

Emergency Department Visits for Ankle Fractures Through COVID-19: An Analysis of the National Electronic Injury Surveillance System

Kevin Mo, MHA¹ , Arjun Gupta, BS^{1,2}, Priya Singh, MS¹, Samuel Malan, BS¹ , Claire McDaniel, MD¹, John M. Thompson, MD¹, and Amiethab Aiyer, MD¹

Abstract

Background: Societal changes that occurred during the COVID-19 pandemic may have altered the epidemiology of ankle fractures. The aim of this study was to assess trends in emergency department visits for ankle fractures from 2019 to 2020 in the United States.

Methods: The National Electronic Injury Surveillance System (NEISS) database is a sample of hospitals in the United States stratified and weighted based on emergency department (ED) size, which was used to generate national estimates (NEs). The NEISS database was queried for patients who sustained an ankle fracture. Patients before COVID-19 (BC) (July 2019–December 2019) were compared to those during COVID-19 (DC) (July 2020–December 2020).

Results: This study assessed 3350 (NE: 131,672) patients. Of these, 1683 (NE: 67,292) patients presented BC and 1667 (NE: 64,380) DC, representing a 4% decrease. The rate of alcohol-related ankle fractures increased (1.9% BC vs 2.6% DC; $P < .001$). The fraction of ankle fractures at school (3% BC vs 0.7% DC; $P < .001$) and during sports (19% BC vs 14% DC; $P < .001$) decreased. ED visits for ankle fracture leading to hospitalization marginally increased (23% BC vs 24% DC). The top 3 ankle fracture causes during COVID-19 were stairs (NE: 18,026, 28%), floors (ie, falling on floor) (NE: 4635, 7.2%), and skateboards (NE: 2832, 4.40%). The 3 largest increases in ankle fracture causes during COVID-19 were skateboards (+2.80%), floors (+1.10%), and powered scooters (+0.80%).

Conclusion: There was a decrease in ankle fractures during the COVID-19 pandemic compared to the year before. Alcohol-related fractures increased as did fractures resulting in hospitalization. Ankle fractures caused by skateboards, powered scooters, and mopeds increased during COVID-19, whereas fewer occurred in school or during sports, consistent with restrictions to group activities. These findings may aid in proper health care budgeting in times of national and global crises.

Level of Evidence: Level III, retrospective comparative study.

Keywords: ankle, fracture, COVID-19, emergency department, national, cross-sectional, epidemiology

Introduction

Prior to the COVID-19 pandemic, more than 5 million ankle injuries occurred each year in the United States, with the incidence of ankle fractures ranging from 42 to 187 fractures per 100 000 person-years.^{5,7,11,18} The incidence of these injuries has been increasing over the past few decades—particularly among women and the elderly¹¹—as more people are participating in sports and average life expectancy is

¹Department of Orthopaedic Surgery, The Johns Hopkins University School of Medicine, Baltimore, MD, USA

²Department of Orthopaedic Surgery, Rutgers New Jersey Medical School, Newark, NJ, USA

Corresponding Author:

Amiethab Aiyer, MD, Department of Orthopaedic Surgery, The Johns Hopkins Hospital, 1800 Orleans St, Baltimore, MD 21287, USA.
Email: aaiyer2@jhmi.edu



increasing.^{3,20} Low-energy trauma, predominately from falls, accounts for the majority of ankle fractures.^{7,18} These fractures cause not only pain and disability at the time of injury but also have long-term repercussions such as functional impairment, post-traumatic arthritis, and chronic pain. This can lead to patients experiencing difficulties returning to work or sport as well as prolonged dependence on disability benefits.²¹

However, societal changes that occurred for most citizens during the COVID-19 pandemic may have changed the epidemiology of ankle fractures. In response to the pandemic, 48 states issued versions of stay-at-home directives and encouraged social distancing.¹⁴ These directives resulted in the closure of schools, parks, playgrounds, and nonessential businesses leading to the cancellation of numerous recreational activities, which could have impacted the risk of sustaining an ankle fracture. Additionally, nonurgent and elective surgeries were canceled or postponed, negatively impacting the number of surgeries performed annually which prior to the pandemic averaged 1.5 million orthopaedic procedures each year.^{4,12} Despite this nationwide impact, most previous studies assessing the effect of COVID-19 on ankle fracture epidemiology across the United States have been limited to only 1 or 2 regions. In the state of New York, there was a reported 62% decrease in foot and ankle trauma²² and a 72% reduction in ankle fractures as a function of the pandemic.⁹ Other studies reported the impact of the pandemic on length of stay, time to surgery, and postoperative follow-up of acute ankle fractures,¹⁹ and ankle and foot injuries overall. To our knowledge, no study has analyzed the impact COVID-19 on ankle fracture epidemiology at a national level in an emergency department (ED) setting.

