The Relationship between Alcohol Intake and Falls Hospitalization: Results from the EPIC-Norfolk

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Short running title: Alcohol and Falls Hospitalizations

Word Count: 3345 words (without abstract) 3567 (with abstract)

Abstract:

Aim: To evaluate the relationship between habitual alcohol consumption and risk of falls hospitalization.

Methods: The EPIC-Norfolk is a prospective population-based cohort study in Norfolk, United Kingdom. A total of 25,637 community dwelling adults aged 40-79 were recruited. Units of alcohol consumed per week were measured using a validated Food Frequency Questionnaire. The main outcome was the first hospital admission following a fall.

Results: Over a median follow-up period of 11.5 years (299,211 total person years), the cumulative incidence function (95% confidence interval, CI) of hospitalized falls at 121-180 months for non-users, light (>0 to ≤7 units/week), moderate (>7 to ≤28 units/week) and heavy (>28 units/week) were 11.08 (9.94-12.35), 7.53 (7.02-8.08), 5.91 (5.29-6.59), and 8.20 (6.35-10.56), respectively. Moderate alcohol consumption was independently associated with a reduced risk of falls hospitalization after adjustment for most major confounders (hazard ratio=0.88;95%CI:0.79-0.99). The relationship between light alcohol consumption and falls hospitalization was attenuated by gender differences. Alcohol intake higher than the recommended threshold of 28 units/week was associated with an increased risk of falls hospitalization (HR 1.40 (1.14-1.73))

Conclusions: Moderate alcohol consumption appears to be associated with a reduced risk of falls hospitalization, intake above the recommended limit is associated with an increased risk. This provides incentive to limit alcohol consumption within the recommended range and has important implications for public health policies for ageing populations.

Keywords: alcohol, elderly, falls, geriatric, hospitalization

Introduction

Globally, the number of persons aged 60 years and above has been estimated to be over 900 million in 2015. This number is projected to rise to 1.4 billion by 2030 and 2.1 billion by 2050.(1) Falls are commonly reported among older people, with over a quarter of the American adult population (27.7%), without severe visual impairment, reporting having had falls.(2) It is also a common cause of mortality among adults. In the United States alone, more than 25,000 deaths, among the population aged 65 years and above, is attributable to unintentional falls in 2013.(3)

While several studies have shown that alcohol intake is not a significant predictor of falls, (4) other studies show that there is a significant association between alcohol intake and falls. (5, 6) There are also studies showing that alcohol intake is associated with a reduced risk of falls. (7) The positive association between moderate alcohol consumption in cardiovascular disease is now considered well established (8). The relationship between moderate alcohol intake and other health outcomes such as falls, is less well researched. A better understanding of the relationship between alcohol and falls is important to determine whether current alcohol consumption guidelines are potentially beneficial in reducing falls risk.

Therefore, based on the current evidence for the association between alcohol intake and health, we postulate that judicious use of alcohol may be protective of falls while drinking in excess is linked to increased risk of falls. The objective of this study is, therefore, to determine the potential differential relationship between different levels of habitual alcohol consumption with falls hospitalization over long term follow up in a general population of middle and older age. Individuals in middle age were included as

the length of follow-up, allowed us to explore the prospective relationship between alcohol consumption in middle age and falls hospitalization in later life.

Methods

Study design and setting

The EPIC-Norfolk is a prospective population-based cohort study. Participants were recruited between 1993-1997 from the city of Norwich and its surrounding rural areas in Norfolk, United Kingdom. Norfolk is a county in the East of England and Norwich is the largest city in Norfolk and serves as its administrative capital. With a population 859,400 people; a population density of 155 persons per km square. 40% of the population live in the urban areas while 60% are in the rural areas.

Participants

Men and women aged from 40 to 79 years of age were recruited from the general practice age-sex registers into the EPIC-Norfolk study. Protocol for the EPIC-Norfolk study has been published elsewhere in detail; the characteristics of the cohort were comparable to the UK population as a whole, although the percentage of current smokers were lower. (9) All participants gave written informed consent. Ethical approval was obtained from the Norwich Local Research Ethics Committee.

Baseline assessments and measurements

At baseline, all consenting participants were completed a detailed health and lifestyle questionnaire that collected information on participants' educational status, occupation, socioeconomic status, physical activity, smoking status, prevalent illness and medications. Prevalent illnesses collected included self-reported physician-diagnosed condition of heart disease, diabetes mellitus, cancer, asthma, and chronic obstructive

pulmonary disease Socioeconomic status was defined according to the Registrar General's occupation-based classification scheme.

