

# The importance of alcohol in elderly's hospital admissions for fall injuries: a population case-control study

Elin K. Bye 

Norwegian Institute of Public Health, Oslo, Norway

Stig Tore Bogstrand

Oslo University Hospital; and University of Oslo, Oslo, Norway

Ingeborg Rossow 

Norwegian Institute of Public Health, Oslo, Norway

## Abstract

**Background:** Fall injuries account for a substantial part of the health burden among elderly persons, and they often affect life quality severely and impose large societal costs. Alcohol intoxication is a well-known risk factor for accidental injuries, but less is known about this association among elderly people. In this study, our aim was to assess whether risk of fall injuries among the elderly is elevated with an intoxication-oriented drinking pattern. **Method:** We applied a population case-control design and data from persons aged 60 years and over in Norway. Cases comprised patients with fall injuries admitted to a hospital emergency department ( $n = 424$ ), and controls were participants in general population surveys ( $n = 1859$ ). Drinking pattern was assessed from self-reports of drinking frequency and intoxication frequency. Age and gender-adjusted association between fall injury and drinking pattern was estimated in logistic regression models. Fall injuries were considered alcohol-related if blood alcohol concentration exceeded 0.01% and/or the patient reported alcohol intake within six hours prior to injury. **Results:** The risk of fall injuries was highly elevated among those reporting drinking to intoxication monthly or more often ( $OR = 10.2$ , 95% CI 5.5–19.0). Among cases, the vast majority of those with alcohol-related fall

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## Corresponding author:

Elin K. Bye, Norwegian Institute of Public Health, Department of Alcohol, Tobacco and Drugs, PO Box 222, Skøyen, 0213 Oslo, Norway.

Email: [ElinKristin.Bye@fhi.no](mailto:ElinKristin.Bye@fhi.no)



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injuries (64 of 68) reported drinking to intoxication. **Conclusions:** A drinking pattern comprising alcohol intoxication elevated the risk of fall injuries among elderly people. As alcohol use is a modifiable risk factor, the findings suggest a potential to curb the number of fall injuries and their consequences by employing effective strategies to prevent intoxication drinking among the elderly.

### Keywords

alcohol, drinking pattern, elderly, fall injuries, population case control design

Globally, people are living longer, and the proportion of older people in the population is increasing (Lutz et al., 2008). Among the many health challenges typically experienced by older adults are accidental falls. Each year around a third of those aged 65 and over, and about half of those aged 85 and over experience at least one accidental fall (Pfortmueller et al., 2014). About one in ten fall accidents results in a severe injury, such as a fracture or a traumatic brain injury (Pfortmueller et al., 2014). The consequences of severe fall injuries include disability and reduced quality of life for individuals and substantial financial costs to society (Goodwin et al., 2014; Pfortmueller et al., 2014). Hospital treatment and subsequent rehabilitation of fall injuries account for a substantial part of the healthcare costs in the older adult population (Heinrich et al., 2010). Thus, accidental falls constitute a common and, for some, a devastating health problem among older adults (Rubenstein, 2006), and such falls place a substantial economic burden on society. Thus, effective strategies to prevent accidental falls and thereby curb their adverse consequences are of utmost importance, and identification of important risk factors is essential in the development of such strategies.

Literature reviews have identified a number of risk factors for fall injuries among older adults; for instance, impaired balance and gait, confusion and use of psychotropic medication (Ambrose et al., 2015; Deandrea et al., 2010; Pfortmueller et al., 2014; Rubenstein, 2006). While alcohol consumption, and in particular acute alcohol intake, is considered an important

and avoidable risk factor for accidental injuries in general (Rehm et al., 2009) as well as for accidental falls in particular (Cherptitel et al., 2015; Kool et al., 2009), the general epidemiological review literature on falls among older adults seems to have paid little attention to this risk factor. Two publications (Ambrose et al., 2015; Kannus et al., 2005) mention, in passing, that heavy alcohol use is a risk factor for osteoporosis and, implicitly, a distal risk factor for falls among older adults.

