Geospatial Mapping of Orthopaedic Surgeons Age 60 and Over and Confirmed Cases of COVID-19

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Background: Although elective surgical procedures in the United States have been suspended because of the coronavirus disease 2019 (COVID-19) pandemic, orthopaedic surgeons are being recruited to serve patients with COVID-19 in addition to providing orthopaedic acute care. Older individuals are deemed to be at higher risk for poor outcomes with COVID-19. Although previous studies have shown a high proportion of older providers nationwide across medical specialties, we are not aware of any previous study that has analyzed the age distribution among the orthopaedic workforce. Therefore, the purposes of the present study were (1) to determine the geographic distribution of U.S. orthopaedic surgeons by age, (2) to compare the distribution with other surgical specialties, and (3) to compare this distribution with the spread of COVID-19.

Methods: Demographic statistics from the most recent State Physician Workforce Data Reports published by the Association of American Medical Colleges were extracted to identify the 2018 statewide proportion of practicing orthopaedic surgeons ≥60 years of age as well as age-related demographic data for all surgical specialties. Geospatial data on the distribution of COVID-19 cases were obtained from the Environmental Systems Research Institute. State boundary files were taken from the U.S. Census Bureau. Orthopaedic workforce age data were utilized to group states into quintiles.

Results: States with the highest quintile of orthopaedic surgeons ≥60 years of age included states most severely affected by COVID-19: New York, New Jersey, California, and Florida. For all states, the median number of providers ≥60 years of age was 105.5 (interquartile range [IQR], 45.5 to 182.5). The median proportion of orthopaedic surgeons ≥60 years of age was higher than that of all other surgical subspecialties, apart from thoracic surgery.

Conclusions: To our knowledge, the present report provides the first age-focused view of the orthopaedic workforce during the COVID-19 pandemic. States in the highest quintile of orthopaedic surgeons ≥60 years old are also among the most overwhelmed by COVID-19. As important orthopaedic acute care continues in addition to COVID-19 frontline service, special considerations may be needed for at-risk staff. Appropriate health system measures and workforce-management strategies should protect the subset of those who are most potentially vulnerable.

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

Coronavirus disease 2019 (COVID-19) presents unique challenges to the orthopaedic workforce within the U.S.[1,2]. As confirmed case numbers continue to rise nationwide, health systems are urgently diverting resources and personnel toward the surge of patients who have been hospitalized because of COVID-19. Various governmental agencies and other organizations, such as the American College of Surgeons (ACS), have called for the postponement of all elective procedures and have issued guidelines for the triage of new patients[3-6]. Certain orthopaedic acute operations, including those for the treatment of fracture, dislocation, and infection, may continue. However, with the supplies of personal protective equipment (PPE) expected to dwindle and hospital bed utilization rising, it is crucial to understand the potential risk of COVID-19 to the orthopaedic workforce.

The Centers for Disease Control and Prevention (CDC) has determined that the highest rates of hospitalization and death within the U.S. population are among individuals ≥60 years of age[7]. Consequently, reports from several countries have suggested that older populations (generally ≥60 years of

Disclosure: The authors indicated that no external funding was received for any aspect of this work. On the **Disclosure of Potential Conflicts of Interest** forms, *which are provided with the online version of the article*, one or more of the authors checked "yes" to indicate that the author had a relevant financial relationship in the biomedical arena outside the submitted work (http://links.lww.com/JBJS/F865).

age) are more vulnerable to COVID-19[8-10]. This finding is particularly concerning given the high proportion of older practitioners in the U.S. workforce. In an analysis of U.S. Census Bureau American Community Survey data between 2014 and 2018, Buerhaus et al. estimated that 29% (336,000) of the >1.2 million physicians in the U.S. are ≥55 years of age[11]. This estimate is further supported by the Federation of State Medical Boards (FSMB) physician census, with 30.3% (297,915) of licensed physicians in 2018 being ≥60 years of age[12]. Together, these findings encourage additional safety precautions and limited patient contact in order to protect this vulnerable population. However, there remains a paucity of data regarding the proportion of older physicians among specific surgical specialties, including orthopaedic surgery.

