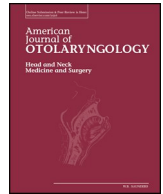




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Geospatial analysis of COVID-19 and otolaryngologists above age 60

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ABSTRACT

Objective: The 2019 novel coronavirus (COVID-19) is disproportionately impacting older individuals and healthcare workers. Otolaryngologists are especially susceptible with the elevated risk of aerosolization and corresponding high viral loads. This study utilizes a geospatial analysis to illustrate the comparative risks of older otolaryngologists across the United States during the COVID-19 pandemic.

Methods and materials: Demographic and state population data were extracted from the State Physician Workforce Reports published by the AAMC for the year 2018. A geospatial heat map of the United States was then constructed to illustrate the location of COVID-19 confirmed case counts and the distributions of ENTs over 60 years for each state.

Results: In 2018, out of a total of 9578 practicing U.S. ENT surgeons, 3081 were older than 60 years (32.2%). The states with the highest proportion of ENTs over 60 were Maine, Delaware, Hawaii, and Louisiana. The states with the highest ratios of confirmed COVID-19 cases to the number of total ENTs over 60 were New York, New Jersey, Massachusetts, and Michigan.

Conclusions: Based on our models, New York, New Jersey, Massachusetts, and Michigan represent states where older ENTs may be the most susceptible to developing severe complications from nosocomial transmission of COVID-19 due to a combination of high COVID-19 case volumes and a high proportion of ENTs over 60 years.

1. Introduction

The 2019 novel coronavirus (COVID-19) is a global pandemic that has rapidly spread across the world. Although the virus infects individuals of all ages, epidemiological reports demonstrate that older age is a significant contributing factor for symptomatic presentation, severe disease course, and death [1]. This is illustrated by the significant increase in case fatality rates (CFR) with age. In China, the CFR of the general populace is 2.3% with rates skyrocketing to 8.0% and 14.8% in patients 70–79 and over 80, respectively [2]. In Italy, reports of case fatality are even higher, with 8.6% in individuals 60–69 years, 12.8% in individuals 70–79 years, and 20.2% in individuals over 80 years [2].

In addition to age, nosocomial exposure also serves as a significant risk factor, rendering health care workers particularly susceptible. Early data from Wuhan, China reported that nearly 29% of COVID-19 infections in a single hospital system were comprised of health care workers [3]. The novel coronavirus' dramatic impact on medical personnel parallels the epidemiology of the 2003 severe acute respiratory

disease (SARS) outbreak in which 21% of global cases were health care worker infections [4].

COVID-19 colonizes the upper respiratory mucosa with a high viral load, whether a patient is symptomatic or asymptomatic [5]. As COVID-19 demonstrates the potential for both respiratory and aerosol transmission, otolaryngologists (ENTs) are at an elevated risk working in close proximity to the upper respiratory tract within the head and neck region [6,7]. Due to the vast diversity in diagnostic and operative procedures performed on the upper airway within ENT, there is a high risk of aerosolization, leading to the potential for transmission of high viral loads to the provider [8]. The director of an intensive care unit in Wuhan, China commented that otolaryngologists and ophthalmologists were infected at higher rates when compared to other doctors in the same hospitals, and the same trends are reported in Europe [9]. In response, an international collaboration among thirteen institutions has put forth recommendations to ensure the safety of the otolaryngology community throughout the course of this pandemic [10].

Protecting vulnerable members of the work force during these

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Table 1
Demographic information of ENTs in the states with the highest proportion of Otolaryngologists ≥ 60 yrs [n (%)].^a

State	Otolaryngologists ≥ 60 yrs [n (%)]	Total ENTs per state	State population per ENT provider
Maine	20 (58.8)	34	39,365
Delaware	12 (48.0)	25	38,687
Hawaii	18 (43.9)	41	34,646
Louisiana	93 (41.7)	223	20,897
Alabama	69 (40.4)	171	28,584
Connecticut	46 (40.0)	115	31,067
Rhode Island	11 (39.3)	28	37,761
Nebraska	25 (39.1)	64	30,145
New Mexico	20 (38.5)	52	40,293
New Jersey	98 (38.3)	256	34,799
Idaho	16 (38.1)	42	41,767
New York	272 (37.6)	723	27,029
West Virginia	21 (37.5)	56	32,247
Oklahoma	30 (36.6)	82	48,086
Florida	210 (36.0)	584	36,471
Mississippi	28 (35.9)	78	38,289
Pennsylvania	139 (35.8)	389	32,923
Indiana	60 (35.3)	170	39,364
Tennessee	65 (35.1)	185	36,595
Washington	77 (34.8)	221	34,098

^a This table is organized by states with the highest percentage of ENTs over 60 years in descending order.

unprecedented times is of the utmost importance. The present study compares the geospatial distribution of COVID-19 confirmed cases against the distribution of ENTs over the age of 60 to highlight the potential risks to this segment of vulnerable health care providers.