Trained nurses then took measurements of the weight, height, body mass index (BMI) and blood pressure, and obtained non-fasting venous blood samples. Hip circumference were measured at the widest portion of the buttocks in accordance to WHO recommendations.(10) Physical activity, graded according to a four-level physical activity index, was derived from the validated EPIC short physical activity questionnaire. (11)

The use of medications was ascertained by enquiring whether the participant has taken any drugs or medications either prescribed by their doctor or from the chemist. The use of aspirin, steroids or diuretics was determined by asking about continual use for three months or more. Smoking history was determined using the questions: *"Have you ever smoked as much as one cigarette a day for as long as a year?"* and *"Do you smoke cigarettes now?"*. Educational status was recorded as no qualification, O-level (five years of secondary education), A-level (sixth form or college), degree or higher qualification.

Area deprivation was assessed from residential postcodes using the Townsend Deprivation Index. The Townsend Deprivation Index assessed an area to be deprived based on the percentages of the following: a) households with fewer rooms than persons b) households lacking a car c) economically active persons seeking work d) children aged 5 to 15 who received school meals free and e) households experiencing disconnection of electricity in the previous 12 months.(12)

Three separate questions were asked about the reported weekly intake of fresh fruits, green leafy vegetables, and other vegetables. The options given were never, seldom, once a week, 2-3 times a week, 5-6 times a week, once or more daily and don't know.(13)

Alcohol consumption

The EPIC food frequency questionnaire, mentioned above, was used to assess the amount of alcohol habitually consumed. The participants reported the type of alcoholic beverage and volume in terms of cans, pints, glasses, and shots consumed within an average week. From that information the total weekly consumption of alcohol was determined. The number of units of alcohol consumed per week was then calculated based on the UK government recommended guidelines, as this is a British population. One unit of alcohol according to the National Health Service (NHS) is defined as 10ml or 8g of pure alcohol. This is different from the United States where a "standard drink: is defined as 14g of pure alcohol. An estimated consumption of more than 28 units (>224g) of alcohol per week was considered heavy alcohol consumption. Among those who consumed 28 units or less, 7 units (56g) or less per week was considered light consumption while over 7 units to 28 units (56g-228g) was considered moderate consumption. For comparison one pint of beer with an ABV of 5% is considered 3 units.

Hospitalization due to falls

Hospital admission episodes were identified from the National Health Service hospital information system and ENCORE (East Norfolk Commission Record). The ENCORE system has previously been validated for other diseases such as stroke.(14)

Falls as the reason for admission was identified using the International Classification of Diseases -10th Revision (ICD-10) codes W00-W19.

Statistical methods

Statistical analysis was performed using SPSS version 21.0. The baseline characteristics of different alcohol consumption categories (0, >0 to ≤7, >7 to ≤28 and >28 units/week) were compared with the analysis of variance for continuous data and Chi-squared test for categorical data. A Kaplan-Meier survival curve was produced for the various categories of alcohol usage in relationship to time to first hospitalization with a fall. The length of follow-up was censored at the date of death while the time to event was the actual date of the fall. We did not look consider fall-related death only fall-related hospitalization in relation alcohol consumption. The proportion of those hospitalized during the duration of follow-up was plotted serially. We created a graph for each of the categories of alcohol intakes in 3.5 unit increments. We then repeated the analysis for all participants but this time we divide the groups into those aged <65 years and ≥65 years to examine for other patterns of association. Cox proportional hazards regression analysis was employed to determine the hazard ratios (HR) with 95% confidence intervals (CI) for risk of falls hospitalization according to alcohol categories. Using dummy variables, with the no alcohol consumption category as the reference group, the individual models compared low (>0, ≤7 units/week), moderate (>7, ≤28 units/week) and heavy (>28 units/week) against no alcohol intake. There is no specific standardized cut-off point used across different studies and our cut-off points were defined based on the visual interpretation of the relationship between fall hospitalization and alcohol consumption in our graphical representations and the UK

196 recommendations.(15) Independent variables within the Cox proportional hazard
197 analysis were added using a hierarchical approach and the variables selected for the
198 included within the Cox proportional hazard models were informed by available
199 published literature and clinical experience. In previous studies falls was associated
200 with increasing age, female gender, social deprivation (16), anti-depressant use (17),
201 reduced physical activity (18), lower BMI (19), stroke (20), diabetes mellitus (21), and
202 increasing vegetable intake(22). Other variables were selected on the basis on difference
203 between groups and this included smoking and educational level.
204

205 ## Results

206 ### Participants

207 Data on alcohol consumption and the presence or absence of hospitalization from a fall
208 was available for 25,639 participants. The participants were recruited from the years
209 1993 to 1997. The median follow-up period was 11.5 years (mean 16.23 years; total
210 person years 299,211). The minimum follow-up period was for one month with a
211 maximum of 277 months.
212