Although elective surgical procedures have been suspended in light of the current COVID-19 pandemic, care related to orthopaedic emergencies will continue. While previous studies have shown a high proportion of older, higher-risk providers nationwide, we are not aware of any previous study that has analyzed the age distribution among the orthopaedic workforce and its relationship to the spread of the novel coronavirus SARS (severe acute respiratory syndrome)-CoV-2, which causes COVID-19. Therefore, the purposes of the present study are (1) to determine the geographic distribution of older orthopaedic surgeons in the U.S., (2) to compare the distribution with those of other surgical specialties, and (3) to compare this distribution with the spread of COVID-19 in the U.S.

Materials and Methods

Demographic statistics for 2018 were extracted from the most recent State Physician Workforce Data Reports published by the Association of American Medical Colleges (AAMC) to identify the proportion of practicing orthopaedic surgeons ≥60 years of age in each state[13]. Demographic data were also collected on all surgical specialties as defined by the ACS[14]. Geospatial data on the distribution of COVID-19 cases were obtained from the online resource hub of the Environmental Systems Research Institute (ESRI)[15]. Data sets were combined and were imported into Quantum Geographic Information System (QGIS) geospatial analysis software (version 3.12.1; open source license GNU GPLv2). State boundary files were obtained from the U.S. Census Bureau web site[16]. Orthopaedic workforce age data were used to group states into quintiles and a corresponding graduated color scheme was used for visual representation. A map of all 50 states was constructed and overlaid with the most recent COVID-19 confirmed case coordinates[15].

Results

For the top 10 states affected by COVID-19 cases, the percentage of orthopaedic surgeons ≥60 years of age reached as high as 48% (Fig. 1, Table I). States in the highest quintile of older-age orthopaedic surgeons were Rhode Island, Maine, Connecticut, New Hampshire, Hawaii, California, New Jersey, New York, New Mexico, and Florida (Table II). The state with the highest number of orthopaedic surgeons ≥60 years of age was California. For all states, the median number of orthopaedic surgeons ≥60 years of age was 105.5 (interquartile range [IQR], 45.5 to 182.5). The median state population per orthopaedic surgeon was determined to be 16,456.6.

The specialty with the highest per capita ratio of state population to surgeons was vascular surgery (Table III). The specialty with the lowest ratio was obstetrics/gynecology. The median proportion of orthopaedic surgeons ≥60 years of age was higher than that of all other surgical workforces, apart from thoracic surgery (Fig. 2). The surgical specialty with the lowest proportion of surgeons ≥60 years of age was obstetrics/gynecology.

Discussion

The present analysis demonstrates a visual geospatial approach to understanding potential risks to the orthopaedic surgery workforce during the COVID-19 pandemic. Several states in the highest quintile (i.e., >46.4%) with respect to the proportion of orthopaedic surgeons ≥60 years of age were also among the states most currently overwhelmed by COVID-19. Of note, the percentage of surgeons who are ≥60 years of age appears to be reflective of the state percentage of this demographic at large (Table I).

Orthopaedic operations for the treatment of fracture, dislocation, and infection will continue during the pandemic. The need to support these procedures must be balanced with the care of burgeoning patient populations affected by COVID-19. While these competing needs should be followed closely as the pandemic progresses, our study serves to continually emphasize planning, workforce management, and careful resource utilization for all orthopaedic surgeons and associated staff. The risks of fulminant, possibly fatal disease in older orthopaedic surgeons must be considered carefully in the setting of frontline COVID-19 work[8-10].