Over the past decade, the importance of alcohol use as a risk factor for adverse health outcomes among older adults has been gaining increased attention (Anderson et al., 2012; Breslow et al., 2017; Bye & Østhus, 2012). The biological changes that come with ageing imply elevated susceptibility to alcohol's psychomotor effects (Anderson et al., 2012; Galluzzo et al., 2012). Specifically, older adults tend to have less dose tolerance to alcohol, due to less body fluid and slower liver function (Anderson et al., 2012). Moreover, older adults often suffer conditions, such as impaired balance and confusion, that further deteriorate under the influence of alcohol (Hartikainen et al., 2007; Woolcott et al., 2009). This may explain why alcohol use, and in particular heavy episodic drinking, is likely to increase the risk of fall injuries in older adults.

So far, the epidemiological literature on alcohol use and fall injuries among older adults is fairly sparse and inconclusive. In their systematic review, Reid and colleagues (2002) identified 26 studies examining the alcohol–fall injury association among older adults. Most of

these studies (21) found no association, four studies reported elevated risk with some alcohol exposure, and one study found reduced risk among daily users compared to non-users of alcohol. Both this review (Reid et al., 2002) and a more recent review of alcohol as risk factor for various health outcomes in the elderly (Anderson et al., 2012) concluded there is a paucity of data on the risk posed by alcohol use for falls or fall injuries among the elderly, and that more research is still needed.

In the absence of an updated review on alcohol use as a possible risk factor for falls and fall injuries in elderly people, we searched the MEDLINE database for studies published in English during the period after Reid et al.'s systematic review (2002) (i.e., from 1998 to January 2018) (search terms were "alcohol", "fall", "risk", and "old"/"elderly"). We retrieved a total of 14 primary studies examining a possible association between alcohol use and non-fatal falls or fall injuries. The findings of these studies were mixed; three studies found no association (Clausen et al., 2015; Suelves et al., 2010; van Schooten et al., 2016), eight studies reported increased risk of fall with some kind of alcohol exposure (e.g., any alcohol use; regular drinking; high intake per month; alcohol-related problems) (Adebisi et al., 2009; Cawthon et al., 2006; Chang & Do, 2015; Grundstrom et al., 2012; Guse & Porinsky, 2003; Orces, 2013; Pluijm et al., 2006; Stenbacka et al., 2002), and four studies reported decreased risk with "moderate" alcohol exposure (e.g., < 2 drinks/day) (Cawthon et al., 2006; Coutinho et al., 2008; Kado et al., 2007; Peel et al., 2006). Notably, in most (11) of these studies, the outcome measure was self-reported, and only a few studies ( $n = 4$ ) applied hospital record data or the like to assess severe fall injury (Cawthon et al., 2006; Coutinho et al., 2008; Guse & Porinsky, 2003; Stenbacka et al., 2002). Considering that acute alcohol use and heavy episodic drinking constitute a significant risk factor for accidental injuries in general (Taylor et al., 2010), it is particularly noteworthy that none of these studies examined

the role of acute alcohol use and exposure to heavy episodic drinking specifically.

In summary, fall injuries among older adults constitute a major health problem and concern for the health and care services, and knowledge about the role of alcohol use, as an avoidable and potentially increasingly important risk factor, is still limited. Against this backdrop, the aim of the present study was to examine the role of alcohol exposure in fall injuries among older adults, paying particular attention to drinking patterns comprising intoxication. More specifically, in a population case-control design, we examined whether a drinking-intoxication-oriented drinking pattern was associated with the risk of in-patient hospital treatment for accidental fall injury among older adults.

## Materials and methods

Fall injuries requiring in-patient treatment in a hospital occur rather rarely and, therefore, this study applied a case-control design, which is more efficient than other observational study designs when the outcome is rare (Healthknowledge, 2021; Rothman et al., 2008; Setia, 2016; Vandenbroucke & Pearce, 2012). We applied two independent samples for which we had identical long-term exposure measures: a sample of hospital-admitted fall-injured patients (comprising the cases) and a general population sample (the controls). Thus, the study design is a population case-control (Vinson et al., 2003; Zeisser et al., 2013). By using data from hospital-admitted patients, the content validity and reliability of the outcome measure is considered less problematic, as compared to survey studies. In both samples, participants were aged 60 years and over, and study participation was based on informed consent.