213 The baseline characteristics measured at enrolment between 1993-1997 are summarized
214 in Table 1, according to alcohol usage categories.
215 Table 1
216
217
218 The number of participants who experienced hospitalization due to a fall during
219 the follow-up period was 700 (19.2%) for those who do not drink; 1867 (13.7%) for
220 those who drink >0, ≤7 units/week; 494 (10.9%) who drink >7, ≤14 units/week; 207

(10.7%) for those who drink >14, ≤21 units/week; 84 (9.2%) for those >21, ≤28 units/week; and 118 (12.3%) for those drinking >28 units/week. There were significant differences between the gender, age, body-mass index, waist-hip ratio, mean diastolic and systolic blood pressure, physical activity, smoking status, education level, occupational social class, the Townsend index, prevalent major co-morbid conditions such as diabetes mellitus, stroke, cancer, medications including anti-depressant use, aspirin use, anti-hypertensive use and vitamin D supplementation as well as fruit and fish intake between the different alcohol consumption categories ($p<0.05$). Time to falls hospitalization at various time points is summarized in Table 2. The cumulative incidence function (95% confidence interval, CI) at 121-180 months was 11.08 (9.94 to 12.35) % for teetotalers, 7.53 (7.02-8.08)% for >0 but ≤7 units/week, 5.91 (5.29 to 6.59) % for >7 and ≤28 units/week and 8.20 (6.35 to 10.56) % for >28 units/week. Figure 1 provides the trend for fall hospitalization for overall population according to alcohol consumption categories.

Table 2

Figure 1

Cox proportional hazards models

Table 3 shows the Cox's proportional hazards models according to alcohol consumption categories. In the unadjusted analysis, falls hospitalization was significantly less likely in those with low, moderate and high intake compared to those with no alcohol intake (Model 1 and Figure 2). Following adjustment for age differences, the low intake and moderate intake groups remained significantly less likely to experience falls hospitalization compared to the no alcohol intake group. The high intake group was now significantly more likely to experience falls hospitalization

compared to the no alcohol intake group (Model 2). The relationship remained unchanged after additional adjustment for physical activity (Model 3) However, after adjustment for age, physical activity, stroke and diabetes, asthma and anti-depressant use the protective relationship of low alcohol intake with number of falls hospitalization against no alcohol intake was attenuated (Model 4). Moderate alcohol intake continued to be associated with reduced risk, while high intake remained deleterious after the latter adjustments. The above models suggest that the apparent lower likelihood of falls hospitalization among those with high alcohol intake over those with no alcohol intake in the unadjusted analysis was accounted for by age and gender differences. Additionally, the association of low intake with reduced falls compared to no alcohol intake appeared to be accounted for by differences in age, gender, presence comorbidities such as stroke, diabetes and physical activity. After adjusting for age, physical activity, stroke, diabetes, asthma, antidepressant use, the Townsend index, fish intake, fruit & vegetable consumption, low alcohol usage and moderate usage was still associated with a reduced risk of falls compared to non-consumers (Model 6). However after adjusting for age the reduction in falls risk in the low consumption group is no longer significant while the moderate consumption group remained significant (Model 7). For Model 8, in addition to the variables adjusted in Model 7 we also adjusted for the usage of medications such as aspirin, anti-hypertensive, and vitamin D; and the physical measurements of systolic and diastolic blood pressure, body mass index and prevalent cancer. Finally, when we further adjusted for differences in smoking status and educational level whereby moderate consumption remained significantly associated with a reduction in risk of falls hospitalization (Model 9). The sub-group analysis, as stated in the methodology, for those below 65 years and those 65 years and above,

found that the relationship was unchanged for those aged less than 65 but the relationship was no longer present for those aged 65 years and older (Supplementary Table 1 and Supplementary Table 2).

Table 3

Figure 2

Discussion

Our study has revealed a U-shaped relationship between alcohol consumption and falls hospitalization over a median follow-up period of 11.5 years, after adjustments for as many potential confounders as possible. We found that those with a moderate alcohol intake experienced a 12% relatively lower risk of falls hospitalization compared to those who abstained from alcohol after controlling for potential confounders. The effect of light alcohol usage on reduced falls risk was accounted for by gender differences, physical activity, a history of diabetes, and cerebrovascular disease. Heavy alcohol consumption, as defined by the UK Chief Medical Officer's guidelines of >28 units per week, was an independent predictor (40% increase in relative risk) of falls hospitalization over those who consumed no alcohol. Though the UK Chief Medical Officer's guideline now recommends <14 units per week for both men and women, our study shows that the risk of falls hospitalization is increased in those who drink ≤7 units per week and >28 units per week. Drinking > 14 units per week can be associated with increase health risks but the risk of falls hospitalization from does not increase until > 28 units per week. This must be cautiously interpreted, however in the light of current evidence.

