classes | Seven classes |
|---|---|---|---|---|---|---|
| Loglikelihood | −21153.000 | −20945.365 | −20785.751 | **−20671.319** | −20641.150 | −20625.153 |
| Number of free parameters | 15 | 23 | 31 | **39** | 47 | 55 |
| Akaikes Information Criterion (AIC)[1] | 42336.001 | 41936.730 | 41633.502 | **41420.638** | 41376.301 | 41360.306 |
| Bayesian Information Criterion (BIC)[1] | 42440.045 | 42096.265 | 41848.527 | **41691.153** | 41702.307 | 41741.803 |
| Sample-size adjusted Bayesian Information Criterion (ABIC)[1] | 42392.378 | 42023.176 | 41750.016 | **41567.219** | 41552.950 | 41567.024 |
| Vuong-Lo-Mendell-Rubin Likelihood Ratio Test | | | | | | |
| H0 Loglikelihood Value | −25631.556 | −21153.000 | −20945.365 | **−20785.751** | −20671.319 | −20641.150 |
| P-value | <0.0001 | 0.2501 | 0.0084 | **0.0011** | 0.5892 | 0.4407 |
| Lo-Mendell-Rubin Adjusted Likelihood Ratio Test | | | | | | |
| Value | 8833.550 | 409.542 | 314.824 | **225.707** | 59.505 | 31.553 |
| P-value | <0.0001 | 0.2535 | 0.0088 | **0.0012** | 0.5929 | 0.4421 |
| Entropy | 0.867 | 0.830 | 0.800 | **0.801** | 0.816 | 0.803 |

[1] Fit indices with lower values indicate a better model-fit.
[2] n = 2 excluded from LCA due to missing values.

**Table 3**
Class proportions and indicator probabilities for the six-class model in age group 55 - 64 years (n = 6630).

| | Class 1 "Normative" | Class 2 "Distress" | Class 3 "Mental health limitations" | Class 4 "Pain-related limitations and distress" | Class 5 "Broad limitations and pain distress" | Class 6 "High overall burden" |
|---|---|---|---|---|---|---|
| Class proportion (%) | 60.9 | 5.8 | 5.3 | 9.9 | 7.2 | 10.8 |
| **Class indicators** | | | | | | |
| Limited ability to function | | | | | | |
| Physical health limitations | 0.05 | 0.14 | 0.64 | 0.61 | 0.96 | 0.97 |
| Mental health limitations | 0.04 | 0.32 | 0.88 | 0.00 | 0.88 | 0.79 |
| Pain limitations | 0.01 | 0.01 | 0.04 | 0.81 | 0.90 | 0.89 |
| Distress | | | | | | |
| Sleep distress | 0.04 | 0.56 | 0.26 | 0.12 | 0.00 | 0.67 |
| Pain distress | 0.10 | 0.57 | 0.00 | 0.85 | 0.77 | 0.90 |
| Tiredness distress | 0.01 | 0.53 | 0.28 | 0.15 | 0.10 | 0.66 |
| Loneliness | 0.17 | 0.45 | 0.53 | 0.21 | 0.40 | 0.59 |

**Table 4**
Class proportions and indicator probabilities for the five-class model in age group 65 - 74 years (n = 7603)[1].

| | Class 1 "Normative" | Class 2 "Mental health limitations" | Class 3 "Pain distress" | Class 4 "Physical health and pain limitations and pain distress" | Class 5 "Broad limitations and pain distress" |
|---|---|---|---|---|---|
| Class proportion (%) | 63.1 | 8.1 | 7.4 | 12.5 | 9.0 |
| **Class indicators** | | | | | |
| Limited ability to function | | | | | |
| Physical health limitations | 0.06 | 0.63 | 0.17 | 0.98 | 0.99 |
| Mental health limitations | 0.01 | 0.72 | 0.17 | 0.50 | 0.82 |
| Pain limitations | 0.02 | 0.11 | 0.40 | 0.87 | 0.92 |
| Distress | | | | | |
| Sleep distress | 0.04 | 0.13 | 0.31 | 0.04 | 0.48 |
| Pain distress | 0.07 | 0.00 | 0.87 | 0.74 | 0.84 |
| Tiredness distress | 0.01 | 0.11 | 0.14 | 0.07 | 0.61 |
| Loneliness | 0.15 | 0.46 | 0.32 | 0.23 | 0.49 |

[1] n = 2 excluded from LCA due to missing values.

