

Analysis of Severity of Finger, Hand, and Wrist Injuries Among Department of Air Force Workers

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Objective: This study examined US Department of the Air Force (DAF) work-related finger, hand, and/or wrist (FHW) injuries and focused on injury characteristics, severity, and outcomes. **Methods:** Characteristics, details, and severity of work-related, noncombat FHW injuries (2008–2018) were examined. Rates, patterns of severity, and identification of at-risk populations within DAF were calculated. **Results:** Nearly a quarter of DAF injuries were FHW-related and decreased from 2008 to 2018. The highest rates were among males, younger workers, and enlisted workers. Odds of severe injury increased with age group. After adjustment, sex was not significantly different. Aircraft maintenance had the most severe injuries, whereas metal workers had the highest rate. **Conclusions:** Surveillance and focused interventions of high-risk groups, standardized codes, and regular updating of training and procedures contribute to continued reduction of FHW injuries.

Keywords: finger, hand, wrist, enlisted, officers, civilian, military, occupational injuries

In the US military, noncombat work-related injury rates are higher than combat-related injuries and result in a considerable burden to the healthcare system as well as days away from work, which hinders

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Funding Sources: None declared.

Conflicts of Interest: None declared.

All Sources of Support Relevant to Publication: The following journal article reviewers from the National Institute for Occupational Safety and Health provided feedback: Jennifer Bell, Jim Collins, and Emily Haas.

Authors' Contributions: M.K.G. and S.A.H. conducted the data and statistical analysis. M.K.G., S.A.H., K.E.I., and G.S.S. designed the adjusted analysis. M.K.G., C.M.S.-M., S.A.H., G.S.S., K.E.I., A.A.R., H.A.S., L.K.P., and A.E.R. performed the writing of journal article and review and editing. M.K.G., G.S.S., and K.E.I. performed the supervision. M.K.G., C.M.S.-M., and H.A.S. performed the data curation. M.K.G., C.M.S.-M., S.A.H., K.E.I., A.A.R., H.A.S., and G.S.S. performed the visualization.

Data Availability: The data belong to the Department of Air Force. The data were shared with the National Institute for Occupational Safety and Health as part of a research partnership.

EQUATER Network checklist utilized (if applicable): Not applicable.

AI detailed statements as fully described in the AI section of Information for Authors: No AI was utilized in this study.

Ethical Considerations and Disclosures: Not applicable.

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Supplemental digital contents are available for this article. Direct URL citation appears in the printed text and is provided in the HTML and PDF versions of this article on the journal's Web site (www.joem.org).

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DOI: 10.1097/JOM.0000000000003553

LEARNING OUTCOMES

- Identify leading characteristics and details among work-related, noncombat FHW injuries by severity, which could be used to develop more specific research and prevention efforts in the US Department of the Air Force.
- Compare differences in trends by severity of FHW injuries in the US Department of the Air Force workers and identify prevention strategies and areas for continued research.

military readiness.^{1–4} More than one third of 30,000 injuries among US soldiers overseas between 2003 and 2014 in Iraq and Afghanistan were from noncombat related incidents, and two thirds of those injuries occurred among members of the US Department of the Air Force (DAF).² Among deployed US Army military requiring medical evacuations for severe injuries, 30% were from noncombat related injuries.⁵

Examining injuries within the military worker population offers a valuable opportunity to better understand the specific causes and consequences among this population, which may provide insights different from those found in the civilian workforce, due to the nature of military tasks, environments, and physical demands.⁶ Studying these injuries can reveal distinct risk factors, patterns of injury, and outcomes, potentially leading to more effective safety measures, training programs, and prevention strategies, which are tailored to the military.

The complexity of the FHW anatomy can result in costly medical treatments.^{7–9} Lost production increases the cost of work-related hand injuries beyond the healthcare costs.^{10,11} According to Occupational Safety and Health Administration (OSHA) Severe Injury Reports, 40% of employer-reported severe injuries involved upper extremities (including arms, hands, fingers), with more than a fourth of those occurring to the fingertips.¹² Finger and hand injuries accounted for 17% of the Bureau of Labor Statistics (BLS) nonfatal lost-time occupational injuries in all industries, representing 581,720 injuries involving days away from work, restricted work activity, or job transfer cases in 2021 and 2022.¹³ Workers rely on the dexterity, flexibility, and tactile sensation of their FHWs to perform a wide variety of work activities.¹⁴ This is especially true among occupations that have high rates of acute traumatic hand injuries, in conjunction with more time away from work, such as mechanics, welders, maintenance workers, manual workers, and laborers.^{14–16}

The severity of a hand injury can be defined by the resulting disability, cost of recovery, functional impacts, and the ability to return to work.^{8,17,18} Hand injuries with a loss of grip strength have resulted in a longer return to work.⁸ Even though some injuries may not appear to be serious, they can result in lost work time, temporary change in job, or loss of job.^{8,19} In a study of mine workers, more than half of FHW injuries did not result in long recovery times, but some resulted in lengthy and costly recoveries and led to disability.²⁰ Efforts to prevent work-related FHW injuries could benefit from a better understanding of the events and activities that lead to those injuries.²⁰ Severe injuries resulting in the inability to return to work can reduce quality of life; therefore, it is important to improve return to work outcomes.²¹

Fingers, hands, and wrists are the leading areas of the body injured among US Army active duty personnel.²² Finger and hand injuries were among the four leading diagnoses among military ambulatory visits in 2022.²³ The rate of hand and wrist injuries was among the three highest injury rates in the US military between fiscal years 2008 to 2017, and the leading nature of these injuries was open wounds (27%) as well as sprains and strains (25%).¹¹

The DAF provides ground safety guidance for workers to reduce the high number of hand injuries.²⁴ Previous findings indicated a lower rate of FHW injuries in the DAF compared with US workers; however, these injuries are a burden, especially because they are the most frequently injured body parts among DAF workers.²⁵ As with other worker populations, the majority of FHW injuries in the DAF are low severity. Although most severe injuries receive thorough investigations in the DAF, there is a need for more research on nondisabling injuries that lead to lost workdays.²⁶ Understanding the events and activities that produce nonfatal FHW injuries can improve the prevention efforts by the DAF.²⁶

The overall goal of this study was to examine FHW injuries by severity among DAF personnel to enhance understanding of severe FHW injuries to the DAF, as well as other military agencies and private industry. Also, this article was part of a dissertation examining work-related FHW injuries.²⁷ We analyzed data from the Air Force Safety Automated System (AFSAS) from 2008 to 2018 to better understand how FHW injuries occur and which demographic and occupational groups may be at greatest risk. Specifically, we aimed to determine rates and patterns of both severe and nonsevere FHW injuries in a large sample of DAF workers, evaluate trends over time, and identify potential key demographic risk factors.

METHODS

Air Force Safety Automated System (AFSAS)

Local safety professionals in the DAF input data related to military and civilian work-related mishaps into the injury surveillance system, AFSAS. The Department of Defense Instruction policy 6055.07 defines the conditions for mishap notification, investigation, reporting, and recordkeeping of mishaps.²⁸ Mishaps, in the US military, are identified as injuries to individuals or damage to property that occur as a result of an unforeseen event.^{29,30} The focus of this analysis is mishaps as a result of an injury; therefore, property damage–related mishaps that resulted in no injury were excluded. Exclusions in AFSAS include suicides, homicides, or combat-related injuries; this is due to AFSAS noncombat unintentional injuries.^{25,26} This study included all personnel injured in an injury event because they can include multiple personnel and was limited to on-duty DAF enlisted, officer, and civilian personnel. Basic military training being completed by enlisted and officer is not included in this dataset.²⁶ Appendix 1 (<http://links.lww.com/JOM/C113>) contains the complete list of inclusion and exclusion criteria of AFSAS for this study. The AFSAS classifies the severity of the injury-producing events into five classes: Class A being the most severe through Class E resulting in minor injuries and close calls/near misses; details of the classes can be found elsewhere.^{25,26} This analysis excluded Class E injuries.

