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Prevalence of alcohol and other drug use in patients presenting to hospital for fall-related injuries: a systematic review

Georgina Lau ,[1] Jia Ying Ang,[1] Nayoung Kim,[1] Belinda J Gabbe,[1,2] Biswadev Mitra,[1,3,4] Paul M Dietze,[1,5,6] Sandra Reeder,[1,7] Ben Beck [1,8]

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[1]School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia
[2]Health Data Research UK, Swansea University, Swansea, UK
[3]National Trauma Research Institute, The Alfred Hospital, Melbourne, Victoria, Australia
[4]Emergency and Trauma Centre, The Alfred Hospital, Melbourne, Victoria, Australia
[5]Behaviours and Health Risks Program, Burnet Institute, Melbourne, Victoria, Australia
[6]National Drug Research Institute, Curtin University, Perth, Western Australia, Australia
[7]Central Clinical School, Monash University, Melbourne, Victoria, Australia
[8]Faculty of Medicine, Laval University, Quebec City, Quebec, Canada

Correspondence to
Dr Ben Beck, School of Public Health and Preventive Medicine, Monash University, Melbourne, VIC 3800, Australia; ben.beck@monash.edu

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ABSTRACT

Background Alcohol and other drug (AOD) use is a key preventable risk factor for serious injuries. Prevention strategies to date have largely focused on transport injuries, despite AOD use being a significant risk factor for other injury causes, including falls. This systematic review aimed to report the prevalence of AOD use in patients presenting to hospital for fall-related injuries.

Methods This systematic review includes studies published in English after the year 2010 that objectively measured the prevalence of AOD use in patients presenting to hospital for a fall-related injury. Screening, data extraction and risk of bias assessments were completed by two independent reviewers. Data were presented using narrative synthesis and, where appropriate, meta-analyses.

Results A total of 12 707 records were screened. Full texts were retrieved for 2042 records, of which 29 were included. Four studies reported the combined prevalence of any alcohol and/or drug use, generating a pooled prevalence estimate of 37% (95% CI 25% to 49%). Twenty-two records reported on the prevalence of acute alcohol use alone and nine reported specifically on the prevalence of drugs other than alcohol, with prevalence ranging from 2% to 57% and 7% to 46%, respectively. The variation in prevalence estimates likely resulted from differences in toxicology testing methods across studies.

Conclusions AOD exposure was common in hospitalised fall-related injuries. However, research addressing prevalence across different types of falls and the use of drugs other than alcohol was limited. Future research should address these areas to improve our understanding of which populations should be targeted in AOD and injury prevention strategies .

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INTRODUCTION

Falls are a leading cause of injury globally and can lead to substantial morbidity and mortality for people of all ages.[1] Beyond the initial physical harm associated with injury, falls can lead to long-term disabilities that require ongoing and costly care.[2] Such injuries can also have considerable effects on mental health through their impact on an individual's independence and quality of life.[3]

One of the key preventable risk factors for serious injuries, including fall-related injuries, is alcohol and other drug (AOD) use. Acute AOD use is often associated with impairments in physical coordination, balance, risk perception and decision making, all of which may increase the risk of fall-related injuries.[4 5] Furthermore, AOD use can be associated with unstable moods, anxiety and suicidal behaviours, potentially increasing the risk of intentional falls.[4 5] Previous research has demonstrated a linear dose–response relationship between acute alcohol use and the risk of fall-related injuries, with the odds of injury increasing by 25% for every 10 g of alcohol consumed.[6] Alcohol-related falls are also associated with a distinct injury pattern, with intoxicated patients being more likely to sustain serious craniofacial injuries compared with non-intoxicated patients.[7]

While a systematic review reported that 17%–53% of non-fatal falls involved exposure to alcohol in studies published between 1950 and 1987,[8] research addressing the prevalence of drugs other than alcohol remains limited. A key exception to this is research examining the relationship between psychotropic medications and falls in older adults.[9 10] These medications, commonly referred to as falls risk increasing drugs, include antipsychotics, antidepressants, anxiolytics, sedatives and hypnotics. The prevalence of falls risk increasing drugs can be as high as 65%–93% in older patients presenting to hospital after falls[11] and depending on the drug, can double the odds of an injurious fall.[10] However, this research commonly relies on information from prescriptions, which may not represent acute use (eg, in the case of prescription drug misuse), or account for tolerance effects.

Research to date on AOD use and injury has largely focused on motor vehicle collisions.[12] Comparatively, non-transport injury causes have received less attention despite studies reporting similar, if not higher, AOD involvement in non-transport injuries such as falls.[13] This systematic review aimed to report on the prevalence of acute AOD use in individuals presenting to hospital for fall-related injuries.

METHODS

This manuscript reports on part of a larger systematic review examining the testing and prevalence of AOD involvement in injury events of all causes, excluding transport events. This review focuses specifically on studies that reported fall-related injuries. Patients or the public were not involved in the design, reporting or dissemination of this review.

Search strategy

Systematic searches were conducted on four electronic databases (Medline, Embase, CINAHL and PsycINFO) on 11 May 2020. Searches used a combination of keywords and subject headings related to injury and AODs (see online supplemental appendix A for an example). Grey literature was identified through a series of nine advanced Google searches using keywords related to injury, alcohol and various other drug types (online supplemental appendix A), and through a database search on ProQuest. Google searches were restricted to PDF file types in English to help capture relevant health or government reports. The first 100 results from each Google search were screened.[14] The reference lists of included studies were also searched for eligible studies.

Inclusion and exclusion criteria

This review was restricted to observational studies published in English from the year 2010 onwards. Given that trends in AOD use have shifted significantly over time,[15 16] this enabled more recent and therefore relevant prevalence research to be identified. The inclusion criteria were: (1) Participants aged ≥15 years who presented to hospital for fall-related injuries and (2) Use of an objective AOD measure to report prevalence (eg, a blood, urine or breath test). AOD use was broadly defined to include both illicit and licit drugs, including prescription medications, but excluding nicotine and tobacco. Given the differences in protocol and timing between AOD testing in hospital and forensic settings, forensic studies were excluded. Studies that examined mixed injury cohorts were included if the prevalence of AOD use in falls could be ascertained.

Study selection

Two reviewers (GL and JYA) independently screened the titles and abstracts of all identified records. Full texts were screened for any record classified as potentially relevant by either reviewer, and included if both reviewers deemed the record to be relevant. Disagreements were resolved through discussion. Reference list screening was completed by GL.

Data extraction

Data were extracted for relevant records by two reviewers (GL and either JYA or NK) using a customised form. Extracted data included: (1) first author; (2) publication year; (3) country; (4) study design, duration and setting; (5) study aims; (6) sample size; (7) recruitment methods; (8) study inclusion and exclusion criteria; (9) sample characteristics (age, sex, socioeconomic status); (10) injury characteristics (cause, type and severity of injury); (11) non-acute AOD use (including any measures related to current prescription medications, usual AOD use or AOD dependence); (12) definition of acute AOD use; (13) proportion of sample tested; (14) method and timing of AOD testing and (15) prevalence of acute AOD use.

