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Detection of ethanol, cannabinoids, benzodiazepines, and opioids in older adults evaluated for serious injuries from falls

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Abstract

Background: In 2020, there were 36.7 million reported falls among older adults (65+) in the United States. Ethanol and other sedating substances may increase fall risk among older adults due to their effect on cognitive and physical function. We estimate the prevalence of these substances in blood specimens of older adults presenting with a fall injury at selected trauma centers.

Methods: The initial study collected blood specimens from May 2020 through July 2021 from adults undergoing a trauma team evaluation at selected United states level 1 trauma centers. We limited our study to older adults evaluated after a fall (n = 1,365) and selected a random sample (n = 300) based on age, sex, and trauma-center quotas. Medical health records and blood specimens obtained at trauma center presentation were analyzed. We estimated the prevalence of ethanol, benzodiazepines, cannabinoids, and opioids in the blood specimens. Two-sample tests of

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Author contributions

KMB and RCM had full access to all of the data in the study and take responsibility for the integrity of the data and accuracy of the data analysis. Study concept and design: KMB, YKH, STC, EMG, JDD, JAB, BPC, JTL, RS, RE AJK, DDT, BKL, and RCM. Analysis of data/statistical analysis: CCV, PMM, AJK, SEW, and RCM. Interpretation of data: KMB, YKH, STC, CCV, PMM, EMG, JDD, BPC, JTL, AJK, SEW, DDT, BKL, and RCM. Drafting of the manuscript: KMB, YKH, BPC, PMM, CCV, JTL, EMG, AJK, SEW, RCM. Critical revision of the manuscript for important intellectual content: LAG and DDT. Final review and approval of manuscript: KMB, YKH, and RCM.

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binomial proportions and Chi-square two-tailed tests were used to compare prevalence estimates of substances by demographic characteristics.

Results: At least one substance was detected among 31.3% of samples analyzed. Prevalences of specific substances detected were 9.3% (95% CI: 6.0–12.6%) for benzodiazepines, 4.3% (95% CI: 2.0–6.7%) for cannabinoids, 8.0% (95% CI: 5.2–11.7%) for ethanol, and 15.0% (95% CI: 10.9–19.1%) for opioids. There were 18 deaths (6%; 95% CI: 3.6–9.3%). One-third of decedents had at least one substance detected in their blood.

Discussion: Opioids were the most frequently detected substance, followed by benzodiazepines, ethanol, and cannabinoids. Substance use prevalence was not uniform across demographics, with differences observed by sex and age.

Conclusions: This study provides insight into the frequency of the presence of substances that may contribute to fall risk and serious injury among older adults. Screening older adults for substances that impair cognitive and physical function can enhance clinical fall prevention efforts.

Keywords

Emergency medicine; ethanol; falls; older adults; substances

Background

The older adult (aged 65 and older) population is growing at a faster rate than any other age group globally [1]. Falls among older adults remain a substantial and concerning health issue, with the prevalence of falls estimated at 26.5% of older adults in the world [1]. From the Global Burden of Disease study [2], the age-adjusted fall death rate globally was 9.2 per 100,000, which equated to over 16 billion fall-related deaths in 2017. In 2021, the United States (US) experienced a two-decade high in fall-related fatalities, with approximately 39,000 older adults losing their lives due to a fall [3]. Falls are also a leading cause of morbidity, injury and disability. Injurious falls frequently lead to a loss of independence and, in some cases, necessitate skilled nursing facility placement [4]. Age-related physical and physiologic changes and comorbidities increase fall risk [5].

Older adult falls are multifactorial. Certain risk factors are modifiable, such as gait and balance disorders and the use of medications that impact cognitive function and physical abilities [6]. Sedating substance use and ethanol consumption contribute to fall risk as they can impair both balance and cognition [7, 8]. Furthermore, the physiologic changes associated with advancing age, including alterations in the absorption, distribution, metabolism, and excretion of substances, can intensify adverse effects [9, 10]. The American Geriatric Society 2023 update to the Beers Criteria® includes numerous classes of medications to avoid in older adults with a history of falls or fractures. These include psychoactive substances like antidepressants, antiepileptics, antipsychotics, opioids, and benzodiazepine and non-benzodiazepine sedative hypnotics. Beyond these psychoactive substances, the list of fall-risk-increasing drugs includes other classes, such as cardiovascular medications and hypoglycemics [11–13]. Previous reports have highlighted the role of ethanol-medication interactions (specifically with psychoactive medications) and the link to increased risk of falls among older adults [14]. Accurate measures of the

