U·P·O·J

Historical and Projected Incidence of Alcohol-related Upper Extremity Fractures

Christina Nypaver, MD[1]
Kevin Pirrucio, BS[1]
Nikolas Kazmers, MD, MSE[3]
Benjamin Gray, MD[1]

[1]Department of Orthopaedic Surgery, University of Pennsylvania

[2]Perelman School of Medicine, University of Pennsylvania

[3]Department of Orthopaedic Surgery, University of Utah

Introduction

Hand and upper extremity fractures are exceedingly common injuries in the United States population, and have been estimated to comprise 1.5% of all emergency department visits nationwide.[1-3] The most common of these fractures involves the distal forearm (particularly the distal radius), though certain age groups are more likely to be afflicted with certain hand and upper extremity fractures than others.[1,4-6]

These injuries can markedly reduce quality of life. Among the elderly, wrist fractures have been associated with subsequent dependence on caregivers for activities of daily living in addition to the inherent risk for persistent pain and dysfunction.[7-8] Hand and upper extremity fractures also play a major role in disability for younger patients, as they commonly require dedicated time off work with prolonged, aggressive rehabilitation to maximize return to function.[9-10]

A principal goal in healthcare is primary prevention of conditions that result in patient morbidity. Specific to orthopaedic trauma, one critical step in prevention is the identification of associated mechanisms of injury.[11] Falls to the ground on outstretched hands have repeatedly been determined to be the leading cause of hand and upper extremity fractures.[1,6,12-13] Alcohol use and abuse is relatively common[14] and has previously been associated with fractures of the hand and upper extremity via an increased propensity for falls and risky behavior, which could lead to unintentional injury.[15-17] Not only does alcohol use contribute to postural imbalance,[15-16,18] but it also is associated with increased violence and accidents due to impaired judgment. Alcohol consumption has also been identified as a risk factor for both obesity and decreased bone mineral density; this may exacerbate injury risk due to heavier individuals sustaining more forceful impacts on fragile bones.[19-21] To the best of our knowledge, the effects of alcohol consumption on the incidence of traumatic hand and upper extremity fractures has not been reported or investigated.

The purpose of this study is to report national estimates and demographic characteristics of patients presenting to U.S. emergency departments between 2000 and 2017 with traumatic hand and upper extremity fractures associated with alcohol consumption. Our secondary aim is to project alcohol-associated fracture estimates between 2017 and 2030 as well as the annual percentage of the overall number of hand and upper extremity fractures presenting to U.S. emergency departments that are associated with alcohol consumption.

Methods

Data Sources

The Consumer Product Safety Commission's (CPSC) publicly available and deidentified National Electronic Injury Surveillance System (NEISS) was used for this cross-sectional, retrospective epidemiological study. The database is a national representative probability sample of roughly 100 hospital emergency departments that serves the purpose of observing and reliably characterizing the epidemiology of injuries in the United States. It is stratified by both hospital size and geographic location, which allows for statistically validated, weighted national estimates and sampling errors of queried injuries to be derived. The database contains a unique case record for each patient and includes date of treatment, age, sex, race, diagnosis, body part affected, patient disposition, location of injury, as well as narrative fields to provide additional comments. This data is entered into the database by providers and data coordinators and updates (i.e. recognizing and filling in any missing data) are performed daily. The NEISS has previously been utilized in hand surgery studies evaluating the epidemiology of finger amputations[22] and scaphoid fractures.[23] Specific data collection methodologies, quality control precautions, and other general information are available on the CPSC webpage.[24-26]

First, each yearly sample in the NEISS database was queried between 2000 and 2017 using the diagnosis of "fracture" and the affected body parts "finger", "hand", "wrist", and "lower arm" (excluding all injuries at and above the elbow), which were herein considered as "the hand and upper extremity". All hand and upper extremity fracture cases were subsequently identified for

each year during this time period. The narrative sections within these identified case records were then individually analyzed and queried using several keywords to help identify any relevant history of alcohol intoxication or consumption prior to admission and related to the injury event. Examples of these keywords included "alcohol", "drank", "ingested", "consumed", as well as various forms of alcoholic beverages such as "beer", "wine", "vodka", etc. Case records were also included if patients were explicitly noted to be intoxicated with alcohol and had a blood alcohol concentration above 0.08 g/dL. Following the analysis of the narrative section, unique cases of traumatic hand and upper extremity fractures associated with alcohol consumption were subsequently identified for each year during this time period.