Risk of bias assessment

Risk of bias was independently assessed by two reviewers (GL and either JYA or NK) using the Joanna Briggs Institute Checklist for Prevalence Studies, which is a validated, nine-item critical appraisal tool used for assessing prevalence data across various study designs.[17] Following the methods of Ekegren *et al*,[18] the item assessing sample size was deemed irrelevant due to the descriptive nature of prevalence data. Non-response bias was assessed as high if refusals exceeded 25%.[18 19] Detailed criteria for assessing risk of bias are available in online supplemental appendix B. Disagreements between reviewers were resolved through discussion.

Quality of evidence

Consistent with existing recommendations,[20] Grading of Recommendations, Assessment, Development and Evaluations (GRADE) guidelines[21] were used to assess the quality of evidence across studies as high, moderate, low or very low. Following the methods of Chiarotto *et al*,[22] meta-analyses were initially coded as high quality but could be downgraded based on the following criteria:

1. Risk of bias: Downgrade if at least half of the included studies have high risk of bias.
2. Inconsistency: Downgrade is there is substantial heterogeneity (ie, I^2 ≥60%).
3. Precision: Downgrade if there are <400 participants in the pooled sample.
4. Indirectness: Downgrade if subject characteristics and prevalence cannot be generalised.
5. Publication bias: Only assess if ≥10 studies are included in the analysis.

Data synthesis

Narrative synthesis was used to summarise and compare the findings of relevant studies. Prevalence was reported as proportions, using the number of people who tested positive as the numerator and the total number of people who were tested as the denominator. Where these data were unavailable, prevalence was reported as included in the original study.

Meta-analyses were performed using the metaprop command in Stata V.5 (Statacorp), stratified by AOD type. The metaprop command generates a pooled prevalence estimate with corresponding 95% CIs using the exact binomial method and Freeman-Tukey double arcsine transformations and presents results as a forest plot.[23] Heterogeneity was assessed using the I^2 statistic and was considered significant where $p<0.05$. Subgroup analyses were performed to explore potential sources of heterogeneity. Where multiple papers reported on the same outcome using overlapping datasets, only one was selected for inclusion in meta-analyses based on sample size, publication date and completeness of the data presented.

RESULTS

Overview of included studies

For all causes of injury (excluding transport events), 14 604 records were identified including 10 756 from database searches and 3848 from other sources (figure 1). After removing duplicates, 12 707 records were screened, of which 2042 records underwent full-text screening. There were 100 records that reported on the prevalence of AOD involvement in injury events. Of the 100 records that reported on all causes of injury (excluding transport events), 30 studies reported on the prevalence of AOD involvement in patients presenting to hospital after falls.[24–52] One of these studies was excluded, since it reported exclusively on patients who denied consuming alcohol in the past year.[38] Therefore, 29 studies were included in this review.

Twenty-two independent cohorts were reported on across the 29 records. Multiple papers reported findings from the Trondheim traumatic brain injury (TBI) (n=2),[29 46] TRACK-TBI (n=2)[51 52] and MOTIVA (n=2) studies.[33 34] Additionally, several papers examined overlapping datasets, including two studies each from the National Trauma Data Bank in the USA,[27 44] the Oslo University Hospital Emergency Department,[25 30] the R

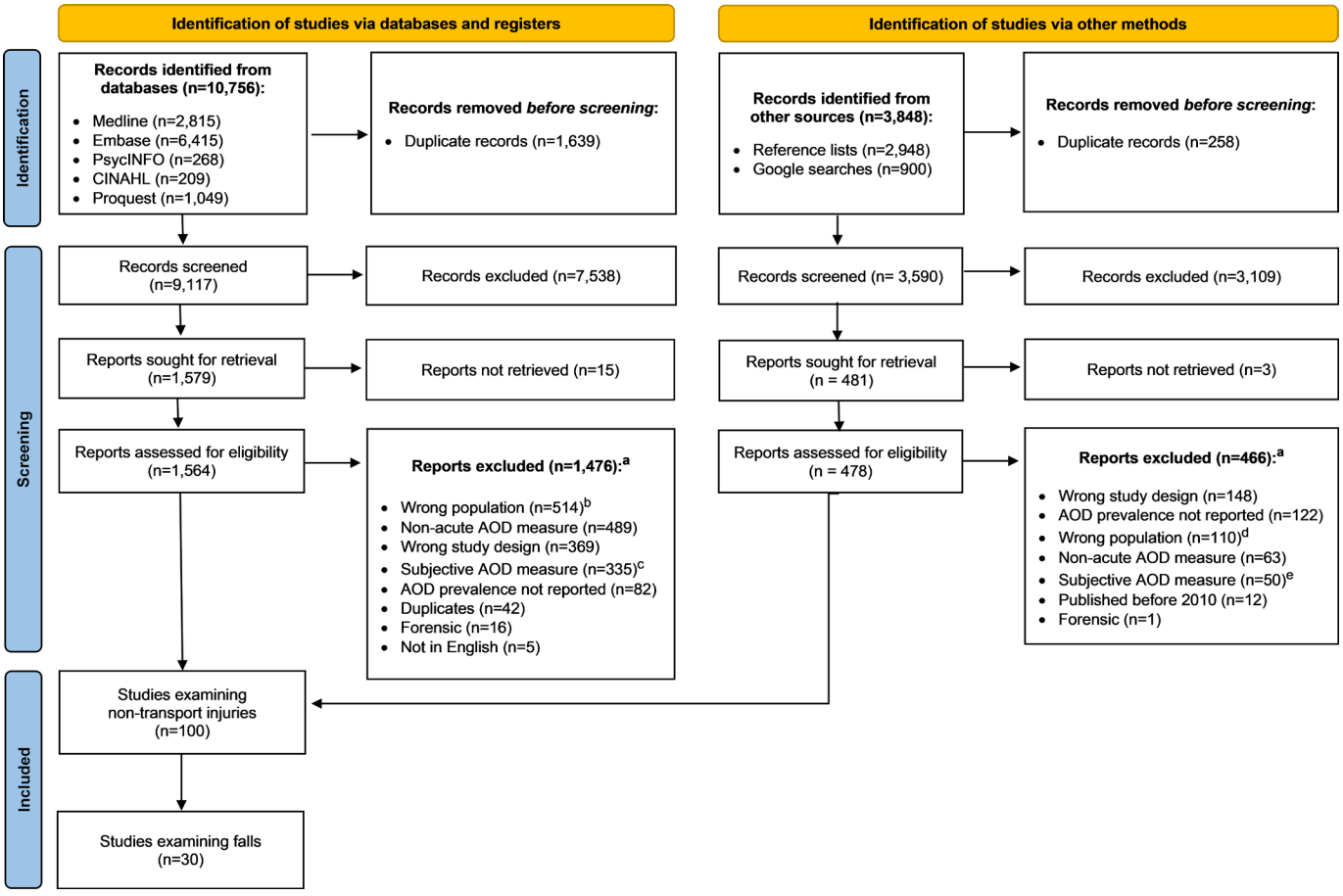

Figure 1 PRISMA flow chart. (a) Records could have met multiple exclusion criteria. (b) Included patients <15 years of age or did not report the minimum age of included patients (n=343), did not include injury patients presenting to hospital (n=243), animal studies (n=2). (c) Measure unclear (n=197), self-report (n=118), clinician judgement (n=20). (d) Included patients <15 years of age or did not report the minimum age of included patients (n=68), did not include injury patients presenting to hospital (n=45), animal studies (n=3). (e) Measure unclear (n=31), self-report (n=14), clinician judgement (n=5). AOD, alcohol and other drug; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Adams Cowley Shock Trauma Centre[24 48] and a trauma centre in Taiwan.[32 45] Two papers obtained data from the Los Angeles County database, but used datasets with non-overlapping timeframes.[26 49]