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prevalence of substance use, including ethanol, among older adult falls remain limited largely due to older adults not seeking care at the time of fall; trauma center staff not routinely measuring the presence of ethanol and other substances at the time of evaluation; or trauma center staff measuring the presence of byproducts in urine samples after considerable elapsed time since the fall [15].

In this study, we focused our evaluation of psychoactive substances associated with increased fall risk to opioids, benzodiazepines, ethanol, and cannabinoids. To gain a deeper understanding of the role these substances play in fall-related injuries, we aim to estimate the prevalence in blood specimens collected from older adults who suffered a fall injury and who were treated at selected trauma centers in the US. The findings from this study provide valuable insights to enhance fall prevention by describing the prevalence of ethanol and other substances, potentially modifiable fall risk factors, among severely injured older adults.

Methods

The initial study (Drug and Ethanol Prevalence in Road Users in Serious and Fatal Crashes) collected blood specimens from May 2020 through July 2021 from adult patients undergoing a trauma team evaluation at seven US Level 1 trauma centers (Baltimore, MD; Charlotte, NC; Iowa City, IA; Jacksonville, FL; Miami, FL; Sacramento, CA; and Worcester, MA) to assess the prevalence of substance exposure in patients with roadway trauma. Data were also collected for patients with other mechanisms of injury necessitating trauma team evaluation [16]. We evaluated specimens from patients aged 65 and older who were evaluated by a trauma team for potential injury due to a fall (Figure 1). Due to resource constraints, we then selected a random sample of 300 of those specimens for further analysis and studies. These 300 specimens were selected based on patient age, sex, and trauma-center quotas designed to maintain the representation of the underlying trauma center population (see Supplementary Material for methodology).

Blood specimens obtained at trauma center presentation were bio-banked and stored refrigerated at each site prior to being frozen upon receipt in the laboratory. Samples were analyzed for ethanol, cannabinoids, benzodiazepines, and opioids (illicit and prescribed) at the Center for Forensic Science Research and Education (Willow Grove, PA). Blood ethanol concentrations were measured using gas chromatography flame ionization detection. Comprehensive toxicological analysis was conducted for >1,000 drug targets; qualitative drug results for benzodiazepines, cannabinoids, and opioids were obtained using liquid chromatography quadrupole time-of-flight mass spectrometry (see supplementary Material for list). Cannabinoid testing included, but was not limited to, assessing for presence of delta-9 tetrahydrocannabinol and metabolites (11-hydroxy-delta-9 tetrahydrocannabinol and 11-nor-9-carboxy-delta-9 tetrahydrocannabinol). Testing for benzodiazepines included, but was not limited to, assessing for the presence of diazepam, alprazolam, lorazepam, and clonazepam, in addition to their metabolites (e.g., nordiazepam, alpha-hydroxy alprazolam, and 7-amino clonazepam). Opioid testing included, but was not limited to, assessing for the presence of tramadol, fentanyl, hydrocodone, dihydrocodeine, oxycodone, noroxycodone, norfentanyl, morphine, codeine, methadone, beta-hydroxyfentanyl, and 4-

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anilino-N-phenethyl-piperidine (4-ANPP), among appropriate metabolites. Age-, sex-, and trauma center-stratified prevalence of the substances detected was estimated along with corresponding 95% confidence intervals (95% CIs).

Manual chart reviews were conducted by trained research staff at each site. This included reviewing and abstracting information regarding medication administration (name of medication, time of administration, etc.) in both hospital and pre-hospital settings (via emergency medical services run reports). At the individual patient level, any administered medications found in the analytical toxicology testing were excluded from the data prior to statistical analyses. Two-sample tests of binomial proportions and Chi-square two-tailed tests with 95% CI were used when appropriate to compare prevalence estimates of substances by demographic characteristics. We conducted analyses with Stata/SE 16.0 (StataCorp., College station, TX).

