

A characterization of home maintenance equipment-related hand and lower arm injuries



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ABSTRACT

Background: Thousands of Americans sustain injuries from various household appliances each year, though injury patterns have not been well characterized. We thus sought to determine the incidence, characteristics, and trends of household appliance-related hand injuries over the past decade.

Methods: The National Electronic Injury Surveillance System database (NEISS) was queried from 2010 through 2019. Our analysis grouped patients into 10-year age groups. We defined types of appliances and injuries. Chi-square tests were used to compare the most common injury mechanisms by age group.

Results: Between 2010 and 2019, 30,336 total cases of home workshop equipment-related upper extremity injuries were recorded; 2,574 (8.48%) of these affected females, compared to 27,762 (91.52%) of the cases affecting males. Across all age groups, males were between 6 and 13 more times likely to be injured than females ($p < 0.001$). Between 2010 and 2019, we recorded a decline in total injuries from 168,795 to 147,584, with a Pearson correlation coefficient of -0.68 ($p = 0.031$). The appliances most likely to injure those in their 10s through 40s were mechanical tools such as screwdrivers. Meanwhile, those in their 50s through 70s were most likely to be injured by saws. Both amputations and avulsions were found to significantly increase with age ($p = 0.038$, $p = 0.027$, respectively). Most injuries result from manual tools and saws.

Discussion: Males are significantly more likely to incur injuries than females from maintenance equipment, and risk of avulsions and amputations increase significantly with age. This aligns with previous research which also suggested that older saws were most likely to injure older individuals; namely, following new regulations on saws, older adults were more likely to be affected. This is especially worrisome in light of recent research showing that older adults with amputations are less likely to be offered replantations. Overall, these results can continue to guide and optimize community interventions on an epidemiological basis.

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1. Introduction

Thousands of Americans sustain injuries from various appliances each year, which can result in debilitating injuries. Although a strong understanding of these injuries is important for preventing injuries and improving reconstructive management of injuries, the incidence of hand injuries related to household appliances, in

particular, has not been well characterized. This is especially concerning considering that hand conditions are among the main reasons for emergency department (ED) resource usage in the United States. Further, trauma is consistently the most common reason for presentation to the ED.¹ Overall, there is a gap in knowledge with regard to exact prevalence and trends of injuries incurred from household appliance use.

The current literature has described hand injuries secondary to specific appliances, including oven doors, washing machines, and rice cookers.^{2–10} Still, the literature does not contain large-scale studies investigating classes of consumer items. Types of hand trauma described in the literature include crush injuries, fractures, and amputations. The majority of studies focused on specific patient populations and is comprised of case reports, and thus does

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not capture the scope of injuries at the level of the general population. Several groups, such as Rubinstein et al., have been able to successfully characterize appliance related injuries to the hand at the population level by describing the incidence of snow blower-related injuries in the US by querying the National Electronic Injury Surveillance System (NEISS).⁷ This authorship group identified snow-blower injuries as a highly preventable and increasingly common mechanism of hand injury. They also demonstrated that the approach of querying the NEISS database was useful for evaluating trends in electronic appliance-related injuries for a single appliance.

Due to the lack of comprehensive population-based studies regarding household appliance-related hand injuries, we examined current national data to describe injuries related to household appliances use among patients presenting to EDs in the United States. We utilized the NEISS database to determine the incidence, characteristics, and trends of household appliance-related hand injuries. This study thus aims to characterize the current state of hand injuries due to home improvement equipment as an entire class of consumer appliances.

2. Methods

This study utilized the United States Consumer Product Safety Commission (CPSC) National Electronic Injury Surveillance System (NEISS) in order to gather national estimates of household appliance-related upper extremity (UE) injuries over the past decade, from 2010 to 2019. The NEISS database serves as a representative sample of 100 hospital emergency departments nationwide. The large sample size and probability-weighted sampling allows for increased external validity of conclusions drawn from this database. These weighted numbers (termed cases) are recommended for use in analysis, rather than raw patient numbers; hence, our statistical analyses use NEISS-provided case numbers.