Agahi and colleagues have shown that in the oldest old, abstaining from alcohol and heavy usage (>30 drinks/month) was associated with reduced survival.(23) However, our study found that no such effect in those aged 65 years and above even if it is present in those below the age of 65 years. The rationale for the reduced survival in those who abstained were two-fold, potential drug interaction with alcohol, and the association with alcohol consumption and social interaction, with social participation now considered a major protective factor against ill-health and mortality. It could be that in those aged 65 years at the outset within this study, either the effects of even mild and moderate alcohol consumption in this age group would have contributed to falls risk and therefore cancelling out any potential benefits of social inclusion. Over the long period of follow-up provided by this study those aged 65 years and over would have acquired an increasing number of comorbidities, which could then predominate over alcohol as factors which influence falls hospitalization risk.

Our study is the first to report hospitalization from falls rather than falls events in relation to alcohol consumption. Other studies have shown conflicting evidence. This is likely to have occurred because these studies assumed a rigid dichotomy either between those who consume alcohol and those who are abstinent or between those who drink heavily and those who don't. Hospitalization could be regarded as an indicator of the severity of the falls and captures falls that lead to complications such as fracture or other injuries, which are linked to morbidity, institutionalization, and death. Furthermore, hospitalization is also associated with major cost implications, with falls requiring hospitalizations regarded as an important health outcome. As alcohol consumption was determined using the food frequency questionnaire, the amount of

316 alcohol consumed could be considered as part of habitual intake (24) and results from
317 the Agahi and colleague's study showed that drinking habits over time do not
318 change(25). We were also able to control robustly for potential confounders. Falls
319 events in previous studies were mostly determined by the retrospective recall of falls,
320 which could be liable to reporting bias. Ganz had suggested that in order to overcome
321 this, information should be gathered weekly or monthly. (26) In this study however, the
322 falls hospitalization event was not dependent on self-report, but on objectively
323 documented hospital records, vetted by the clinicians, and therefore can be considered
324 hard outcomes. This will of course miss minor falls for which the patients were not
325 hospitalized but the main thrust of our study was falls sufficiently serious to warrant an
326 admission.
327
328 In another Swedish cohort study involving 20,212 participants, falls was
329 associated with increased age and reduced physical activity but the tendency to drink
330 was not associated with increased risk of falls. In this study, alcohol consumption was
331 categorized into those who did not drink, those who drank a little or moderately, and
332 those who drank heavily. (27) In a longitudinal analysis of five Australian cohorts
333 involving a total of 16,785 patients, alcohol categories were separated into abstinent,
334 <20g per day (low risk), 20g to 40g per day (long-term risk) and >40g per day (short-
335 term risk). Abstainers of both sexes in this study did have increased odds of falling in
336 the unadjusted models which was accounted for by depression, diabetes and if the
337 person was female or had musculoskeletal conditions (28) In another prospective cohort
338 study involving 5974 men a significant association with reduction in falls was shown
339 with light alcohol intake, which was defined as less than 14 units a week. (29) Our

study findings suggest that the conflicting evidence produced by previous studies could be explained by the biphasic relationship between alcohol consumption with consumption of alcohol within the recommended limits being associated with a reduction of falls hospitalization compared to no alcohol and excess alcohol intake.

The association of heavy alcohol intake with falls leading to injuries, such as fractures and subdural hemorrhage, thus leading to hospitalization is well established. In a previous study examining the etiology of traumatic brain injuries, alcohol intoxication and older age were associated with increasing likelihood of traumatic brain injury from ground level falls. (30) Alcohol intoxication also increases body movements spans and balance perturbations but reduces the ability to readjust postural alignment and this lead to an increase chance of injury. Functional magnetic resonance imaging studies have demonstrated that chronic alcohol excess is associated with structural and functional changes in areas of the brain responsible for motivation and behavioral control.

We observed the U-shaped relationship in which no or low alcohol consumption increases falls hospitalization and the reason is unclear. It could be that individuals in the no alcohol intake category had health issues or financial difficulties thus requiring the individuals to be abstinent. Conversely the observed association with falls reduction of moderate alcohol consumption may be due to a reduced level of other risk factors for falls such as polypharmacy.