This study received approval from the Advarra Institutional Review Board (#00022129; central IRB for six sites) and the University of Florida Institutional Review Board (for UF Health Jacksonville). De-identified specimens and other data were obtained under IRB-approved waivers of consent and authorization to allow practicable conduct of this protocol (see supplementary Material for additional detail).

Results

The original cohort of fall patients included 1,365 patients. In the study sample of 300 patients, the median age was 79 years old (range 65–104); 51.7% were male (Table 1). Of the 300 samples, 31.3% had at least one of the evaluated substances detected in blood (Table 2). Substance prevalence among all participants was: benzodiazepines 9.3% (95% CI: 6.0–12.6%), cannabinoids 4.3% (95% CI: 2.0–6.7%), ethanol 8.0% (95% CI: 5.2–11.7%), and opioids 15.0% (95% CI: 10.919.1%). Ethanol concentrations ranged from 300 mg/L to 3,200 mg/L, with a median concentration of 1,800 mg/L. Tramadol, the most common opioid identified, was found in 4.7% of participant samples. Multiple substances were detected in some blood samples: 2.3% had benzodiazepines and opioids, 2.0% had cannabinoids and opioids, 1.0% had ethanol and benzodiazepines, and 0.7% had cannabinoids and benzodiazepines.

Ethanol was detected more often among those 65–74 years old, as compared to other older adult age groups (Table 2). Opioids were more commonly detected among women (Table 3), while benzodiazepines, cannabinoids, and ethanol prevalence were similar by sex. The trauma center in Baltimore, MD, had the highest percentage of unique patients with opioids detected, while the trauma center in Miami, FL, had the highest percentage of unique patients with benzodiazepines detected (Table 4). There were 18 deaths (11 men and seven women) reported in the study sample (6%, 95% CI: 3.6–9.3%). One-third of those who died after their evaluation for a fall had at least one substance detected in their blood: ethanol was detected in one, benzodiazepines in two, opioids in two, and benzodiazepines and opioids in one of the deceased. The prevalence for other substances found in this group of patients is included in the Supplementary Material.

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Discussion

Sedating substances that can negatively affect cognitive function and ability, both risk factors for falls, were found in the blood of more than 30% of specimens evaluated in the study. Opioids were the most frequently detected substance, followed by benzodiazepines, ethanol, and cannabinoids. Substance use prevalence was not uniform across demographics, with differences observed by sex and age. Additionally, one-third of those who died after their evaluation for a fall had at least one substance detected in their blood.

Ethanol use and binge drinking have increased in older adults over the past decade [17–19]. In a study examining trends of ethanol use and fall injuries, the rate of ethanol-involved emergency department visits among older adults increased steadily between 2011 and 2020 [19]. Many older adults are consuming ethanol at higher than the recommended daily and weekly limits [20, 21]. Prior research on ethanol-related falls found that for every 10 g increment in ethanol consumption, the odds of experiencing a fall-related injury increased by a factor of 1.25 [21]. Additionally, during the early months of 2020, among older adults, there was a notable increase in the frequency of drinking days per week from April to June compared to March [22].

Prior driving research studies report that psychomotor impairment begins at blood ethanol concentrations of 400 mg/L, with nearly universal impairment of reaction time, divided attention, and depth perception at concentrations of 800 mg/L [23]. Of the 24 older adults with ethanol detected in their blood at trauma center presentation, 21 would be expected to have had psychomotor impairment at the time of the fall, given that their ethanol concentrations exceeded 800 mg/L. For the remaining three older adults, depending on the time elapsed from the fall to trauma center evaluation, and possible ethanol degradation over time in the bio-banked sample, their ethanol concentration would have been higher at the time of the fall, potentially at concentrations causing psychomotor impairment. Comparable quantitative correlates of impairment are not available for cannabinoids, opioids, or benzodiazepines.

Opioid, benzodiazepine, and other psychoactive substance use among older adults have also increased in recent years [24]. Similarly, cannabinoid use among older adults is on the rise due to changes in accessibility related to changing regulations [25, 26]. While many of these substances offer therapeutic benefits, adverse effects such as slowed reaction time and impaired balance can contribute to falls. Education about responsible use and open conversations between providers and patients can ensure that older adults make informed choices regarding the impacts of substance use on their overall health.