Injuries related to home appliances were identified using the NEISS database product codes for “home maintenance equipment”. These included the following: automotive tools, batteries, battery chargers, chains, engines, hoists/lifts/jacks, miscellaneous equipment, power tools (excluding saws), power saws, welding/cutting

tools, wires and cords, workshop chemicals, and manual tools. Miscellaneous equipment was defined as any equipment that did not fit into the categories in the NEISS system, and manual tools encompassed objects such as handheld saws, screwdrivers, hammers, manual drills, chisels, nail guns, and pliers. Emergency department visits for home appliance-related UE injuries were identified using NEISS injury diagnosis codes (50: amputation, 53: contusion, 54: crushing, 55: dislocation, 56: foreign body, 57: fracture, 58: hematoma, 59: laceration, 61: nerve damage, 63: puncture, 66: hemorrhage, & 72: avulsion) and body part codes (33: lower arm, 34: wrist, 82: hand, & 92: finger). Patient demographics examined included patient age, sex, location of UE injury, and home appliance responsible for injury. Our analysis grouped patients into the following 10 year age groups: 10s (10–19), 20s (20–29), 30s (30–39), 40s (40–49), 50s (50–59), 60s (60–69), and 70s (70–79). Each of these variables was stratified against one another in order to better characterize trends within this patient population. Patient disposition was excluded from this analysis, and analysis was performed using direct NEISS query output.

Standard error and 95% confidence intervals were calculated for all national estimates. Chi-square tests were used to compare injury rate between age groups. IBM SPSS statistical package version 26 (Armonk, New York) was used to perform chi-squared (X^2) testing with the intent of determining whether there were significant differences in rates of incidence between age-groups and gender. Pearson correlation coefficients were determined for time with total injury rate, and percentage of total injury due to queried injuries. Statistical significance was set for a p-value of 0.05 a priori.

3. Results

3.1. Patient demographics

Between 2010 and 2019, 30,336 total cases of home workshop equipment-related upper extremity injuries were recorded; 2,574 (8.48%) of these affected females, compared to 27,762 (91.52%) of the cases affecting males (Table 1). There were 1,489,840 total patients presenting to an ED for any reason over the study period:

Table 1
Number of Cases, National Estimates, 95% CI, and Yearly Incidence of UE Injury, Stratified by Age and Gender.

Age, sex	Cases (% of total)	National Estimate (% of total)	95% CI	p-value
10s	2,292 (7.55)	104,342 (7.00)	104,018–104,665	<0.001
Female	318	13,341	10,117–16,564	
Male	1,974	91,001	74,899–107,103	
20s	4,554 (15.01)	220,010 (14.77)	219,541–220,479	<0.001
Female	424	20,128	16,305–23,950	
Male	4,130	199,882	169,907–229,858	
30s	5,420 (17.86)	260,900 (17.51)	260,389–261,410	<0.001
Female	456	21,523	18,085–24,961	
Male	4,964	239,377	203,959–274,794	
40s	5,522 (18.20)	264,115 (17.72)	263,601–264,629	<0.001
Female	469	23,183	19,117–27,188	
Male	5,053	240,932	202,038–279,825	
50s	5,542 (18.26)	271,002 (18.19)	270,481–271,522	<0.001
Female	454	22,561	18,766–26,356	
Male	5,088	248,441	210,733–286,148	
60s	4,453 (14.67)	232,142 (15.58)	231,660–232,624	<0.001
Female	304	15,880	12,801–18,960	
Male	4,149	216,262	184,776–247,757	
70s	2,553 (8.41)	137,329 (9.22)	136,958–137,699	<0.001
Female	149	8090	110,050–148,427	
Male	2,404	129,239		
Total	30,336 (100)	1,489,840 (100)	1,488,616–1,491,058	<0.001
Female	2,574	124,706	101,273–148,137	
Male	27,762	1,365,134	1,156,352–1,573,912	

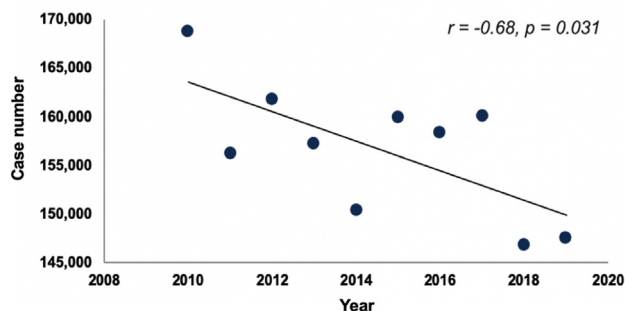


Fig. 1. Cases of Upper Extremity Injuries due to Home Workshop Equipment. Total cases of injuries by each year are plotted on the graph.

Table 2

Injury cases over the study period, showcasing a spike in injuries in 2012 and a marked decline in the years 2018–2019.

