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Prevalence and Spectrum of Occupational Injury Among Orthopaedic Surgeons

A Cross-Sectional Study

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Investigation performed at the University of Miami, Miami, Florida

Background: Orthopaedic surgeons are at increased risk for many occupational hazards, both physical and mental. The aim of this study was to evaluate a wide range of work-related injuries among orthopaedic surgeons in the United States.

Methods: An electronic survey was developed to assess both physical and mental occupational hazards among orthopaedic surgeons. Descriptive statistics were analyzed for all survey items and compared using chi-square and paired t tests, as appropriate.

Results: The 1,645 responding orthopaedic surgeons (7% response rate) reported a total of 2,702 work-related musculoskeletal injuries, 17.9% of which required surgical treatment. Of the 61 who filed a disability claim, only 66% returned to work and 34% retired early. Additionally, 17.4% of respondents reported having been diagnosed with cancer since starting practice, and 93.8% reported experiencing a finger stick at some point in their career. Over one-half (55.8%) had experienced feelings of psychological distress since beginning practice, and nearly two-thirds (64.4%) reported burnout from work.

Conclusions: This study captured a spectrum of occupational injuries that pose longitudinal risks to an orthopaedic surgeon's physical and mental well-being. Our hope is that this analysis of occupational hazards will help to raise awareness among the orthopaedic and medical communities and lead to efforts to reduce these risks.

Level of Evidence: Prognostic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Orthopaedic surgeries are physically demanding, often subjecting surgeons to work-related musculoskeletal injury (MSI) due to the use of tools, exertion of force in non-ergonomic positions, and general manipulation of heavy limbs that is often required[1]. Orthopaedic surgeons are also more prone to non-musculoskeletal occupational injuries compared with other surgeons[1]. The risks involve proximity exposure to radiation due to intraoperative C-arm use[1,2]; infection secondary to skin puncture from handling drills, saws, Kirschner wires, and sharp bone fragments[1-3]; exposure to Bovie smoke as well as chemicals such as polymethylmethacrylate (PMMA) and isocyanate[1,4-6]; and exposure to high-intensity noise, secondary to use of power tools and high-powered suction, which increases the risk of noise-induced hearing loss[7]. Lastly, emotional and psychological disturbances affect all physicians, and orthopaedic surgeons are no exception, but traditionally there has not been much discourse regarding this topic within our specialty.

The objective of this study was to perform a large-scale evaluation of work-related injuries in a wide spectrum of practicing orthopaedic surgeons in the United States. A cross-sectional study of the American Academy of Orthopaedic Surgeons (AAOS) membership was used as a proxy to approximate the true prevalence and spectrum of work-related MSIs and non-MSIs among orthopaedic surgeons. This information could inform decision-making about implementation of altered practices in the workplace that may prevent work-related injuries in the future. Although the study was partially limited by the response rate, to our knowledge it is larger than any previous cross-sectional study that has attempted to capture the physical and mental occupational injuries among all subspecialties of orthopaedic surgery[8,9].

Materials and Methods

Participants

An electronic survey was emailed to all 23,270 members of the AAOS currently practicing in the United States; all others were excluded. The original invitation was sent in March 2021, and the survey was closed on April 12, 2021. During that

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSOA/A463).

TABLE I Demographic and Practice Characteristics of the Survey Respondents

	Value*	Sample Size†
Demographics		
Age *(yr)*	58.3 ± 28.1	1,408
Height *(cm)*	178.1 ± 9.4	1,609
Weight *(kg)*	86.0 ± 15.1	1,635
Gender		
Male	1,456 (89.6%)	
Female	169 (10.4%)	
AAOS membership type		
Candidates	99 (6.0%)	
Candidates in fellow	10 (0.6%)	
Emeritus	285 (17.3%)	
Fellows	1,251 (76.0%)	
Practice characteristics		
Subspecialties‡		1,645
General	467 (28.4%)	
Spine	144 (8.8%)	
Pediatrics	109 (6.6%)	
Adult reconstruction	398 (24.2%)	
Trauma	168 (10.2%)	
Hands	228 (13.9%)	
Shoulder and elbow	174 (10.6%)	
Foot and ankle	94 (5.7%)	
Oncology	46 (2.8%)	
Sports	345 (21.0%)	
Other	41 (2.5%)	
Years in practice, including training		1,637
>25	958 (58.5%)	
21-25	213 (13.0%)	
16-20	150 (9.2%)	
11-15	173 (10.6%)	
5-10	121 (7.4%)	
<5	22 (1.3%)	
Operating position		1,628
Sitting	265 (16.3%)	
Standing	1,363 (83.7%)	
Patient care team characteristics		
Do fellows assist in the clinic, OR, or both?		256
Clinic	4 (1.6%)	
OR	61 (23.8%)	
Both	191 (74.6%)	
Do mid-levels assist in the clinic, OR, or both?		1,005
Clinic	224 (22.3%)	
OR	83 (8.3%)	
Both	698 (69.4%)	
Do residents assist in the clinic, OR, or both?		472
Clinic	4 (0.85%)	
OR	120 (25.4%)	
Both	348 (73.7%)	

*The values are given as the mean ± standard deviation or as the number of patients with the percentage in parentheses. †The number of responses was <1,645 for some questions because the final analysis included all respondents who completed >95% of the questions. ‡Several respondents identified as having trained in 2 subspecialties, and were therefore counted under both.

time, 3 reminder emails were sent to encourage member participation. No incentives were offered.

Survey

The survey was divided into 8 sections regarding work-related injuries, including demographics, training and practice settings, work-related MSIs, disabilities, cancer diagnoses and radiation-induced injuries, infections, hearing loss, and psychological and emotional health (see Appendix). The musculoskeletal portion of the survey was built using the standardized Nordic questionnaire[10].

Statistical Analysis

Descriptive statistics are reported for all survey items, and chi-square and paired t tests were used to identify significant associations between occupational injury and any relevant risk factors.