Categories of injury in the study sample were limited to ground, aviation, and motor vehicle. Events related to criminal activity, self-harm, or worker dependents and workplace violence–related injuries were excluded because they were not routinely included in AFSAS. Military unique tasks like afloat and weapons-related injuries were excluded. Class A through Class C injuries were categorized together as severe injuries due to the small number of Class A and B injuries that could potentially be identifiable. Class D injuries, those treated but resulting in less than 1 day away from work beyond the day of injury, were categorized as nonsevere injuries.

As the FHW is event-based only, the most serious or main injury category is captured based on the initial assessment by the Safety

Office at the time of injury. The FHW body parts of interest in this study were coded as “finger” and “hand/wrist.” Because of possible inconsistencies with how finger and hand/wrist injuries were coded (eg, knuckle injuries) and some hand and wrist injuries can affect the use of fingers, FHW injuries were combined. Additionally, multiple parts of the body could be involved, but only the part of the body affected by the main injury is coded.

Demographic Data

Demographic data were obtained from the Interactive Demographic Analysis System (IDEAS), an aggregated DAF personnel demographic database that is updated monthly for civilians and weekly for military personnel and captures the entire DAF military and civilian population. Demographic data provided included age groups, sex, and personnel status (ie, enlisted, officer, civilian). Seventeen occupational groups were developed utilizing occupational codes with the assistance of a DAF human resources specialist. Analysis of occupational groups was limited to 2009 to 2018.

Rate and Adjusted Rate Calculations

Injury rates were calculated for FHW injuries in the DAF from 2008 to 2018 per 10,000 workers using the number of injuries from AFSAS divided by the population of workers from IDEAS. Confidence intervals were calculated on the rates by assuming that the count of injuries was one realization derived from a Poisson distribution with a lambda parameter equal to the count. Rate confidence intervals were determined by:

$$\text{Confidence interval per 10,000 workers} = (\text{number injured} \pm 1.96 \times \sqrt{\text{number injured}}) / \text{number of workers} \times 10,000$$

A χ^2 test was used to determine if there was a statistically significant relationship between variables and severity of FHW injury.

Unadjusted odds ratios (uORs) with accompanying 95% confidence intervals (CIs) were calculated using univariate logistic regression. The outcome variable was severity of FHW injury (Class A–C versus Class D). A modeling process was used to develop a multivariable logistic regression, adjusting for the following: sex; age group; sex and age group; sex, age group, and occupational group; and sex, age group, occupational group, and Air Force group (enlisted, officer, and civilian). The adjusted odds ratios (aORs) with accompanying 95% CIs can be considered adjusted for all other variables included in the model. Analysis for this article was conducted using SAS 9.4.

Trend Analysis

The analysis of annual trends was performed using piecewise linear regression with joinpoint models.³¹ This approach evaluates adjustments in trends over time and identifies significant increases and decreases in trends. The joinpoint analysis examined time trends in a structured manner and tested if trends between joinpoints were statistically significant. The recommended number of joinpoints applied in the model was derived using statistical algorithms based on the number of data points, with a default of a maximum of 1 joinpoint for 7 to 11 data points.³² The slope of the line segment, direction, and magnitude of the trends were used to create the annual percent change (APC) of the line segment between joinpoints. A *P* value of <0.05 indicated if an increase or decrease of the slope was considered a statistically significant change in the trend (hereafter referenced as “significant” in the results). The analysis was conducted using Joinpoint Regression Program Version 5.0.2 (National Cancer Institute).³³ This activity was reviewed by CDC, deemed research not involving human subjects, and was conducted consistent with applicable federal law and CDC policy.³⁴

RESULTS

Demographics

After applying study exclusion criteria to AFSAS, 14,549 FHW injuries were reported during the 11-year study period. The cumulative total population of the DAF (enlisted, officers, and civilians) during the study timeframe was 5,219,230 (an annual average of 474,470), of which 32% were civilian workers (Table 1). Of those in the DAF, more than half (54%) of the study population were enlisted, and the majority were younger than 30 years (64%) and male (81%). Officers were a smaller proportion of the study population (13%), and the majority were younger than 35 years (55%) and male (80%). Although there are age requirements for enlisted and officers joining the DAF, there are no such requirements for civilian personnel. The DAF civilian population was older (93%, 30 years and older) than the enlisted personnel and officers. The number of DAF workers annually remained stable over the study period (Table 1).

Injury Characteristics by Severity of FHW Injury

Finger, hand, and wrist-related injuries were the most common DAF work-related, noncombat body part injuries. Nearly a quarter (24%) of injuries in the DAF were FHW-related injuries, with an overall injury rate of 27.9 per 10,000 workers (Table 2). The majority of the FHW injuries in the DAF were nonsevere injuries (88%). The majority of FHW injuries were among males in the DAF (80%) compared to females (20%), and males had the highest rate of FHW injury (29 per 10,000 workers) compared to females. More than half of FHW injuries (58%) were among those aged 30 years and younger compared to all other age groups. Those 30 years and younger also suffered the highest rate of FHW injuries (38.9 per 10,000 workers) compared to all other age groups, including those of both severe and nonsevere injuries (severe, 4.5; nonsevere, 34.4 per 10,000 workers). Workers aged 60 years and older had the second leading severe injury rate (3.7 per 10,000 workers).

More than half (62%) of FHW injuries were among enlisted DAF workers, and they had the highest rate of FHW injuries (all, 31.8; severe, 3.8; nonsevere, 27.9 per 10,000 workers) compared to officers and civilians. The occupational group with the largest number of FHW injuries was aircraft maintenance workers (all: 25%, $n = 3246$; severe: 26%, $n = 409$). This is more than twice as high as other occupational groups (Fig. 1A). Also, they had the second highest rate of severe injury (6.3 per 10,000 workers). The highest rate of injuries was among metal workers (114.7 per 10,000 workers, Table 2), which was more than twice as high as all other occupational groups (Fig. 1B). Severe FHW injury rates were nearly twice as high among metal workers (11.6 per 10,000 workers, Table 2).

Most nonsevere FHW injuries were open wounds (56%), whereas fractures were the most common severe FHW injuries (37%). The occupations with the highest percentage of severe FHW injuries with a fracture were aircraft maintenance workers (23%) and law enforcement, safety, and investigations (13%). Among aircraft maintenance workers, over half (53%, 1735) of the FHW injuries were open wounds. The leading FHW injury among metal workers was open wounds (58%, $n = 499$), followed by sprains and strains (14%, $n = 119$). The large majority of FHW injuries among the medical sciences were open wounds (89%, $n = 1633$), more specifically punctures (74%, $n = 1363$).

Severe FHW injuries most commonly involved parts and materials (15%) as well as machinery (14%), whereas nonsevere FHW injuries most often involved tools, instruments, and equipment (12%), as well as machinery (12%). The leading object involved in FHW injury among aircraft maintenance workers was aircrafts (28%, $n = 923$), followed by machinery (18%, $n = 583$). The leading objects involved in FHW injuries among metal workers were tools, instruments, and equipment (24%, $n = 207$) and aircrafts (22%, $n = 194$).

The leading mechanism of injury was contact with objects (64% nonsevere; 48% severe), followed by falls (16%). The highest

rates of severe injury from a fall were among those aged 50 to 59 years (1.0 per 10,000 workers) and 60 years and older (2.1 per 10,000 workers). In addition, over two thirds (67%) of all severe FHW fall injuries resulted in a fracture. More than two thirds of FHW injuries among aircraft maintenance workers were from contact with an object (68%, $n = 2197$). Half (50%, $n = 434$) of the FHW injuries among metal workers were from contact with an object.

The large majority of FHW injuries occurred during the day (7:00 AM to 5:59 PM, 80% of nonsevere and 76% of severe FHW injuries, Fig. 2A). More specifically, the highest proportion (27%) of severe FHW injuries occurred during the late morning, from 8:00 AM to 10:59 AM (Fig. 2B).