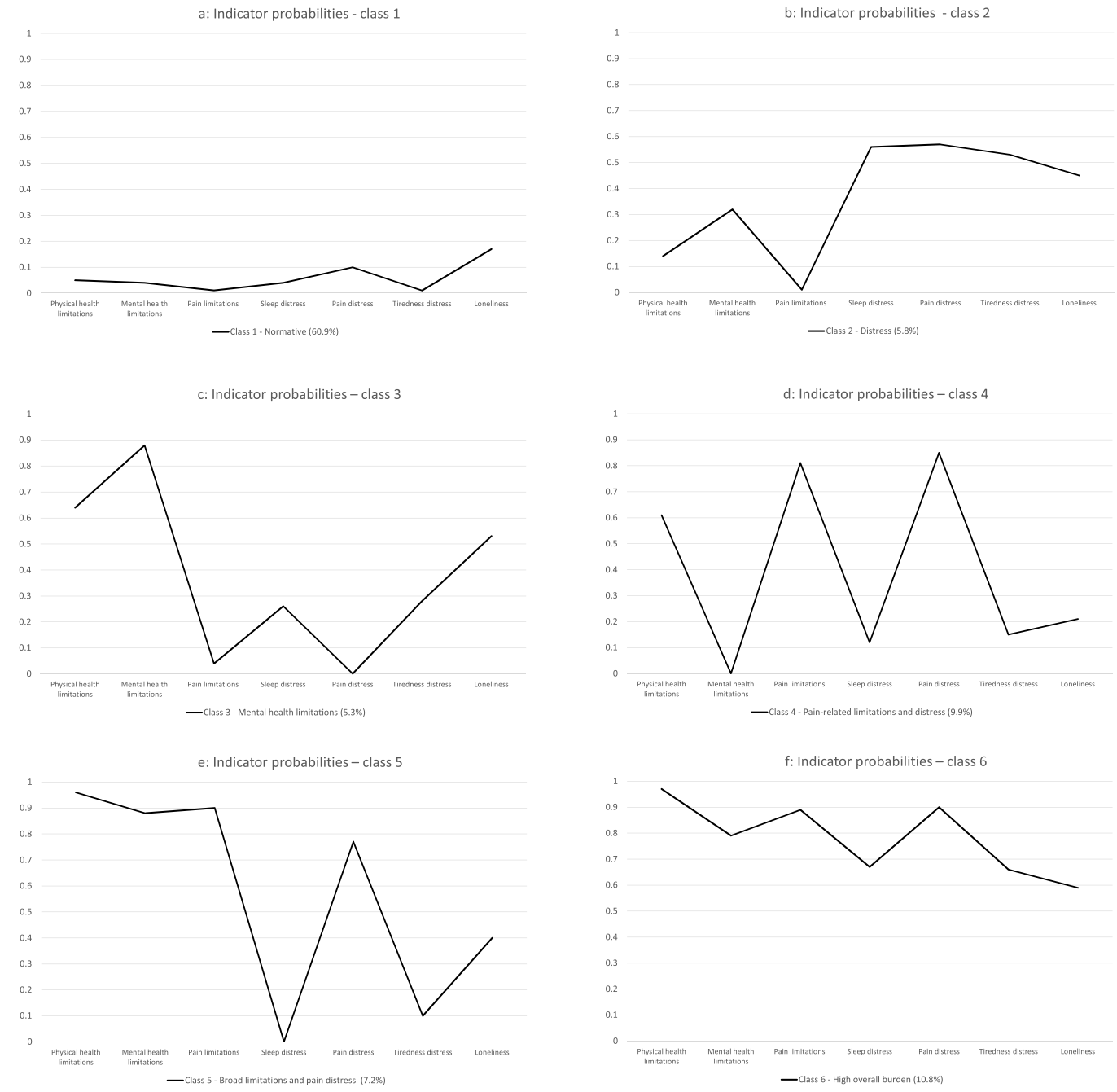


**Fig. 1.** latent classes among 55 - 64 year olds.

(7.4%): this class had a high probability for pain-related distress (0.87). Class 4 "Physical health and pain limitations and pain distress" (12.5%): this class had high probabilities for limitations due to physical health (0.98) and pain (0.87), and pain distress (0.74). The probability for mental health limitations was also elevated (0.50). Class 5 "Broad limitations and pain distress" (9.0%): this class was mainly characterized by all types of limitations (0.82 – 0.99) and pain-related distress (0.84) (Fig. 2).