Year	Cases
2011	156,186
2012	161,810
2013	157,180
2014	150,423
2015	159,909
2016	158,369
2017	160,062
2018	146,779
2019	147,584

124,706 (8.37%) females and 1,365,134 (91.63%) males. We recorded significant differences in proportions of injury estimates across sexes in all age groups, with males between 6 and 13 more times likely to have injuries than females, depending on the age group tested ($p < 0.001$). Those in their 50s had the highest patient estimates annually ($n = 5,542$), while those in their 10s experienced the fewest injuries annually ($n = 2,292$).

3.2. Temporal trends in injuries

Beginning with the year 2010, our query of the NEISS database yielded an estimated 168,795 home workshop-related upper extremity injuries (Fig. 1 and Table 2). Over the next years sampled, we observed a decline in total cases of injuries. Though there was some fluctuation from year to year, over the total period surveyed, case numbers declined by roughly 9,000. The calculated Pearson correlation coefficient for this decline in total injuries was -0.68 ($p = 0.031$).

3.3. Mechanism of injury by age

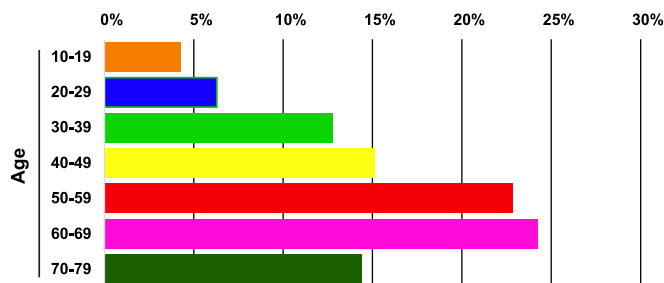
The appliances most likely to injure those in their 10s through 40s were manual tools (Table 3). Meanwhile, those in their 50s

Table 3

Most common injury mechanisms (%), by 10-year age group.

Rank	10s	20s	30s	40s	50s	60s	70s
1	Manual Tools (42.13)	Manual Tools (42.13)	Manual Tools (43.23)	Manual Tools (38.65)	Power saws (45.51)	Power Saws (54.25)	Power Saws (59.97)
2	Power Saws (23.96)	Power Saws (24.84)	Power Saws (29.76)	Power Saws (37.65)	Manual Tools (32.05)	Manual Tools (25.69)	Manual Tools (22.93)
3	Misc. Equipment (13.19)	Misc. Equipment (11.09)	Misc. Equipment (11.19)	Misc. Equipment (9.71)	Misc. Equipment (9.11)	Misc. Equipment (8.38)	Misc. Equipment (8.37)
4	Power tools (8.72)	Power tools (7.77)	Power tools (8.58)	Power tools (8.48)	Power tools (7.98)	Power tools (8.04)	Power tools (6.35)
5	Hoists, Lifts, Jacks (5.81)	Hoists, Lifts, Jacks (5.83)	Hoists, Lifts, Jacks (4.13)	Hoists, Lifts, Jacks (3.72)	Hoists, Lifts, Jacks (2.74)	Hoists, Lifts, Jacks (2.46)	Hoists, Lifts, Jacks (1.26)

Amputations as a Percentage of Total Injuries



Avulsions as a Percentage of Total Injuries

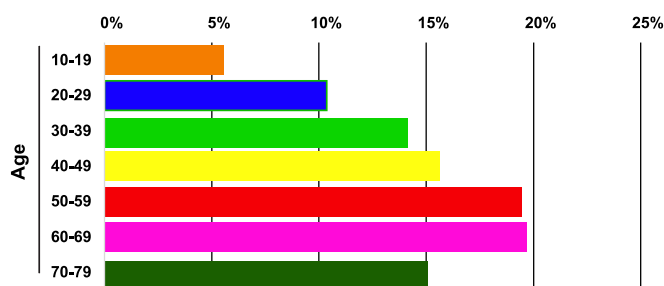


Fig. 2. Amputations and Avulsions as percentages of total injuries. This graph shows the proportion of injuries due to amputations and avulsions on the top and bottom, respectively, within each age.

through 70s had the most saw-related injuries. The piece of equipment next-most associated with injuries in those in their 10s through 40s was saws. In patients in their 50s through 70s, manual tools were the next-most associated with injuries. In this cohort of patients between their 50s and 70s, we observed decreased injury likelihoods with increased age; the percentage of total injuries due to saws among those in their 50s was 32.05%, while among those in their 70s, the total amount of saw-related injuries was 22.93%. The third, fourth, and fifth most dangerous pieces of equipment were the same for all age groups and were miscellaneous equipment, power tools, and hoists, lifts, and jacks, respectively.