The Us Centers for Disease Control and Prevention (CDC) Stopping Elderly Accidents, Deaths, and Injuries (STEADI) initiative advocates for annual screening of older adults for fall risk, followed by assessments to identify modifiable risk factors. For older adults at risk for falls with known risk factors, evidence-based strategies can be employed to reduce the risk (www.cdc.gov/steadi).

The Check Your Drinking Alcohol Screening Tool, developed by the CDC, offers older adults and healthcare providers a valuable resource for assessing ethanol consumption

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patterns. By visiting the tool's website (www.cdc.gov/alcohol/CheckYourDrinking), individuals gain insights into the factors influencing their drinking habits, helping them identify both barriers and motivators for making informed choices about ethanol consumption.

When conducting a comprehensive medication review, healthcare providers can initiate conversations with their older patients about all medications and substance use, whether prescribed or used recreationally. Medication management resources such as the Screening Tool of Older Persons Prescriptions in Older adults with High Fall Risk (STOPPFall) can be employed to identify medications that pose an increased risk of falls among older adults [27]. The tool highlights psychoactive medication classes such as opioids and benzodiazepines and offers deprescribing guidance to assist healthcare providers in making informed clinical decisions to reduce or stop high-risk medications or substances.

Our study contributes to current research around modifiable risk factors by shedding light on the prevalence of ethanol and other sedating substances. This study also identified subgroups of older adults that may be more likely to have substances detected in their system, emphasizing the need to prioritize these groups for primary fall prevention, focusing on medication and substance use management.

Limitations

The findings from this investigation are subject to several limitations. First, although the sample was randomly selected and stratified by age, sex, and trauma center, the prevalence estimates might not be externally valid to older adults who fall but do not require evaluation for a serious injury, are not evaluated in trauma centers, or not evaluated in Level 1 trauma centers. Secondly, the small subgroup size may have precluded our ability to detect statistically significant differences. Thirdly, deaths could be underestimated because we did not follow older adults beyond their hospitalization. Fourthly, we cannot determine if the substances detected caused the fall. Although identification of these substances in blood samples supports recent use (as compared to urine drug testing, which has a longer window of detection), the timing, frequency, and chronicity of ingestion of these substances in relation to the fall are not known. In addition, because certain benzodiazepines and opioids may be prescribed by providers, we could not determine if these substances were used as prescribed or misused or make an assessment of tolerance. With respect to elapsed time, we were unable to accurately ascertain the interval between fall and blood specimen acquisition in this study. Additionally, patients may have been seen by trauma teams after transfer from another hospital, leading to variability in time to presentation.

Conclusions

Our study sheds light on the prevalence of substances that could play a role in falls among older adults, especially those who experienced serious injuries. Nearly one-third of our sample had one or more of the evaluated substances detected in their blood. Among these substances, opioids were the most commonly detected, followed by benzodiazepines and ethanol. Clinical fall prevention efforts may benefit from further screening for substance use,