Patterns and Trends in FHW Injuries

Annual Trend Analysis of FHW Injuries

The number and rate of FHW injuries decreased during the 11-year period from 29.6 FHW injuries per 10,000 workers in 2008 to 22.7 per 10,000 workers in 2018, as did the rates by the level of severity. The joinpoint regression analysis determined that there was a significant decrease in rates among FHW injuries in the DAF between 2011 and 2018, with a decrease of 1.4 per 10,000 workers per year (95% CI, 1.0–1.8; $P < 0.001$) for all FHW injuries and a decrease of 1.3 per 10,000 workers per year (95% CI, 0.9–1.6; $P < 0.001$) for nonsevere FHW injuries (Fig. 3A).

During the 11-year study period, DAF enlisted personnel had a significant annual decrease in severe FHW injuries (Fig. 3B, a decrease of 0.3 per 10,000 workers per year; 95% CI, 0.2–0.4; $P = 0.003$) between 2012 to 2018. DAF civilians had an annual decrease in severe FHW injuries between 2008 and 2018 (Fig. 3B, a decrease of 0.2 per 10,000 workers per year; 95% CI, 0.1–0.3; $P < 0.0005$). DAF civilians had a significant annual decrease in nonsevere FHW injuries (Fig. 3C, a decrease of 2.0 per 10,000 workers per year; 95% CI, 1.8–2.1; $P < 0.0005$) between 2015 and 2018. Enlisted personnel had a significant annual increase in nonsevere FHW injuries (Fig. 3C, an increase of 2.4 per 10,000 workers per year; 95% CI, 3.8–1.0; $P = 0.02$) between 2008 and 2011 and a significant annual decrease in nonsevere FHW injuries (a decrease of 1.4 per 10,000 workers per year; 95% CI, 1.0–1.8; $P = 0.001$) between 2011 to 2018. Officers had a significant annual increase in nonsevere FHW injuries (Fig. 3C, an increase of 1.7 per 10,000 workers per year; 95% CI, 2.3–1.1; $P = 0.001$) between 2008 and 2013 and a significant annual decrease in nonsevere FHW injuries (a decrease of 1.6 per 10,000 workers per year; 95% CI, 1.0–2.2; $P = 0.002$) between 2013 and 2018.

Three of the six occupational groups with the highest number of FHW injuries had significant annual decreases among severe injuries during the study period (Fig. 3D): aircraft maintenance workers (a decrease of 0.8 per 10,000 workers per year; 95% CI, 0.5–1.1; $P < 0.005$, between 2014 and 2018), engineering and construction (a decrease of 0.8 per 10,000 workers per year; 95% CI, 0.3–1.2; $P = 0.02$, between 2013 to 2018), and military specific occupations (a decrease of 0.2 per 10,000 workers per year; 95% CI, 0.1–0.3; $P = 0.001$, between 2009 and 2018).

Five of the occupational groups with the highest number of FHW injuries demonstrated a significant decline in nonsevere FHW injuries: metal workers (Fig. 3E, a decrease of 14.6 per 10,000 workers per year; 95% CI, 7.0–22.1; $P = 0.01$, between 2009 and 2014); law enforcement, safety, and investigations (a decrease of 1.8 per 10,000 workers per year; 95% CI, 1.2–2.4; $P < 0.003$, between 2012 and 2018); aircraft maintenance (a decrease of 1.4 per 10,000 workers per year; 95% CI, 0.7–2.1; $P = 0.01$, between 2009 and 2016); military specific (a decrease of 1.3 per 10,000 workers per year; 95% CI, 0.7–1.8; $P = 0.002$, between 2009 and 2018); and engineer and construction (a decrease of 1.2 per 10,000 workers per year; 95% CI, 0.9–1.5; $P = 0.0001$, between 2009 and 2018). In contrast, DAF personnel

TABLE 1. Injury Characteristics of National Estimates of Work-Related, Emergency Department (ED)-Treated Finger, Hand and Wrist Injuries in the U.S., 2015–2022