Studies were predominantly from the USA (13 studies).[24 26–28 31 36 39 41–44 48–52] There were two studies from Norway,[25 29 30 46] and one each from Bhutan,[35] Ghana,[37] Spain,[33 34] Taiwan,[32 45] Tanzania[45] and the UK.[40] One additional record compiled data from 22 studies across 10 countries from North and South America including Canada, the USA, Mexico, Brazil, Argentina, the Dominican Republic, Guatemala, Guyana, Nicaragua and Panama.[53] While most records reported on mixed injury cohorts, nine specifically examined patients with TBI.[24 28 29 42 44 46 49 51 52] Key characteristics for each paper are provided in table 1 and online supplemental appendix C.

Risk of bias

Risk of bias assessments for each study are shown in table 2 and discussed in detail in online supplemental appendix D. The risk of sampling bias was low overall. However, the risk of coverage, measurement and attrition biases were often unclear. While most studies clearly reported sample characteristics, approximately one-third of studies did not report prevalence with sufficient detail.

Any AOD involvement

Six records reported on the prevalence of any alcohol and/or drug involvement in falls, with prevalence ranging from 25% to 53% (table 3).[25 30 33 34 39 41] Two papers reported on the MOTIVA study[33 34] and two reported on overlapping cohorts from the Oslo University Hospital.[25 30] For the MOTIVA study, which involved systematic AOD screening in trauma patients to determine eligibility for a brief intervention to reduce trauma recidivism, Cordovilla-Guardia *et al*[34] was included in meta-analyses as it reported on a larger subset of the total MOTIVA study population compared with the other paper from this study.[33] For the studies from the Oslo University Hospital, Bakke *et al*[25] was included despite reporting on a smaller sample as it was more recent and included more complete prevalence data compared with Bogstrand *et al*.[30] Missing toxicology data ranged from 11% to 54% across the six papers (table 3).

Meta-analysis of the four studies (pooled n=4292) generated a pooled prevalence estimate of 37% (95% CI 25% to 49%; figure 2). While this model had significant heterogeneity (I^2=96.4%, p<0.01), this heterogeneity was resolved when Martin *et al*[39] was omitted from the analysis (pooled n=935, I^2=0%, p=0.51), after which the pooled prevalence increased slightly to 40% (95% CI 37% to 43%; Figure 2). This heterogeneity likely occurred because Martin *et al*[39] used the total number of patients with fall-related injuries

Table 1 Characteristics of included studies*

First author (year)[ref]	Country (Study duration)	Age range (years)	Male, n (%)	Injury type	Injury severity
Albrecht (2018)[24]	USA (NR)	≥18	783 (72.2)	Isolated TBI	n (%): AIS 3=262 (24), AIS 4=466 (43), AIS ≥5=356 (33)
Bakke (2016)[25]	Norway (1 year)	≥18	618 (62.0)	Mixed injuries	NR
Banks (2019)[26]	USA (1 January 2012–21 December 2016)	≥16	16 035 (75.4)	Mixed injuries	Median ISS (IQR)=5 (2–11)
Benson (2018)[27]	USA (2007–2012)	≥18	22 891 (80.7)	Mixed injuries requiring laparotomy	Mean ISS (SD)=20.2 (15)
Bernier (2016)[28]	USA (January 1992–December 2009)	≥18	8389 (70.2)	Moderate to severe TBI	NR
Bjarkø (2019)[29]	Norway (1 October 2004–30 September 2014)	≥16	365 (74)	Moderate to severe TBI	Median GCS score (IQR)=8 (4–12)
Bogstrand (2011)[30]	Norway (December 2007–December 2008)	≥18	762 (59.9)	Mixed injuries	NR
Chippendale (2017)[31]	USA (November 2013–May 2015)	>55	299 (42.1)†	Mixed injuries	NR
Chuang (2016)[32]	Taiwan (January 1 2009–December 31 2013)	NR	1194 (45.4)	n(%): head/neck=585 (22), face=166 (6), thorax=194 (7), abdomen=147 (6), extremity=2009 (76)	Median ISS (range): obese=9 (1–45), normal=9 (1–50)
Cordovilla-Guardia (2017)[33]	Spain (32 non-consecutive months between November 2011 and March 2015)	16–70	194 (80.2)	Mixed injuries	Median ISS (IQR)=19 (14–26)
Cordovilla-Guardia (2018)[34]	Spain (31 non-consecutive months between November 2011 and June 2015)	16–70	612 (65.88)	Mixed injuries	n (%): Mild (ISS 1–8)=698 (75.1), moderate (ISS 9–15)=161 (17.3), severe (ISS ≥16)=70 (7.5)
Dorji (2017)[35]	Bhutan (April 8 2015–October 21 2015)	NR	NR	Mixed injuries	n (%): No apparent injury=36 (11), minor or superficial=144 (43), moderate=147 (43), severe=8 (2)
Ekeh (2014)[36]	USA (January 2006–December 2010)	≥65	728 (55.9)*	Mixed injuries	Mean ISS (SD): Substance use=12.8 (8.8), no substance use=14.3 (9.2)
Forson (2016)[37]	Ghana (November 3 2014–April 11 2015)	≥18	756 (70)	Mixed injuries	n (%) maximum AIS≥3=311 (28.7)
Martin *et al* (2017)[39]	USA (September 2013–March 2015)	>17	6810 (66.8)	Blunt trauma	Mean ISS (SD)=11 (10)
McAllister (2013)[40]	UK (January 2011–January 2012)	>16	NR	Maxillofacial injuries	NR
McLaughlin (2017)[41]	USA (March 2012–May 2014)	≥18	233 (61.5)	Mixed injuries	Mean ISS (SD)=12.1 (8.3)
Nguyen (2014)[42]	USA (January 1 2010–December 31 2012)	≥15	349 (78.3)	TBI	Mean ISS (SD)=20.8 (10.9)
Nweze (2016)[43]	USA (January 2013–December 2013)	15–70	527 (71.4)	Mixed injuries	Mean ISS (SD)=7.37 (7.01)
Pandit (2014)[44]	USA (2007–2010)	≥18	16 045 (66.9)	Isolated severe blunt TBI	AIS≥4
Peng (2016)[45]	Taiwan (January 1 2009–December 31 2014)	20–65	6934 (62.8)	Mixed injuries	Median ISS (IQR): Intoxicated=10 (5.17), not intoxicated=5 (4.9)
Rundhaug (2015)[46]	Norway (October 2004–October 2011)	16–70	206 (77.7)	Moderate to severe TBI	Median ISS (IQR): BAC measured=25 (17-32), BAC not measured=25 (17-29)
Staton (2018)[47]	Tanzania (August 5 2013–July 21 2014)	≥18	394 (76.4)	n(%): Fracture=185 (35.8), Dislocation=80 (15.5), Open wound=197 (38.2), Bruise=111 (22.5), Concussion=149 (28.9), Organ injury=56 (10.9)	Mean Kampala Trauma Score (SD)=14.3 (0.9)
Strong (2016)[48]	USA (January 1997–December 2008)	≥18	4980 (66.8)	Hip fractures=578 (7.7)	n(%): ISS 1–8=3,849 (51.0), ISS 9–15=1,651 (21.9), ISS 16–24=1,050 (13.9), ISS 25–49=663 (8.8), ISS ≥50=32 (0.4), ISS missing=296 (3.9)
Talving (2010)[49]	USA (2003)	18–64	692 (84.9)	Severe isolated TBI	Mean ISS (SD): 7.5 (6.8)
Valdez (2016)[50]	USA (1 January 2012–31 December 2012)	≥18	977 (70.0)	Mixed injuries	Mean ISS (SD)=7.5 (6.8)