Source of Funding

No external funding was received for this study.

Results

Demographics

Of the 1,826 surveys that were returned, 1,645 (7% response rate) were >95% complete and were included in this study. Basic demographic and practice characteristics of the survey respondents are given in Tables I and II.

Musculoskeletal and Related Injuries

A total of 3,031 respondents reported experiencing musculoskeletal pain locations and/or MSI. Of these, 2,702 work-related MSIs were reported by the 1,645 respondents, and 17.9% of the injuries required surgical treatment (Figs. 1, 2, and 3).

Table III lists the most common surgeries at each anatomic location that the orthopaedic surgeons underwent because of MSIs that they experienced in their workplace.

All orthopaedic subspecialties were represented in this study, with some respondents self-identifying as trained and/or practicing in multiple subspecialties. Among the subspecialties, the highest rates of self-reported, work-related pain and MSI were among adult reconstruction surgeons (165%, 657 injury and pain reports) and general orthopaedists (144%, 674 injury and pain reports) (Fig. 4).

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TABLE II Practice Characteristics

	Hospital (N = 412)	University-Based Academic (N = 310)	Private Group (N = 904)
Average hours/week in OR			
<10	63 (15.3%)	24 (7.7%)	149 (16.5%)
10-19	216 (52.4%)	129 (41.6%)	413 (45.7%)
20-29	112 (27.2%)	124 (40.0%)	286 (31.6%)
30-39	16 (3.9%)	25 (8.1%)	50 (5.5%)
≥40	5 (1.2%)	8 (2.6%)	6 (0.7%)
Average procedures/month			
<10	36 (8.7%)	17 (5.5%)	84 (9.3%)
10-19	87 (21.1%)	66 (21.3%)	159 (17.6%)
20-29	125 (30.3%)	92 (29.7%)	228 (25.2%)
30-39	83 (20.1%)	65 (21.0%)	189 (20.9%)
40-49	49 (11.9%)	46 (14.8%)	127 (14.1%)
≥50	32 (7.8%)	24 (7.7%)	117 (12.9%)
Average patients/day seen in clinic			
<10	18 (4.4%)	5 (1.6%)	43 (4.8%)
10-19	101 (24.5%)	53 (17.1%)	137 (15.2%)
20-29	172 (41.7%)	109 (35.2%)	319 (35.3%)
≥30	121 (29.4%)	143 (46.1%)	405 (44.7%)

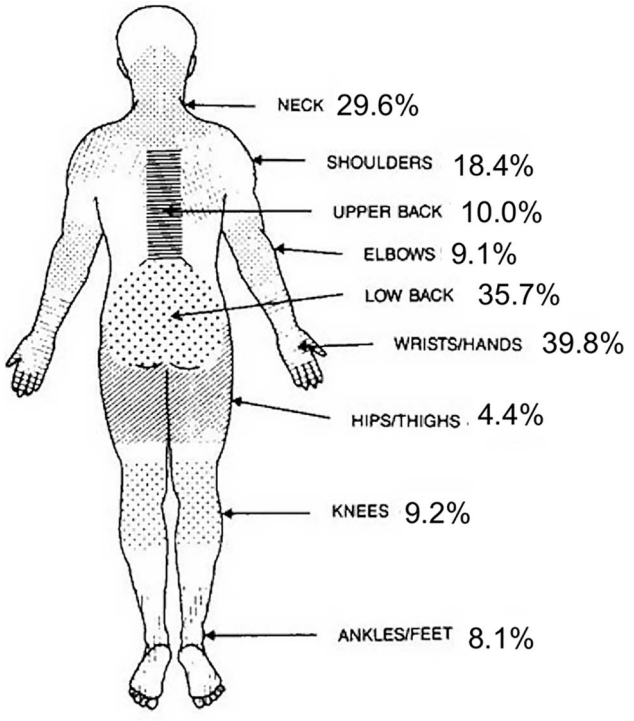

Fig. 1
Percentage of surgeons reporting a musculoskeletal injury by body part.

Varicose Veins

A total of 490 respondents had developed varicose veins since beginning practice (30.2%). Of these, 62 (12.7%) had surgery or other interventions (not including compression stockings) for their varicose veins, and 174 (35.7%) reported wearing compression stockings (Fig. 5). In comparison, 88 (7.6%) of the respondents without varicose veins reported wearing compression stockings.

Finger Stick Injuries and Infections

Finger sticks were reported by nearly all orthopaedic surgeons: 93.8%, from a needle; 66%, from an orthopaedic instrument; and 61.8%, from bone. On average, bone sticks had the lowest rates of reporting to the institution (32.9%), evaluation (30.4%), and treatment (2.9%) for possible infection (Fig. 6).

Disability and Time Off Work

Of the respondents, 1,129 (76.4%) had active disability insurance and 243 (14.9%) had reported a work-related injury to their place of employment during their career (Table IV). Rates of disability claims, return to work, and early retirement differed according to the MSI location.

Oncologic Occupational Hazards and Radiation Exposure

Of the respondents, 286 (17.4%) had been diagnosed with any type of cancer since starting practice, with some having multiple cancer diagnoses (Fig. 7). Lead use varied by orthopaedic subspecialty (Fig. 8), but overall, 61.7% of the respondents reported always wearing lead when exposed to radiation.