As previously described, 27 weighted national estimates were calculated (for total and one-year interval numbers of both total and alcohol associated upper extremity fractures) using a svyset function in a statistical software which uses the NEISS data columns "PSU", "Weight", and "Stratum" as inputs for its sampling unit, sample weight, and strata fields, respectively. The software function then generates weighted national estimates for the given inputs with associated 95% confidence intervals. The incidence of alcohol associated upper extremity fractures out of total upper extremity fractures was then calculated for the total seventeen year time frame as well as one-year intervals. 95% confidence intervals for incidence were calculated using the upper and lower borders from the aforementioned weighted national estimates 95% confidence intervals.

The NEISS database allows for unique case record group analysis and will automatically calculate incidence with respect to various demographic characteristics. Specifically, anatomical location of fracture, age, sex, race, disposition, and location (of injury) were evaluated within our previously identified unique group of hand and upper extremity fractures associated with alcohol. The same svyset function was, again, used to apply standard errors and confidence intervals to the demographic incidence data.

A standard linear regression function (which generates a linear line of best fit for the inputted data and its associated equation) was then used to evaluate trends in the annual national estimate of both total and alcohol-associated hand and upper extremity fractures presenting to U.S. emergency departments over time. Projections were made by applying this regression model forward to the year 2030, by inputting future years into the function to output the predicted national number of injuries if the same linear line were extended forward in time. Significance of trends were determined using adjusted Wald tests. Two-sided p-values < 0.05 were considered significant.

Results

The NEISS database revealed a total of 394,055 cases of patients presenting to an Emergency Department in the United States with traumatic hand and upper extremity fractures between the years 2000 and 2017, which correlated to a total national estimate of 13,544,461 cases. Of these 394,055 cases, 1,541 unique cases of patients whose fracture(s) were associated with alcohol consumption were identified, which correlated to a total national estimate of 62,373 cases. These data by corresponding year, including incidence and their associated 95% CIs are provided in Table 1.

Overall demographics of the patients whose fracture(s) were associated with alcohol consumption can be observed in Table 2. The majority of fractures were located in the hand (37.8%), occurred in young adults between the ages of 20-29 (33.9%), occurred in males (70.9%), occurred in whites (54.7%), were sustained in the home (39.7%), and were also more likely to be treated and admitted to the hospital as opposed to being discharged (60.5%).

The number of total national estimated cases of any cause decreased linearly within this seventeen-year time with a statistically significant p-value of < 0.05 (0.001) and of R2 of -0.79 (Figure 1). Specifically, the number of cases decreased 13% from 788,210 cases in the year 2000 to 686,419 cases in the year 2017 (Table 1).

The number of national estimated cases that were associated with alcohol significantly increased linearly within this seventeen-year time frame with a statistically significant p-value of < 0.05 (0.001) and R2 of -0.86 (Figure 2). Specifically, the number of cases more than doubled from 2,368 cases in the year 2000 or 0.30% to 5,182 cases in the year 2017 or 0.75% (Table 1).

Projected weighted national estimates of traumatic hand and upper extremity fractures associated with alcohol consumption are provided in Figure 3. The existing, current linear trend that has been observed between 2000 and 2017 is projected to continue, with a number of total national estimate cases of 6,802 or 1.04%, by the year 2030.

Discussion

Our main finding was that the number of patients presenting to an emergency department with an alcohol-related hand and upper extremity fracture increased roughly two-fold over the duration study period, from 2,368 annual cases in 2000 to 5,182 annual cases in 2017. This linear trend is projected to continue on the same trajectory into the year 2030, at which point the number of annual cases will reach roughly 7,000, encompassing more than 1% of all hand and upper extremity fractures that present to an emergency department. We demonstrated that these alcohol-related fractures most commonly occur in the hand, more frequently occur in white males between the ages of 20-29 while at home, and are more likely to be admitted to the hospital rather than discharged from the emergency department. Combined, our results suggest that alcohol-related hand and upper extremity fractures, which may be preventable, result in a substantial burden on society in terms of lost productivity and expenditure of healthcare resources.