Although we controlled for medical risk factors, we were not able to control adequately for residual confounding and known or unknown confounders which were

not adjusted for. While there are concerns of recall bias when asking for an alcohol history, according to Streppel and colleagues the use food frequency questionnaire showed high correlation with 24 hour recall.(24) To minimize this bias, participants were clearly shown what would constitute a unit of alcohol. Given the prospective relationship between exposure and outcome, it is unlikely that the results are due to reverse causality (i.e. people who fell consumed more alcohol as the result of falls history). Whilst we acknowledge the usual limitations of observational cohort studies such as potential healthy responder bias, EPIC-Norfolk sample is comparable to other representative UK cohorts and thus generalizable to the UK population as whole. The hospitalization outcomes were determined based on alcohol history obtained at baseline. Alcohol consumption may have changed over the 13-year follow-up period. However, this random over/underestimate is unlikely to have impact on the direction of results. Another limitation of this study, was the EPIC-Norfolk dataset for originally collected to determine the nutritional risk factors for cancer and because of that well known fall risk factors such as previous the history of falls, fear of falling, frailty status, physical performance and gait speed were not determined at the outset.

Our study confirms the deleterious effects of drinking to excess but it also suggests that the beneficial associations of alcohol extends beyond cardiovascular diseases. Therefore, we conclude that moderate alcohol consumption may be associated with a reduced risk hospitalization from falls but the mechanism by which it may exert this effect is still unknown. Future studies should be conducted to identify the mechanisms underlying potential beneficial effect of moderate alcohol. Our findings

suggest that the revised recommended safe consumption level of <14 units/week is less applicable than the previous levels of <28 units/week.

Acknowledgement

The EPIC-Norfolk study (DOI 10.22025/2019.10.105.00004) has received funding from the Medical Research Council (MR/N003284/1 and MC-UU_12015/1) and Cancer Research UK (C864/A14136). We are grateful to all the participants who have been part of the project and to the many members of the study teams at the University of Cambridge who have enabled this research. All authors have no conflict of interests to declare.

Disclosure Statement

All authors have no conflict of interests to declare. This manuscript has not been published or submitted for publication elsewhere.

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Figure Legend

Figure 1. Alcohol Consumption and Fall Hospitalization

Alcohol consumption and hospitalization due to falls for all participants and for those aged <65 years and ≥65 years. Hospitalization from falls appeared lower among groups who consumed more than 7 units of alcohol to less than and up to 28 units of alcohol per week for categories for all categories.

Figure 2. Kaplan Meier Survival Curve for Falls Hospitalization

Kaplan Meier survival curve for time to hospitalization due to falls for the four different alcohol consumption categories using unadjusted statistics. Unadjusted figures suggest that individuals who consume no alcohol were most likely to be hospitalized with falls, while those who consume >7 units but ≤28 units of alcohol per week were least likely to be hospitalized for falls.

Table Legend

Table 1 Basic Characteristics According to Alcohol Usage

Table 2: First Falls Hospitalization at Various Time Points

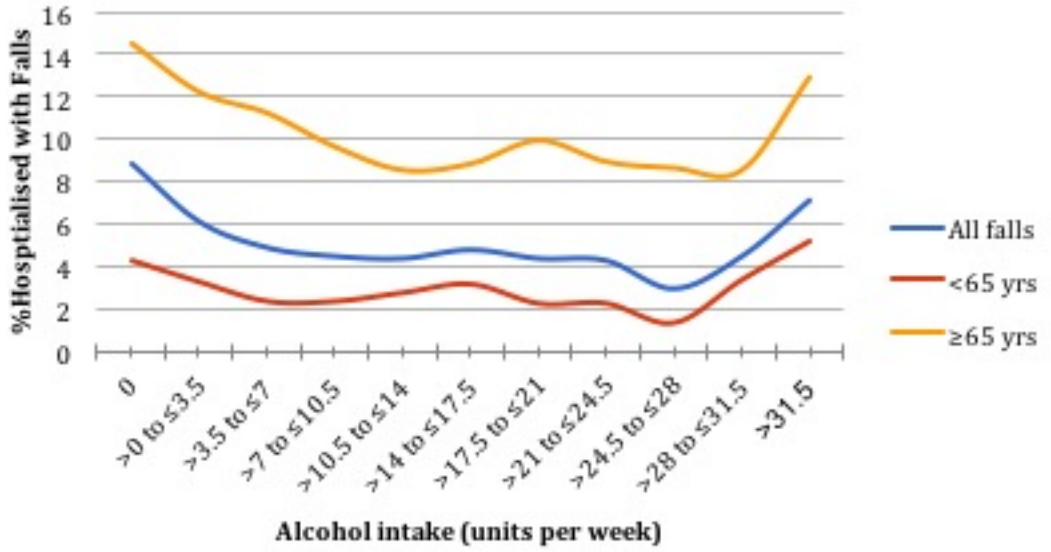
Table 3: Hazard Ratios for Falls Hospitalizations Adjusted for Various Potential Confounders

Supplementary Tables

Supplementary Table 1: Hazard Ratios for Falls Hospitalizations Adjusted for Various Potential Confounders aged below 65 Years