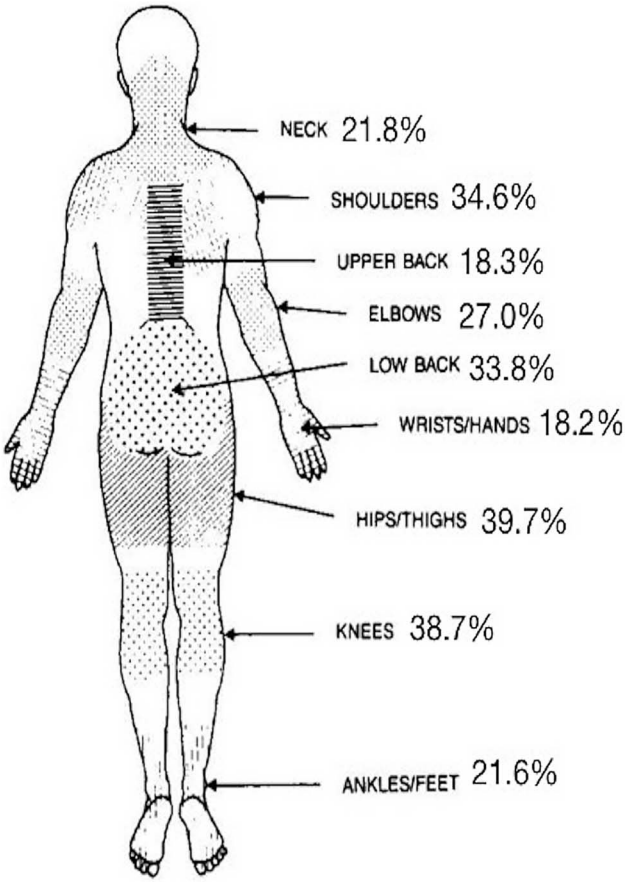

Fig. 2

Percentage of surgeons with musculoskeletal injuries who underwent nonoperative treatment (medications and/or rehabilitation) by body part.

Noise-Induced Hearing Loss

One-third (33.3%) of orthopaedic surgeons reported having experienced hearing loss since beginning practice, and 15.9% had been diagnosed with noise-induced hearing loss during that time. The average age of participants in this study was 58 years, and there was a significant relationship between increased age (≥67 years old) and noise-induced hearing loss ($p < 0.00001$). Additionally, the rate of hearing loss was highest (211 of 958) among those who had been in practice for >25 years.

Emotional and Psychological Health

Emotional Health Characteristics

Overall, 576 (35.4%) of the orthopaedic surgeons reported feelings of social isolation due to their career, 909 (55.8%) reported feelings of psychological distress since beginning practice, and 1,045 (64.6%) had experienced burnout since starting work.

Burnout

Of the 1,045 orthopaedic surgeons (64.4%) who reported experiencing burnout from work, 181 (17.3%) had taken time off due to burnout. Additionally, 511 (49.1%) reported that feelings of burnout adversely affected their social life, and 351 (33.6%) reported that feelings of burnout adversely affected their work performance. Of the orthopaedic surgeons who experienced burnout at some point in their career, 108 (10.4%) had sought professional counseling. Surgeons with >25 years in practice had the highest rate of experiencing burnout during their career (542, 51.9%). Additionally, 73.5% of female orthopaedic surgeons (122) compared with 63.3% of male orthopaedic surgeons (923) experienced burnout; the rate was significantly higher among the female surgeons ($p = 0.01$). There was no significant difference in burnout rate according practice type ($p > 0.05$).

Psychological Distress

Of the 909 orthopaedic surgeons (55.8%) who reported feelings of psychological distress since beginning practice, 461 (50.8%) reported that these feelings adversely affected their social life and 307 (33.8%) reported that they affected their performance at work. The proportion of respondents who reported that feelings of psychological distress adversely affected their work performance was highest among general orthopaedists (85, 37.4%), followed by spine surgeons (28, 36.4%) (Fig. 9).

Discussion

Multiple injuries were identified by the survey respondents, but we wish to call particular types to the attention of the orthopaedic community.

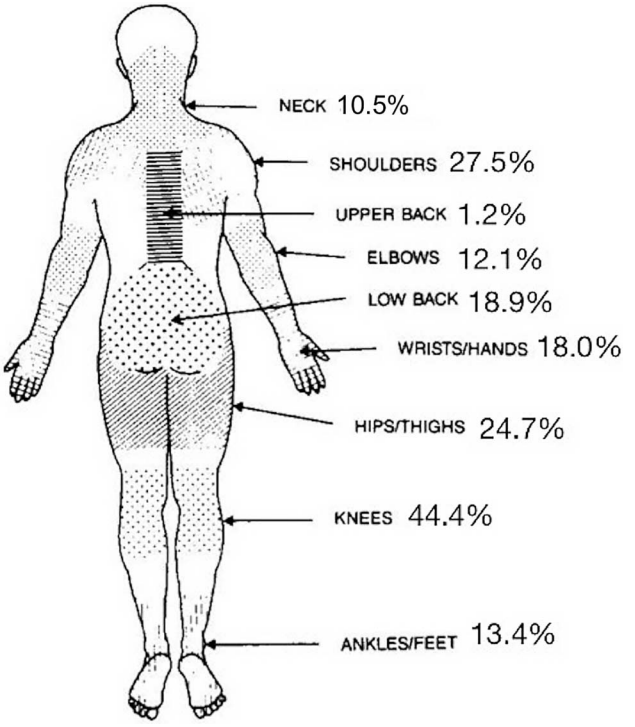

Fig. 3

Percentage of surgeons with musculoskeletal injuries who underwent operative treatment by body part.