The National Electronic Injury Surveillance System (NEISS) database contains a nationally representative sample of ED visits across the United States and has previously been used to assess the epidemiology of ankle fractures prior to COVID-19.¹⁸ Its strengths include the ability to evaluate patient demographics, trends in specific etiologies, substance use related to injuries, and patient disposition for recovery. By sampling the NEISS database, we aimed to assess changes in the incidence, etiologies, and trends of ankle fractures across the United States from 2019 to 2021 before and during the COVID-19 pandemic. We hypothesized that COVID-19-related directives would decrease the incidence of ankle fractures and alter the etiology compared to before the pandemic.

Methods

This was a cross-sectional epidemiologic study examining cases of ankle fracture in the United States. An analysis of ankle fractures was conducted using the Consumer Product Safety Commission's (CPSC's) National Electronic Injury

Surveillance System (NEISS) database, which is a nationally representative sample of injuries presenting to EDs in the United States. The NEISS was created by stratifying all hospitals in the country by geographic location, hospital size, and ED volume. NEISS data were gathered from a probability sample of 100 EDs including that are representative of the ≥ 5000 hospitals with EDs. Data on whether an admission occurred in an urban, rural, academic, or community were not available in NEISS. Data from each sample hospital were assigned statistical sample weights, which were created by stratifying participating hospitals into 5 groups: 1 group representing children's hospital EDs and the remaining 4 representing general hospitals and EDs of varying sizes. The CPSC conducts yearly sampling of participating hospitals and adjusts the sampling frame as necessary to maintain a probability sample that is representative of all hospitals nationally. Numerous studies have used NEISS as a reliable and validated source of national epidemiologic data for various injury types and causes presenting to EDs around the United States.^{1-4,16}

Information gathered from the NEISS included age, gender, race, ethnicity, injury diagnosis, affected body part, incident locale, discharge disposition, injury etiology, consumer products associated with the injury, and a narrative description of the incident. Incident locales studied included "home," "farm," "street," "other public property," "mobile home," "industrial," "school," and "sport." "Street" refers only to location and does not specifically relate to motor vehicle accidents. Discharge dispositions studied included "released," "transfer," "hospitalization," "observed," "left AMA," and "death." Injury etiologies studied included "stairs or steps," "floors or flooring materials," "skateboards," "exercise," "bicycles," "ladders," and "trampolines," among others. "Floors or flooring materials" include etiologies such as slips and falls, where the primary point of physical contact causing the ankle fracture was the floor.

Statistical Analysis

NEISS databases from 2019 to 2021 were queried for patients who had a "fracture" injury type in the "ankle" body part. From these records, 3 cohorts were generated: before COVID-19 (BC) (March 2019–August 2019), during COVID-19 (DC 2020) (March 2020–August 2020), and during COVID-19 (DC 2021) (March 2021–August 2021). All cohorts spanned the same 6 months of the year to control for seasonal variation in ankle fractures.

Initial analysis focused on basic descriptive statistics of ankle fracture. National estimates are calculated through summation of all statistical weights for all cases of interest in accordance with NEISS complex sampling design. Using sample-weighted national estimates, proportional demographic data of the NEISS sample population was analyzed relative to patient demographics (age, sex, and race) and