Continued

Table 1 Continued

First author (year)[ref]	Country (Study duration)	Age range (years)	Male, n (%)	Injury type	Injury severity
Ye (2013)[53]	Canada (1989–2009)	NR	NR	NR	NR
	USA (1985–1996)				
	Brazil (2001)				
	Argentina (2001)				
	Dominican Republic (2010–2011)				
	Guatemala (2010–2011)				
	Guyana (2010–2011)				
	Mexico (1986–2002)				
	Nicaragua (2010–2011)				
	Panama (2010–2011)				
Yue (2017)[51]	USA (2010–2012)	≥18	72 (67.3)	Blunt, uncomplicated mild TBI	n (%): GCS 13=5 (4.7), GCS 14=33 (30.8), GCS 15=69 (64.5)
Yue (2020)[52]	USA (2010–2012)	≥16	NR (68.4)	TBI	n (%): GCS<15=71 (53.4), GCS 15=60 (45.1)

*See online supplemental appendix C for additional study characteristics including socioeconomic status, non-acute AOD use, injury type and injury severity.
†Some values were estimated using available data.
AIS, Abbreviated Injury Scale; BAC, blood alcohol concentration; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; NR, not reported; TBI, traumatic brain injury.

Table 2 Risk of bias assessments

First author (year)[reference]	Criteria* 1	2	3	4	5	6	7	8	9
Albrecht (2018)[24]	+	+	NA	+	+	+	?	+	NA
Bakke (2016)[25]	+	+	NA	+	+	+	+	+	+
Banks (2019)[26]	+	+	NA	+	?	+	–	?	NA
Benson (2018)[27]	+	+	NA	+	?	+	–	+	NA
Bernier (2016)[28]	+	+	NA	+	?	+	?	+	NA
Bjarkø (2019)[29]	+	+	NA	+	–	+	?	–	+
Bogstrand (2011)[30]	+	+	NA	+	+	+	+	–	+
Chippendale (2017)[31]	+	+	NA	+	?	+	?	–	NA
Chuang (2016)[32]	+	+	NA	+	?	+	?	+	NA
Cordovilla-Guardia (2017)[33]	+	+	NA	+	–	+	+	+	?
Cordovilla-Guardia (2018)[34]	+	+	NA	+	–	+	+	+	?
Dorji (2016)[35]	+	?	NA	–	+	+	+	+	+
Ekeh (2014)[36]	+	+	NA	+	–	+	?	–	NA
Forson (2016)[37]	+	+	NA	+	?	+	–	+	NA
Martin (2017)[39]	+	+	NA	+	?	+	–	–	?
McAllister (2013)[40]	+	+	NA	–	+	+	+	+	+
McLaughlin (2017)[41]	+	+	NA	+	–	+	–	+	?
Nguyen (2014)[42]	+	+	NA	+	–	+	?	+	NA
Nweze (2016)[43]	+	?	NA	+	?	+	+	+	NA
Pandit (2014)[44]	+	+	NA	+	?	+	?	–	NA
Peng (2016)[45]	+	+	NA	+	?	+	–	–	NA
Rundhaug (2015)[46]	+	+	NA	+	+	+	?	+	?
Staton (2018)[47]	+	+	NA	+	+	+	+	+	+
Strong (2016)[48]	+	+	NA	+	–	+	?	+	NA
Talving (2010)[49]	+	+	NA	+	+	+	?	–	NA
Valdez (2015)[50]	+	+	NA	+	?	+	?	+	NA
Ye (2013)[53]	+	?	NA	–	–	+	?	–	?
Yue (2017)[51]	+	+	NA	+	–	+	?	+	?
Yue (2020)[52]	+	+	NA	+	–	+	?	+	?

Symbols: '+' indicates low risk of bias, '–' indicates high risk of bias, '?' indicates unclear risk of bias, 'NA' indicates not applicable.
*Risk of bias criteria: 1. Was the sample frame appropriate to address the target population? 2. Were study participants sampled in an appropriate way? 3. Was the sample size adequate? 4. Were the study subjects and the setting described in detail? 5. Was the data analysis conducted with sufficient coverage of the identified sample? 6. Were valid methods used for the identification of the condition? 7. Was the condition measured in a standard, reliable way for all participants? 8. Was there appropriate statistical analysis? 9. Was the response rate adequate, and if not, was the low response rate managed appropriately?.

as the denominator, despite AOD testing being performed at the discretion of each of the 17 sites that contributed to the study sample. Furthermore, Martin *et al*[39] defined intoxication as a blood alcohol concentration (BAC) >0.08%, while the other studies used thresholds ranging from BAC >0% to BAC >0.03% to define alcohol use, likely resulting in a lower prevalence estimate.

Since heterogeneity was accounted for, the pooled sample was greater than 400 participants, and all studies examined broad injury cohorts, quality of the evidence was not downgraded for inconsistency, imprecision or indirectness. Publication bias was not assessed, as less than 10 studies were included. However, three studies had either considerable levels of missing AOD data or only completed AOD testing at the discretion of clinicians, which may have biased results.[34 39 41] Therefore, based on GRADE criteria, quality of the evidence was assessed as moderate.