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TABLE III The Most Common Surgical Interventions for Each Body Part

Injury Site	Most Common Surgeries	
Knee		
	Arthroscopic debridement	19 (43.2%)
	Total knee replacement	11 (25.0%)
	Meniscal surgery	9 (20.5%)
Ankle or foot		
	Ankle arthrodesis	3 (20.0%)
	Ligament reconstruction	2 (13.3%)
	Open reduction and internal fixation	2 (13.3%)
Neck		
	Cervical fusion	31 (63.3%)
	Decompression	4 (8.2%)
	Laminectomy	2 (4.1%)
Lower back		
	Discectomy	42 (42.0%)
	Injections	12 (12.0%)
	Fusion	11 (11.0%)
	Laminectomy	11 (11.0%)
Hip or thigh		
	Total hip replacement	10 (62.5%)
	Labral repair	1 (6.7%)
Wrist or hand		
	Carpal tunnel release	85 (62.0%)
	Trigger finger release	12 (8.8%)
	Laceration repair	8 (5.8%)
Elbow		
	Ulnar nerve decompression or transfer	6 (30.0%)
	Lateral epicondylitis release	5 (25.0%)
	Distal biceps repair	3 (15.0%)
Shoulder		
	Rotator cuff repair	22 (32.8%)
	Arthroscopic debridement	18 (29.6%)
	Labral repair	10 (14.0%)

Musculoskeletal and Related Injuries

The 1,645 AAOS members in the United States who provided reasonably complete responses reported a total of 2,702 MSIs. A survey by Davis et al. regarding work-related MSIs among orthopaedic surgeons practicing in Tennessee revealed high rates of injury to the lower back and hand[11]. Similar to the available literature, the present study found the highest rates of MSI occurring in the wrists and hands (39.8%), lower back (35.7%), and neck (29.6%).

The present study found general orthopaedists and adult reconstruction surgeons to have the highest rates of injury. Repetitive use of heavy hammers, drills, and heavy equipment including jigs and instruments in joint replacement may be related to these findings. Although MSIs are common in orthopaedics, improving the ergonomics in the operating room (OR) can help to minimize these risks. Most notably, the surgeon should maintain a neutral posture throughout surgery to minimize the risk of injury[12]. The spine is vulnerable to occupational injury, as 35.7% of orthopaedic surgeons in our study reported a lower-back injury. The most common injury location in the present study was the hands and wrists (39.8%), and the most common type of hand injury among the respondents was carpal tunnel syndrome. This has been attributed to the constant forceful gripping of instruments[14]. Orthopaedic surgeons have also been reported to be prone to upper-extremity injuries, especially lateral epicondylitis, due to repeated manual surgical tasks as well as the use of electronic medical records (EMRs) in non-ergonomic positions[12]. In the present study, 25% of the surgeons with elbow pain underwent surgery for lateral epicondylitis. According to the literature, orthopaedic surgeons experience both carpal tunnel syndrome and lateral epicondylitis at higher rates than the general population[1]. Three categories of ergonomic solutions could be considered to mitigate these MSI risks: engineering controls (changes to physical environment), administrative controls (workforce or human changes), and personal protective equipment[15]. Implementing these solutions can be achieved via ergonomic training; Koshy et al. evaluated the literature on interventions currently used to minimize MSI in surgeons and reported that 69.9% of surgeons noted improvement in symptoms after implementing the aforementioned ergonomic solutions[15].

A total of 490 surgeons (30.2%) had developed varicose veins since beginning practice, and 12.7% of them needed surgery or another intervention. Of the 490 respondents who had developed varicose veins, only 174 (35.7%) reported wearing compression stockings regularly. Education regarding stocking use could potentially increase the number of surgeons using stockings and thus help to mitigate the risk of varicose vein development or worsening.

Finger Stick Injuries and Infections

Occupational hazards other than MSI include infection due to bloodborne pathogens and the high rate of puncture injuries. Orthopaedic surgeons have a higher risk than other surgeons because of their routine use of sharp power instrumentation (e.g., saws and drills) and Kirschner wires, as well as manipulation of sharp bone fragments[1]. In the present study, 93.8% of respondents had experienced a needle stick; 66%, an instrument stick; and 61.8%, a bone fragment stick. Of these, only 68.6% of needle sticks, 49.5% of instrument sticks, and 30.4% of bone sticks resulted in a workup for an infection. A total of 235 orthopaedic surgeons (15.3%) required medical treatment due to finger sticks. Future studies are needed to determine the reasons for underreporting, which could involve fear of legal consequences or lack of concern regarding sticks with a non-bore needle. These exposures and infection risks can be minimized by wearing the proper personal protective equipment, including gloves, face masks and shields, eyewear, and gowns, as well as diligent handling of surgical instrumentation and bone.

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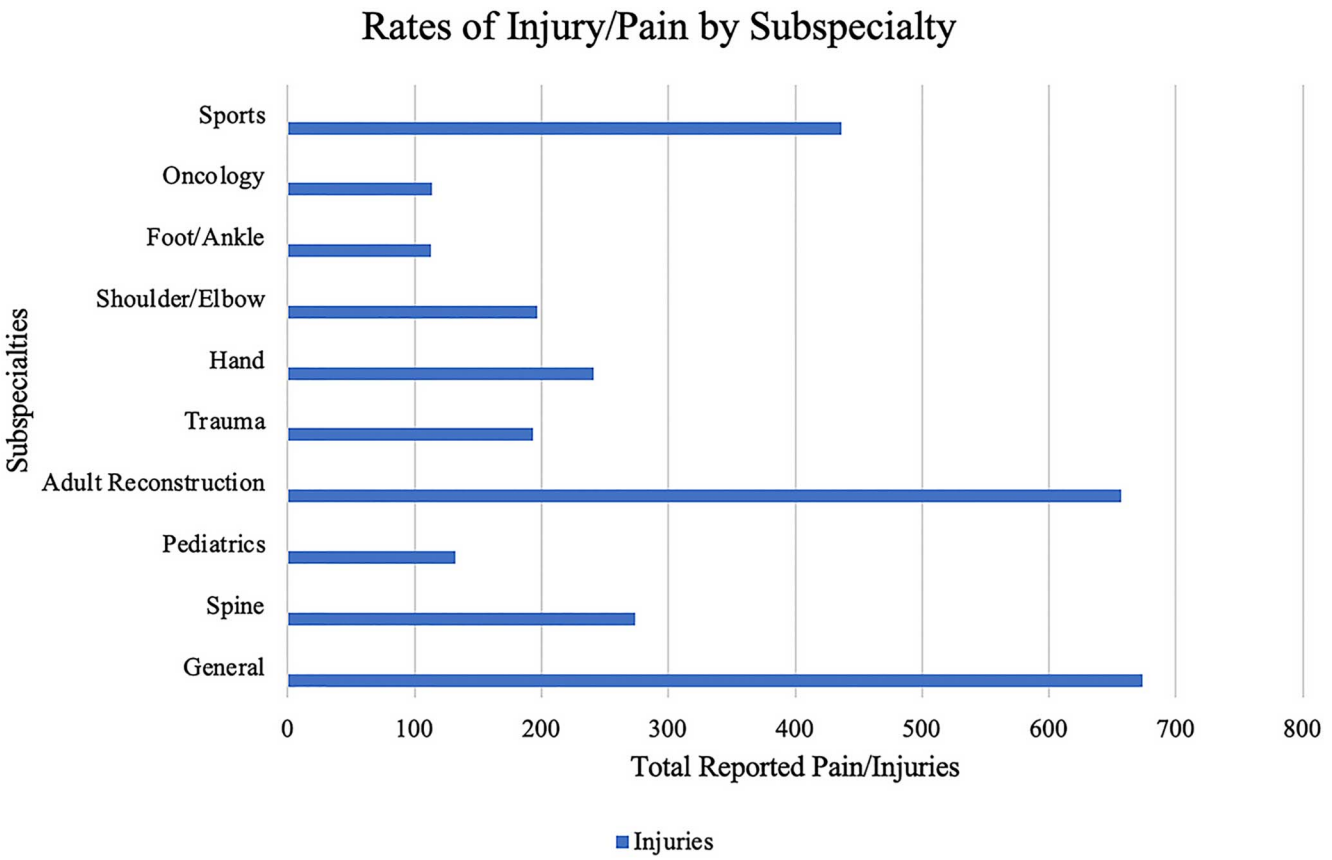