Supplementary Table 2: Hazard Ratios for Falls Hospitalizations Adjusted for Various Potential Confounders for Those Aged 65 Years and Above

Figure 1 Alcohol Consumption and Falls Hospitalization



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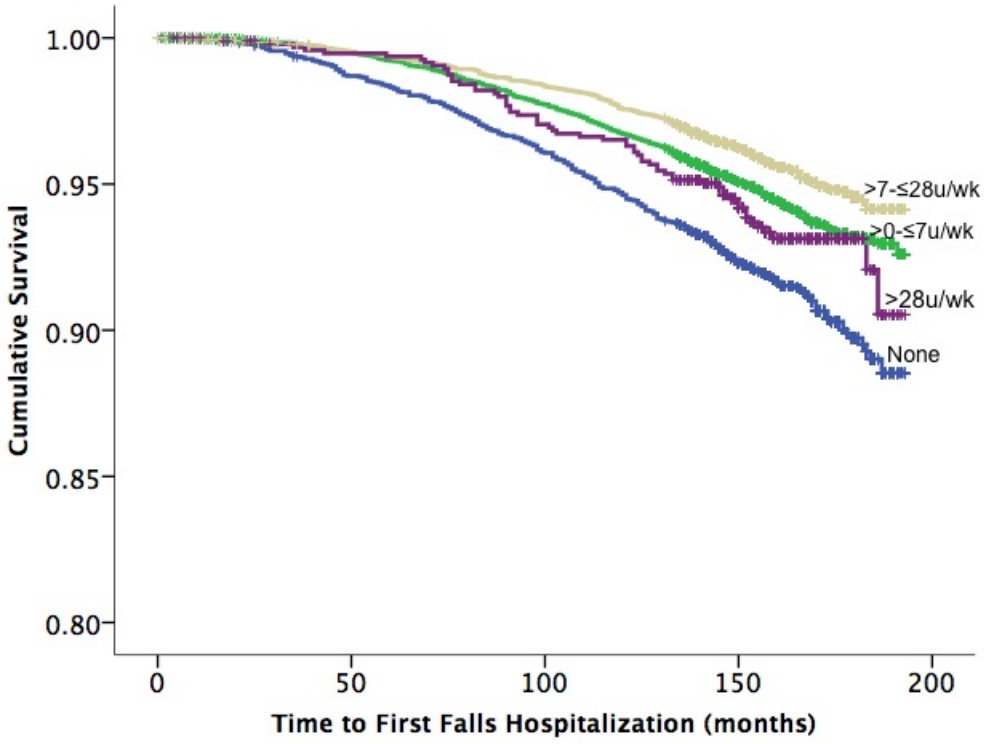

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Tables for Alcohol and Falls Hospitalizations

Table 1 Basic Characteristics According to Alcohol Usage

		Alcohol Usage				p-value
		0 units/ week (n=3638)	>0, ≤7 units/week (n=13675)	>7, ≤28 units/week (n=7367)	>28 units/week (n=959)	
Age (years), mean (standard deviation		62.15 (9.02)	59.17 (9.23)	58.22 (9.33)	57.07 (9.09)	<0.001
Female, n (%)		2478 (68.1%)	8577 (62.7%)	2885 (39.2%)	92 (9.6%)	<0.001
Physical activity, n (%)	Inactive	1564 (43.0%)	4076 (29.8%)	1957 (26.6%)	266 (27.7%)	<0.001
	Moderately inactive	912 (25.1%)	4035 (29.5%)	2146 (29.1%)	258 (26.9%)	
	Moderately active	660 (18.1%)	3179 (23.2%)	1744 (23.7%)	193 (20.1%)	
	Active	502 (13.8%)	2385 (17.4%)	1519 (20.6%)	242 (25.2%)	
Cigarette smoking, n (%)	Current	511 (14.0%)	1547 (11.3%)	936 (12.7%)	210 (21.9%)	<0.001
	Former	1183 (32.5%)	5151 (37.7%)	3839 (52.1%)	588 (61.3%)	
	Never	1944 (53.4%)	6977 (51.0%)	2592 (35.2%)	161 (16.8%)	
Occupation, n(%)	Professional	149 (4.1%)	833 (6.1%)	696 (9.4%)	76 (7.9%)	<0.001
	Managerial and Technical	918 (25.2%)	4504 (32.9%)	3287 (44.6%)	449 (46.8%)	
	Skilled non-manual	592 (16.3%)	2351 (17.2%)	1087 (14.8%)	109 (11.4%)	
	Skilled manual	921 (25.3%)	3293 (24.1%)	1374 (19.7%)	184 (19.2%)	
	Semi-skilled	673 (18.5%)	1908 (14.0%)	677 (9.2%)	103 (10.7%)	
	Unskilled	234 (6.4%)	496 (3.6%)	135 (1.8%)	20 (2.1%)	
Myocardial infarction, n (%)		135 (3.7%)	417 (3.0%)	223 (3.0%)	32 (3.3%)	0.197
Cerebrovascular accident, n (%)		95 (2.6%)	159 (1.2%)	96 (1.3%)	13 (1.4%)	<0.001
Cancer, n (%)		226 (6.2%)	775 (5.7%)	374 (5.1%)	35 (3.6%)	0.004
Diabetes mellitus, n (%)		149 (4.1%)	289 (2.1%)	132 (1.8%)	18 (1.9%)	<0.001