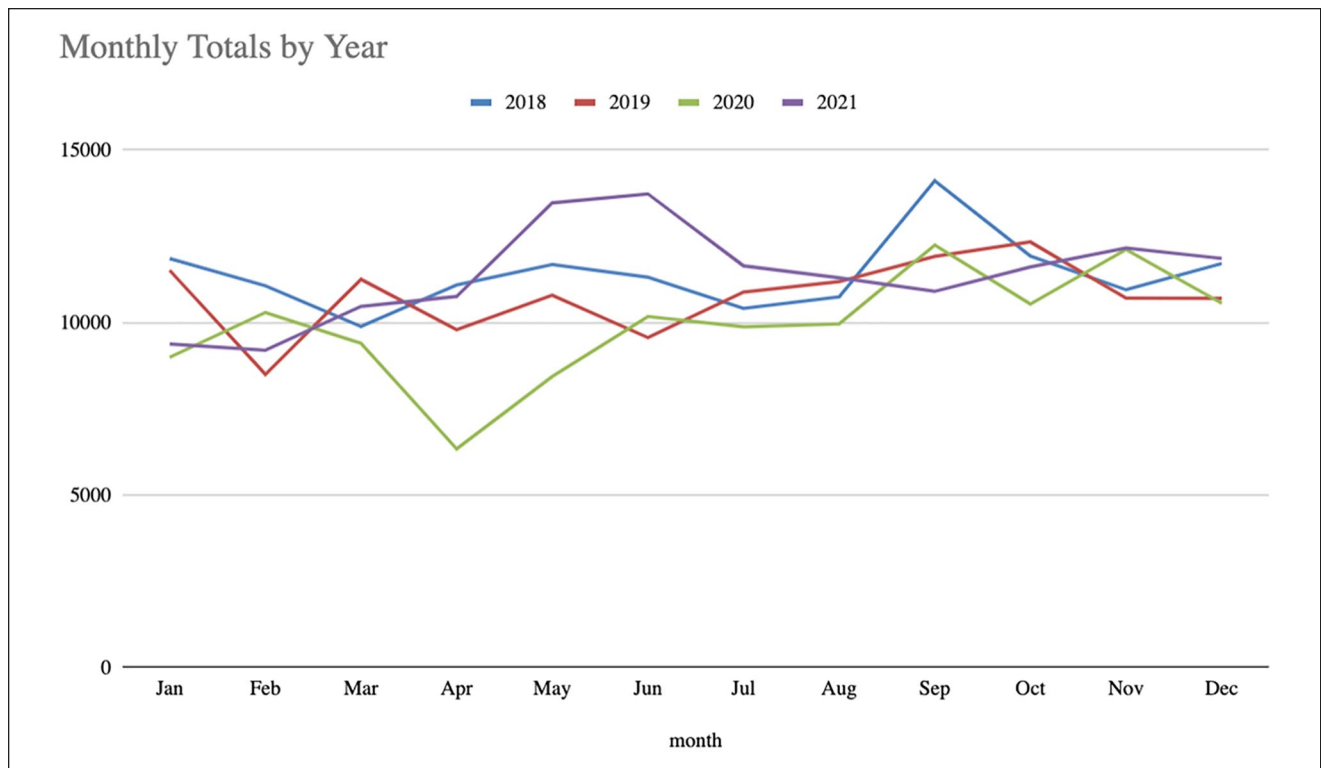


Figure 1. Change in ankle fractures per month from 2018 to 2021.

variable-defined subgroups (eg, locale, discharge disposition, fracture etiology). Categorical data were assessed using chi-square tests. Continuous data were assessed using 2-tailed Student *t* tests. Statistical significance was set to a threshold of $P < .05$. All analysis was conducted using Stata statistical software, version 17.0 (StataCorp, College Station, TX).

Results

During the assessed period from 2019 to 2021, NEISS emergency departments recorded a total of 5027 ankle fractures. Of these, 1597 patients presented BC and 1435 presented DC 2020, and 1995 presented DC 2021. National estimates (NE) were calculated to be 185 118 total ankle fractures, with a 15% decrease after the onset of COVID-19 in 2020 and rebounding 34% in 2021 compared to the year prior (62 100 BC vs 52 610 DC 2020 vs 70 408 DC 2021). Ankle fractures decreased during the beginning of the pandemic in March but rebounded to 2019 levels by June (Figure 1). Demographic, Location, and Disposition information are found by national estimates in Table 1.