Our study has certain limitations. Older age has been considered to be an important factor related to increased disease severity and mortality, particular with the novel coronavirus SARS-CoV-2. However, we were unable to control for other influential factors such as a history of asthma, chronic obstructive pulmonary disease (COPD), or immunosuppression in our geospatial mapping. We acknowledge that the contracting of COVID-19 and its severity may be influenced by existing comorbid conditions (e.g., smoking status, pulmonary disease, hypertension)[17] and that younger populations also have been severely affected in certain cases[17]. Nevertheless, the age-associated risks of COVID-19 have been demonstrated, and it is unknown how the health of orthopaedic surgeons compares with that of an age-matched general population. Furthermore, the majority (92.3%) of orthopaedic surgeons are male[18], which has emerged as another risk factor for COVID-19 severity[17]. The case fatality rate of COVID-19 for males in China was reported as 2.8%, as compared with 1.7% for females[19], and New York City, California, and Italy have mimicked this mortality difference by sex[20].

Additionally, our analysis does not indicate a direct relationship between older orthopaedic providers and their risk of contracting COVID-19. Rather, our findings may suggest that the high proportion of these providers in areas of high

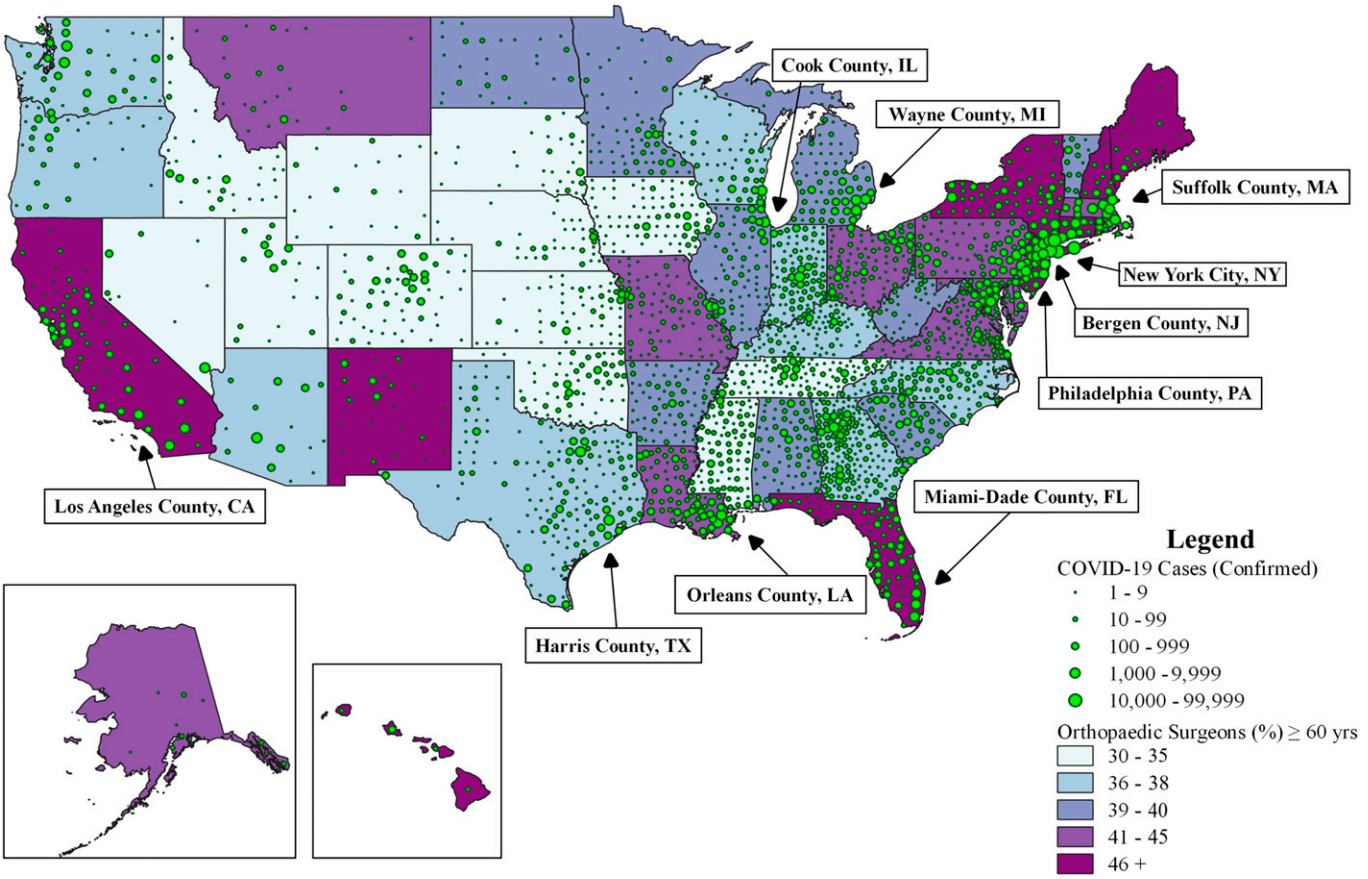

Fig. 1

Map demonstrating the proportion of orthopaedic surgeons ≥60 years of age in the workforce, overlain on the distribution of confirmed COVID-19 cases as of April 8, 2020. Hawaii and Alaska were repositioned for this visualization and are not shown to scale. The green dots represent clusters of confirmed COVID-19 cases, with size adjustments proportional to the number of cases in each cluster. Labeled counties and cities have the highest proportion of COVID-19 cases in their states as of April 8, 2020.