### 3.4. Associations between auxiliary variables and the latent class variable

Table 5 shows the associations between auxiliary variables and the latent class variable among the 55–64 year-olds. Female sex was associated with a lower risk of being in class 5 ("Broad limitations and pain distress") and a higher risk of being in class 2 ("Distress"), compared to class 1 (adjusted for age). Age was marginally associated with a lower risk of being in classes 6 ("High overall burden"; OR 0.9, 95% CI 0.8 – 0.96) and 2 (OR 0.9, 95% CI 0.8 – 0.95; adjusted for sex). High-risk drinking and a positive CAGE-C were associated with a higher risk of being in all classes except class 4 compared to class 1 (e.g., class 3 "Mental health limitations" on CAGE-C: OR 3.3, 95% CI: 2.1–5.0; adjusted for age and sex). At least weekly smoking was associated with the risk of being in classes 3, 4, 5, and 6.

Among 65–74 year-olds, female sex was associated with a lower and age was associated with a slightly higher risk of being in class 4 "Physical health and pain limitations and pain distress" (OR for age: 1.04, 95% CI: 1.002–1.1; see Table 6). High-risk drinking and weekly smoking were associated with a higher risk of being in classes 2 ("Mental health limitations"), 4, and 5 ("Broad limitations and pain-related distress"). A positive CAGE-C was associated with a higher risk of


**Fig. 2.** latent classes among 65 - 74 year olds.

being in classes 2, 3 ("Pain distress"), and 5.

## 4. Discussion

In each of two large nationally representative Danish samples with risky AU, aged 55–64 and 65–74 years, respectively, we found evidence for distinct health-profiles related to different types of limited functioning, distress, and loneliness. In short, overall, both age groups had a large normative class (about 60%) and several 'problematic health profiles' characterized by varying probabilities of different types of limitations and distress.

### *4.1. Heterogeneity of health profiles*

Our results imply substantial health-related heterogeneity among middle-aged and older adults with risky AU. This heterogeneity of health profiles within each age group does not appear to be attributable to age, despite a ten-year age range. Because older adults frequently reduce their AU (Moos et al., 2010) as they age, and the fact that health variables are associated with AU patterns (Brennan and SooHoo, 2013), we decided to explore health profiles among older adults with risky AU to explore whether heterogeneity in health profiles exist apart from reduction and cessation of AU.

**Table 5**
Associations between the categorical class-variable and age, sex, smoking, and alcohol use behaviors in age group 55 - 64 years (n = 6630).

| | Class 1 | Class 2 | | Class 3 | | Class 4 | | Class 5 | | Class 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | "Normative" | "Distress" | | "Mental health limitations" | | "Pain-related limitations and distress" | | "Broad limitations and pain distress" | | "High overall burden" | |
| | | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Sex (female)[3] | Ref. | 1.76 | 1.1 - 2.7 | 0.69 | 0.4 - 1.0 | 0.79 | 0.6 - 1.0 | 0.52 | 0.3 - 0.7 | 0.98 | 0.7- 1.2 |
| Age[4] | Ref. | 0.88 | 0.8 - 0.95 | 0.96 | 0.9 - 1.0 | 1.01 | 0.9 - 1.1 | 1.03 | 0.9 - 1.1 | 0.93 | 0.8 - 0.96 |
| High-risk drinking[1,2] | Ref. | 1.76 | 1.1 - 2.7 | 2.80 | 1.8 - 4.2 | 1.31 | 1.0 - 1.7 | 2.28 | 1.6 - 3.1 | 2.85 | 2.2 - 3.6 |
| CAGE-C $\geq 2$[2] | Ref. | 4.18 | 2.7 - 6.4 | 3.28 | 2.1 - 5.0 | 1.08 | 0.7 - 1.5 | 1.74 | 1.2 - 2.5 | 3.43 | 2.6 - 4.4 |
| At least weekly smoking[2] | Ref. | 1.00 | 0.6 - 1.6 | 2.39 | 1.6 - 3.5 | 1.53 | 1.1 - 2.0 | 2.81 | 2.0 - 3.9 | 3.05 | 2.4 - 3.9 |

[1] Over 14 standard drinks of 12 g ethanol per week in women and over 21 in men.
[2] Adjusted for age and sex.
[3] Adjusted for age.
[4] Adjusted for sex.

**Table 6**
Associations between the categorical class-variable and age, sex, smoking, and alcohol use behaviors in age group 65 - 74 years (n = 7603)[5].