Fig. 4
Rates of injury and/or pain locations by subspecialty.

Disability and Time Off Work

Although it has been known that orthopaedic surgeons are at risk for MSIs, we believe this to be the first study to analyze the long-term implications of these injuries with respect to surgeons and their careers. Work-related injuries can result in absenteeism and decreased productivity, and 12.0% of the survey respondents in the

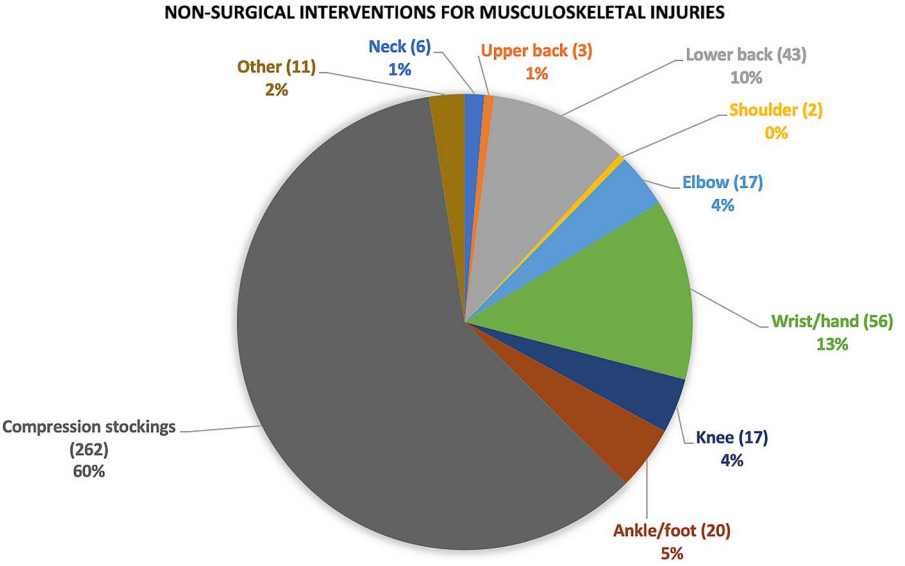

Fig. 5
Nonsurgical interventions for musculoskeletal injuries.

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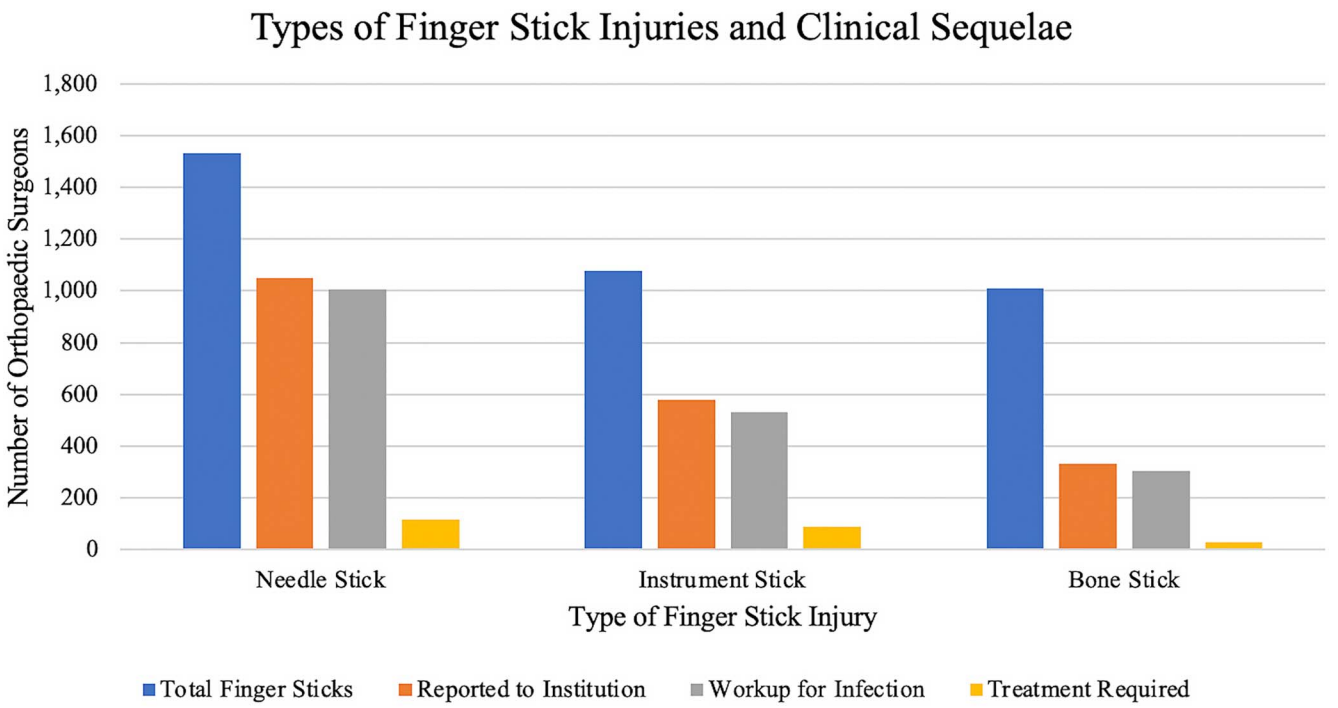