Demographics

The study population consisted of 112 162 (61%) females and 72 956 (40.0%) males. Ankle fractures were more

common among females both BC (61% vs 40%), DC 2020, and DC 2021, with females experiencing a 1.3% point and 1.1% point increase DC 2020 and DC 2021 compared to BC. Ankle fractures in those aged ≥ 40 years comprising a higher percentage of total ankle fractures in females than males (38.2% female vs 15% male).

Mean age BC was 43 years (SD 23). By race classification, 54.8% of patients were White, 12.5% were Black, 1.1% were Asian, 0.4% were American Indian, and 0.1% were Native Hawaiian Pacific Islander. The fraction of estimated ankle fractures among White patients increased by 4.2% points DC 2020, and decreased 7.4% DC 2021. Among Black patients, ankle fractures decreased by 1.5% points DC 2020 and rebounded 3.7% points DC 2021. Finally, there was an increase of 4.4% points in proportion of ankle fractures in patients ≥ 65 years old DC 2020, and a subsequent decrease of 2.8% points DC 2021.

Location

Fractures were examined to assess the most common locales in which injury occurred. Most fractures occurred at home (41.6%) followed by sporting facilities (15.9%), public property (6.8%), public streets (3.4%), and schools (1.8%). The number of ankle fractures at sporting facilities decreased (19.2% BC vs 12.3% DC). The number of ankle fractures at school decreased (3.0% BC vs 0.0% DC).

Table 1. Demographics of Ankle Fracture Patients Presenting to ED Before and After COVID-19 Adjusted by National Estimates.^a

	National Estimates of Total Sample (N=185 118)	National Estimates Before COVID-19 (Referent) (n=62 100)	National Estimates During COVID-19 Year 2020 (n=52 610)	P	National Estimates During COVID-19 Year 2021 (n=70 408)	P
Mean age (SD)	43 (23)	42 (23)	45 (23)	<.001	43 (23)	<.001
Age category				<.001		<.001
0-15 y	23 680 (12.8)	8846 (14.2)	5644 (10.7)		9190 (13.1)	
16-25 y	27 759 (15.0)	9187 (14.8)	7197 (13.7)		11 375 (16.2)	
26-40 y	35 068 (18.9)	11 833 (19.1)	9907 (18.8)		13 328 (18.9)	
41-65 y	62 459 (33.7)	21 260 (34.2)	18 252 (34.7)		22 947 (32.6)	
≥65 y	36 152 (19.5)	10 974 (17.7)	11 610 (22.1)		13 568 (19.3)	
Sex				<.001		<.001
Male	72 956 (39.4)	24 974 (40.2)	20 470 (38.9)		27 512 (39.1)	
Female	112 162 (60.6)	37 126 (59.8)	32 140 (61.1)		42 896 (60.9)	
Female by age group				<.001		<.001
0-15 y	12 240 (6.6)	4475 (7.2)	3094 (5.9)		4671 (6.6)	
16-25 y	10 360 (5.6)	3065 (4.9)	2761 (5.2)		4534 (6.4)	
26-40 y	18 812 (10.2)	6446 (10.4)	5170 (9.8)		7196 (10.2)	
41-65 y	43 143 (23.3)	14 871 (23.9)	12 482 (23.7)		15 790 (22.4)	
≥65 y	27 607 (14.9)	8269 (13.3)	8633 (16.4)		10 705 (15.2)	
Male by age group				<.001		.058
0-15 y	11 440 (6.2)	4371 (7.0)	2550 (4.8)		4519 (6.4)	
16-25 y	17 399 (9.4)	6122 (9.9)	4436 (8.4)		6841 (9.7)	
26-40 y	16 256 (8.8)	5387 (8.7)	4737 (9.0)		6132 (8.7)	
41-65 y	19 316 (10.4)	6389 (10.3)	5770 (11.0)		7157 (10.2)	
≥65 y	8545 (4.6)	2705 (4.4)	2977 (5.7)		2863 (4.1)	
Drug related	1689 (0.9)	300 (0.5)	534 (1.0)	<.001	855 (1.2)	<.001
Alcohol related	5933 (3.2)	1678 (2.7)	1896 (3.6)	<.001	2359 (3.4)	<.001
Race				<.001		<.001
Not stated	54 405 (29.4)	19 411 (31.3)	14 870 (28.3)		20 124 (28.6)	
White	101 516 (54.8)	33 620 (54.1)	30 657 (58.3)		37 239 (52.9)	
Black	23 131 (12.5)	7527 (12.1)	5570 (10.6)		10 034 (14.3)	
Other	3005 (1.6)	652 (1.0)	742 (1.4)		1611 (2.3)	
Asian	1989 (1.1)	553 (0.9)	671 (1.3)		765 (1.1)	
American Indian	800 (0.4)	266 (0.4)	100 (0.2)		434 (0.6)	
Native Hawaiian	272 (0.1)	71 (0.1)	0 (0.0)		201 (0.3)	
Pacific Islander						
Location				<.001		<.001
Home	72 956 (39.4)	24 248 (39.0)	24 134 (45.9)		24 574 (34.9)	
Farm	160 (0.1)	0 (0.0)	78 (0.1)		82 (0.1)	
Street	7427 (4.0)	2058 (3.3)	2330 (4.4)		3039 (4.3)	
Other public property	12 335 (6.7)	4254 (6.9)	3254 (6.2)		4827 (6.9)	
Mobile home	57 (0.0)	0 (0.0)	0 (0.0)		57 (0.1)	
Industrial	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	
School	3032 (1.6)	1636 (2.6)	191 (0.4)		1205 (1.7)	
Sports	30 766 (16.6)	12 057 (19.4)	6312 (12.0)		12 397 (17.6)	
Not recorded	58 385 (31.5)	17 847 (28.7)	16 311 (31.0)		24 227 (34.4)	
Disposition				<0.001		<.001
Released	135 829 (73.4)	47 206 (76.0)	37 303 (70.9)		51 320 (72.9)	
Transfer	4025 (2.2)	1455 (2.3)	876 (1.7)		1694 (2.4)	
Hospitalization	42 561 (23.0)	12 476 (20.1)	13 895 (26.4)		16 190 (23.0)	
Observed	2218 (1.2)	899 (1.4)	402 (0.8)		917 (1.3)	
Left against medical advice	485 (0.3)	64 (0.1)	134 (0.3)		287 (0.4)	
Death	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	
Not recorded	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)	