	All ED Treated Work-Related Injuries				Severe ED Treated Work-Related Injuries ^a			
	National Estimates of Injuries (95% CI)	% (95% CI)	Rate per 100,000 FTE Workers (95% CI)		National Estimates of Injuries (95% CI)	% (95% CI)	Rate per 100,000 FTE Workers (95% CI)	
All finger, hand & wrist injuries	4,909,300 (4,041,800, 5,776,800)	100 (98.5, 101.5)	412.0 (340.8, 483.3)		113,300 (89,000, 137,600)	2 (1.9, 2.8)	9.5 (7.5, 11.5)	
Finger	2,858,000 (2,339,800, 3,376,200)	58 (56.8, 59.6)	239.9 (197.3, 282.5)		63,200 (49,800, 76,600)	56 (52.9, 58.7)	5.3 (4.2, 6.4)	
Hand	1,331,900 (1,104,700, 1,559,100)	27 (26.2, 28.1)	111.8 (93.1, 130.5)		36,800 (28,100, 45,500)	32 (29.6, 35.4)	3.1 (2.4, 3.8)	
Wrist	719,400 (582,600, 856,300)	15 (13.9, 15.4)	60.4 (49.1, 71.6)		13,300 (9,200, 17,400)	12 (9.5, 13.9)	1.1 (0.8, 1.5)	
Year								
2015	721,900 (537,900, 905,900)	15 (12.7, 16.7)	499.2 (374.6, 623.8)		15,700 (11,100, 20,400)	15 (10.1, 19.7)	10.9 (7.7, 14.0)	
2016	726,400 (560,900, 891,900)	15 (13.1, 16.5)	491.8 (382.1, 601.5)		14,600 (10,600, 18,500)	14 (9.7, 17.8)	9.9 (7.3, 12.5)	
2017	664,400 (555,700, 773,100)	14 (12.5, 14.6)	445.3 (374, 516.7)		13,800 (9,700, 17,900)	12 (7.4, 17.0)	9.3 (6.5, 12.0)	
2018	625,900 (523,100, 728,700)	13 (11.7, 13.8)	409.7 (343.9, 475.6)		16,100 (12,200, 19,900)	15 (11.6, 19.0)	10.5 (8.1, 13.0)	
2019	617,900 (505,500, 730,300)	13 (11.7, 13.5)	398.9 (327.9, 469.9)		13,400 (9,700, 17,200)	12 (8.3, 16.3)	8.7 (6.3, 11.0)	
2020	471,500 (372,100, 570,900)	10 (8.7, 10.6)	334.5 (265.5, 403.6)		11,800 (7,900, 15,700)	9 (5.2, 11.8)	8.4 (5.7, 11.1)	
2021	487,600 (395,600, 579,500)	10 (9.0, 10.9)	329.4 (268.5, 390.2)		12,100 (8,900, 15,300)	11 (7.5, 14.2)	8.2 (6.0, 10.3)	
2022	593,700 (460,900, 726,600)	12 (10.6, 13.6)	387.1 (302.4, 471.9)		15,800 (9,600, 22,000)	12 (7.6, 16.9)	10.3 (6.3, 14.2)	
Sex ^b								
Male	3,310,500 (2,717,200, 3,903,700)	67 (66.1, 68.8)	493.8 (407.1, 580.4)		99,800 (77,900, 121,800)	88 (86.4, 90.0)	14.9 (11.7, 18.1)	
Female	1,598,700 (1,312,200, 1,885,100)	33 (31.2, 33.9)	306.8 (253, 360.7)		13,400 (10,200, 16,600)	12 (10.0, 13.6)	2.6 (2.0, 3.2)	
Age group ^c								
15–24	1,056,100 (865,200, 1,247,000)	22 (20.2, 22.9)	869.6 (714.9, 1024.3)		16,200 (12,300, 20,000)	14 (12.2, 16.4)	13.3 (10.2, 16.4)	
25–34	1,456,200 (1,192,000, 1,720,300)	30 (28.4, 30.9)	530.3 (435.9, 624.6)		26,400 (20,800, 32,100)	23 (21.5, 25.1)	9.6 (7.6, 11.6)	
35–44	989,200 (804,700, 1,173,600)	20 (19.5, 20.8)	375.5 (306.8, 444.1)		24,200 (17,900, 30,500)	21 (18.8, 23.8)	9.2 (6.8, 11.5)	
45–54	762,100 (618,900, 905,300)	16 (14.9, 16.2)	291.8 (238, 345.6)		23,100 (17,600, 28,600)	20 (18.4, 22.4)	8.9 (6.8, 10.9)	
55 Plus	645,800 (527,500, 764,100)	13 (12.3, 14.0)	238.5 (195.6, 281.3)		23,400 (16,900, 29,900)	21 (17.5, 23.7)	8.6 (6.3, 11.0)	
Industry								
Health Care & Social Assistance 7970-8470	814,100 (613,900, 1,014,300)	20 (16.6, 23.0)	507.8 (385.3, 630.2)		2,300 (1,400, 3,300)	3 (1.6, 3.8)	1.5 (0.9, 2.0)	
Manufacturing 1070-3990	637,600 (441,900, 833,400)	15 (11.5, 19.5)	492.1 (344, 640.3)		20,100 (14,500, 25,800)	23 (16.9, 28.8)	15.5 (11.3, 19.8)	
Accommodation & Food Services 8660-8690	582,900 (447,700, 718,000)	14 (12.3, 16.0)	812.0 (626.7, 997.2)		4,100 (2,800, 5,500)	5 (3.3, 6.0)	5.7 (3.9, 7.6)	
Construction 0770	506,700 (329,600, 683,800)	12 (9.9, 14.7)	571.1 (375.4, 766.8)		20,700 (13,500, 27,900)	24 (18.9, 28.1)	23.4 (15.4, 31.3)	
Retail Trade 4670-5790	421,500 (321,800, 521,200)	10 (9.3, 11.1)	350.9 (269.5, 432.4)		5,700 (3,600, 7,700)	6 (4.9, 8.0)	4.7 (3.1, 6.4)	
Public Administration 9370-9590	208,900 (161,600, 256,200)	5 (4.0, 6.1)	348.1 (270.4, 425.8)		2,100 (1,100, 3,200)	2 (1.3, 3.5)	3.6 (1.8, 5.4)	
Administrative & support & waste management services 7580-7790	168,200 (120,500, 215,900)	4 (3.4, 4.7)	335.8 (242.1, 429.4)		6,300 (3,900, 8,700)	7 (5.5, 8.9)	12.6 (7.9, 17.4)	
Other Services, Except Public Administration 8770-9290	149,400 (117,400, 181,400)	4 (3.3, 4.0)	278.1 (219.3, 336.8)		4,900 (3,000, 6,800)	6 (3.8, 7.3)	9.1 (5.7, 12.5)	
Transportation & Warehousing 6070-6390	139,000 (109,900, 168,100)	3 (3.0, 3.8)	231.3 (183.5, 279.1)		3,300 (1,800, 4,800)	4 (2.5, 5.0)	5.5 (3.0, 7.9)	
Agriculture, Forestry, Fishing, & Hunting 0170-0290	123,800 (81,400, 166,100)	3 (2.0, 4.0)	608.5 (402.9, 814.1)		7,200 (3,500, 10,900)	8 (4.7, 11.5)	35.3 (17.5, 53.1)	
All other ^d	364,100 (279,400, 448,800)	9 (8.0, 9.7)	96.6 (74.6, 118.7)		11,300 (7,500, 15,200)	13 (10.1, 15.5)	3 (2.0, 4.0)	
Event								
Contact with objects & equipment	3,042,300 (2,496,200, 3,588,300)	62 (59.8, 64.2)	255.3 (210.5, 300.2)		85,600 (66,700, 104,500)	76 (72.7, 78.5)	7.2 (5.9, 8.4)	
Exposure to harmful substances or environments	693,200 (520,200, 866,300)	14 (12.2, 16.0)	58.2 (44, 72.4)		7,200 (5,000, 9,300)	6 (5.0, 7.6)	0.6 (0.4, 0.8)	
Exposure through unintentional needlestick or sharp injury ^e	432,200 (294,200, 570,200)	9 (7.1, 10.9)	36.3 (24.9, 47.6)		*	—	—	
Overexertion & bodily reactions	436,300 (338,400, 534,100)	9 (7.8, 10.0)	36.6 (28.6, 44.7)		*	—	—	
Violence & other injuries by persons or animals ^f	367,800 (293,600, 442,000)	7 (6.4, 8.6)	30.9 (24.8, 37)		5,700 (3,700, 7,800)	5 (3.9, 6.3)	0.5 (0.3, 0.6)	
Falls, Slips, & Trips	288,600 (241,200, 336,100)	6 (5.6, 6.2)	24.2 (20.3, 28.1)		8,600 (5,800, 11,300)	8 (5.8, 9.4)	0.7 (0.5, 0.9)	
Transportation incidents	32,200 (27,000, 37,400)	1 (0.6, 0.7)	2.7 (2.3, 3.1)		2,300 (1,200, 3,400)	2 (1.2, 2.9)	0.2 (0.1, 0.3)	
Fires & Explosions	12,700 (9,800, 15,700)	<1 (0.2, 0.3)	1.1 (0.8, 1.3)		*	—	—	
Nonclassifiable	36,200 (28,000, 44,300)	1 (0.6, 0.9)	3.0 (2.4, 3.7)		*	—	—	

TABLE 2. National Percentages of Work-Related, Emergency Department (ED)-Treated Finger, Hand and Wrist Injuries in the U.S. by Sex and Industry, 2015–2022