Our epidemiologic findings are consistent with the literature examining the epidemiology of upper extremity fractures in the United States. In 2001, Chung et al1 studied

Table 1 demonstrates the annual number of national estimated traumatic hand and upper extremity fractures as well as the annual number and incidence of national estimated hand and upper extremity fractures associated with alcohol presenting to emergency departments between the years 2000-2017, and their associated confidence intervals.

Years	National Estimate of Cases Associated with Alcohol Consumption	Total National Estimate of Hand and Upper Extremity† Fractures	Percentage of Hand and Upper Extremity† Fractures Associated with Alcohol Consumption	95% Confidence Interval
2017	5,182	686,419	0.75%	0.55% - 0.96%
2016	5,146	679,653	0.76%	0.57% - 0.94%
2015	4,354	670,753	0.65%	0.45% - 0.85%
2014	3,990	675,055	0.59%	0.44% - 0.75%
2013	3,618	687,686	0.53%	0.35% - 0.70%
2012	3,872	738,941	0.52%	0.42% - 0.62%
2011	3,252	739,063	0.44%	0.30% - 0.58%
2010	3,787	765,177	0.49%	0.35% - 0.64%
2009	3,823	758,601	0.50%	0.38% - 0.63%
2008	3,675	776,862	0.47%	0.33% - 0.61%
2007	3,367	796,817	0.42%	0.33% - 0.52%
2006	3,483	794,358	0.44%	0.32% - 0.56%
2005	2,526	786,556	0.32%	0.21% - 0.44%
2004	2,815	830,509	0.34%	0.24% - 0.44%
2003	2,527	792,243	0.32%	0.21% - 0.42%
2002	2,279	786,606	0.29%	0.21% - 0.37%
2001	2,307	790,952	0.29%	0.18% - 0.40%
2000	2,368	788,210	0.30%	0.19% - 0.41%

Legend:
† - Anatomical locations included in this analysis are as follows: Finger, Hand, Wrist, Lower Arm. Importantly, excludes all fractures/injuries at and above the elbow.

1,465,874 cases of hand/forearm fractures and noted that most fractures occurred in the home (30%) and that whites made up the largest proportion of fractures (83%). While they found that the proportion of all fracture types was evenly divided between genders, they did report that males were more likely to sustain fractures of the hand, and that metacarpal fractures occurred most commonly in the 15-24 year age group, which is consistent with our data. Likewise, Karl et al[2] studied 590,193 upper extremity fractures and found that metacarpal and phalangeal fractures occurred most commonly in the 18-34 year age group. Finally, Ootes et al[3] reviewed 92,601 records of upper extremity injuries from the same National Electronic Injury Surveillance System (NEISS) from 2009, and also found that the majority of cases occurred in the home (45.4%). Though this study included all forms of upper extremity injury, the most common type of injury in their data was fracture (29.2%).

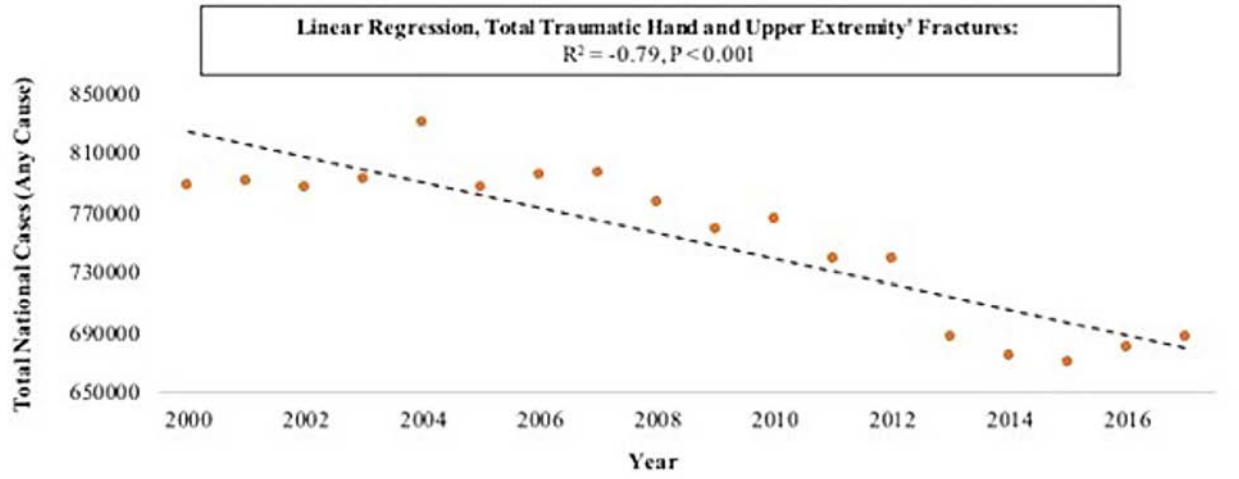
While our epidemiologic data appears to be consistent with previous literature, these studies did not examine alcohol association as our study did. In assessing for a concomitant increase in alcohol consumption, recent surveillance by the National Institute on Alcohol Abuse and Alcoholism28 reported that the per capita alcohol consumption (which is based on reported volumes of alcoholic beverages released to the market for sale) has increased from 1.3 gallons in 1977 to almost 2.4 gallons in 2017. This denotes that the population is consuming more alcohol overall. In addition, other recent epidemiologic studies have noted increases in alcohol use, alcohol use disorder, and high-risk drinking amongst certain population subgroups.[29] The increase in alcohol-related fractures seen in our study thus would correlate with the overall increase in alcohol consumption in the United States.