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including illicit drugs, cannabinoids, and ethanol use when assessing for fall risk factors among older adults.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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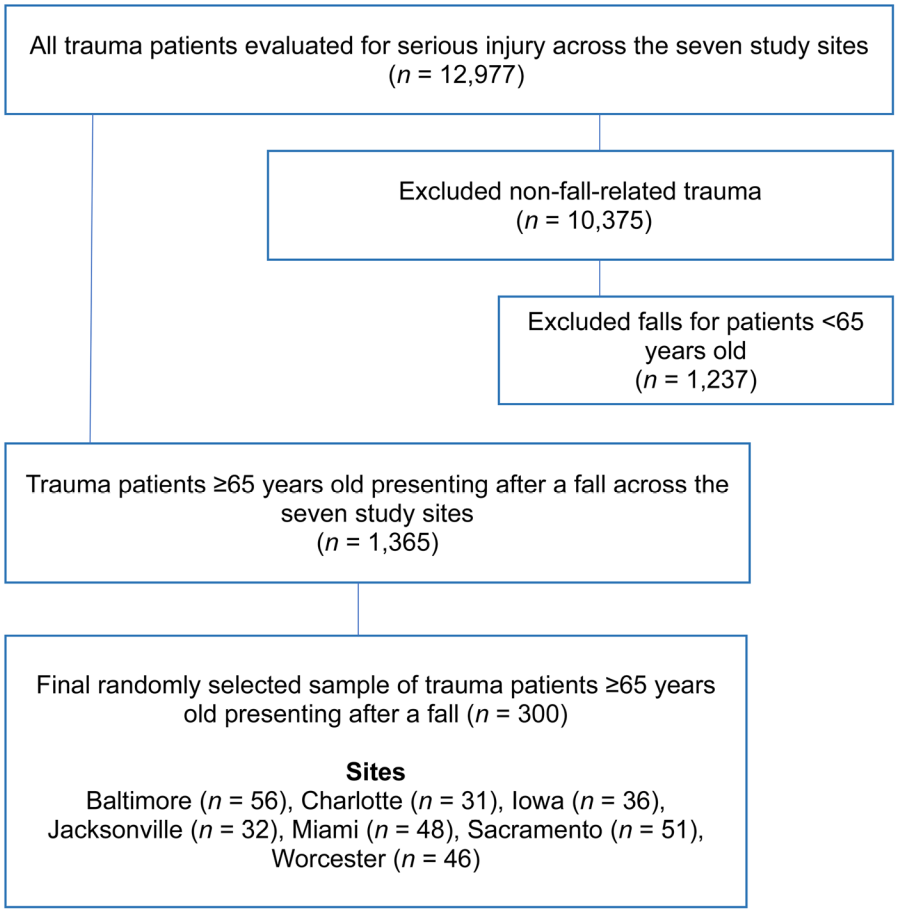

Figure 1.
Enrollment schema.

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Table 1.

Demographic characteristics of older adults evaluated for serious injury after a fall, all sites and trauma center location.

	All sites		Substance used, *n* (%)			Baltimore, MD		Charlotte, NC		Jacksonville, FL		Miami, FL		University of California, Davis, CA		University of Iowa, Iowa City, IA		Worcester, MA	
	n = 300		94 (31.3)			*n* = 56 (18.7%)		*n* = 31 (10.3%)		*n* = 32 (10.7%)		*n* = 48 (16.0%)		*n* = 51 (17.0%)		*n* = 36 (12.0%)		*n* = 46 (15.3%)	
Age (years), median (IQR)	79 (71–86)		74 (68–82)			75.5 (71–85)		77 (71–84)		76.5 (68.5–85)		83 (74–86)		80 (71–86)		79.5 (74–88.5)		79 (72–88)	
	n	%	*n*	%	*P*-value	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Age groups (years)					<0.001														
65–69	57	19.0	29	30.9		11	19.6	6	19.4	9	28.1	9	18.8	9	17.7	6	16.7	7	15.2
70–74	53	17.7	22	23.4		11	19.6	7	22.6	5	15.6	6	12.5	9	17.7	5	13.9	10	21.7
75–79	49	16.3	12	12.8		11	19.6	6	19.4	6	18.8	6	12.5	7	13.7	7	19.4	6	13.0
80–84	50	16.7	13	13.8		8	14.3	5	16.1	4	12.5	9	18.8	11	21.6	6	16.7	7	15.2
85–89	55	18.3	12	12.8		10	17.9	5	16.1	5	15.6	10	20.8	9	17.7	7	19.4	9	19.6
≥90	36	12.0	6	6.4		5	8.9	2	6.5	3	9.4	8	16.7	6	11.8	5	13.9	7	15.2
Male sex	155	51.7	47	50.0	0.70	29	51.8	17	54.8	14	43.8	24	50.0	22	43.1	22	61.1	27	58.7
Race					0.21														
White, non-Hispanic	213	71.2	61	64.9		39	69.6	20	64.5	28	87.5	14	29.2	38	74.5	33	91.7	41	89.1
Black, non-Hispanic	28	9.3	13	13.8		12	21.4	6	19.4	2	6.3	3	6.3	3	5.9	1	2.8	1	2.2
Asian	7	2.3	4	4.3		2	3.6	1	3.2	0		0		3	5.9	0		1	2.2
Hispanic	41	13.7	12	12.8		1	1.8	2	6.5	2	6.3	29	60.4	4	7.8	1	2.8	2	4.4
Other	10	3.3	4	4.3		2	3.6	1	3.2	0		2	4.2	3	5.9	1	2.8	1	2.2
Not reported	1	0.3	0			0		1	3.2	0		0		0		0		0	
Deceased	18	6.0	6	6.4	0.85	4	7.1	3	9.7	1	3.1	0		0		6	16.7	4	8.7

Note: Numbers and percentages are unweighted.