| | Class 1 | Class 2 | | Class 3 | | Class 4 | | Class 5 | |
|---|---|---|---|---|---|---|---|---|---|
| | "Normative" | "Mental health limitations" | | "Pain distress" | | "Physical health and pain limitations and pain distress" | | "Broad limitations and pain distress" | |
| | | OR | 95% CI | OR | 95% CI | OR | 95% CI | OR | 95% CI |
| Sex (female)[3] | Ref. | 0.81 | 0.6 - 1.1 | 1.24 | 0.9 - 1.7 | 0.76 | 0.6 - 0.9 | 1.22 | 0.9 - 1.6 |
| Age[4] | Ref. | 1.04 | 0.9 - 1.1 | 1.01 | 0.9 - 1.1 | 1.04 | 1.002 - 1.1 | 1.02 | 0.9 - 1.1 |
| High-risk drinking[1,2] | Ref. | 1.71 | 1.2 - 2.3 | 1.45 | 1.06 - 2.0 | 1.62 | 1.3 - 2.0 | 1.59 | 1.2 - 2.0 |
| CAGE-C $\geq 2$[2] | Ref. | 2.66 | 1.9- 3.7 | 2.45 | 1.6 - 3.6 | 1.30 | 0.9 - 1.8 | 3.50 | 2.5 - 4.8 |
| At least weekly smoking[2] | Ref. | 2.62 | 1.9 - 3.6 | 1.01 | 0.6 - 1.6 | 2.33 | 1.8 - 3.0 | 2.82 | 2.1 - 3.7 |

[1] Over 14 standard drinks of 12 g ethanol per week in women and over 21 in men.
[2] Adjusted for age and sex.
[3] Adjusted for age.
[4] Adjusted for sex.
[5] n = 2 excluded from LCA due to missing values.

### 4.2. *Differences in health profiles between middle-aged and older adults*

Overall, the health-related profiles in both age groups were comparable in size and content. In other studies with OA, more distinct differences between 'old' and 'young' latent classes have been found; however, this is most likely due to the inclusion of abstainers and/or not analyzing middle-aged and old adults separately (Jemberie et al., 2020; Roche et al., 2020). Here, a few notable differences need to be discussed: the 'Distress'-subgroup (characterized by elevated probabilities of sleep distress, pain distress, and tiredness distress) appeared to be unique for the younger group. One might speculate that the reason this class occurs in the younger but not the older age group is due to differences in employment rates. The younger group (of which 65% were working) may have felt distress from pain and tiredness more intensely than the older group (of which only 12% were currently working) due to greater societal expectations by others and of themselves resulting from employment. Also, compared to those aged 65+, middle-aged adults have higher prevalence rates of anxiety disorders and major depression (Jacobi et al., 2015). One could also speculate that the individuals with the "Distress"-profile could be among those who become abstinent as older adults, and thus did not appear in the older group (Danish Health Authority - National Institute of Public Health, 2018; Geels et al., 2013; Seitz et al., 2019). Alternatively, lifestyle factors (such as, smoking or obesity) may lead to this group to experience health-related distress in middle age and to develop more serious issues in old age. This may then lead to this group 'merging' with classes with more limitations in older adulthood (Bosnes et al., 2019). In the classes related to "Pain limitations and/or distress", the older group (class 3) was only characterized by pain distress while the younger group (class 4) was characterized by both. In the classes with the relatively broad overall burden, the older group (class 5) had somewhat lower probabilities for sleep distress (vs. class 6 in the younger sample). Again, one might speculate about the role of being in the workforce in these differences.

### 4.3. *Sex differences*

Notably, few sex differences showed. The association between being female and 'Distress'-profile membership in the younger sample might be related to the higher prevalence of mental disorders and pain in middle aged women compared to men (Jacobi et al., 2015) or to higher caregiver burden among women. The associations between being male and classes with high overall limitations and pain distress may be related to professions requiring hard physical labor.

### 4.4. *Subgroup characteristics and public health implications*

Finding two large normative groups among risky drinkers probably underlines the role of good health and social contacts (Canham et al., 2016) in risky drinking in OA and has important public health implications: low-threshold interventions as educational material, text messaging, or brief health-advice may be most suitable for cost-effective intervention and prevention in this group (Barry and Blow, 2016; Bhatia et al., 2015; Muench et al., 2017). Among OA, pain is prevalent and chronic pain, especially if severe, is associated with lower life-satisfaction (Dong et al., 2020). Pain predicts problematic AU (Brennan and SooHoo, 2013), especially among those who treat pain by using alcohol (Moos et al., 2010). In the present study, substantial proportions (about 28%) of both samples were characterized by classes with high likelihoods of pain-related distress and/or pain limitations, putatively placing them at risk of self-medicating behavior. Of interest, in the younger sample, associations between class membership, high-risk AU and a positive CAGE-C-score were found for the classes

where pain-probabilities occurred in the context of other elevated health-problem probabilities. In contrast, in the older group, a class mainly characterized by pain-distress alone was also associated with further problematic AU. In terms of clinical implications, it appears crucial that screenings address pain limitations and/or distress along with other functional limitations and self-medication with AU.