There are several additional explanations for the linear increase seen in our data. Obesity, of which alcohol use is a risk factor, is rapidly rising in the United States.[21,30-31] This added body mass may contribute to more forceful impacts in a population that is at higher risk of falls.[20-21] These individuals often have decreased bone mass density from alcohol consumption and thus more brittle bones.[19] In addition, with increased awareness of the dangers of drunk driving, more people may be drinking alcohol in their homes. This is supported in our study as most hand and upper extremity fractures tend to occur in the home and was noted in previous studies for all hand fractures.[1,3] Finally, the introduction of newer technologies such as phones and other electronic portable devices have increased the danger of activities such

Table 2 demonstrates the demographic variables and associated categorical percentages of patients presenting to emergency departments with alcohol associated traumatic hand and upper extremity fractures between 2000-2017. Standard error and confidence intervals for each variable are also shown.

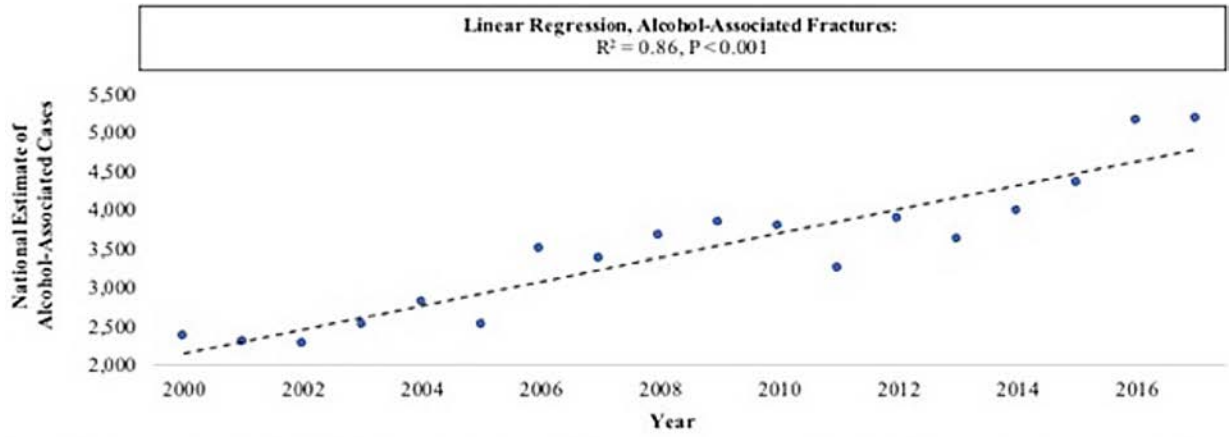
Demographic Variable	Percentage	Standard Error	95% Confidence Interval		
Anotomical Location of Fracture					
Lower Arm	19.4%	1.4%	16.6%	-	22.2%
Wrist	28.6%	2.3%	23.9%	-	33.2%
Hand	37.8%	1.8%	34.2%	-	41.4%
Finger	14.2%	1.1%	12.0%	-	16.4%
Age					
0 to 9 Years*	0.0%				
10 to 19 Years	4.3%	1.1%	2.0%	-	6.6%
20 to 29 Years	33.9%	2.0%	30.0%	-	37.8%
30 to 39 Years	20.5%	1.1%	18.3%	-	22.7%
40 to 49 Years	18.9%	1.3%	16.3%	-	21.6%
50 to 59 Years	13.5%	1.1%	11.2%	-	15.7%
60 to 69 Years	6.7%	0.9%	4.9%	-	8.5%
70 to 79 Years	2.1%	0.6%	0.9%	-	3.3%
80 Years or Older*	0.1%				
Sex					
Male	70.9%	1.9%	67.1%	-	74.8%
Female	29.1%	1.9%	25.2%	-	32.9%
Race					
White	54.7%	4.0%	46.8%	-	62.5%
Black	7.8%	1.9%	4.0%	-	11.7%
Other*	1.2%				
Asian*	0.5%				
Native American*	0.7%				
Pacific Islander*	0.1%				
Hispanic	6.1%	1.7%	2.7%	-	9.4%
Race Not Specified	28.9%	4.1%	20.8%	-	37.0%
Disposition					
Treated and Released	35.3%	2.5%	30.3%	-	40.2%
Treated and Admitted	60.5%	3.2%	54.1%	-	66.9%
Location					
Unknown	38.3%	2.8%	32.7%	-	43.9%
Home	39.7%	2.8%	34.2%	-	45.3%
Street	7.3%	1.2%	5.0%	-	9.6%
Public	12.3%	1.3%	9.8%	-	14.7%
School*	0.6%				
Sports*	1.9%				