rates of disease prevalence may increase their susceptibility if they are to continue to care for patients with COVID-19 in those geographic areas. Unfortunately, given that we were only able to extract state-level data, our analysis does not consider age distributions for specific cities versus rural and suburban areas. As cities such as New York City (New York) and counties such as Orleans Parish (Louisiana) are experiencing most of their states' confirmed cases, our analysis is limited by the potential for ecological fallacy. However, we still contend that these findings on a statewide level can provide meaningful information for those on the front lines of infection mitigation across the nation. Our utilized data did not distinguish between whether providers were engaged in care on a full-time or part-time basis[21]. A recent Orthopaedic Practice in the United States (OPUS) survey found that 88.9% of orthopaedic surgeons surveyed who were ≥60 years of age were practicing on a part-time basis[18]. This finding may explain why the orthopaedic workforce carries a disproportionate number of providers in the older age range. We additionally cannot be proscriptive to health systems that might inherently need older physicians to serve in front-line roles given the depletion of either specialty-specific (e.g., critical care or emergency room-trained) providers or younger care providers who have succumbed to COVID-19 themselves or who have been impacted by an overwhelming patient burden[22]. The present study further outlines key recommendations for the deployment of older physicians first to virtual care roles; only if the health system is sufficiently stressed to the point where the front line is failing should older physicians be deployed in this capacity. Our institution at this time has held back surgeons ≥60 years of age from front-line work. We also point out that states with exceedingly high proportions of older orthopaedic surgeons may benefit from specifically recruiting younger physicians from other states with lower COVID-19 caseloads. This process has already begun, with multiple states waiving licensing requirements in order to allow providers to practice across state lines[23]. Despite these limitations, we believe that the present study is the first to compare the distribution of older orthopaedic providers to that of COVID-19 confirmed cases across the U.S.