Event	ED Treated Work-Related FHW Injuries						Severe ED Treated Work-Related FHW Injuries					
	Male			Female			Male			Female		
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)
Contact with objects & equipment	72 (70, 75)	41 (38, 43)	82 (80, 84)	41 (38, 43)	82 (80, 84)	80 (76, 83)	52 (48, 55)	79 (75, 82)	54 (45, 62)	—	—	—
Exposure to harmful substances or environments	8 (7, 9)	26 (22, 30)	3 (2, 3)	26 (22, 30)	3 (2, 3)	3 (3, 4)	21 (18, 24)	6 (4, 8)	—	—	—	—
Overexertion & bodily reactions	6 (6, 7)	14 (12, 16)	6 (5, 7)	14 (12, 16)	6 (5, 7)	11 (8, 14)	9 (8, 10)	—	—	—	—	—
Violence & other injuries by persons or animals	6 (5, 7)	11 (10, 12)	1 (1, 1)	11 (10, 12)	1 (1, 1)	1 (0, 1)	11 (10, 13)	3 (2, 4)	18 (12, 24)	—	—	—
Falls, Slips, & Trips	5 (5, 5)	7 (7, 8)	7 (6, 8)	7 (7, 8)	7 (6, 8)	4 (3, 4)	6 (5, 6)	7 (5, 8)	13 (5, 21)	—	—	—
Transportation incidents	1 (1, 1)	0.4 (0.3, 0.5)	0 (0, 0)	0.4 (0.3, 0.5)	0 (0, 0)	0 (0, 0)	1 (1, 1)	2 (1, 3)	—	—	—	—
Fires & Explosions	0.4 (0.3, 0.4)	—	0 (0, 0)	—	0 (0, 0)	0 (0, 0)	0 (0, 0)	—	—	—	—	—
Nonclassifiable	1 (1, 1)	1 (0, 1)	1 (0, 1)	1 (0, 1)	1 (0, 1)	1 (1, 1)	1 (0, 1)	—	—	—	—	—
Source												
Persons, plants, animals, & minerals	15 (13, 17)	42 (38, 45)	5 (4, 6)	42 (38, 45)	5 (4, 6)	7 (5, 10)	34 (31, 38)	7 (5, 9)	26 (20, 33)	—	—	17 (13, 20)
Tools, instruments, & equipment	26 (25, 28)	15 (14, 16)	32 (30, 34)	15 (14, 16)	32 (30, 34)	22 (20, 24)	20 (18, 21)	19 (17, 21)	—	—	14 (8, 20)	15 (11, 18)
Machinery	14 (13, 16)	9 (8, 10)	10 (9, 12)	9 (8, 10)	10 (9, 12)	26 (24, 28)	10 (9, 10)	32 (27, 36)	28 (20, 36)	—	54 (48, 61)	27 (23, 32)
Parts & materials	13 (12, 14)	2 (1, 2)	27 (25, 30)	2 (1, 2)	27 (25, 30)	17 (14, 20)	5 (4, 5)	16 (14, 18)	—	—	11 (7, 15)	10 (7, 12)
Containers, furniture & fixtures	8 (7, 8)	11 (10, 12)	4 (3, 4)	11 (10, 12)	4 (3, 4)	7 (6, 8)	10 (9, 11)	4 (2, 5)	—	—	—	5 (3, 7)
Structures & surfaces	7 (7, 7)	11 (10, 11)	7 (6, 8)	11 (10, 11)	7 (6, 8)	5 (5, 6)	9 (8, 9)	6 (4, 7)	12 (7, 17)	—	—	7 (4, 9)
Vehicles	5 (5, 5)	2 (2, 2)	3 (2, 3)	2 (2, 2)	3 (2, 3)	2 (2, 3)	5 (5, 6)	8 (6, 9)	—	—	—	12 (9, 14)
Chemicals & chemical products	1 (1, 1)	1 (1, 2)	1 (1, 1)	1 (1, 2)	1 (1, 1)	1 (1, 2)	1 (1, 1)	3 (2, 3)	—	—	—	—
Other sources	10 (9, 11)	7 (6, 8)	10 (9, 12)	7 (6, 8)	10 (9, 12)	12 (10, 13)	7 (7, 8)	7 (6, 9)	11 (6, 17)	—	—	6 (4, 8)
Diagnosis												
Laceration	43 (41, 45)	23 (22, 25)	45 (43, 47)	23 (22, 25)	45 (43, 47)	40 (37, 43)	32 (30, 35)	16 (13, 20)	—	—	17 (10, 24)	15 (11, 18)
Fracture & dislocation	12 (11, 13)	6 (6, 7)	16 (15, 18)	6 (6, 7)	16 (15, 18)	14 (11, 16)	8 (7, 9)	28 (25, 32)	27 (19, 35)	—	31 (23, 38)	26 (21, 32)
Puncture	6 (5, 7)	19 (15, 23)	5 (4, 6)	19 (15, 23)	5 (4, 6)	3 (2, 3)	15 (12, 18)	4 (2, 5)	—	—	—	5 (2, 8)
Contusions, abrasions, & hematoma	8 (8, 9)	10 (9, 11)	6 (5, 6)	10 (9, 11)	6 (5, 6)	9 (7, 10)	10 (9, 11)	—	—	—	—	—
Sprain or strain	6 (5, 6)	12 (11, 14)	4 (3, 5)	12 (11, 14)	4 (3, 5)	7 (5, 8)	9 (8, 10)	—	—	—	—	—
Amputation & avulsion	5 (5, 6)	3 (2, 3)	5 (4, 5)	3 (2, 3)	5 (4, 5)	7 (6, 8)	4 (3, 4)	22 (19, 25)	13 (8, 18)	—	27 (19, 34)	21 (17, 24)
Burn	3 (2, 3)	4 (3, 4)	2 (1, 2)	4 (3, 4)	2 (1, 2)	2 (2, 3)	4 (3, 4)	5 (3, 7)	—	—	—	7 (5, 9)
Crushing	3 (2, 4)	2 (1, 2)	3 (3, 4)	2 (1, 2)	3 (3, 4)	5 (4, 6)	2 (2, 2)	6 (4, 7)	—	—	11 (7, 16)	5 (3, 6)
All Other**	14 (12, 15)	22 (19, 25)	15 (13, 16)	22 (19, 25)	15 (13, 16)	14 (11, 17)	17 (15, 19)	18 (15, 21)	24 (18, 31)	—	23 (18, 28)	19 (15, 22)

*Estimates did not meet NEISS-Work minimum reporting requirements.

**All other diagnosis includes: All other includes: ingested foreign object, aspirated foreign object, concussions, dental injury, internal organ injury, anoxia, hemorrhage, electric shock, poisoning, submersion, not stated, and other.

***All other includes the following industries: agriculture, forestry, fishing, & hunting (0170–0290), mining, quarrying, and oil and gas extraction (0370–0490), utilities (0570–0690), wholesale trade (4070–4590), retail trade (4670–5790), transportation & warehousing (6070–6390), information (6470–6790), finance and insurance (6870–6990), real estate and rental and leasing (7071–7190), professional, scientific, and technical services (7270–7490), management of companies and enterprises (7570), administrative & support & waste management services (7580–7790), educational services (7860–7890), health care & social assistance (7970–8470), arts, entertainment, and recreation (8560–8590), accommodation & food services (8660–8690), other services, except public administration (8770–9290), public administration (9370–9590).

†Data are statistically unreliable when the % CV >30% and < 50%.

FHW = finger, hand and wrist.



FIGURE 1. Number and rate of FHW injuries by severity and occupation group, DAF, 2009–2018. (A) Number by severity of FHW injuries by occupation group, DAF, 2009–2018. (B) Rate by severity of FHW injuries by occupation group, DAF, 2009–2018.

working in medical sciences experienced a significant increase in nonsevere FHW injuries from 2009 to 2013 (an increase of 6.9 per 10,000 workers per year; 95% CI, 10.2–3.6; $P < 0.01$) followed by a decline in nonsevere FHW injuries from 2013 to 2018 (a decrease of 5.9 per 10,000 workers per year; 95% CI, 3.6–8.1; $P = 0.004$).

Relation of Demographic Factors to Likelihood of FHW Injury

Unadjusted Odds Ratios

Males experienced 22% higher odds (Table 3) for a severe FHW injury compared to females. There were increasing odds of severe FHW injury among older age groups, with a significant trend (P value < 0.0001). Those aged 60 years and older were 79% ($P < 0.0001$), and those 50 to 59 years were 24% ($P = 0.02$) more significantly likely to have a severe FHW injury compared to those 30 years and younger. Civilians and enlisted were both more than twice as likely to have a severe FHW injury than officers. Equipment, facilities, and services ($P < 0.0001$); law enforcement, safety, and investigation ($P = 0.005$); transportation ($P = 0.01$); and administrative and professional ($P = 0.046$) workers were significantly more likely

to have a severe FHW injury than maintenance workers. Metal workers ($P = 0.0001$) and medical science workers ($P < 0.0001$) were significantly less likely to have a severe FHW injury than maintenance workers.

The odds of a severe FHW amputation ($P < 0.0001$), which includes loss of fingertips, were 69 times higher, and burns ($P < 0.0001$) were more than twice as high, compared to crush injuries. Severe FHW crush injuries were significantly more likely to occur compared to severe open wounds ($P < 0.0001$), sprains and strains ($P < 0.0001$), contusions ($P < 0.0001$), and dislocation injuries ($P = 0.0004$). The odds of severe FHW injuries involving vehicles (excluding aircrafts) ($P < 0.0001$), and chemicals and toxic substances ($P = 0.01$) occurring were more than twice as high as the occurrence of severe FHW injuries involving aircrafts (Table 3). Injuries involving tools, instruments, and equipment ($P < 0.0001$) were significantly lower (47%) compared to those involving aircrafts. The odds of a severe FHW injury occurring from transportation ($P < 0.0001$) were more than six times higher compared to tools and machines.