Legend:
† - Anatomical locations included in this analysis are as follows: Finger, Hand, Wrist, Lower Arm. Importantly, excludes all fractures/injuries at and above the elbow.



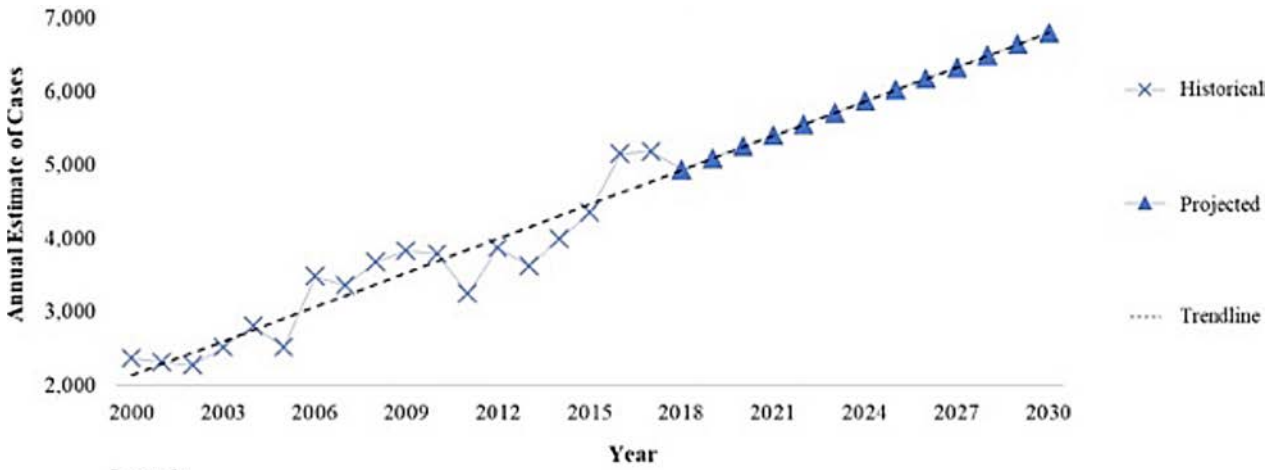
Legend: † - Anatomical locations included in this analysis: Finger, Hand, Wrist, Lower Arm. Importantly, excludes all fractures/injuries at and above the elbow.

Figure 1 demonstrates the national estimated total number of cases of traumatic hand and upper and upper extremity fractures presenting to emergency departments each corresponding year between 2000-2017. These estimates displayed a negative linear regression pattern with a $R^2 = -0.79$ and statistically significant p-value of < 0.001.



Legend: † - Anatomical locations included in this analysis: Finger, Hand, Wrist, Lower Arm. Importantly, excludes all fractures/injuries at and above the elbow.