Loneliness is frequently reported among middle-aged and older adults (Canham et al., 2016). Surprisingly, we found no class with high loneliness-probabilities. Moderately elevated probabilities showed in classes with high mental health and other limitations that were associated with a positive CAGE-C and high-risk AU. The role of loneliness in risky AU in OA likely needs to be seen in the context of other factors, such as functional limitations (Purser, 2020). Loneliness could also occur as a result of social isolation in OA with chronic AUD (Wolter, 2018). On the other hand, for some OA, loneliness is related to a reduced risk of problematic AU (Canham et al., 2016), which is consistent with our findings on low loneliness probabilities for the two normative classes. Interventions should screen for and address loneliness in the context of potential factors contributing to it. In this instance, mental health limitations may indicate the need for more complex psychological interventions that address problematic AU along with mental health conditions and loneliness.

Physical illness is common among OA and has been implicated in AU in OA. However, like loneliness, poor health is reported to be negatively related to AU (Blazer and Wu, 2009). This is possibly due to so-called "sick-quitters" (Choi et al., 2015a). Here, among risky drinkers, three out of four classes with high probabilities for physical health limitations (two in the younger, two in the older sample) were associated with problematic AU. Classes with high probability of these limitations were further characterized by other functional limitations and pain distress. OA with these profiles may need interventions that include education about the risk AU poses for physical health and functioning, to avoid solely attributing such experiences to normal aging (Caputo et al., 2012; O'Connell et al., 2003). Furthermore, they may need targeted psychological help to support coping with physical health limitations, pain limitations, and mental health limitations, as well as pain distress.

### 4.5. Associations with health-relevant behaviors

The numerous associations between the 'problematic' profiles and a higher risk of positive CAGE-C-score and high-risk AU in both age groups underscore the potential of these identified health-related profiles to inform AU-interventions. Screening for AUD and high-risk AU can thus be considered relevant in non-normative health-profiles among middle-aged and older adult risky drinkers. Specific treatment approaches for AUD and high-risk AU as Motivational Interviewing, Community Reinforcement Approach and CBT might be needed in stepped-care interventions for these risk profiles (Andersen et al., 2020). A higher risk of at least weekly smoking was associated with being in all except two 'problematic' classes. Given the detrimental health effects of smoking, screenings should address this topic and smoking cessation interventions should be offered (Bhatia et al., 2015; West, 2017).

### 4.6. Implications for future research

Future research should investigate putative risk factors for high-risk AU and AUD in OA and investigate whether pain-related distress/limitations alone or in combination with other types of distress play a role in elevating risk for problematic drinking among OA. Finally, among OA, health profiles in subgroups of abstainers, low-, and high-risk drinkers should be compared.

### 4.7. Limitations and strengths

Results may not be generalizable to other countries because of cultural and healthcare provision differences in Denmark compared to other countries. Information on pain intensity and chronicity was unavailable, but an alternative, valid, indicator of pain-related functioning was applied instead (Yeung et al., 2020). We did not analyze data from very old adults (e.g., aged 80+). We analyzed data from risky drinkers, which may have reduced heterogeneity in the sample. Different class structures may emerge out of data from other groups of OA.

Strengths of this study include a large representative sample from an ageing western country with high AU rates. Institutionalized individuals were included, which reduces selection bias towards 'healthy survivors' in research with OA (O'Connor, 2006). Different types of distress and functional limitations were addressed separately. Focusing on subjects with at least risky AU allows for focus on the substantial population in need of AU-related prevention and intervention.

### 4.8. Conclusions

Middle-aged and older adults with risky AU constitute a heterogenous population in terms of health-related risk profiles, which are indicative of different treatment and prevention needs. Importantly, health-related factors that are prevalent in older age, such as physical health limitations and pain limitations, are not ubiquitous among older adults but are prevalent in the context of distinct risk profiles. For the largest group (about 60%) with low probabilities on health-related indicators, low-threshold secondary preventive efforts for risky AU are indicated. For the other groups with distinct health-related features, established interventions for problem AU may need to be extended by psychotherapy components addressing pain and distress management, coping with loss of functioning, limited functioning due to mental health problems, and loneliness. In addition, their risk of high-risk AU and possible AUD should be monitored.

## Role of funding source

Nothing declared.

## Contributors

Silke Behrendt conceptualized and conducted the analysis, and wrote the manuscript.

Anna Mejldal contributed significantly to the planning of the statistical analysis, the interpretation of data, and the writing of the manuscript.

All other authors contributed significantly to the interpretation of data and the writing of the manuscript.

## Declaration of Competing Interest

The authors report no declarations of interest.

## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.drugalcdep.2021.108872.

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