Fig. 6

Types of finger stick injuries and clinical sequelae.

TABLE IV Disability

Disability-Related Characteristic	No. (%)	Sample Size
Work-related injury reported to place of employment		1,628
Yes	243 (14.9%)	
No	1,385 (85.1%)	
Time off work due to work-related injury, in any clinical setting		1,630
Yes	196 (12.0%)	
No	1,434 (88.0%)	
Work missed due to surgery-related injury		1,632
Yes	168 (10.3%)	
No	1,464 (89.7%)	
Time taken off work due to work-related injury		193
<1 month	138 (71.5%)	
≥1 month	55 (28.5%)	
Disability claim secondary to injury sustained as a direct result of providing treatment to a patient		1,629
Yes	61 (3.7%)	
No	1,568 (96.3%)	
Disability insurance		1,629
Yes	1,129 (76.4%)	
No	349 (23.6%)	
Work status after disability claim		59
Return to work	39 (66.1%)	
Returned at pre-injury baseline workload		38
Yes	20 (52.6%)	
No	18 (47.4%)	
Average percentage of previous baseline reached	66.94%	18
Early retirement	20 (33.9%)	

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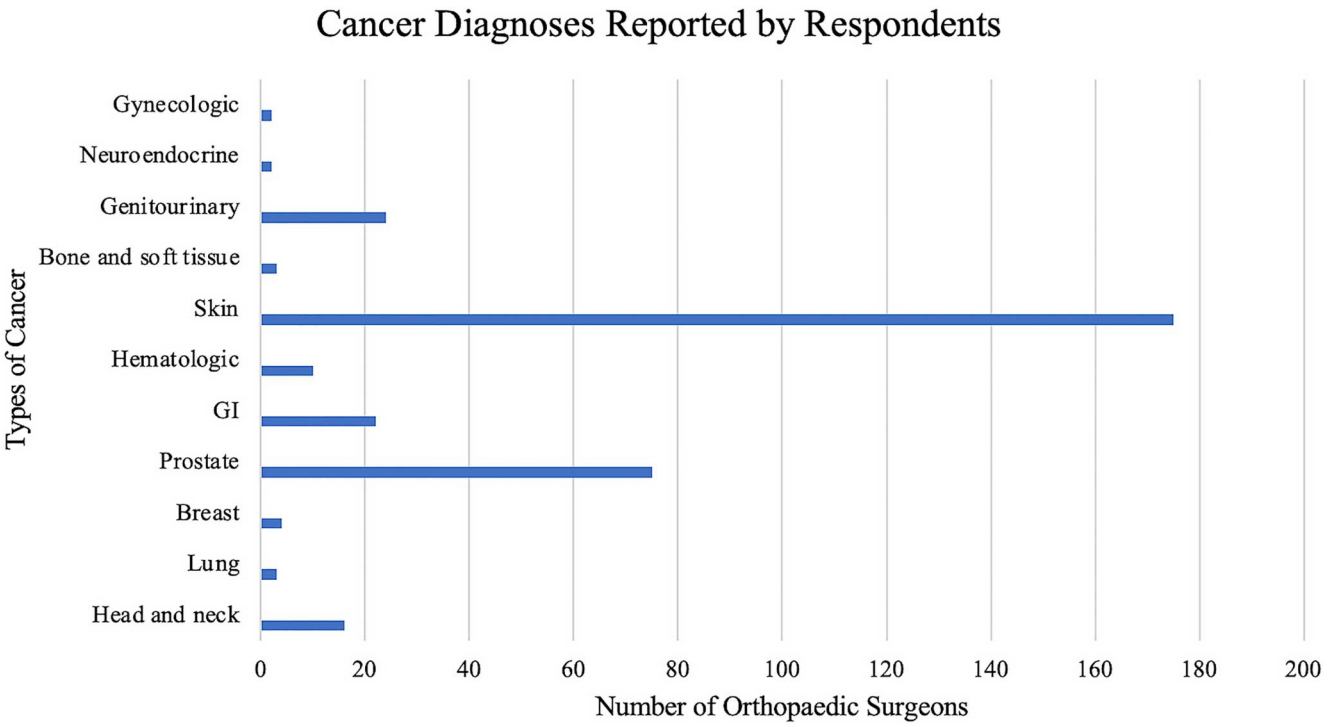

Fig. 7

Cancer diagnoses. GI = gastrointestinal.

present study reported having taken time off work at some point due to a work-related injury[13]. More notably, 20% of the latter group took >1 month off, potentially creating a large financial burden for both the surgeon and the institution. Additionally, 33.9% of the orthopaedic surgeons who filed a disability claim had to take early retirement secondary to a work-related injury. With