Adjusted Odds Ratios

After adjusting for age group, the results indicated that DAF males ($P = 0.0017$) were 24% more likely to experience a severe FHW injury compared to females (Table 3). However, after adjusting for multiple groups (sex, age group, and occupational group; sex,

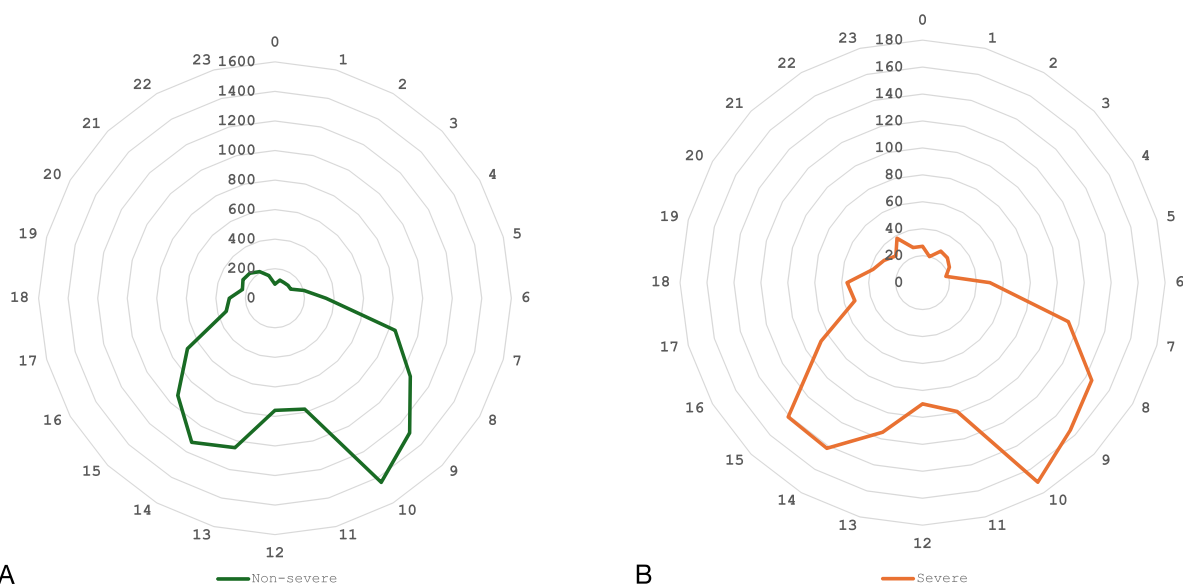


FIGURE 2. Number of severe and nonsevere finger, hand, and wrist injuries by time of day, DAF, 2008–2018. (A) Number of nonsevere finger, hand, and wrist injuries by time of day, DAF, 2008–2018. (B) Number of severe finger, hand, and wrist injuries by time of day, DAF, 2008–2018.

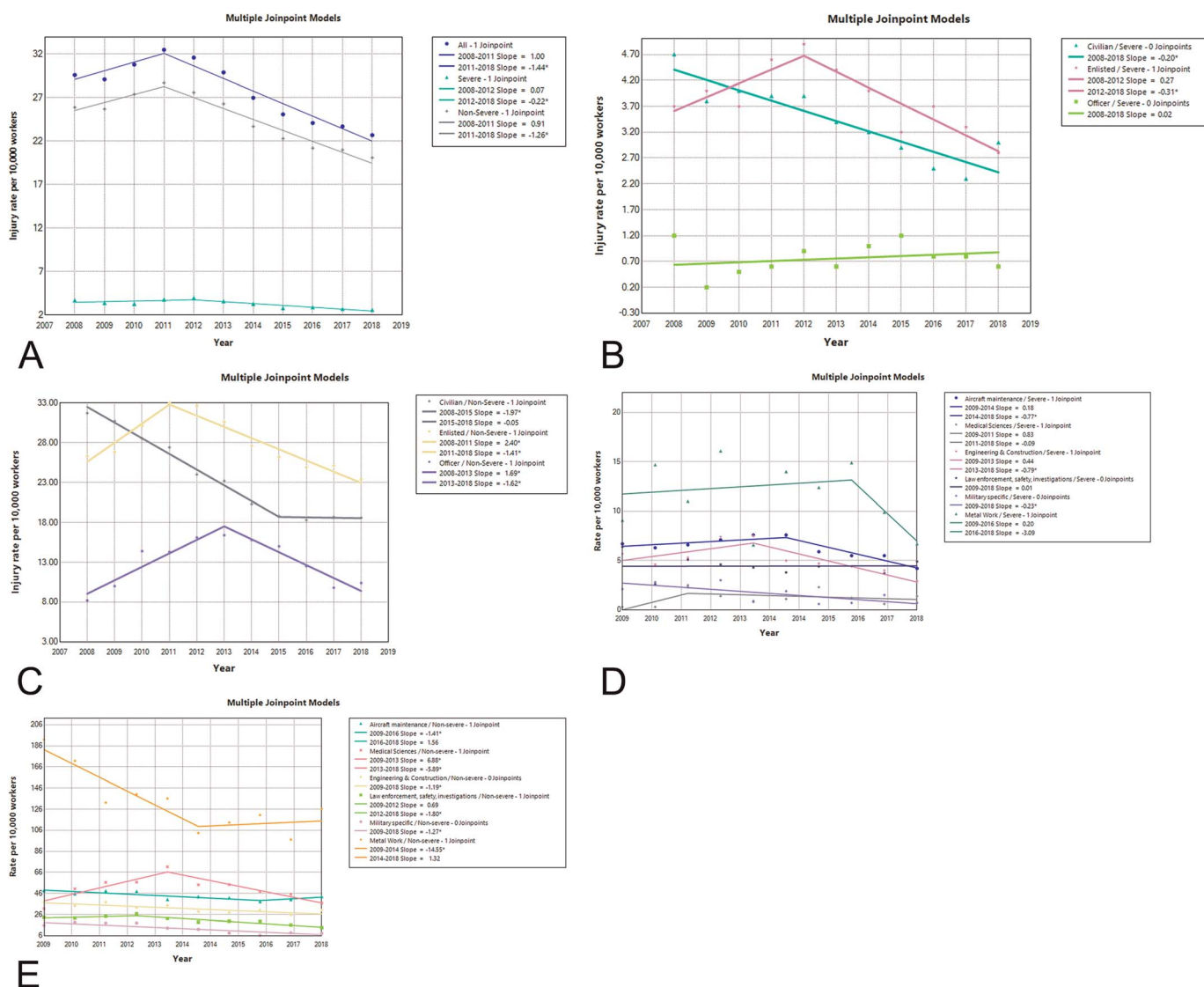


FIGURE 3. Annual trends in FHW injuries rates per 10,000 workers in the DAF, 2008–2018. (A) Annual trends in FHW injuries rates per 10,000 workers in the DAF, 2008–2018. (B) Annual trends in severe FHW injuries rates per 10,000 workers among DAF groups: civilian, enlisted, and officer, 2008–2018. (C) Annual trends in nonsevere FHW injuries rates per 10,000 workers among DAF groups: civilian, enlisted, and officer, 2008–2018. (D) Annual trends in severe FHW injuries rates per 10,000 workers among occupational groups in the DAF, 2009–2018. (E) Annual trends in nonsevere FHW injuries rates per 10,000 workers among occupational groups in the DAF, 2009–2018.

age group, occupational group, and Air Force group), DAF females had a 4% higher likelihood of severe FHW injury compared to males, but this was not significant ($P = 0.47$). This result suggests that occupational group is a confounder and that, in some occupations, females have a higher risk of severe FHW injury.

Those aged 50 to 59 years ($P = 0.01$) and 60 years and older ($P < 0.0001$) remained significantly more likely to have severe FHW injuries compared to those 30 years and younger after adjusting for sex. After adjusting for sex, age group, and occupational group, only those aged 60 years and older ($P < 0.0001$) were significantly more likely to have a severe FHW injury compared to those 30 years and younger. However, after adjusting for sex, age group, occupational group, and Air Force group, those aged 40 to 49 years ($P = 0.009$), 50 to 59 years ($P = 0.0017$), and 60 years and older ($P < 0.0001$) had a significantly higher likelihood to have a severe FHW injury compared

to those 30 years and younger. This indicated that Air Force group was a confounder (magnitude of change ranging between 11% and 15%).

After adjusting for sex, age, and sex and age, civilians and enlisted remained at a significantly higher likelihood of severe FHW injuries compared to officers. However, after adjusting for multiple variables (sex, age group, and occupation; sex, age group, occupation, and Air Force group), the results were not significantly different.