### Sample of injured patients

The present study applied a sub-sample from a data set collected in a study of substance use and injuries (see Bogstrand et al., 2011, for details). Between December 2007 and

December 2008, all adult patients admitted to a hospital emergency department in Oslo, Norway because of traumas or less severe injuries from accidents, assaults or acute poisonings, were asked to participate. The catchment area was the wider Oslo region. Of the 2118 invited patients, 7% refused to participate and 4% were unable to provide blood samples (for alcohol and drug testing). Hence, the participation rate in the sample of injured patients was high, which is likely to reduce the risk of sampling selection bias. From the net sample of 1882 injured patients aged 18 years and over, 1611 patients arrived in the hospital within 48 hours after injury, and among these, 472 patients were aged 60 years and over admitted due to a fall injury. Identification of fall injuries was based on information from the medical staff on an admission form applied for all patients included in the broader hospital study.

The injured patients were asked to complete a small questionnaire, which included a few questions about their alcohol use. Those unable to complete the questionnaire, due to severe injuries, were interviewed by a nurse. However, interviews were not conducted when patient confidentiality was threatened, and therefore self-report data are missing for some patients. Shortly after hospital admission, blood samples were collected from all injured patients to determine blood alcohol concentration level and presence of psychotropic drugs (see Bogstrand et al., 2011, for details). Patients with missing data on the exposure measures were excluded ( $n = 48$ ), and we analysed a sub-sample comprising 424 patients.

This part of the study was approved by the Regional Ethics Committee in Norway and the Norwegian Data Inspectorate (S-05026).

### General population sample

In each of the four years 2012–2015, a general population sample was contacted by Statistics Norway and asked to participate in a telephone

survey on alcohol and drug-related topics. Each sample was intended to reflect a nationally representative sample of the adult population (aged 16–79 years) in Norway, and the net sample comprised 8427 respondents (average response rate 57%). For the purpose of this study, we applied a sub-sample comprising respondents aged 60–79 years ( $n = 1879$ ). The control sample thus resembles the population at risk, implying that some cases may also be found among the controls (Rothman et al., 2014). By employing a larger sample of controls than of cases, statistical power is increased. However, the sample of controls was not matched by age and gender, thus requiring statistical adjustment in the analyses. The surveys were conducted according to the *Personal Data Act* and the *Statistics Act*.

### Measures

**Drinking pattern.** In both samples, the participants were asked about how often they had drunk alcohol (drinking frequency), and they were asked how often they had so much to drink that they felt clearly intoxicated (intoxication frequency). For both questions, the reference period was the past 12 months with eight response categories ranging from “None” to “Several times a week or more often”. The responses were collapsed into “Never”, “Less than monthly” and “Monthly or more often”. By combining the responses to these two questions, a measure of intoxication-oriented drinking pattern reflecting categories of injury risk due to drinking was constructed with four categories: (0) “No risk” (no drinking); (1) “Low risk” (no intoxication and drinking frequency less than monthly), (2) “Medium risk” (no intoxication and drinking frequency monthly or more often, *or* intoxication frequency less than monthly and drinking frequency monthly or more often/less than monthly), and (3) “High risk” (intoxication *and* drinking frequency monthly or more often). Among injured patients, 10% had missing observations on this

measure, whereas the corresponding proportion among controls was 1%.

**Alcohol-related injuries.** Among the patients with fall injuries, we identified alcohol-related injuries, that is injuries that likely occurred under the influence of alcohol. We assessed blood alcohol concentration (BAC) from routine full blood sampling shortly after hospital admission. BAC was determined using the enzymatic dehydrogenase method (see Bogstrand et al., 2011, for further details). However, half (48.3%) of the elderly patients arrived in hospital more than six hours after the injury. For these patients, BAC was a less valid indicator of alcohol influence at the time of the injury, as alcohol is rapidly eliminated from the blood, and we therefore applied data on self-reported alcohol use within six hours prior to the injury. A previous study has demonstrated good accordance between BAC and self-report of alcohol use prior to injury among patients who arrived in hospital within six hours after the injury (Bogstrand et al., 2013). Based on information from the blood screen and the self-reports, we distinguished between *Alcohol-related fall injuries* and *Other fall injuries*. The former category included patients who had either a BAC level  $\geq 0.01\%$ , or who reported having consumed alcohol in the six hours prior to the injury, or both.