^aUnless otherwise noted, values are n (%).

Disposition

National estimates of discharge disposition are found in Table 1. Of the included patients, 73.4% were released home, 23% were admitted to the hospital, 2.2% were transferred to another facility, 1.2% were observed in the ED, and 0.3% left AMA. No deaths (including dead on arrival, death in ED, and death after admission) were recorded during the period studied.

Proportion of ED visits leading to hospitalization increased 6% points DC 2020 and decreased 3.4% points DC 2021. Proportion of patients released directly from the ED decreased 5.1% points DC 2020, and increased 2% points DC 2021.

Etiology

The most common causes of ankle fractures during the COVID-19 pandemic are found in Table 2. The 3 leading mechanisms of injury BC were stairs/steps (NE: 14383, 23.48%), floors (NE: 3881, 6.25%), and exercise without equipment (NE: 2995, 4.82%). Fracture etiology changed slightly DC 2020, with the top 3 causes being stairs (NE: 12988, 24.69%), floors (NE: 3641, 6.92%), and bicycles (NE: 3849, 4.37%). The 10 ankle fracture etiologies with the largest percent point increases during the COVID-19 pandemic in 2020 are found in Table 3. The largest increases were seen with skateboards (+4.03% points), 2-wheeled offroad vehicles (+1.34% points), and beds (+1.28% points) ($P < .001$ for all). E-scooters injuries increased +0.66% points DC 2020 and 1.09% DC 2021.

In total, 5933 (3.2%) alcohol-related and 1689 (0.9%) drug-related ankle fractures occurred during our study periods. Ankle fractures associated with alcohol use increased 0.9% points DC 2020, with that increase being maintained relative to BC DC 2021. Injuries associated with other recreational drug use increased 0.5% points DC 2020 and again 0.2% points DC 2021.