The recent study by Guo et al. highlighted the importance of PPE and physician education to prevent the spread of COVID-19 among orthopaedic providers[24]. In their survey of

TABLE I Orthopaedic Workforce Characteristics for the Top 10 States Impacted by COVID-19*

State	No. of Confirmed COVID-19 Cases	No. of Orthopaedic Surgeons ≥60 Years of Age (% of Total No. of Orthopaedic Surgeons in State)	Total No. of Orthopaedic Surgeons in State	Total State Population ≥60 Years of Age (% of Total State Population)
New York	140,386	546 (47.6%)	1,148	4,480,458 (22.9%)
New Jersey	44,416	264 (47.5%)	556	2,022,272 (22.7%)
Michigan	18,970	204 (39.5%)	516	2,421,416 (24.2%)
California	17,625	1,092 (48.0%)	2,274	7,963,713 (20.2%)
Louisiana	16,284	132 (43.0%)	307	1,019,862 (21.9%)
Massachusetts	15,202	211 (44.4%)	475	1,588,116 (23.0%)
Pennsylvania	14,956	347 (45.8%)	758	3,227,151 (25.2%)
Florida	14,747	545 (46.6%)	1,170	5,765,648 (27.2%)
Illinois	13,553	250 (39.4%)	634	2,804,799 (22.0%)
Texas	9,211	508 (38.8%)	1,309	5,139,025 (18.0%)

*COVID-19 case numbers are accurate as of April 8, 2020. Orthopaedic surgeon demographic data are taken from the 2019 AAMC State Physician Workforce Data Reports and are accurate as of December 31, 2018. State population demographics are taken from 2018 U.S. Census Bureau data (https://www.census.gov/newsroom/press-kits/2018/pop-estimates-national-state.html).

26 infected orthopaedic surgeons in city of Wuhan in the People's Republic of China, the authors demonstrated that real-time training in preventative measures (odds ratio [OR] = 0.12; p = 0.0072) as well as the consistent use of masks or N95 respirators (OR = 0.15; p = 0.0038) were associated with significant protective effects. Additionally, patients not wearing masks were found to significantly increase the risk of transmission to their surgeon (OR = 6.05; 95% confidence interval [CI], 1.70 to 21.51). Coupled with the findings of the present study, those results may inform the matching of critically limited PPE supplies to higher-risk providers if necessary and if appropriate risk situations arise.

Additionally, while general wards (79.2%) and public places in the hospital (20.8%) were the most common suspected sites of exposure, Guo et al. reported that operating rooms were believed to be sites of exposure for 12.5% of those infected[24]. Therefore, additional precautions should be taken when performing procedures on patients with confirmed or

TABLE II Workforce Characteristics for States in the Highest Quintile of Proportion of Orthopaedic Surgeons ≥60 Years of Age*

State	No. of Confirmed COVID-19 Cases	No. of Orthopaedic Surgeons ≥60 Years of Age (% of Total No. of Orthopaedic Surgeons in State)	Total No. of Orthopaedic Surgeons in State	Total State Population ≥60 Years of Age (% of Total State Population)
Rhode Island	1,229	43 (56.6%)	76	257,992 (24.5%)
Maine	537	55 (52.9%)	104	384,322 (28.8%)
Connecticut	7,781	130 (50.8%)	256	865,770 (24.2%)
New Hampshire	747	60 (48.8%)	123	346,662 (25.6%)
Hawaii	410	46 (48.4%)	95	355,338 (25.1%)
California	17,625	1,092 (48.0%)	2,274	7,963,713 (20.2%)
New Jersey	44,416	264 (47.5%)	556	2,022,272 (22.7%)
New York	140,386	546 (47.6%)	1,148	4,480,458 (22.9%)
New Mexico	902	55 (47.0%)	117	504,653 (24.1%)
Florida	14,747	545 (46.6%)	1,170	5,765,648 (27.2%)

*COVID-19 case numbers are accurate as of April 8, 2020. Orthopaedic surgeon demographic data are taken from the 2019 AAMC State Physician Workforce Data Reports and are accurate as of December 31, 2018. State population demographics are taken from 2018 U.S. Census Bureau data (https://www.census.gov/newsroom/press-kits/2018/pop-estimates-national-state.html).