Table 3 Prevalence of any alcohol or other drug use in patients presenting to hospital for injurious falls

First author (year)[ref]	Country (study duration)	Sample type	Proportion tested, n/N (%)	Patients with fall-related injuries, n/Total patients in the study, N (%)	Drugs tested for (concentration cut-off, % for alcohol or ng/mL for other drugs)*	Prevalence, n/N (%)
Bakke (2016)[25]	Norway (1 year)	Blood	1074/2118 (50.7)	487/996 (48.9)	Alcohol (0.01), alprazolam (5), amphetamines and/or methamphetamines (4/4,5), tetrahydrocannabinol (0.15), clonazepam (5), cocaine (6), codeine (3), diazepam (29), flunitrazepam (0.8), methadone (30), morphine (3), nitrazepam (7), oxazepam (143), zolpidem (8), zopiclone (10)	198/487 (40.7)
Bogstrand (2011)[30]	Norway (December 2007–December 2008)	Blood	1882/2118 (88.9)	605/1272 (47.6)	Alcohol (0.01), alprazolam (4.63), amphetamine (4.06), benzoylecgonine (cocaine metabolite, 28.9), buprenorphine (0.58), tetrahydrocannabinol (0.16), carbamazepine (591), carisoprodole (0.58), clonazepam (143), cocaine (6.07), codeine (2.99), dextropropoxyphene (34), diazepam (1.75), ecstasy (5.80), ethylmorphine (6.27), flunitrazepam (0.78), gamma hydroxybutyrate (10,410), heroin (0.98), meprobamate (546), methadone (31), methamphetamine (4.48), morphine (2.85), nitrazepam (7.03), oxazepam (143), oxycodone (7.89), phenazepam (1.75), phenobarbital (2,322), zolpidem (7.68), zopiclone (9.72)	NR/605 (41)
Cordovilla-Guardia (2017)[33]	Spain (32 non-consecutive months between November 2011 and March 2015)	Blood (alcohol), urine (drugs)	204/242 (84.3)	88/242 (36.4)	Alcohol (0.03), amphetamines (NR), barbiturates (NR), benzodiazepines (NR), cannabis (NR), cocaine (NR), methadone (NR), methamphetamines (NR), opiates (NR), tricyclic antidepressants (NR)	33/71 (46.5) ► Low falls: 11/25 (44.0) ► High falls:21/46 (45.7)
Cordovilla-Guardia (2018)[34]	Spain (31 non-consecutive months between November 2011 and June 2015)	Blood (alcohol), urine (drugs)	1187/1818 (65.3)	433/929 (46.6)	Alcohol (0.03), amphetamines (NR), barbiturates (NR), benzodiazepines (NR), cannabis, cocaine (NR), methadone (NR), methamphetamines (NR), opiates (NR), tricyclic antidepressants (NR)	169/433 (39.0) ► Low falls: 120/307 (39.1) ► High falls: 49/126 (38.9)
Martin (2017)[39]	USA (September 2013–March 2015)	Serum (alcohol), Serum/urine (drugs)	NR	3357/10191 (32.9)	Alcohol (0.08), various other unspecified drugs (NR)	823/3357 (24.5)
McLaughlin (2017)[41]	USA (March 2012–May 2014)	Blood (alcohol), urine (drugs)	174/379 (45.9)	97/379 (25.6)	Alcohol (0), amphetamines (1000), barbiturates (200), benzodiazepines (200), cannabinoids (50), cocaine (300), opiates (300), phencyclidines (25)	8/15 (53.3)

*Note that all studies reported reviewing medical records to identify and account for patients who received prescription medications as part of their treatment prior to testing.
NR, not reported.

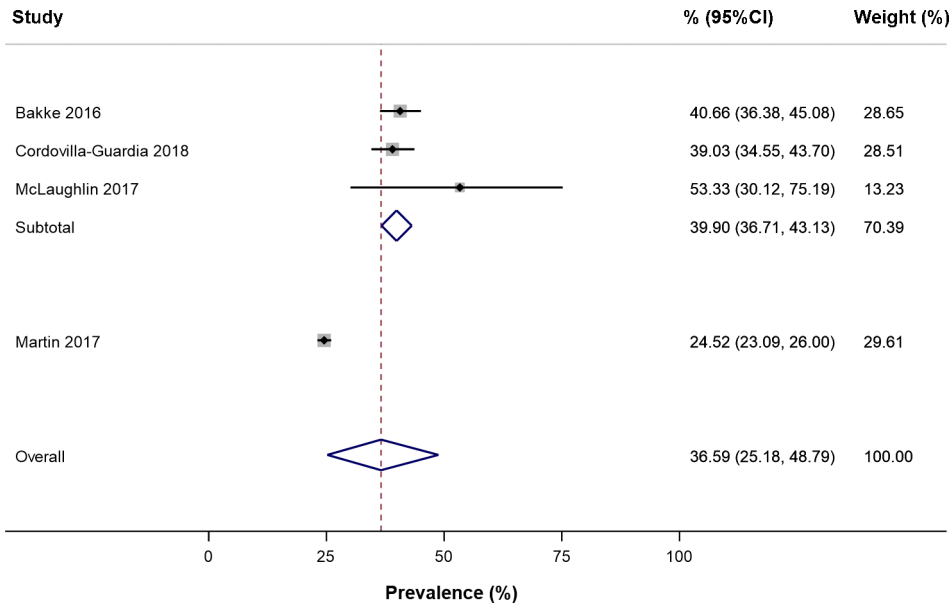

Figure 2 Forest plot reporting the prevalence (%) of any alcohol and/or drug use in patients presenting to hospital for fall-related injuries (pooled n=4292).

Alcohol involvement

Twenty-two records reported the prevalence of alcohol involvement in falls (table 4). Multiple records reported on cohorts from the University of Maryland Shock Trauma Centre,[24 48] the Oslo University Hospital,[25 30] a trauma centre in Taiwan,[32 45] and the National Trauma Data Bank in the USA.[27 44] Across the 18 independent cohorts identified, most studies (n=14, 78%) used blood or serum samples to test for alcohol.[24 27–33 36 39 43–46 48–51] The remaining studies used breath or saliva samples[35 37 47] or did not report the sample type used.[53] The blood alcohol thresholds used to define alcohol involvement ranged from 0% to 0.08% across studies. Eleven records (50%) did not report what BAC value was used to define a positive result. The proportion of missing alcohol data ranged from 1% to 88%, with studies suggesting that patients who missed routine alcohol testing were older and less seriously injured compared with those who were tested.[29 46]

The prevalence of alcohol involvement ranged from 2% to 57%. Included studies were not sufficiently similar to generate a pooled prevalence estimate (I^2=99.5%, p<0.01). Heterogeneity remained significant when excluding studies that only examined older populations (I^2=99.5%, p<0.01), or that were conducted outside of the USA (I^2=99.1%, p<0.01). Significant heterogeneity also remained when independently examining high (I^2=96.7%, p<0.01) and low falls (I^2=99.0%, p<0.01).

Studies were predominantly conducted in North America, where only two studies reported a prevalence less than 15%.[31 36] Both of these exclusively examined older populations, with Chippendale *et al*[31] reporting a prevalence of 11% in patients aged ≥55 years and Ekeh *et al*[36] reporting a prevalence of 13% in patients aged ≥65 years. These findings are consistent with another study, which reported that participants aged <65 years had a higher alcohol prevalence compared with participants aged ≥65 years (26% vs 11%).[48]

The cohort from Taiwan had a substantially lower alcohol prevalence.[32 45] While Chuang *et al*[32] reported a prevalence of 2% in patients aged >18 years, Peng *et al*[45] reported a prevalence of 4% in patients aged 20–65 years. Lower prevalence was also reported across South America, particularly for Brazil and the Dominican Republic.[53]

Four studies reported on high and low falls independently with varying results.[34 43 48 50] The prevalence of alcohol involvement ranged from 15% to 67% in low falls and 11% to 33% in high falls. While alcohol involvement was consistently greater in low falls compared with high falls in the three studies from the USA,[43 48 50] the opposite was reported in the study from Spain.[34]

Illicit and prescription drug involvement

Nine studies examined the prevalence of drugs other than alcohol in falls (table 5).[26 30 34 36 39 40 42 48 52] Six studies used urine samples to test for drug use[34 36 40 42 48 52] and one used blood samples.[30] Two studies used a combination of blood and urine samples.[26 39] Missing toxicology data ranged from 11% to 88% (table 5). While it was uncommon for patients with and without toxicology test results to be compared, one study reported that patients with TBI tested for tetrahydrocannabinol were slightly older than those who were not tested.[42]

Six studies reported the combined prevalence of any drug other than alcohol, with prevalence ranging from 7% to 46%.[34 36 39 40 48 52] However, these studies were not sufficiently homogeneous for meta-analysis (I^2=99.6%, p<0.01). Heterogeneity remained significant even after omitting Martin *et al*,[39] which likely underestimated AOD prevalence by assuming that patients who were not tested had not engaged in AOD use (I^2=72.3%, p=0.01).