### Statistical analyses

In the case-control design, the outcome variable is a dichotomous measure, separating between being a case or not (i.e., control), which in this study translates to separating between fall-injury patients and respondents in the general population surveys. First, we examined whether the outcome measure varied with regard to demographic characteristics (age and gender) and the exposure measure (risky drinking pattern) in bi-variate analyses. Differences were tested using Pearson chi square statistics for categorical variables and with an F-test for the continuous control variable age. As case and

control samples were not age and gender matched, any significant associations between the outcome variable and demographic variables implied confounding, and a need to adjust for confounders in further analyses. Next, we regressed the likelihood of fall injury on the exposure measure, risky drinking pattern, in a logistic regression model. Risky drinking pattern was entered as categorical, with the “No risk” category (no drinking) as the reference group, and identified confounding variables were entered as co-variables. Thus, the risk of fall injury as a function of drinking behaviour was estimated as odds ratios (which correspond closely to relative risk estimates for low incident outcomes). In all analyses, subjects with missing information on the exposure variables were excluded. Thus, the total number of valid observations in the analyses was 2283; 424 patients with fall injuries and 1859 controls.

### Sensitivity analyses

The case and control samples differed regarding distribution of age. We therefore conducted a sensitivity analysis to assess possible impact of different source populations for cases and controls. To match the age distribution among controls, the logistic regression analysis was re-run with a sub-sample of cases, including only those aged 60 to 79 years ( $n = 251$ ). Moreover, as use of psychotropic medication is a risk factor for fall injuries per se (Deandrea et al., 2010; Pfortmueller et al., 2014) and possibly also via its pharmacological interaction with alcohol (Holton et al., 2017), we examined the association between alcohol exposure and risk of fall injury, employing a sub-sample of cases with negative drug screens. In this analysis, we excluded fall-injury patients with positive blood screens for the following psychotropic drugs: diazepam, zopiclone, codeine, oxazepam, clonazepam, flunitrazepam, morphine, nitrazepam, zolpidem, meprobamat, dextropropoxyphen, oxycodone, and phenobarbital ( $n = 155$ ) (see Bogstrand et al., 2011, for further details).

**Table 1.** Distribution of frequency of drinking, frequency of intoxication and risky drinking pattern in the preceding year among fall-injured patients and controls ( $n = 2283$ ).

	Fall-injured patients ( $n = 424$ )	Controls ( $n = 1859$ )	Test statistics
Men, % ( $n$ )	33 (138)	49 (912)	$\chi^2 = 37.9, p = 0.000$
Age, mean (SD)	77.9 (10.1)	67.9 (5.5)	$F = 422.9, p = 0.000$
Risky drinking pattern (%)			
No risk	25	19	$\chi^2 = 37.4, p = 0.000$
Low risk	24	19	
Medium risk	45	60	
High risk	6	3	

## Results

The injured patients differed from the controls in several respects; among the cases, women were in majority (66%) and the mean age was higher (77 years) compared to controls (Table 1). A vast majority reported having consumed alcohol in the past 12 months: 74.8% among the cases and 81.4% among the controls. A significant difference in the distribution of the risky drinking pattern measure between cases and controls was observed, indicating a more risky drinking pattern among the fall-injury cases (Table 1). The high-risk drinking pattern, comprising monthly or more frequent intoxication, was less prevalent among female than male patients (1% and 17%, respectively;  $\chi^2 = 41.7, p = 0.000$ ), and less prevalent among female than male controls (1% and 5%, respectively;  $\chi^2 = 17.5, p = 0.000$ ).

We explored the associations between risky drinking pattern and risk of fall injury, controlling for age and gender. Those with a high-risk drinking pattern, that is, drinking to intoxication monthly or more often, had a statistically significantly elevated risk of fall injury, as compared to the reference category ( $OR = 10.2$ , 95% CI 5.5–19.0) (Table 2). The risk of fall injury increased with increasing age and was higher among females compared to males (Table 2). We explored whether the association between risky drinking pattern and fall injury was moderated by gender; however, the interaction term was not statistically significant ( $p =$

0.070). The sensitivity analyses applying (i) cases in the age range 60–79 years, and (ii) drug screen negative cases, both obtained results fairly similar to those from the initial analysis (Table 2).