Figure 2 demonstrates the national estimated number of cases alcohol associated traumatic hand and upper extremity fractures presenting to emergency departments each corresponding year between 2000-2017. These estimates displayed a positive linear regression pattern with a $R^2 = 0.86$ and statistically significant p-value of < 0.001.



Legend:
† - Anatomical locations included in this analysis are as follows: Finger, Hand, Wrist, Lower Arm. Importantly, excludes all fractures/injuries at and above the elbow.

Figure 3 demonstrates the historical (2000-2017) and projected (2017-2030) national estimated number of cases of alcohol associated traumatic hand and upper extremity fractures presenting to emergency departments per corresponding year using a linear regression model.

as distracted walking, which could be potentiated by alcohol use.[32] Ultimately, the linear trend we observe in our data is most likely the result of a multitude of factors as opposed to a single reason.

Our demographic data, nonetheless, is subjectively similar to that in recent literature. The prevalence of drinking, and therefore its associated consequences from risky behavior, peaks in young adults aged 18-29 and is most prevalent amongst white males, 33 who were the majority population in our patient cases.

We acknowledge several limitations of this study, which are related to the nature of the NEISS survey. Most importantly, the accuracy of our estimates depended on the accuracy of the narrative sections, which are prone to reporting and sampling biases. While the CPSC will regularly conduct internal analyses to ensure proper and comprehensive data collection processes, it cannot be ruled out that alcohol consumption was not mentioned in certain hand and upper extremity fractures. Similarly, alcohol consumption may have been underreported by patients. This, however, would suggest that our data potentially underestimates the total burden of alcohol associated hand and upper extremity fractures.

In conclusion, alcohol consumption is associated with fractures of the hand and upper extremity, and the numbers of these cases are increasing over time and this trend is predicted to continue in the future. This is new information that should motivate physicians to educate their patients regarding the risk of fracture associated with alcohol consumption. This data may also aid in the prevention of these injuries, which can be a major burden for patients in terms of cost, time off of work, and long-term function as well as a noteworthy financial burden for the healthcare system.

References

1. Chung KC and Spilson SV. The frequency and epidemiology of hand and forearm fractures in the united states. *Journal of Hand Surgery* 2001; 26(5):908-915.

2. Karl JW, Olson PR, Rosenwasser MP. The epidemiology of upper extremity fractures in the united states, 2009. *Journal Orthopedic Trauma* 2015; 29(8):242.

3. Ootes D, Lambers KT, Ring DC. The epidemiology of upper extremity injuries presenting to the emergency department in the united states. *Hand (NY)* 2012; 7(1):18-22.

4. Hedstrom EM, Svensson O, Bergstrom U, *et al.* Epidemiology of fractures in children and adolescents. *Acta Orthopaedica* 2010; 81(1):148-153.

5. Immerman I, Livermore MS, Szabo RM. Use of emergency department services for hand, wrist, and forearm fractures in the United States in 2008. *Journal Surgical Orthopaedic Advances* 2014; 23(2):98-104.

6. Kelsey JL and Samelson EJ. Variation in risk factors for fractures at different sites. *Current Osteoporosis Reports* 2009; 7(4):127-133.

7. MacDermid JC, Roth JH, Richards RS. Pain and disability reported in the year following a distal radius fracture: A cohort study. *BMC Musculoskeletal Disorders* 2003; 4:24.

8. Vergara I, Vrotsou K, Orive M, *et al*. Wrist fractures and their impact in daily living functionality on elderly people: A prospective cohort study. *BMC Geriatrics* 2016; 16:11.

9. Hardy MA. Principles of metacarpal and phalangeal fracture management: a review of rehabilitation concepts. *Journal Orthopaedic Sports Physical Therapy* 2004; 34(12):781-99.

10. Wong JY. Time off work in hand injury patients. *The Journal of Hand Surgery* 2008; 33(5):718-25.

11. Bot AG, Doornberg JN, Lindenhovius AL, *et al.* Long-term outcomes of fractures of both bones of the forearm. *Journal of Bone and Joint Surgery* 2011; 93(6):527-532.

12. Chiu J and Robinovitch SN. Prediction of upper extremity impact forces during falls on the outstretched hand. *Journal of Biomechanics* 1998; 31(12):1169-1176.

13. Tsuda T. Epidemiology of fragility fractures and fall prevention in the elderly: a systematic review of the literature. *Current Orthopaedic Practice* 2017; 28(6):580-585.