TABLE III Comparison of Surgical Workforce Age Distributions Across Specialties as Defined by the American College of Surgeons*

	Proportion of Workforce ≥60 Years of Age			No. of Surgeons ≥60 Years of Age			No. of People per Surgeon		
Surgical Specialty	Quartile 1	Median*	Quartile 3	Quartile 1	Median*	Quartile 3	Quartile 1	Median*	Quartile 3
Thoracic Surgery	41.1%	45%	50%	19	32	58	66,160	75,190	88,224
Orthopaedic Surgery	36.8%	40.1%	44.6%	46	106	183	14,845	16,457	18,170
Plastic Surgery	36.7%	39.4%	44.5%	16	36	69	46,831	54,526	60,266
Ophthalmology	34%	37.8%	41.3%	40	89	162	16,049	19,412	22,862
General Surgery	31.5%	34.4%	36.3%	53	115	211	10,625	12,882	14,354
Otolaryngology	31%	33.8%	37.9%	22	46	79	32,020	35,166	38,856
Neurosurgery	28.8%	32.5%	34.7%	22	32	54	49,681	57,774	66,441
Vascular Surgery	26.2%	31.2%	34.1%	18	26	47	72,233	87,521	116,271
Obstetrics & Gynecology	28.3%	30.7%	32.6%	66	169	317	7,415	8,056	9,245

*Data calculated across all states providing information. For privacy, workforce data regarding surgeons ≥60 years of age was not available for any state in which the number of these individuals was ≤10. Data are taken from 2019 AAMC State Workforce Data Reports and are accurate as of December 31, 2018. AAMC State Physician Workforce Data Reports do not include demographic information on 3 surgical specialties defined by the ACS: pediatric surgery, rural surgery, and colorectal surgery.

suspected COVID-19. Rodrigues-Pinto et al. recently proposed the utilization of multiple rooms for the donning and removal of PPE in order to reduce virus spread[25]. Their strategy involves performing sterile decontamination procedures before entering the operative suite, consistently utilizing N95 or FFP2 respirators, minimizing the use of power tools during procedures, using suction devices to minimize aerosol spread, and bathing following each operation. Although the ideal method of reducing COVID-19 spread remains to be determined, the strategy proposed by those authors may be a promising risk-reduction strategy and therefore should be heavily considered if older physicians continue to operate in the midst of this crisis.

Along with these safety precautions for all orthopaedic providers, our findings suggest that shifts in practice organization