Among patients with fall injuries, 16% ( $n = 68$ ) were alcohol-related. The vast majority of these patients ( $n = 64$ ) reported alcohol use in the six hours prior to the injury, and half ( $n = 34$ ) had a positive BAC screen (i.e.,  $> .01\%$ ). Alcohol-related fall injuries were more prevalent among male (25%) than among female patients (12%) ( $\chi^2 = 11.2, p = 0.001$ ) and strongly associated with the patient's drinking pattern ( $\chi^2 = 114.1, p < 0.001$ ). Thus, the vast majority of patients with alcohol-related fall injuries (64 out of 68) reported a drinking pattern comprising drinking to intoxication (Table 3). In other words, alcohol-related injuries were strongly indicative of an intoxication-oriented drinking pattern.

## Discussion

By employing a population case-control design and using data from hospital admissions of injured patients, this study demonstrated an association between drinking pattern and risk of fall injury among older adults. The risk was strongly elevated among those reporting monthly or more frequent episodes of alcohol intoxication. This drinking pattern occurred mainly among males. Alcohol-related fall injuries (i.e., with BAC  $> 0.01\%$  or self-reported

**Table 2.** Adjusted odds ratios (95% CI) for the association between risky drinking pattern and risk of fall injuries in (A) full samples of cases and controls; (B) sub-sample of cases (age group 60–79 years); and (C) sub-sample of cases, excluding drug-influenced fall injuries.

	(A) Full samples of cases and controls (C.I) N = 2283	(B) Sub-sample of cases (age group 60–79 years) (C.I) N = 2077	(C) Sub-sample of cases, excluding drug-influenced (C.I) N = 2128
<b>Drinking pattern</b>	1.00	1.00	1.00
No risk (reference)			
Low risk	1.13 (0.77–1.66)	0.96 (0.59–1.55)	1.66* (1.04–2.64)
Medium risk	1.31 (0.94–1.82)	1.20 (0.81–1.77)	1.87** (1.24–2.82)
High risk	10.17*** (5.45–18.96)	7.02*** (3.78–13.07)	15.66*** (7.98–30.70)
Age	1.21*** (1.18–1.23)	1.07*** (1.04–1.10)	1.19*** (1.16–1.21)
Female	1.70*** (1.30–2.22)	1.60*** (1.18–2.16)	1.48* (1.10–2.01)

\* $p < 0.05$ . \*\* $p < 0.01$ . \*\*\* $p < 0.001$ .

**Table 3.** Distribution of risky drinking pattern in the preceding year among alcohol-related and other fall injuries. Percentages (n).

	Alcohol-related fall injuries (n = 68)	Other fall injuries (n = 356)
No risk	0 (0)	30 (107)
Low risk	6 (4)	27 (97)
Medium risk	63 (43)	41 (146)
High risk	31 (21)	2 (6)

drinking six hours prior to injury, or both) were strongly indicative of a drinking pattern comprising intoxication.

By examining hospital-treated injuries, our focus was on the most severe forms of fall injuries that likely account for the major toll on health, life quality, and healthcare resources. Studies applying a case-control design or the like when examining the role of alcohol use as risk factor for such severe outcomes among older adults, have applied different alcohol exposure measures and produced mixed findings. Several reported no association (Reid et al., 2002), some have found an elevated risk of fall injury with more frequent use (Reid et al., 2002) or higher intake (Stenbacka et al.,

2002), whereas two studies reported reduced risk of fall injury among those with “moderate” alcohol consumption as compared to abstainers (Coutinho et al., 2008; Peel et al., 2006). The latter finding may reflect insufficient control for confounding. Notably, none of these previous studies among older adults examined the role of intoxication-orientated drinking pattern in fall injuries.