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Table 2.

Substances detected among older adults evaluated for serious injury after fall by sex, age group and trauma centers, United States.

	Substance group											
	Alcohol, *n* = 300, %	**95% Confidence intervals**	**Cannabis, *n* = 300, %**	**95% Confidence intervals**	**Opioids, *n* = 300, %**	**95% Confidence intervals**	**Benzodiazepines, *n* = 300, %**	**95% Confidence intervals**	**Any detected, *n* = 300, %**	**95% Confidence intervals**	**None detected, *n* = 300, %**	**95% Confidence intervals**
All participants	8.0	5.2–11.7	4.3	2.0–6.7	15.0	10.9–19.1	9.3	6.0–12.6	31.3	26.1–36.6	68.7	63.4–73.9
Sex												
Female	6.2	2.9–11.5	3.4	1.1–7.9	**19.3**	13.2–26.7	9.0	4.9–14.8	32.4	24.9–40.7	67.6	59.3–75.2
Male	9.7	5.5–15.5	5.2	2.3–9.9	**11.0**	6.5–17.0	9.7	5.5–15.5	30.3	23.2–38.2	69.7	61.8–76.8
Age groups												
65–69	**19.3**	10.0–31.9	8.8	2.9–19.3	24.6	14.1–37.8	8.8	2.9–19.3	**50.9**	37.3–64.4	**49.1**	35.6–62.7
70–74	**17.0**	8.1–29.8	7.5	2.1–18.2	13.2	5.5–25.3	9.4	3.1–20.7	**41.5**	28.1–55.9	**58.5**	44.1–71.9
75–79	**6.1**	1.3–16.9	2.0	0.1–10.9	14.3	5.9–27.2	6.1	1.3–16.9	**24.5**	13.3–38.9	**75.5**	61.1–86.7
80–84	**2.0**	0.1–10.6	4.0	0.5–13.7	16.0	7.2–29.1	12.0	4.5–24.3	**26.0**	14.6–40.3	**74.0**	59.7–85.4
85–89	**0**	0			12.7	5.3–24.5	10.9	4.1–22.2	**21.8**	11.8–35.0	**78.2**	65.0–88.2
≥90	**0**		2.8	0.1–14.5	5.6	0.7–18.7	8.3	1.8–22.5	**16.7**	6.4–32.8	**83.3**	67.2–93.6
Site												
Baltimore, MD	**14.3**	6.4–26.2	7.1	2.0–17.3	19.6	10.2–32.4	**10.7**	4.0–21.9	39.3	26.5–53.2	60.7	46.8–73.5
Charlotte, NC	**12.9**	3.6–29.8			19.4	7.5–37.5	**6.5**	0.8–21.4	38.7	21.8–57.8	61.3	42.2–78.2
University of Iowa, Iowa City, IA	**5.6**	0.7–18.7			13.9	4.7–29.5	**8.3**	1.8–22.5	27.8	14.2–45.2	72.2	54.8–85.8
Jacksonville, FL	**3.1**	0.1–16.2	6.3	0.8–20.8	21.9	9.3–40.0	**6.3**	0.8–20.8	31.3	16.1–50.0	68.8	50.0–83.9
Miami, FL	**4.2**	0.5–14.3	2.1	0.1–11.1	8.3	2.3–20.0	**22.9**	12.0–37.3	29.2	17.0–44.1	70.8	55.9–83.0
University of California, Davis, Sacramento, CA	**0**	0	9.8	3.2–21.4	17.6	8.4–30.9	**3.9**	0–10.4	25.5	14.3–39.6	74.5	60.4–85.7
Worcester, MA	**15.2**	6.3–28.9	2.2	0.1–11.5	6.5	1.4–17.9	**4.3**	0.5–14.8	28.3	16.0–43.5	71.7	56.5–84.0

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Bold values indicate statistically significant differences in proportions by sex, age group, and location within substance categories.