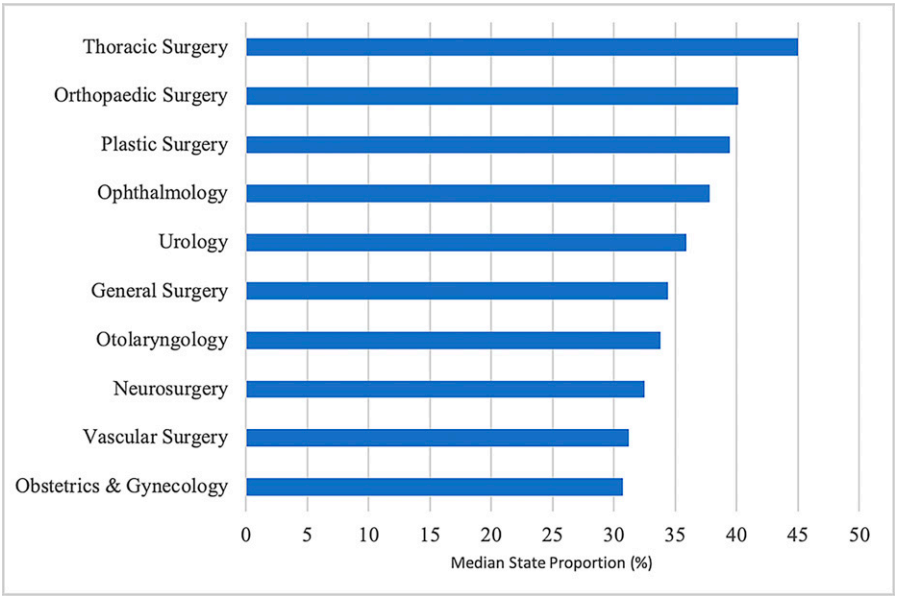

Fig. 2

Bar graph showing the median state proportion of surgeons ≥60 years of age according to surgical specialty. Median proportions were calculated across all states on the basis of AAMC workforce reports documenting age distributions of active surgeons. For privacy, workforce data were not available in any state where the number of individuals identified was ≤10. AAMC State Physician Workforce Data Reports do not include demographic information on 3 surgical specialties defined by the ACS: pediatric surgery, rural surgery, and colorectal surgery.

should be considered to minimize contact between older providers and infected patients. One promising option would be through the implementation of telemedicine services. Related technologies have tremendously expanded across medical specialties given current social distancing mandates[26,27] and can allow older orthopaedic providers to continue helping patients without increasing their risk of contracting the illness. Additionally, restricting interaction between providers caring for patients with confirmed or suspected COVID-19 and those providing inpatient care to other patients can prevent spread among orthopaedic teams. This measure was recently suggested by Liang et al., who detailed the segregation of inpatient and outpatient teams in order to minimize cross-contamination among their orthopaedic personnel[28]. Furthermore, older orthopaedic surgeons may serve an important role in resident training during this time[29], with various platforms currently available for remote education[30,31]. Therefore, although older providers may be protected by removal from direct patient care, there are various options for their continued service to the orthopaedic community.

It is important to note that the present study does not imply that COVID-19 infection among younger providers is in any way less severe or less important to minimize. Similarly, we do not aim to provide blanket advocacy regarding the protection of older providers by deploying younger orthopaedic surgeons preferentially to the front lines. The current situation has been trying for all age sectors of the population, with difficult decisions that have both ethical and societal implications being made daily[23]. Our findings serve to educate health-care systems about the proportion of older, high-risk orthopaedic providers as well as to encourage practice restructuring to reduce disease spread among higher-risk providers as a whole, if possible. While we use age as a surrogate of risk in this model, guidelines should be followed with regard to adequate PPE dissemination, shifting to telemedicine, maintaining social distancing between care team members, and ensuring training on preventative measures for all providers in the field of orthopaedics who may be at risk, regardless of the level of that risk. Therefore, we believe that our findings do not imply that any particular ethical position should be taken but rather that they provide insight into the risk posed to our nation's workforce, especially among those with well-reported risk factors. Specifically, it should remain up to the individual health-care system, considering the local workforce characteristics and burden of disease, to choose which surgeons are deployed at this time and in what capacity. As a profession, we must also consider the long-term consequences of further exacerbating the age distribution of orthopaedic surgeons if younger surgeons are disproportionally impacted by COVID-19 because of earlier deployment.

Given the high percentages of older orthopaedic surgeons nationwide, our analysis highlights that special precautions should be taken to ensure the safety of older physicians involved in the care of patients affected by COVID-19. In order to reduce their exposure to the virus, orthopaedic providers should consider shifting toward providing orthopaedic care remotely/virtually or in acuity-appropriate sites of care in relation to purported disease exposure and transmission. Additionally, older orthopaedic surgeons can continue to play a vital role in other ways, including systems management, leadership, acute orthopaedic surgical care provision, resident education, and clinical and epidemiology-focused research in order to serve the orthopaedic community safely. While the high proportion of orthopaedic surgeons ≥60 years of age may prove problematic during the COVID-19 pandemic, there are further implications for workforce management and patient access to care in the future because of the aging of this demographic group and a potentially critical gap in the total number of practicing orthopaedic surgeons in the U.S.[21]. Current orthopaedic practices should continue to develop and implement ways of reducing virus transmission among members of their care team, and we must advocate for protecting those who are most vulnerable to disease. ■

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