Three studies reported specifically on the prevalence of prescription medications.[30 34 40] McAllister *et al*[40] reported an overall prevalence of 38.5%, comprised of a 15.4% prevalence for opioids and a 23.1% prevalence for benzodiazepines. Comparatively, the prevalence of prescription medications was just 19% in Spain[34] and 23% in Norway.[30] However, McAllister *et al*[40] included just 13 maxillofacial injury patients.

Research on illicit drug involvement in fall-related injuries was limited. Cannabis involvement was most commonly reported on, with prevalence ranging from 0% to 13%.[34 40 42] One additional study reported a cannabis prevalence of 41% specifically for

Table 4 Prevalence of acute alcohol use in patients presenting to hospital for injurious falls, organised by defined blood alcohol threshold and country

First author (year)[ref]	Country (study duration)	Sample type (BAC cut-off, %)	Proportion tested, n/N (%)	Patients with fall-related injuries, n/Total patients in the study, N (%)	Prevalence, n/N (%)
BAC threshold <0.05					
Albrecht (2018)[24]	USA (NR)	Blood (>0)	Patients without toxicology data were excluded	499/1084 (46.0)	126/499 (25.3)
Valdez (2016)[50]	USA (January 1 2012–December 31 2012)	Blood (>0)	NR	566/1397 (40.5)	247/566 (43.6) ► Low falls: 180/365 (49.3) ► High falls: 67/201 (33.3)
Nweze (2016)[43]	USA (January 2013–December 2013)	Blood (≥0.001)	Patients without toxicology data were excluded	156/738 (21.1)	62/156 (39.7) ► Low falls: 36/54 (66.7) ► High falls: 26/102 (25.5)
Ye (2013)[53]	USA (1985–1996)	NR (≥0.01)	NR	351/1819 (19.3)*	56/351 (15.9)*
	Canada (1989–2009)			246/787 (31.3)*	24/246 (9.7)*
	Brazil (2001)			160/496 (32.3)*	7/160 (4.4)*
	Argentina (2001)			203/682 (29.7)*	28/203 (13.9)*
	Dominican Republic (2010–2011)			79/501 (15.8)*	5/79 (6.3)*
	Guatemala (2010–2011)			150/513 (29.2)*	13/150 (8.7)*
	Guyana (2010–2011)			115/485 (23.8)*	14/115 (11.9)*
	Mexico (1986–2002)			535/2247 (23.8)*	79/535 (14.7)*
	Nicaragua (2010–2011)			111/518 (21.4)*	10/111 (9.3)*
	Panama (2010–2011)			123/490 (25.1)*	16/123 (12.8)*
Rundhaug (2015)[46]	Norway (October 2004–October 2011)	Blood (>0)	217/265 (81.9)	104/265 (39.2)	46/81 (56.8)
Bogstrand (2011)[30]	Norway (December 2007–December 2008)	Blood (>0.01)	1882/2118 (88.9)	605/1272 (47.6)	NR/NR (23)
Staton (2018)[47]	Tanzania (5 August 2013–21 July 2014)	Breath (≥0.01)	516/523 (98.7)	53/516 (10.3)	14/53 (26.4)
Cordovilla-Guardia (2018)[34]	Spain (31 non-consecutive months between November 2011 and June 2015	Blood (≥0.03)	1187/1818 (65.3)	433/929 (46.6)	74/433 (17.1) ► Low falls: 45/307 (14.7) ► High falls: 29/126 (23.0)
BAC threshold ≥0.05					
Chuang (2016)[32]	Taiwan (1 January 2009–31 December 2013)	Blood (>0.05)	Patients without toxicology data were excluded	2630/2630 (100), including 2072 falls from a height <1 metre and 530 falls from a height ≥1 metre	55/2630 (2.1)
Peng (2016)[45]	Taiwan (1 January 2009–31 December 2014)	Blood (≥0.05)	NR	2103/11 033 (19.1)	93/2103 (4.4)†
Martin (2017)[39]	USA (September 2013–March 2015)	Serum (>0.08)	NR	3357/10 191 (32.9), including 2138 ground level falls and 1219 falls from a height	680/3357 (20.3)†
Talving (2010)[49]	USA (2003)	Blood (≥0.08)	Patients without toxicology data were excluded	204/815 (25)*	NR/NR (46)
Yue (2017)[51]	USA (2010–2012)	Blood (≥0.08)	107/301 (35.5)	51/107 (47.7)	17/51 (33.3)
BAC threshold not reported					
Dorji (2017)[35]	Bhutan (8 April 2015–21 October 2015)	Breath (NR)	339/374 (90.6)	80/339 (23.6)	31 (21–42)‡
Forson (2016)[37]	Ghana (3 November 2014–11 April 2015)	Breath or saliva (NR)	Patients without toxicology data were excluded	172/1085 (15.9)	35/172 (20.3)
Bjarko *et al* (2019)[29]	Norway (October 1 2004–September 30 2014)	Blood (NR)	362/493 (73)	229/493 (46.5)	99/299 (33)*
Benson (2018)[27]	USA (2007–2012)	Blood (NR)	Approximately 82%	855/28 354 (3.0)	299/855 (35.0)
Bernier (2016)[28]	USA (January 1992–December 2009)	Blood (NR)	Patients without toxicology data were excluded	2367/11 943 (19.8)	938/2367 (39.6)
Chippendale (2017)[31]	USA (November 2013–May 2015)	Blood (NR)	NR	711/711 (100)	NR/NR (11.2)
Ekeh (2014)[36]	USAs (January 2006–December 2010)	Blood (NR)	499/4139 (12.1)	2401/4139 (58)	NR/NR (13.3)

Continued

Table 4 Continued

First author (year)[ref]	Country (study duration)	Sample type (BAC cut-off, %)	Proportion tested, n/N (%)	Patients with fall-related injuries, n/Total patients in the study, N (%)	Prevalence, n/N (%)
Pandit (2014)[44]	USA (2007–2010)	Serum (NR)	Patients without toxicology data were excluded	5927/23 983 (24.7)*	1464/5928 (24.7)*
Strong (2016)[48]	USA (January 1997–December 2008)	Blood (NR)	43 403/46 226 (93.9)	7541/7541 (100)	1515/6961 (21.8)

*Some values were estimates using available data.
†Denominator is the total number of patients with fall-related injuries rather than the number of patients who were tested, as reported in the study.
‡Reported as % (95% CI).
AIS, Abbreviated Injury Scale; AOD, alcohol and other drug; BAC, blood alcohol concentration; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; NR, not reported; TBI, traumatic brain injury.

patients who fell from a height >15 ft.[26] Two studies specifically addressed the use of cocaine and amphetamines, with both reporting limited to no use.[34 40]

Only one study reported prevalence stratified by fall type.[34] Psychotropic medications/opioids were twice as prevalent in same level falls compared with falls from a height (23% vs 12%). Comparatively, polydrug use (any combination of alcohol, cannabis, cocaine/amphetamine or psychotropic medications/opioids) was more common in falls from a height than in same level falls (19% vs 5%). Cannabis and cocaine/amphetamine use were low (<3%) for both high and low falls. However, patients who engaged in polydrug use (n=40, 9%) were not included in individual drug estimates, likely leading to underestimations in prevalence for individual drug classes.