Asthma, n (%)		339 (9.3%)	1130 (8.3%)	611 (8.3%)	83 (8.7%)	0.217
Anti-depressant, n (%)		292 (8.0%)	610 (4.5%)	255 (3.5%)	30 (3.1%)	<0.001
Aspirin, n (%)		322 (8.9%)	929 (6.8%)	601 (8.2%)	86 (9.0%)	<0.001
Statin, n (%)		31 (0.9%)	152 (1.1%)	69 (0.9%)	7 (0.7%)	0.325
Anti-hypertensive, n (%)		994 (27.3%)	2506 (18.3%)	1179 (16.0%)	144 (15.0%)	<0.001
Vitamin D, n (%)		1020 (28.0%)	4407 (32.2%)	7367 (30.7%)	224 (23.4%)	<0.001
Education level, n (%)	None	2010 (55.4%)	5397 (39.5%)	1820 (24.7%)	229 (23.9%)	<0.001
	O-level	308 (8.5%)	1457 (10.7%)	768 (10.4%)	97 (10.1%)	
	A-level	1074 (29.5%)	5339 (39.0%)	3386 (46.0%)	459 (47.9%)	
	Degree	240 (6.6%)	1482 (10.8%)	1393 (18.9%)	174 (18.1%)	
Mean systolic blood pressure, mmHg (s.d.)		138.2 (19.3)	134.7 (18.4)	135.0 (17.9)	140.2 (17.3)	<0.001
Mean diastolic blood pressure, mmHg (s.d.)		83.2 (11.6)	81.9 (11.1)	82.8 (11.1)	87.1 (11.3)	<0.001
Mean body mass index (s.d.)		26.80 (4.44)	26.32 (4.01)	26.16 (3.45)	26.97 (3.60)	<0.001
Mean waist-hip ratio (s.d.)		0.85 (0.09)	0.84 (0.09)	0.87 (0.09)	0.93 (0.07)	<0.001
Townsend Index (s.d.)		-1.73 (2.34)	-2.08 (2,13)	-2.17 (2.08)	-1.74 (2.39)	<0.001
Fruit intake (s.d.)		264 (220)	256 (186)	234 (172)	168 (159)	<0.001
Vegetable intake (s.d.)		270 (163)	271 (134)	272 (123)	265 (126)	0.445
Fish intake (s.d.)		36 (28)	37 (25)	40 (27)	39 (25)	<0.001

s.d.=standard deviation

Table 2: First Falls Hospitalization at Various Time Points

Alcohol consumption (units/week)	Time Points (months)	No. at risk	No. falls hospitalization	Cumulative incidence function (%) (95%CI)
None	0-12	3,638	2	0.04 (0.01-0. 22)
	12-36	3,625	21	0.64 (0.42-0.95)
	37-60	3,588	36	1.63 (1.27-2.10)
	61-120	3,551	132	5.29 (4.61-6.07)
	121-180	3,419	124	11.08 (9.94-12.35)
>0, ≤7 units/week	0-12	13,674	3	0.02 (0.01-0.07)
	13-36	13,632	27	0.22 (0.15-0.32)
	37-60	13,551	74	0.77 (0.63-0.93)
	61-120	13,477	337	3.25 (2.96-3.56)
	120-180	13,140	343	7.53 (7.02-8.08)
>7, ≤28 units/week	0-12	7,365	2	0.03 (0.01-0.11)
	13-36	7,353	14	0.22 (0.13-0.36)
	37-60	7,317	29	0.61 (0.46-0.82)
	61-120	7,284	131	2.40 (2.07-2.78)
	120-180	7,153	148	5.91 (5.29-6.59)
>28 units/week	0-12	959	0	0
	13-36	954	3	0.32 (0.10-0.98)
	37-60	944	3	0.63 (0.28-1.40)
	61-120	941	27	3.48 (2.49-4.87)
	120-180	914	26	8.20 (6.35-10.56)
Any Alcohol Use (>0 units/week)	0-12	21,998	5	0.02 (0.01-0.05)
	13-36	21,939	44	0.22 (0.17-0.30)
	37-60	21,812	106	0.71 (0.61-0.83)
	61-120	21,702	495	2.97 (2.76-3.21)
	121-180	21,207	517	7.02 (6.63-7.43)