The aOR results indicated that equipment, facilities, and services; law enforcement, safety, and investigation; and transportation workers were significantly more likely to experience severe injuries than maintenance workers. The aOR results of metal workers and medical science workers remained significantly less likely to experience severe injuries compared to maintenance workers. The aOR (age; sex and age; sex, age group, and occupational group; sex, age group, occupational group, and Air Force group) results indicate that

TABLE 3. Odds Ratios for Variables and ED-Treated and Admitted Finger, Hand and Wrist Injuries, 2015 to 2022

	Unadjusted	Sex Adjusted	Age Adjusted	Industry Adjusted	Sex and age Adjusted	Sex/Age/Industry Adjusted
	uOR (95%CI)	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)	aOR (95%CI)
Sex						
Men	3.67 (3.1, 4.35)		3.64 (3.08, 4.31)	0.48 (0.4, 0.57)	3.64 (3.08, 4.31)	0.48 (0.4, 0.57)
Women	1		1	1	1	1
Age Group						
15–24 years	1	1		1	1	1
25–34 years	1.19 (1.02, 1.39)	1.16 (1, 1.36)		1.14 (0.93, 1.39)	1.16 (1, 1.36)	1.14 (0.93, 1.39)
35–44 years	1.61 (1.29, 2.01)	1.55 (1.25, 1.92)		1.37 (1.1, 1.69)	1.55 (1.25, 1.92)	1.37 (1.1, 1.69)
45–54 years	2.01 (1.68, 2.42)	1.97 (1.65, 2.36)		1.73 (1.41, 2.13)	1.97 (1.65, 2.36)	1.74 (1.41, 2.15)
55+ years	2.42 (1.83, 3.19)	2.36 (1.8, 3.1)		2.07 (1.52, 2.82)	2.36 (1.8, 3.1)	2.06 (1.51, 2.81)
Industry						
Health care and social assistance 7970–8470	0.21 (0.13, 0.36)	0.26 (0.15, 0.44)	0.21 (0.12, 0.35)		0.25 (0.15, 0.43)	0.25 (0.15, 0.43)
Manufacturing 1070–3990	2.39 (1.67, 3.42)	2.07 (1.44, 2.97)	2.32 (1.63, 3.3)		2 (1.4, 2.86)	2 (1.4, 2.86)
Accommodation and food services 8660–8690	0.52 (0.35, 0.76)	0.53 (0.36, 0.77)	0.57 (0.39, 0.83)		0.58 (0.39, 0.85)	0.58 (0.39, 0.85)
Construction 0770	3.13 (2.28, 4.29)	2.47 (1.79, 3.41)	3.08 (2.27, 4.18)		2.42 (1.77, 3.32)	2.42 (1.77, 3.32)
Retail trade 4670–5790	1	1	1		1	1
Public administration 9370–9590	0.76 (0.47, 1.23)	0.65 (0.4, 1.05)	0.76 (0.47, 1.23)		0.65 (0.4, 1.05)	0.65 (0.4, 1.05)
Administrative and support and waste management services 7580–7790	2.87 (2, 4.11)	2.5 (1.73, 3.61)	2.82 (1.97, 4.05)		2.46 (1.7, 3.54)	2.46 (1.7, 3.54)
Other services, except public administration 8770–9290	2.49 (1.6, 3.87)	2.29 (1.47, 3.58)	2.43 (1.55, 3.8)		2.23 (1.42, 3.49)	2.23 (1.42, 3.49)
Transportation and warehousing 6070–6390	1.77 (1.18, 2.65)	1.57 (1.05, 2.36)	1.67 (1.12, 2.48)		1.48 (1, 2.2)	1.48 (1, 2.2)
Agriculture, forestry, fishing, and hunting 0170–0290	4.52 (2.92, 6.98)	3.89 (2.51, 6.03)	4.01 (2.63, 6.1)		3.43 (2.24, 5.25)	3.43 (2.24, 5.25)
All other***	2.35 (1.76, 3.14)	2.23 (1.68, 2.97)	2.25 (1.69, 2.98)		2.12 (1.6, 2.8)	2.12 (1.6, 2.8)

The *P*-value for Wald chi-squared test statistic.

*Estimates did not meet NEISS-Work minimum reporting requirements.

**All other diagnosis includes: All other includes: ingested foreign object, aspirated foreign object, concussions, dental injury, internal organ injury, anoxia, hemorrhage, electric shock, poisoning, submersion, not stated, and other.

*** All other includes the following industries: mining, quarrying, and oil and gas extraction (0370–0490), wholesale trade (4070–4590), utilities (0570–0690), information (6470–6780), finance and insurance (6870–6992), real estate and rental and leasing (7071–7190), professional, scientific, and technical services (7270–7490), management of companies and enterprises (7570), educational services (7860–7890), and arts, entertainment, and recreation (8560–8590)

Boldface indicates statistical significance.

The sex and age adjusted model was adjusted for age only or alternatively, remove the numbers from the table. Similarly, a footnote and/or statement should be added to indicate that when comparing sex the sex/age/industry adjusted model was adjusted for age and industry only. This should be repeated for comparisons for age group and industries. For industry comparisons, the results under sex/age/industry could be removed as they are identical to sex and age adjusted.

production workers were significantly less likely to experience severe injuries compared to maintenance workers.

DISCUSSION

Sex

Similar to the findings of this article, previous research has demonstrated that work-related FHW injuries are higher among males in the military and outside of the military.^{7,11,35} US emergency department data also indicate that about 68% of work-related FHW injuries in 2022 occurred in males.³⁶ The occupational groups with the highest rates of hand injuries (production; installation, maintenance, and repair; and construction and extraction) also have a large proportion of workers who are male (ranging from 71% to 96%).^{37,38} Our overall findings also indicated that the large majority of FHW injuries were among males (80% of all FHW injuries and 83% of severe FHW injuries). However, our adjusted analyses suggest that the apparent association of sex to elevated likelihood of a severe FHW injury is largely attributable to

occupational differences. The two occupational groups that had the highest percentage of severe FHW injuries among females were administrative and professional (60%) and medical sciences (50%).

Age

In this study, we found that rates of severe FHW injuries were highest in the youngest age groups in the DAF. Consistent with our findings, previous research regarding hand and wrist injuries in the military has documented higher rates among those aged 20 to 24 years and in junior service members.¹¹ Similarly, younger workers in construction have been found to have a higher rate of FHW injuries due to lacerations, contusions, and punctures compared to older workers.^{35,39}

The rates of severe FHW injuries in the DAF were the second highest among older workers, and the odds of a severe injury increased with age. Prior work indicates that workers with negative return to work outcomes following injuries are often older and have higher physical demands and a lower level of education.^{8,21} In a prospective study of severe hand injuries at a Swedish Emergency Department,

Rosberg et al found the costs of work-related hand injuries to be higher among those over the age of 50 years, which could be related to severity of injury among older workers.¹⁰ Injuries among older workers have been associated with more lost work days and longer recovery compared to younger workers.⁴⁰ It is especially important to prevent injuries among older workers in industries like construction, because these older workers generally contribute valuable skills and experience, which is beneficial to younger workers.³⁹ This study indicates that this is also important for the DAF.

Occupational Groups

Aircraft maintenance is a critical factor for aviation safety.⁴¹ Aircraft maintenance workers had the highest percentage of FHW injuries and the second highest rate of severe FHW injuries in this study. The large number of FHW injuries within this occupation can create a burden to the DAF and the workers. Although many injuries to FHWs among maintenance and repair workers may result in a short time away from work and low costs, they have a high prevalence, resulting in a cumulative financial burden on employers.⁴² Aircraft maintenance workers in the DAF have the highest injury rate among lift, handle, and carry-related injuries.⁴⁰ Previous research in the DAF found a burden of lost workday injuries among civilian and military personnel involved in aircraft maintenance functions from handling aircraft components, especially among aircraft maintenance technicians, identifying prevention measures such as using mechanical lifts and detailed trainings.⁴⁰ Detailed injury narrative information from safety reports of the severe injuries could be coded in greater depth to determine the circumstances and commonalities of injuries among occupational groups like aircraft maintenance workers.³

Safety among aircraft maintainers is changing due to automation of some tasks and a system of checks and balances to improve safety compliance, such as automatic verification that all task steps were taken and confirming the qualifications of the aircraft maintainer and the inspecting supervisor.⁴³ The overall goal is to improve safety oversight and ensure that maintenance procedures are thoroughly followed, even as automation becomes more prevalent in the process. Worker-informed prevention strategies were previously successful at reducing fall injuries in DAF personnel.⁴⁴ Similar strategies could be employed among DAF aircraft maintenance workers and metal workers with a focus on FHW.