Note: numbers and percentages are unweighted.

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Table 3.

Opioids and benzodiazepines detected in older adults evaluated for serious injury after a fall, by sex and age group.

	Total unique blood samples *n* = 300		Sex					Age group (years)											
			Female (*n* = 145)		Male (*n* = 155)		*P*-value	65–69 (*n* = 57)		70–74 (*n* = 53)		75–79 (*n* = 49)		80–84 (*n* = 50)		85–89 (*n* = 55)		≥90 (*n* = 36)		*P*-value
	Number detected per sample type	%	*n*	%	*n*	%		*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	
Opioids																				
Fentanyl	12	4.0	6	4.1	6	3.9	0.91	6	10.5	2	3.8	1	2.0	2	4.0	1	1.8	0		0.11
Morphine	3	1.0	3	2.1	0		0.07	1	1.8	0		0		2	4.0	0		0		0.23
Tramadol	14	4.7	7	4.8	7	4.5	0.90	2	3.5	3	5.7	2	4.1	3	6.0	4	7.3	0		0.68
Codeine	2	0.7	1	0.7	1	0.6	0.96	2	3.5	0		0		0		0		0		0.13
Hydrocodone	10	3.3	9	6.2	1	0.6	0.01	4	7.0	2	3.8	1	2.0	0		2	3.6	1	2.8	0.49
Dihydrocodeine	8	2.7	8	5.5			0.00	2	3.5	0		3	6.1	1	2.0	0		1	2.8	0.14
Noroxycodone	7	2.3	6	4.1	1	0.6	0.05	2	3.5	0		3	6.1	1	2.0	0		1	2.8	0.30
Oxycodone	7	2.3	5	3.4	2	1.3	0.22	3	5.3	0		2	4.1	1	2.0	0		1	2.8	0.37
Methadone	2	0.7	2	1.4	0		0.14	1	1.8	0		1	2.0	0		0		0		0.59
Norfentanyl	4	1.3	3	2.1	1	0.6	0.28	3	5.3	1	1.9	0		0		0		0		0.10
Beta-hydroxyfentanyl	2	0.7	2	1.4	0		0.14	2	3.5	0		0		0		0		0		0.13
4-Anilino-N-phenethyl-piperidine	1	0.3	1	0.7	0		0.30	1	1.8	0		0		0		0		0		0.51
Total unique blood samples with opioids detected	45	15.0	28	19.3	17	11.0	0.04	14	24.6	7	13.2	7	14.3	8	16.0	7	12.7	2	5.6	0.22
No opioids detected	255	85.0	117	80.7	138	89.0		43	75.4	46	86.8	42	85.7	42	84.0	48	87.3	34	94.4	0.22
Benzodiazepines																				
Lorazepam	7	2.3	4	2.8	3	1.9	0.64	1	1.8	1	1.9	0	0.0	2	4.0	1	1.8	2	5.6	0.61
Nordiazepam	11	3.7	5	3.4	6	3.9	0.85	1	1.8	1	1.9	2	4.1	2	4.0	3	5.5	2	5.6	0.85
Oxazepam	6	2.0	4	2.8	2	1.3	0.36	1	1.8	0		0		1	2.0	3	5.5	1	2.8	0.35
Temazepam	9	3.0	6	4.1	3	1.9	0.26	1	1.8	0		1	2.0	1	2.0	4	7.3	2	5.6	0.26