3.4. Injury type by age

Two types of the injuries surveyed significantly correlated with age: amputations and avulsions ($r = 0.782$; $p = 0.038$). For amputations, this result includes patients in their 70s, even though this group experienced a slight decrease in this injury type relative to those in their 60s. In patients in their 10s, amputations made up

only about 4% of the total injuries (Fig. 2). In patients in their 60s, by contrast, amputations made up 24% of the total injuries. Furthermore, avulsions also increased significantly with age ($r = 0.811$, $p = 0.027$). 5.59% of the total injuries among those in their 10s were secondary to avulsions, compared to nearly 20% of the total injuries among those in their 60s. The rest of the injury types were not statistically associated with age.

4. Discussion

This study analyzes and characterizes the high prevalence of finger, hand, wrist, and lower arm injuries secondary to home improvement and maintenance tools. Prior studies have characterized traumatic hand injuries often due to specific pieces of equipment; still, to the best of the authors' knowledge, no studies have comprehensively examined the current state of upper extremity injuries attributable to an entire class of appliances.^{11,12} Our results suggest that, among the many mechanisms of injury associated with home-maintenance supplies, most injuries result from manual tools and saws. This aligns with previous research which also suggested that older saws were most likely to injury older individuals; namely, following CPSC regulations on saws, older adults became more likely to be affected.¹³ Additionally, our results that adults in their 50s are most likely to experience injuries due to home improvement supplies are corroborated by other studies showing that middle-aged adults tend to be most susceptible to injuries from power tools.¹⁴

Our study provides information that can be used to prioritize patient groups who are in danger of home-appliance related injuries and in need of intervention. Knowing that saws are most likely to cause injuries in those who are older, and that amputations increase with age, for instance, enables us to provide suggestions regarding treatment in this demographic; saw injury usage indeed is declining, but progress may be expedited through targeted interventions. Studies have found that as patients age, they are less likely to undergo replantation than revision amputation when offered reconstruction, potentially due to assumptions that older patients are more likely to experience adverse complications.^{12,15,16} Though these assumptions may be prevalent, prior work has demonstrated that age alone is not an independent factor contributing to increased likelihood of post-operative complications.¹² The amputation location, mechanism, and type of injury all must be carefully considered.¹⁷ Physicians tasked with deciding between revision amputation and replantation in older patients who have suffered saw injuries should perform a comprehensive workup to fully assess the injury.

Targeted education has been performed for dangerous pieces of equipment in the past and has been met with marked success. In addition to CPSC legislation on saws that led to decreased saw-related injuries, other interventions have been performed for items such as cribs and carriages, and resulted in decreased rates of injury.¹⁸ Prevention of home-improvement related injuries, then, could be key to accelerating the decline in injury rates, and might prove highly economical as well. With regard to saws, table-saw injuries alone cost nearly \$2 billion, and significant institution of preventative measures may cost much less.¹⁹ SawStop® (Tualatin, Oregon, USA), a novel technology that shuts down electric saws upon contact with human skin, could be implemented among older adults who are most at risk of injury. While SawStop® is not inexpensive, adding \$700 to the price of electric saws, individual saw-related injuries often yield medical costs surpassing \$4,000. Given that studies have found that many saw users elect to disable the safety features on their devices, users of these new technologies should be instructed to keep them activated.²⁰ Chung et al.¹⁹

recommend that short web-based podcasts be created to more effectively convey this message.

This study has several limitations. First, it is limited by its usage of a public database that does not necessarily offer all parameters of interest. Additionally, data entered into the NEISS system is based on the coders' individual preferences for product and injury classification. Strengths of this study involve other aspects of the NEISS system – namely, its large sample size conferring high power and the ability to analyze trends in data over time. While CPSC initiatives have helped temper the rise in saw-related injuries, future work should examine why middle-aged and older individuals are especially prone to such injuries. This could involve anything from semi-structured interviews to focus groups to obtain answers. This would also permit an additional focus on preventative measures that can be enacted on a population-level. Additionally, further work should be done to elucidate the most dangerous items included within the NEISS category of manual tools so that the most targeted, specialized interventions can be performed. Our results demonstrate that action must be taken, whether through increased patient education or novel devices, to minimize the risk of adverse events from home improvement appliances.

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