Table 3: Hazard Ratios for Falls Hospitalizations Adjusted for Various Potential Confounders

	Hazards Ratio (95% Confidence Interval)			
	0 unit/week (no alcohol)	>0-7.0units/week (low)	>7.0-28 units/week (moderate)	>28 units/week (heavy)
Model 1	reference	**0.70 (0.64-0.77)**	**0.54 (0.49-0.60)**	**0.66 (0.54-0.80)**
Model 2	reference	**0.87 (0.80-0.95)**	**0.71 (0.64-0.79)**	0.95 (0.78-1.15)
Model 3	reference	**0.88 (0.80-0.96)**	**0.72 (0.65-0.80)**	0.96 (0.78-1.17)
Model 4	reference	**0.89 (0.81-0.97)**	**0.73 (0.66-0.81)**	0.97 (0.79-1.18)
Model 5	reference	**0.90 (0.82-0.98)**	**0.74 (0.67-0.82)**	0.97 (0.80-1.19)
Model 6	reference	**0.90 (0.82-0.98)**	**0.75 (0.67-0.83)**	1.00 (0.82-1.22)
Model 7	reference	0.93 (0.85-1.02)	**0.88 (0.79-0.98)**	**1.39 (1.13-1.17)**
Model 8	reference	0.94 (0.85-1.03)	**0.88 (0.79-0.99)**	**1.40 (1.14-1.73)**
Model 9	reference	0.93 (0.85-1.02)	**0.89 (0.79-0.99)**	**1.40 (1.14-1.72)**

Bold letters indicate statistical significance

Model 1=unadjusted

Model 2=adjusted for age

Model 3=adjusted for age, and physical activity

Model 4=adjusted for age, physical activity, stroke, diabetes, asthma and antidepressant use.

Model 5=adjusted for age, physical activity, stroke, diabetes, asthma, antidepressant use, and Townsend index.

Model 6= adjusted for age, physical activity, stroke, diabetes, asthma, antidepressant use, Townsend index, fish intake and fruit and vegetable consumption.

Model 7= adjusted for age, physical activity, stroke, diabetes, asthma, antidepressant use, Townsend index, fish intake, fruit and vegetable consumption, and gender.

Model 8= adjusted for age, physical activity, stroke, diabetes, asthma, antidepressant use, Townsend index, fish intake and fruit & vegetable consumption, gender, aspirin usage, anti-hypertensive medication use, vitamin D supplementation, systolic and diastolic blood pressure, body mass index, waist-hip ratio, and prevalent cancer.

Model 9 = adjusted for age, physical activity, stroke, diabetes, asthma, antidepressant use, Townsend index, fish intake and fruit & vegetable consumption, gender, aspirin usage, anti-hypertensive medication use, vitamin D supplementation, systolic and diastolic blood pressure, body mass index, waist-hip ratio, and prevalent cancer, smoking status, educational status.

The Relationship between Alcohol Intake and Falls Hospitalization: Results from the EPIC-Norfolk

Supplementary Tables and Figures

Supplementary Table 1: Measurements

Smoking history	
"Have you ever smoked as much as one cigarette a day for as long as a year?"	Yes No
"Do you smoke cigarettes now?"	Yes No
EPIC short physical activity questionnaire (in the last one year)	
Occupational activity	Sedentary Standing Manual work Heavy manual work
Participation in walking, cycling, do-it-yourself, gardening, sports, household chores	None ≤ 3.5 hours/week >3.5 to ≤7.0 hours/week >7.0 hours/week
Participation in vigorous non-occupational activities	None ≤ 3.5 hours/week >3.5 to ≤7.0 hours/week >7.0 hours/week
Number of floors of stairs climbed a day	
Educational status (the highest attainment was recorded as follows)	
No qualification	
O-level (five years of secondary education)	
A-level (sixth form or college)	
Degree or higher qualification	

Townsend Deprivation Index	
Percentage of households with fewer rooms than persons and	
Percentage of households lacking a car	
Percentage of economically active persons seeking work	
Percentage of children aged 5 to 15 who received school meals free	
Percentage of households experiencing disconnection of electricity in the previous 12 months	
Weekly Intake of fresh fruits, green leafy vegetables, and other vegetables	
Weekly intake of fresh fruits	Never Seldom Once a week 2-3 times a week 5-6 times a week Once or more daily Don't know
Weekly intake of green leafy vegetables	Never Seldom Once a week 2-3 times a week 5-6 times a week Once or more daily Don't know
Weekly intake of other vegetables	Never Seldom Once a week 2-3 times a week 5-6 times a week Once or more daily Don't know