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	Total unique blood samples *n* = 300		Sex					Age group (years)											
			Female (*n* = 145)		Male (*n* = 155)		*P*-value	65–69 (*n* = 57)		70–74 (*n* = 53)		75–79 (*n* = 49)		80–84 (*n* = 50)		85–89 (*n* = 55)		≥90 (*n* = 36)		*P*-value
	Number detected per sample type	%	*n*	%	*n*	%		*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	
Alprazolam	4	1.3	2	1.4	2	1.3	0.95	0		2	3.8	0		1	2.0	1	1.8	0		0.47
7-Amino clonazepam	5	1.7	2	1.4	3	1.9	0.71	2	3.5	1	1.9	1	2.0	1	2.0	0		0		0.73
Clonazepam	2	0.7	2	1.4	0	0.0	0.14	1	1.8	0		1	2.0	0		0		0		0.59
Diazepam	6	2.0	3	2.1	3	1.9	0.93	1	1.8	0		2	4.1	1	2.0	2	3.6	0		0.60
Total unique blood samples with benzodiazepines detected	28	9.3	13	9.0	15	9.7	0.832	5	8.8	5	9.4	3	6.1	6	12.0	6	10.9	3	8.3	0.94
No benzodiazepines detected	272	90.7	132	91.0	140	90.3		52	91.2	48	90.6	46	93.9	44	88.0	49	89.1	33	91.7	0.94

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Table 4.

Opioids and benzodiazepines detected in older adults evaluated for serious injury after a fall, by trauma center location.

	Emergency department site													
	Baltimore, MD (*n* = 56)		Charlotte, NC (*n* = 31)		Jacksonville, FL (*n* = 32)		Miami, FL (*n* = 48)		University of California, Davis, CA (*n* = 51)		University of Iowa, IA (*n* = 36)		Worcester, MA (*n* = 46)		*P*-value
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	
Opioids															
Fentanyl	6	10.7	2	6.5	0		0		2	3.9	1	2.8	1	2.2	0.1
Morphine	0		2	6.5	0		1	2.1	0		0		0		0.1
Tramadol	4	7.1	2	6.5	1	3.1	2	4.2	2	3.9	2	5.6	1	2.2	0.9
Codeine	0		0		0		1	2.1	1	2.0	0		0		0.7
Hydrocodone	1	1.8	1	3.2	4	12.5	0		2	3.9	2	5.6	0		0.1
Dihydrocodeine	1	1.8	1	3.2	3	9.4	0		2	3.9	1	2.8	0		0.2
Noroxycodone	1	1.8	0		1	3.1	0		4	7.8	0		1	2.2	0.1
Oxycodone	1	1.8	0		2	6.3	0		3	5.9	0		1	2.2	0.3
Methadone	2	3.6	0		0		0		0		0		0		0.2
Norfentanyl	1	1.8	0		0		0		2	3.9	1	2.8	0		0.5
Beta-hydroxyfentanyl	1	1.8	0		0		0		1	2.0	0		0		0.7
4-Anilino-N-phenethyl-piperidine	0		0		0		0		1	2.0	0		0		0.6
Total unique blood samples with opioids detected	11	19.6	6	19.4	7	21.9	4	8.3	9	17.6	5	13.9	3	6.5	0.31
No opioids detected	45	80.4	25	80.6	25	78.1	44	91.7	42	82.4	31	86.1	43	93.5	0.31
Benzodiazepines															
Lorazepam	0		1	3.2	2	6.3	1	2.1	0		2	5.6	1	2.2	0.37
Nordiazepam	2	3.6	0		1	3.1	8	16.7	0		0		0		0.00
Oxazepam	1	1.8	0		0		5	10.4	0		0		0		0.00
Temazepam	1	1.8	0		0		8	16.7	0		0		0		0.00
Alprazolam	2	3.6	0		0		1	2.1	0		0		1	2.2	0.60
7-Amino clonazepam	2	3.6	1	3.2	0		1	2.1	1	2.0	0		0		0.72
Clonazepam	2	3.6	0		0		0		0		0		0		0.19

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	Emergency department site														
	Baltimore, MD (*n* = 56)		Charlotte, NC (*n* = 31)		Jacksonville, FL (*n* = 32)		Miami, FL (*n* = 48)		University of California, Davis, CA (*n* = 51)		University of Iowa, IA (*n* = 36)		Worcester, MA (*n* = 46)		*P*-value
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	
Diazepam	1	1.8	0		1	3.1	2	4.2	1	2.0	1	2.8	0		0.80
Total unique blood samples with benzodiazepines detected	6	10.7	2	6.5	2	6.3	11	22.9	2	3.9	3	8.3	2	4.3	0.03
No benzodiazepines detected	50	89.3	29	93.5	30	93.8	37	77.1	49	96.1	33	91.7	44	95.7	0.03