14. Substance Abuse and Mental Health Services Administration. 2017 National Survey on Drug Use and Health. https://www.samhsa.gov/data/sites/default/files/cbhsq-reports/NSDUHDetailedTabs2017/NSDUHDetailedTabs2017.pdf. Published September 2018.

15. Cremonte M and Cherpitel CJ. Alcohol intake and risk of injury. *Medicina (B Aires)* 2014; 74(4):287-292.

16. Wu HZ, Barry LC, Duan Y, *et al.* Acute effects of moderate alcohol consumption on postural stability in older adults. *Perceptual and Motor Skills* 2017; 124(5):912-931.

17. Pirruccio K, Weltsch D, Baldwin KD. Kickball and its underappreciated pediatric injury burden: an 18-year retrospective epidemiological study. *Orthopaedic Journal of Sports Medicine* 2019; 2;7(4).

18. Chen CM and Yoon YH. Usual alcohol consumption and risks for nonfatal fall injuries in the United States: results from the 2004-2013 national health interview survey. *Substance Use & Misuse* 2017; 52(9):1120-1132.

19. Louer CR, Boone SL, Guthrie AK, *et al.* Postural stability in older adults with a distal radial fracture. *The Journal of Bone and Joint Surgery* 2016; 98(14):1176-1182.

20. Abrahamsen B, Brask-Lindemann D, Rubin KH, *et al.* A review of lifestyle, smoking and other modifiable risk factors for osteoporotic fractures. *Bonekey Reports* 2014; 3:574.

21. Gonnelli S, Caffarelli C, Nuti R. Obesity and fracture risk. *Clinical Cases in Mineral and Bone Metabolism* 2014; 11(1):9-14.

22. Traversy G and Chaput JP. Alcohol consumption and obesity: an update. *Current Obesity Reports* 2015; 4(1):122-130.

23. Reid DBC, Shah KN, Eltorai AEM, *et al.* Epidemiology of finger amputations in the United States from 1997 to 2016. *The Journal of Hand Surgery Global Online* 2019; 1(2):45-51.

24. Van Tassel DC, Owens BD, Wolf JM. Incidence estimates and demographics of scaphoid fracture in the U.S. population. *The Journal of Hand Surgery* 2010; 45(8):1242-5.

25. United States Consumer Product Safety Commission. The National Electronic Injury Surveillance System. https://www.cpsc.gov/Research--Statistics/NEISS-Injury-Data. 2000.

26. Schroeder T and Ault K. The NEISS sample: design and implementation. U.S. Consumer Product Safety Commission: Division of Hazard and Injury Data Systems. https://www.cpsc.gov/s3fs-public/pdfs/blk_media_2001d011-6b6.pdf. 2001.

27. United States Consumer Product Safety Commission. The National Electronic Injury Surveillance System: Coding Manual. https://www.cpsc.gov/s3fs-public/2017NEISSCodingManualCPSConlyNontrauma.pdf. 2017.

28. Slater ME and Alpert HR. Surveillance report #113: apparent per capita alcohol consumption: national, state, and regional trends, 1977-2017. National Institute on Alcohol Abuse and Alcoholism. https://pubs.niaaa.nih.gov/publications/surveillance113/CONS17.pdf. 2019.

29. Grant BF, Chou SP, Saha TD, *et al.* Prevalence of 12-month alcohol use, high-risk drinking, and DSM-IV alcohol use disorder in the united states, 2001-2002 to 2012-2013: results from the national epidemiologic surgery on alcohol and related conditions. JAMA Psychiatry. 2017; 74(9):911-923.

30. Flegal KM, Kruszon-Moran D, Carroll MD, *et al.* Trends in obesity among adults in the united states, 2005 to 2014. *Journal of American Medical Assocation* 2016; 315(21):2284-2291.

31. Sturm R and Hattori A. Morbid obesity rates continue to rise rapidly in the united states. *International Journal of Obesity (London)* 2013; 37(6):889-891.

32. American Academy of Orthopaedic Surgeons. Distracted walking. https://orthoinfo.aaos.org/en/staying-healthy/distracted-walking/. Updated 2015.

33. Delker E, Brown Q, Hasin DS. Alcohol consumption in demographic subpopulations: an epidemiologic overview. *Alcohol Res*earch 2016; 38(1):7-15.