Decreases in machine-related hazards and improved work practices among metal workers occurred in response to ensuring that machine guarding and protective equipment were used and machines were compliant with current safety standards.⁴⁵ Similar to this study, previous research on military hand and wrist injuries found that 11% were caused by tools and machinery.^{2,11} Additionally, tools and machinery have also been associated with hand crushing and clamping-related injuries.⁸ These findings underline the importance of safety protocols, appropriate training, and regular inspections of equipment to reduce the risk of injuries in military settings. This is especially important among occupational groups with high injury rates, like metal workers.

A large proportion of FHW injuries among medical sciences workers involved punctures in this study. Among healthcare industry workers, being treated for work-related needlesticks and sharps injuries in US emergency departments, nearly all (99%) injuries were to the finger and hand, and 63% were from punctures.⁴⁶ It is important for needle- and sharps-related injuries to be reported by personnel working in medical sciences so that they can receive appropriate follow-up care and treatment for exposures to contaminated instruments. Workers in healthcare industries may have a higher likelihood of reporting sharps-related injuries due to healthcare facility policies requiring treatment, where other occupations may not have similar policies.⁴⁶ Efforts to reduce these injuries among medical science workers include continuous education training on handling of sharps and needles, strengthening safety protocols and standards, and the use of safety devices for disposal of sharps and needles.^{47,48}

Injury Type

This study found fractures to be the leading severe FHW injury type in the DAF. These types of injuries can be identified by radiographs, examination, or advanced imaging.⁴⁹ High rates of hand fractures have been found among laborers.⁴⁹ A study of DAF military police injuries found that nearly a quarter (24%) of hand and finger injuries were fractures.⁵⁰ The highest percentage of severe FHW fractures in this study were among aircraft maintenance workers and law enforcement, safety, and investigations. Continued workplace procedures and safety policies addressing reducing hand fractures in the military could help to determine key factors to inform prevention strategies.⁵¹

Mechanism of Injury

The leading mechanism of injury was contact with objects, which is a broad category that would benefit from more detailed coding and narrative review to inform prevention efforts. Falls were found to be the second leading severe FHW mechanism of injury in this study, and the majority of those (67%) resulted in a fracture. Falls have been found to be a leading mechanism of serious injuries in the US military.^{2,52} Previous research found that the risk increases with worker age, and they are more likely to have severe outcomes from falls, indicating the importance of interventions to reduce falls among older workers.^{53,54}

Trend Analysis

The annual decrease in FHW injuries in the DAF cannot be attributed to a specific intervention but is possibly due to a cumulative effect from multiple safety improvements and unmeasurable secondary and tertiary effects caused by upstream decisions. Some studies published in 2010 indicated the DoD's commitment to the prevention of occupational injury utilizing their medical surveillance systems and a greater interest in reducing the number of lost-workday injuries in the DAF.^{55–57} According to the Occupational Medicine Services Chief, a number of factors may have contributed to the reduction of injuries in the DAF: the importance command put on workplace safety and health, the participation of some sites in the OSHA Voluntary Protection Program, installation of safety office efforts to reduce injuries, availability of on-base treatment of injuries, and ongoing collaboration with unions.⁵⁸ Additionally, technological advancements have possibly reduced injuries by replacing manual labor and minimizing exposure to hazardous machinery.

There was a decrease in the number of injuries resulting in fatality, and full and partial permanent disability (Class A and B) in the DAF since 2011; however, there was an increase in injuries resulting in at least 1 day away from work beyond the day of injury (Class C).⁵⁹ In 2013, the DAF implemented the "Air Force Fall Prevention Focus" and began participating in the National Safety Stand-down to prevent falls in construction and adapted widespread countermeasures designed to reduce fall injuries among DAF personnel.^{44,60} The DAF has documented reductions in nearly all types of work-related noncombat injury events since implementation. Additionally, the continued improvements in safety climate in the DAF⁶¹ may have contributed to the decline in injuries.

Strengths and Limitations

A strength of the AFSAS dataset is that it enabled the DAF to convene directed safety investigations to address emerging risks among workers.⁶² Also, AFSAS provides detailed safety data beyond what is available in medical records.⁵⁶ This study was limited to acute FHW injuries among the military and civilians captured by the AFSAS and is unlikely to have included musculoskeletal injuries or injuries that are chronic.⁶³ For example, carpal tunnel syndrome cases, a common work-related condition, are recorded in another Air Force database that captures occupational illness. This study also did not contain FHW injuries if they were self-treated or medical treatment was provided by a source outside of the DAF health network, as it relies on events being reported to the safety office.⁶⁴ We also did not have

access to any information on longer-term medical outcomes, such as time off work or permanent disability. As with many other occupational datasets, there is the possibility of underreporting of injuries, which could be due to many different reasons, including fear of repercussion, convenience, or seeking treatment for injury outside of work. Although some studies define amputation as a loss of bone, the DAF amputation definition does not include loss of bone; for example, the loss of the tip of the finger is coded as an amputation.^{65,66} The FHW injuries captured by AFSAS also lack information on continued medical care, rehabilitation, and return to work. Because of the low number of Class A and B injuries, they had to be grouped with Class C injuries for analysis of severe injuries. For our analysis, we did not have access to more detailed demographic factors, such as education, length of service, medical history, or repeated injuries. In addition, the military could benefit from providing training on ICD-10 guidelines to improve the specific cause of injury coding and provide more specific information on the nature of injuries, especially those that are more severe.^{3,26} The DAF is currently examining how to update injury coding represent detailed injury information better.

CONCLUSIONS

This study examined FHW injuries by severity among DAF personnel to determine rates and patterns among DAF workers, evaluate trends over time, and identify potential key demographic risk factors. The findings of this analysis found that the majority of FHW injuries were among DAF males; however, adjusted analyses suggested that an apparent association of male sex to elevated likelihood of a severe FHW injury is largely attributable to occupational differences. Occupational groups that had the highest percentage of severe FHW injuries among females were administrative and professional, and medical sciences. Additionally, this analysis found that the youngest age group had the highest number of severe FHW injuries, yet the odds of a severe injury increased with age.

Future efforts within the DAF to reduce FHW injuries could focus on developing tailored prevention efforts that address all workers, including the specific needs of high-risk groups, such as males (targeting females in high-risk occupations), younger, older, aircraft maintenance, and metal workers. There is a need to continue to emphasize the significance of safety protocols, training, and inspection of equipment to minimize the risk of fracture and wound injuries in the military from leading sources like parts and materials, machinery, and aircrafts. Further research could be beneficial to understand factors contributing to more severe injuries, as well as the continual enhancement of surveillance efforts to provide more detailed narrative information on the circumstances of the injury event and detailed coding to describe the nature of injuries. The safety reports contain detailed free text on the circumstances surrounding the injury event. Automated analysis of free text comments or machine learning could be used to gain more detailed information on how the injuries occurred and determine if injuries resulted from specific tools or tasks. Such analyses have proven useful in other settings.^{67–70} In addition, there is a continued benefit to regularly examining if current trainings and policies need to be updated and modified to improve worker safety. Examining investigation records of severe FHW injuries (Class A through Class C) could provide useful information on exactly how the injuries occurred and might assist efforts to prevent these injuries. Linkage to other databases on longer-term medical outcomes, such as time off work or permanent disability, would also provide valuable information to better target specific causes of the more disabling injuries.

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