Discussion

Understanding the demographics, etiologies, and disposition of ankle fractures can help direct health care resources appropriately, particularly in times of national and global crises. There is a paucity of evidence regarding the impact of the COVID-19 pandemic on the incidence of orthopaedic injuries, especially ankle fractures, and the few studies that do report on this are limited in scope.^{9,12,22} This study marks the most comprehensive study of ankle fractures during the COVID-19 pandemic in the United States to date. We have found a 4% decrease in fractures between July and December 2020 during COVID as compared to the same months during the year prior. In accordance with demographics for ankle fractures found in previous studies,^{7,11}

the majority (60%) were women, and the median age was 44 years. The rate of alcohol-related ankle fractures increased during the pandemic, whereas the proportion of fractures that occurred at school and during sports decreased. The 3 most common causes of ankle fractures during the pandemic were stairs, floors, and skateboards. However, the 3 etiologies that experienced the greatest increases in frequency were skateboards, floors, and powered scooters.

Ankle fractures in general can have devastating consequences including post-traumatic arthritis and chronic pain.¹³ Those requiring surgical intervention are at risk for more severe complications such as infection, failure of fixation, additional surgery, amputation, and death. These fractures can be a source of significant economic burden both on an individual basis, with cost of inpatient care sometimes exceeding \$62000, and to society in terms of difficulty returning to work and utilization of disability benefits.^{2,18,21} Therefore, it is important to maintain up-to-date knowledge of fracture patterns, demographics, and etiologies at a population level.

During the beginning of the pandemic, stay-at-home directives issued by local governments to limit the transmission of COVID-19 led to the closure of schools, parks, playgrounds, and nonessential businesses. The decreased proportion of ankle fractures occurring at school and in association with sports is likely attributable to the shift to remote learning in addition to suspension of sports practices and events. As people practiced social distancing and quarantined at home, many may have been less active and were therefore less likely to experience low-energy trauma, potentially explaining the overall 4% decrease in ankle fractures seen in our analysis. These findings may aid planning for future national and global crises, as a decreased incidence of orthopaedic injuries such as ankle fractures may allow a shift in budgeting for other more pressing health care needs.^{10,23}

Interestingly, we found an increase in ankle fractures associated with skateboard and e-scooter use. Prior to the pandemic, scooter and bike sharing usage was growing at a rate of 60% per year, with 136 million recorded trips in 2019 alone.¹⁶ For a brief period in March, e-scooter use decreased because of the initial quarantine. However, by July people began returning to work, and e-scooter use increased again as more people sought methods of transportation compatible with social distancing, unlike subways and buses.⁶ Limitations and restrictions on group activities such as team sports may have also encouraged more individual hobbies like skateboarding and scootering. The increased use of scooters and skateboards during COVID could account for the respective increases in ankle fractures associated with these causes. Additionally, we observed an increase in alcohol-related ankle fractures and fractures leading to hospitalization, perhaps suggesting that

Table 2. Top 10 Causes of Ankle Fractures During the COVID-19 Pandemic, 2020.

Product Code	Before COVID-19 (2019) (referent)		During COVID-19 (2020)		During COVID-19 (2021)		% Point Change (2020)	% Change (2020)	% Point Change (2021)	% Change (2021)	P
	n	%	n	%	n	%					
1842 - Stairs or steps	14583	23.48	12988	24.69	16000	22.73	1.20	-10.94	-0.76	9.72	<.001
1807 - Floors or flooring materials	3881	6.25	3640	6.92	4142	5.88	0.67	-6.20	-0.37	6.73	<.001
5040 - Bicycles and accessories, (excl. mountain or all-terrain)	2867	4.62	2297	4.37	2299	3.27	-0.25	-19.85	-1.35	-19.79	<.001
1333 - Skateboards, unpowered or unspecified	1364	2.20	2120	4.03	2386	3.39	1.83	55.37	1.19	74.86	<.001
4078 - Ladders, other or not specified	1976	3.18	1970	3.74	1766	2.51	0.56	-0.32	-0.67	-10.66	<.001
4076 - Beds or bedframes, other or not specified	1414	2.28	1871	3.56	2531	3.59	1.28	32.34	1.32	79.00	<.001
1233 - Trampolines	1754	2.82	1685	3.20	2044	2.90	0.38	-3.90	0.08	16.58	<.001
1817 - Porches, balconies, open-side floors or floor openings	1633	2.63	1539	2.93	1903	2.70	0.30	-5.78	0.07	16.54	<.001
3299 - Exercise (activity or apparel, w/o equip)	2995	4.82	1382	2.63	2773	3.94	-2.20	-53.84	-0.88	-7.40	<.001
1615 - Footwear	1447	2.33	1118	2.12	1311	1.86	-0.21	-22.75	-0.47	-9.40	<.001

Table 3. Largest Increase in Cause of Ankle Fractures During COVID-19, 2020.