However, when considering the broader literature on acute alcohol use and risk of injury, our finding that a drinking pattern comprising monthly or more frequent drinking to intoxication elevated the risk of fall injury, corresponds to previous findings, generally showing an increased risk of injuries with increasing exposure to heavy episodic drinking (Taylor et al., 2010). With regard to accidental falls among young and middle-aged people, a systematic review (Kool et al., 2009) concluded that the fall risk increases with increasing exposure to alcohol use, showing modest evidence of a dose–response relationship with acute alcohol use and inconclusive evidence of an association with usual alcohol use. A general population survey (Scholes et al., 2014), demonstrated an

association between heavy episodic drinking in the past week and lifetime experience of a fracture among people aged 55 years and over. Our observation of a substantial fraction of hospitalised fall injuries being alcohol-related also corroborates those from a number of studies conducted in emergency rooms or the like (Cherpitel et al., 2015).

In general, the acute effects of alcohol on psycho-motor functions are diverse, and include impaired balance and reaction, and there is some evidence suggesting that there is an age-related worsening of performance in people who have consumed alcohol; in other words that older adults are more susceptible to alcohol-related impairment (Adams & Jones, 1998; Squeglia et al., 2014) compared to younger adults. The strong association observed between drinking to intoxication and alcohol-related injuries among the patients observed in the present study, is in line with the assumption of a causal association between heavy episodic drinking and risk of fall injury.

### *Limitations*

Several limitations should be noted. First, the response rate in the general population sample was relatively low, as is generally the case in adult population surveys these days. This may well have led to heavier drinkers being under-represented among survey respondents and thus a downward-biased distribution of the intoxication frequency among controls. If so, the magnitude of the elevated risk of fall injury among high-risk drinkers is overestimated. Second, while it may be argued that the two samples of cases and controls were relatively large, as compared to previous case-control studies on this topic (Coutinho et al., 2008; Peel et al., 2006), we obtained fairly large confidence intervals for the point estimates. Moreover, the controls should ideally be sampled from the same area as the cases, so as to reflect the population at risk; however, it was not possible to separate controls only from the capital area in the available data. The time interval between

data collection for the cases and the controls may have biased the estimates to the extent that drinking behaviour changed in the general population over this time period. While we have no survey data to examine this issue directly, sales data for the period 2008–2012 show that per capita consumption decreased by 8% (SSB, 2020), and later annual surveys show that the prevalence of heavy episodic drinking has remained stable. Overall, this may suggest that the general level of alcohol exposure may have been slightly reduced over the time interval and, if so, this may have biased the estimated association in an upward direction. Finally, a number of unobserved factors that likely correlate with both exposure and outcome, including socioeconomic status and a range of health conditions, may have confounded the observed association.

### *Implications*

Our observation of a significant impact of intoxication-oriented drinking pattern on fall injuries among the elderly, is of utmost importance and concern, given the substantial health burden and economic costs from such injuries and keeping in mind the increasing trends in the proportion of elderly people in the society and the increasing alcohol consumption among older adults. As alcohol use is a modifiable risk factor, the findings suggest a potential to curb the amount of fall injuries and their consequences by employing effective strategies to curb intoxication drinking among the elderly. In general, screening and brief intervention in primary healthcare services are shown to be an effective measure to reduce hazardous drinking (Kaner et al., 2009; O'Donnell et al., 2014), and as primary healthcare services are widely used among the elderly (Ionescu-Ittu et al., 2007), this setting seems promising for identifying and modifying hazardous drinking in this age group. Moreover, physicians in primary healthcare may also pay further attention to alcohol use habits among elderly patients having prescriptions for psychotropic drugs interacting



with alcohol which thereby elevate the risk of falls and other injuries. Also in the specialist health services, brief interventions, including motivational interviewing, seem a promising strategy to reduce hazardous drinking in cases of alcohol induced, or related, health harms (Miller & Rose, 2009; Moyer et al., 2002). In this respect, findings in our study suggest that identification of fall-injured patients with a positive blood alcohol screen and/or report of alcohol consumption shortly prior to the injury, appears to be an appropriate point of departure for such intervention. Finally, more knowledge about the role of alcohol use in fall injuries among older adults is still urgently needed, and this pertains both to the role of alcohol use per se and to the role of alcohol in combination with psychotropic drugs.



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### ORCID iD

Elin K. Bye  <https://orcid.org/0000-0001-7559-8885>  
Ingeborg Rossow  <https://orcid.org/0000-0001-8652-9367>

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