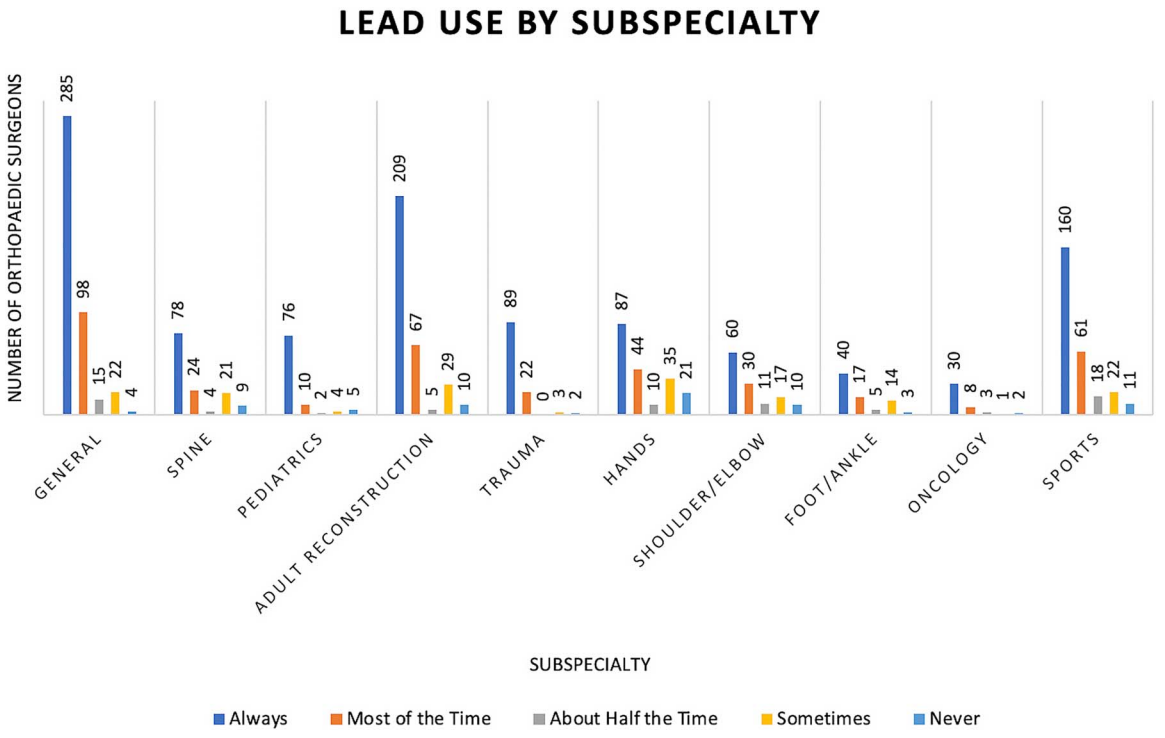

Fig. 8

Lead use by subspecialty.

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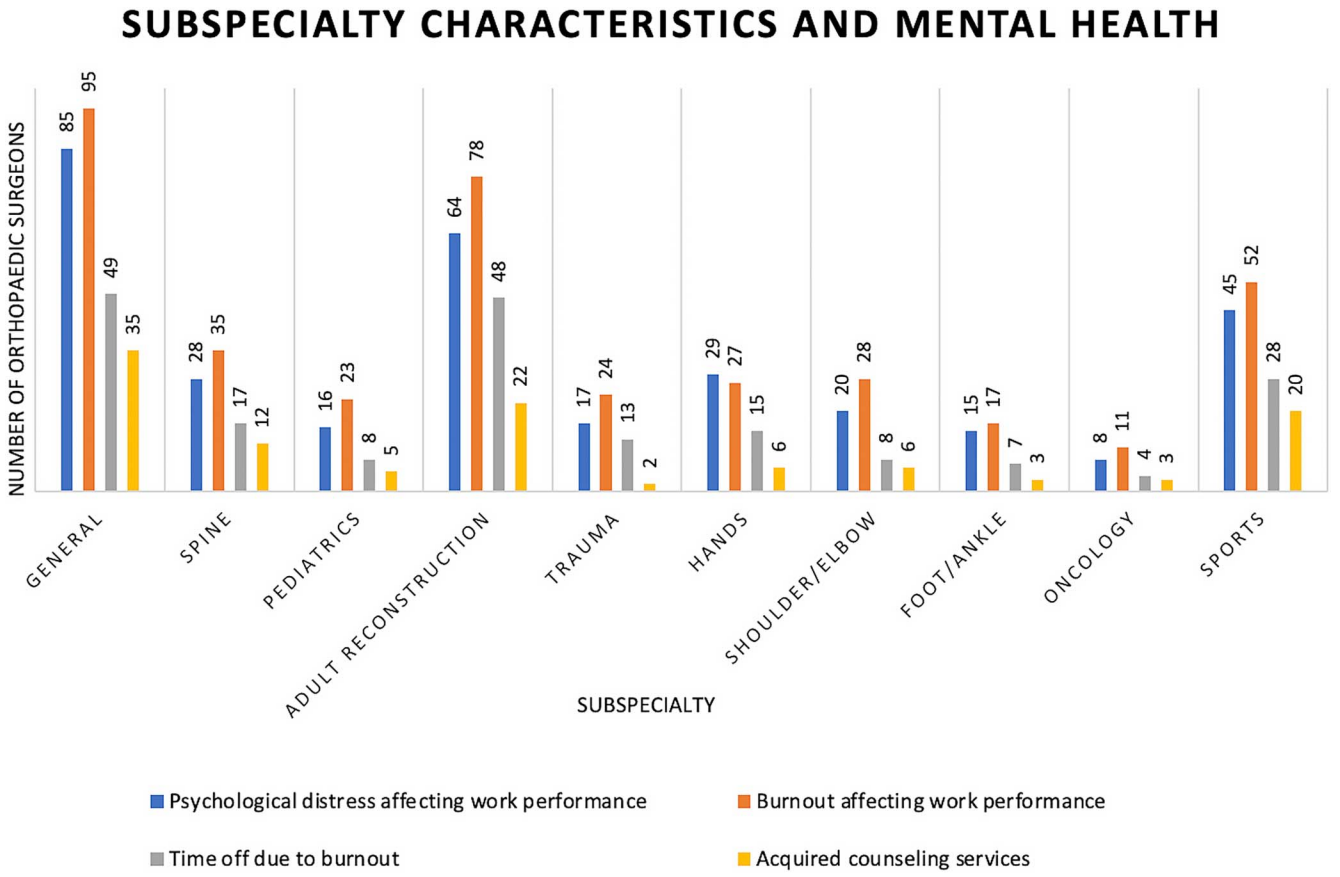