DISCUSSION

To our knowledge, this is the first systematic review examining the prevalence of other drugs in addition to alcohol in patients presenting to hospital for fall-related injuries. The estimated pooled prevalence of 37% for any alcohol and/or drug use at the time of injury reported in this review demonstrates that acute AOD use is common in fall-related injuries. However, the prevalence of acute AOD use varied considerably, with prevalence ranging from 25% to 53% in studies examining any alcohol and/or drug use. For studies that specifically examined acute alcohol use, prevalence ranged from 2% to 57%. Meanwhile, prevalence ranged from 7% to 46% for studies that specifically examined drugs other than alcohol. This review also identified several limitations in existing research. Specifically, there is a need for research that examines the prevalence of AOD use in fall-related injuries outside of the USA, enables detailed examination of drugs other than alcohol and polydrug use, and independently addresses the role of AOD use in high and low falls.

As the majority of research originated from the USA, findings from this review may not generalise well to other countries, particularly low-income and middle-income countries. Importantly, some variation in prevalence is expected between countries since AOD use is heavily influenced by social, cultural and legal factors, which can vary substantially both over time and between locations.[54] Notably, the studies from Taiwan[32 45] and South America[53] reported lower alcohol prevalence compared with other studies in this review. However, the lack of consistent testing approaches across injury populations largely prevents potential geographical differences from being assessed. For example, the study from Taiwan only tested patients who were suspected to be intoxicated, which can substantially underestimate the prevalence of alcohol involvement.[55] Similarly, few studies reported on socioeconomic status and non-acute AOD use (eg, whether patients were current drinkers or had chronic AOD use conditions), both of which may impact on the prevalence of AOD-related harms.[56]

While the overall prevalence of drugs other than alcohol varied across studies, research addressing the prevalence of specific drug classes was limited. For example, at 19%–39%, overall prescription drug use was common in fall-related injuries. However, limited research addressed the prevalence of specific prescription drugs (eg, benzodiazepines, opioids). This impairs our ability to assess the risks associated with these medications, which are important for the management of a variety of health conditions. Only two studies addressed the prevalence of cocaine and amphetamines, with both studies reporting little to no use of these drugs. Notably, the low prevalence of cocaine reported in this review is not consistent with a recent study from Brazil, which reported a 13% prevalence of cocaine use in patients with fall-related injuries based on blood tests as opposed to urine tests.[57] Findings regarding cannabis use were inconsistent, but ultimately difficult to compare since testing methods were not well reported, particularly regarding the timing of testing. Some studies in this review were also conducted in areas which have since legalised recreational cannabis use and may therefore not represent the current prevalence of cannabis involvement in falls.

Research addressing different types of falls was also lacking. Importantly, there are some key demographic differences between people who typically experience low falls, intentional high falls, and unintentional high falls.[58] For example, while low falls are more common in older populations, high falls are more likely to include suicide-related or work-related injuries.[58] Additionally, people injured from intentional high falls often have mental illness[59] and may therefore be more likely to be prescribed certain medications or to have AOD-related comorbidities.[60] Despite this, few studies differentiated between high and low falls and those that did had inconsistent results.

Evidently, AOD exposure is common in fall-related injuries and research has demonstrated that prescription medications can increase the odds of fall-related injuries in older patients by 47%–68%.[61] Notably, research has suggested that polypharmacy alone is not an independent risk factor for falls, but rather the use of specific drugs that independently increase the risk of falls.[62] Therefore, interventions have largely focused on gradual withdrawal and dose reduction of specific risk-increasing medications, which has been shown to successfully reduce fall injuries.[61] However, falls associated with alcohol and illicit drugs will likely require different prevention approaches due to the lack of regulation compared with prescription medications and demographic differences between alcohol, illicit and prescription drug users. For example, a study examining people aged

Table 5 Prevalence of drugs other than alcohol in patients presenting to hospital for injurious falls, organised by drug type and country

First author (year)[ref]	Country (study duration)	Sample type	Proportion tested, n/N (%)	Patients with fall-related injuries, n/total patients in the study, N (%)	Drugs tested for (concentration cut-off, ng/mL)	Prevalence, n/N(%)
Any drugs other than alcohol						
Ekeh (2014)[36]	USA (January 2006–December 2010)	Urine	499/4139 (12.1)	2401/4139 (58)	Various drugs, not specified (NR)	NR/NR (46.2)
Martin (2017)[39]	USA (September 2013–March 2015)	Serum/urine	NR	3357/10 191 (32.9)	Barbiturates, benzodiazepines, cocaine, opiates, phencyclidine, tetrahydrocannabinol and tricyclic antidepressants (NR)	349/3357 (7.4)
Strong *et al* (2016)[48]	USA (January 1997–December 2008)	Urine	23 004/46 226 (49.8)	7541/7541 (100)	Various drugs, not specified (NR)	1332/3577 (37.2)
Yue (2020)[52]	USA (2010–2012)	Urine	133/515 (25.8)	63/133 (47.4)	Various drugs, not specified (NR)	15/63 (23.8)
McAllister (2013)[40]	UK (January 2011–January 2012)	Urine	93/105 (88.6)	13/105 (12.4)	Amphetamines, barbiturates, benzodiazepines, cannabinoids, cocaine metabolites, methadone and opioids (NR)	5/13 (38.5)
Cordovilla-Guardia (2018)[34]	Spain (31 non-consecutive months between November 2011 and June 2015)	Urine	1187/1818 (65.3)	433/929 (46.6)	Amphetamines, barbiturates, benzodiazepines, cannabis, cocaine, methadone, methamphetamines, opiates and tricyclic antidepressants (NR)	135/433 (31.2) ► Low falls: 91/307 (29.6) ► High falls: 44/126 (34.9)
Benzodiazepines, opioids and other prescription medications						
Bogstrand (2011)[30]	Norway (December 2007–December 2008)	Blood	1882/2118 (88.9)	605/1272 (47.6)	Alprazolam (4.63), buprenorphine (0.58), carbamazepine (591), carisoprodol (651), clonazepam (4.74), codeine (2.99), dextropropoxyphene (34), diazepam (28.5), ethylmorphine (6.27), flunitrazepam (0.78), meprobamate (546), methadone (31), morphine (2.85), nitrazepam (7.03), oxazepam (143), oxycodone (7.89), phenobarbital (2,322), zolpidem (7.68), zopiclone (9.72)	NR/NR (23)
Cordovilla-Guardia (2018)[34]	Spain (31 non-consecutive months between November 2011 and June 2015)	Urine	1187/1818 (65.3)	433/929 (46.6)	Benzodiazepines, tricyclic antidepressants, barbiturates and/or prescribed opioids (NR)	84/433 (19.4) ► Low falls: 69/307 (22.5) ► High falls: 15/126 (11.9)
McAllister (2013)[40]	UK (January 2011–January 2012)	Urine	93/105 (88.6)	13/105 (12.4)	Barbiturates (200)	0/13 (0)
					Benzodiazepines (200)	3/13 (23.1)
					Methadone (275)	0/13 (0)
					Opioids (300)	2/13 (15.4)
Cannabis						
Banks (2019)[26]	USA (1 January 2012–21 December 2016)	Blood/urine	Patients without toxicology data were excluded	395/21 276 (1.6)	Cannabis (NR)	High falls: 160/395 (40.5)
Nguyen (2014)[42]	USA (1 January 2010–31 December 2012)	Urine	446/538 (82.9)	219/538 (40.7)	Tetrahydrocannabinol (50)	28/219 (12.8)
McAllister (2013)[40]	UK (January 2011–January 2012)	Urine	93/105 (88.6)	13/105 (12.4)	Cannabinoids (50)	0/13 (0)
Cordovilla-Guardia (2018)[34]	Spain (31 non-consecutive months between November 2011 and June 2015)	Urine	1187/1818 (65.3)	433/929 (46.6)	Cannabis (NR)	5/433 (1.2) ► Low falls: 3/307 (1.0) ► High falls: 2/126 (1.6)
Other drugs						
Bogstrand (2011)[30]	Norway (December 2007–December 2008)	Blood	1882/2118 (88.9)	605/1272 (47.6)	Illicit drugs, not specified (various)	NR/NR (5)