Product Code	National Estimate Before COVID-19		National Estimate During COVID-19, 2020		National Estimate During COVID-19, 2021		% Change (2020)	% Point Change (2020)	% Change (2021)	% Point Change (2021)	P
	n	%	n	%	n	%					
1333 - Skateboards, unpowered or unspecified	1364	2.20	2120	4.03	2386	3.39	55.37	1.83	74.86	1.19	<.001
5036 - Two-wheeled, powered, off-road vehicles	329	0.53	982	1.87	1234	1.75	198.78	1.34	275.49	1.22	<.001
4076 - Beds or bedframes, other or not specified	1414	2.28	1871	3.56	2531	3.59	32.34	1.28	79.00	1.32	<.001
1842 - Stairs or steps	14583	23.48	12988	24.69	16000	22.73	-10.94	1.20	9.72	-0.76	<.001
3215 - Mopeds or power-assisted cycles	204	0.33	592	1.12	676	0.96	189.73	0.80	231.01	0.63	<.001
5024 - Scooters, unspecified		0.00	376	0.72	734	1.04	#DIV/0!	0.72	#DIV/0!	1.04	<.001
611 - Bathtubs or showers	837	1.35	1080	2.05	738	1.05	29.00	0.70	-11.81	-0.30	<.001
1807 - Floors or flooring materials	3881	6.25	3640	6.92	4142	5.88	-6.20	0.67	6.73	-0.37	<.001
5022 - Scooters, powered		0.00	345	0.66	769	1.09	#DIV/0!	0.66	#DIV/0!	1.09	<.001
4078 - Ladders, other or not specified	1976	3.18	1970	3.74	1766	2.51	-0.32	0.56	-10.66	-0.67	<.001

these etiologies are also more susceptible to complex injury patterns. Grossman et al⁸ found an increase in alcohol consumption during the COVID-19 pandemic with reasons including increased stress, alcohol availability, and boredom. Alcohol-related injuries have also been frequently reported with e-scooters and mopeds.^{1,15–17} Overall, these findings highlight the importance of anticipating alterations in etiologies and mechanisms based on societal shifts.

Our study has some limitations associated with the NEISS database, namely, the potential underestimation of ankle fractures. Polytraumatic injuries, for example, concurrent ankle and hip fracture, or those with several comorbidities may be listed under the alternate category, for example, hip fractures, and therefore may not have been included in our analyses because ankle fracture may not have been the primary reason for seeking care. Those who did not seek medical attention at a hospital with an ED or ED participating in the database were not included as well, although national estimates aim to account for these missing data points. Additionally, a few participating emergency departments did not report data on certain variables, such as demographics or mechanism of injury.^{13,21} Finally, this database does not include information on state, region, city, or urban vs rural locality. Thus, accuracy of findings may be impacted by shifts of patient distribution between different geographic locations or rural and urban areas. All of these factors may limit generalizability of this database, and since some of these pandemic directives were specific to the United States alone, these findings may not be applicable to other countries.

Conclusion

There was an overall decrease in the incidence of ankle fractures during the COVID-19 pandemic compared to the year before. Alcohol-related fractures increased as did those resulting in hospitalization. The proportion of fractures caused by skateboards, powered scooters, and mopeds grew during COVID-19. This study is the first analysis of the impact of COVID-19 on ankle fracture epidemiology using a national database representing patients across the United States.

Ethical Approval

Ethical approval was not sought because this data was deidentified and exempt from IRB approval.


Declaration of Conflicting Interests

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ORCID iDs

Kevin Mo, MHA,  <https://orcid.org/0000-0002-7728-0093>

Samuel Malan, BS,  <https://orcid.org/0000-0002-9137-0714>

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