Fig. 9
Mental health by subspecialty.

rates as high as this, it is important for surgeons to understand the long-term implications of occupational injuries and how to best avoid permanent disability and early retirement. This study found that orthopaedic surgeons with ankle or foot injuries had the highest rate of early retirement, followed by those with upper-back injuries. Many of these injuries may be preventable, as lack of proper ergonomics in the OR has been reported to be one of the leading MSI causes among orthopaedic surgeons[12]. Recommendations on surgical ergonomics have been published to inform surgeons of ways to prevent such injuries; for instance, anti-fatigue mats and supportive shoes are recommended interventions to prevent lower-extremity injury[13].

Oncologic Occupational Hazards and Radiation Exposure

Many orthopaedic surgeons encounter ionizing radiation on an almost daily basis due to intraoperative fluoroscopy[16]. Radiation exposure has been linked to chromosome damage and infertility, among other sequelae[1,17]. Only 61.7% of the orthopaedic surgeons in the present study reported wearing lead for all procedures, and 4.7% reported never wearing lead. This is an area for improvement, as it is known that 0.5-mm lead gowns attenuate 99% of the radiation, making them a simple and efficient means of preventing radiation exposure[1]. In this study, 17.6% of orthopaedic surgeons reported having been diagnosed with cancer since beginning practice; in comparison, approximately 9.5% of adults in the United States have been diagnosed with cancer during their lifetime. A study by Chou et al. found that, compared with other surgical specialties, female orthopaedic surgeons had a significantly greater prevalence of any type of cancer[18]. This is notable as mini fluoroscopy and large multiposition C-arm are reported to be most frequently used by orthopaedists compared with other specialties, and the resulting greater radiation exposure could play a role in the greater cancer prevalence among orthopaedic surgeons[19,20]. These findings underscore the large risk of radiation exposure among orthopaedic surgeons and serves as a reminder of the importance of rigorous education and implementation of radiation exposure tracking and prevention protocols. Nevertheless, a family history of cancer and harmful habits are other strong predictors of cancer and must also be considered on a case-by-case basis.

Noise-Induced Hearing Loss

Orthopaedic surgeons are at risk for noise-induced hearing loss due to their use of high-powered suction, electrocautery, hammers, drills, and saws[21]. In the present study, one-third of the respondents self-reported hearing loss since beginning practice. Although a hearing loss diagnosis was significantly associated with an increasing number of years in practice, no conclusions regarding causation can be drawn because hearing loss is a

process that is naturally associated with aging[22]. It is reported that >12% of the global population is at risk for noise-induced hearing loss, but those with constant noise exposure at work have a significantly higher 23% prevalence of noise-induced hearing loss[23]. In the present study, 15.9% of orthopaedic surgeons had been diagnosed with noise-induced hearing loss since beginning practice, which is slightly greater than the proportion of the general population that is considered at risk[23]. As Willett recommends, the use of ear defenders and other ways to decrease noise emissions should be promoted in orthopaedic practice to reduce the possible risks of noise-induced hearing loss[7].

Emotional and Psychological Health

Orthopaedic surgeons experience burnout at rates higher than those in the general population as well as many other medical specialties[24]. Burnout is a major concern as it is associated with poor outcomes for both surgeons and patients[25]. In the present study, 64.4% of responding orthopaedic surgeons reported experiencing burnout from work, and 55.8% reported feelings of psychological distress since beginning practice. These findings are concerning, as Shanafelt et al. found that medical errors reported by surgeons are strongly related to a surgeon's degree of burnout and mental quality of life[26]. Burnout has also been shown to lead to unprofessional conduct and decreased quality of patient care[27]. Of note, women orthopaedic surgeons reported burnout at significantly higher rates than their male counterparts (73.5% versus 63.3%, $p = 0.01$). To our knowledge, this is the first study to report burnout in both female and male orthopaedic surgeons in the same cohort. The difference in burnout rate could potentially be related to the fact that females are a minority in orthopaedic surgery and historically have experienced higher levels of discrimination and microaggressions[27,28]. The COVID-19 pandemic may also have contributed to the high rate of reported mental health issues among the respondents. We encourage orthopaedic departments to create programs to support their surgeons' mental health to prevent burnout and its detrimental effects.

Study Limitations

The limitations inherent to survey-based studies, such as recall bias and self-reporting of measures, are relevant to this study. It is possible that some of the self-reported injuries were not secondary to occupational hazards in the workplace, and possible that some injuries would not have taken place if the current workplace setting had been in place. Although 7.03% is a low response rate, the 1,645 completed responses help to approximate the true spectrum of occupational injuries. Finally, this survey was not exhaustive and was unable to identify every possible occupational hazard.

Conclusions

This study captured a spectrum of occupational injuries that pose longitudinal risks to orthopaedic surgeons' physical and mental well-being. It is our hope that this comprehensive information will help to raise awareness among the orthopaedic and medical communities, as well as encourage further investigation among our professional societies. We plan to conduct an additional study focused on orthopaedists' self-care, which could provide further insight into the effect of occupational injuries on workforce shortages.

Appendix

eA Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJSOA/A464). ■

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