Continued

Table 5 Continued

First author (year)[ref]	Country (study duration)	Sample type	Proportion tested, n/N (%)	Patients with fall-related injuries, n/total patients in the study, N (%)	Drugs tested for (concentration cut-off, ng/mL)	Prevalence, n/N(%)
Cordovilla-Guardia (2018)[34]	Spain (31 non-consecutive months between November 2011 and June 2015)	Urine	1187/1818 (65.3)	433/929 (46.6)	Cocaine, amphetamines and/or methamphetamines (NR)	6/433 (1.4) ▲ Low falls: 3/307 (1.0) ▲ ▲ High falls: 3/126 (2.4)
McAllister (2013)[40]	UK (January 2011–January 2012)	Urine	93/105 (88.6)	13/105 (12.4)	Amphetamines (300)	0/13 (0)
					Cocaine metabolites (300)	0/13 (0)

NR, not reported.

15–64 years showed a 40% increase in falls risk specifically for people who used cannabis on less than a weekly basis, but not for weekly cannabis users.[63] Consequently, existing falls prevention programmes, which are typically targeted towards older populations with chronic prescription medication use and who are at risk of low falls, are unlikely to be appropriate for the prevention of cannabis-related falls. Similarly, existing interventions are unlikely to generalise well to young-aged and middle-aged adult populations, where alcohol is an important risk factor for fall-related injuries.[64] Nevertheless, research addressing the falls risk associated with these AODs remains limited.

Further research is needed to inform the development of effective and targeted injury prevention strategies, including research that addresses how non-prescription drugs contribute to falls and which demographics are most affected. The overall inconsistency in AOD testing methods has also highlighted the importance of routine AOD testing and the adequate reporting of AOD testing methods. Routine testing would assist in generating robust surveillance data that can better inform on the burden and risk of AOD-related falls, as well as in identifying patients who may benefit from interventions. However, regardless of whether testing is routine, it remains crucial for studies to adequately report the relevant sample characteristics and toxicology testing methods to enable comparison of prevalence data across studies.

Limitations

This review was restricted to studies that used objective AOD tests. While this helped to standardise AOD measurement across studies, objective tests can misestimate acute AOD use.[53] For example, urine samples can continue to produce positive test results for cannabis up to a month after use.[65] Testing delays can also make it difficult to differentiate between prescription medications that were present at the time of injury and medications that were later administered as part of the patient's treatment.

Testing rates at individual sites can also vary based on different hospital policies and cultures. In some settings, AOD testing is only performed at the discretion of hospital staff or when a patient is suspected to be intoxicated, which could affect prevalence estimates. Even in settings with routine AOD testing policies, testing can be incomplete and subject to clinician biases.[66] This may particularly impact on the testing of patients injured from low falls, which tend to skew towards an older population who are less likely to be tested.[66] Furthermore, as many studies reported on overall injury cohorts, testing rates for patients with fall-related injuries specifically were often not reported, making it difficult to assess the impact of varying testing rates. Comparatively, studies that required patient consent may have underestimated AOD involvement if patients who engaged in AOD use were less likely to participate. This could be particularly problematic in places where AOD use is highly stigmatised or associated with more serious consequences.

Additionally, this review only examined patients who presented to hospital for medical attention. Therefore, findings may not generalise to less serious injuries or to populations where there may be barriers to accessing healthcare in hospital settings. With limited geographical areas represented, there is also potential for publication bias, particularly for low-income and middle-income countries.

CONCLUSION

AOD involvement is common in fall-related injuries. However, there remains a need for research that addresses the prevalence of drugs other than alcohol and polydrug use, differentiates between various fall types, provides better coverage of geographical and socioeconomic variations, and enables the comparison of prevalence estimates across studies and locations. Improving knowledge in these areas will inform which populations are most affected by AOD-related falls, which is necessary for designing effective injury and AOD prevention strategies.

Key messages

What is already known on this subject

⇒ Acute alcohol use increases the risk of fall-related injuries in a dose-response manner.

⇒ Other drugs including cannabis, benzodiazepines and antidepressants have been suggested to increase the risk of fall-related injuries.

What this study adds

⇒ There is a 37% prevalence of alcohol and/or other drug use in patients presenting to hospital for fall-related injuries.

⇒ The prevalence of alcohol and other drug use varied considerably across studies, likely due to differences in toxicology testing methods.

How this study might affect research, practice or policy

⇒ Further research that objectively measures the prevalence of drugs other than alcohol in fall-related injuries is needed, as is research that differentiates between high and low falls.

Correction notice This article has been corrected since it was first published. The open access licence has been updated to CC BY.

Contributors GL is guarantor for this study and was involved in the conceptualisation of the study, conducting searches, abstract and full text screening, data extraction, risk of bias assessments, data analyses and drafting of the original manuscript. JYA was involved in abstract and full text screening and risk of bias assessments. NK was involved in full text screening and risk of bias assessments. BJG, BM, PMD, SR and BB were involved in the conceptualisation of the study and critical revision of the manuscript.

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ORCID iDs

Georgina Lau http://orcid.org/0000-0001-6519-0405

Ben Beck http://orcid.org/0000-0003-3262-5956

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