2. Methods

We utilized the State Physician Workforce Reports published by the American Association of Medical Colleges (AAMC) to extract demographic information on active ENT physicians during the year 2018 [11]. The resulting dataset included the number of total ENTs per state, the number of ENTs older than age 60 by state, the proportion of ENTs older than age 60, and the 2018 U.S. Census Bureau state populations. We subsequently calculated the ratio of state population per ENT provider for each state by dividing the total state population by the total number of ENTs for that state. Next, we obtained coordinates of all confirmed COVID-19 cases from a disease-specific data repository published by the Environmental Systems Research Institute (ESRI) [12]. Both datasets were then imported into the geospatial mapping software QGIS (version 3.12.1), and superimposed onto state boundary files published by the U.S. Census Bureau.

The percentage of ENTs above age 60 variable was used to group states into discrete quintiles with a graded color scheme for each quintile. Similarly, a logarithmic scale of confirmed COVID-19 case numbers was deployed to adjust the size of all coordinate data points to create a heat map demonstrating the distribution of ENTs over 60 years and the distribution of COVID-19 confirmed cases in the U.S. Determination of states with the highest risk for older otolaryngologists was assessed by dividing the total number of confirmed COVID-19 cases by the total number of otolaryngologists over the age of 60.

The number of ENTs over 60 in each state was totaled and averaged over all of the states within each U.S. census region (Midwest, Northeast, South, and West). A one-way ANOVA was performed to analyze statistical differences in the average proportion of ENTs over 60 across each census region.

The present study was considered exempt from the University Hospitals Cleveland Medical Center IRB approval process (Study 20200433).

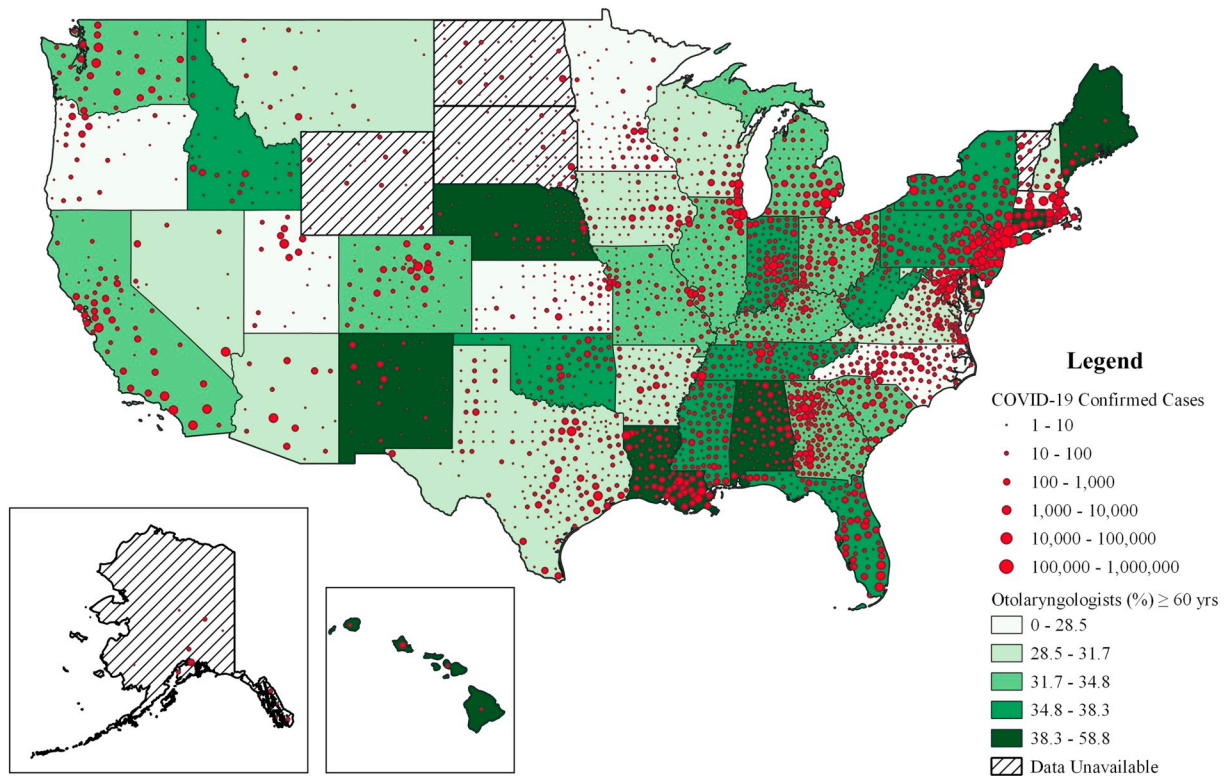


Fig. 1. Geographic distribution of older ENTs and COVID-19 confirmed case numbers. Red bubbles reflect clusters of confirmed COVID-19 cases with sizes proportional to case number. The shading of states corresponds to percentage of ENT workforce over age 60 (with darker colors representing an older workforce). COVID-19 case volume data is accurate as of April 14th, 2020. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 2
States with the highest ratios of COVID-19 confirmed cases to ENTs over the age of 60.^a

State	COVID-19 Cases per older ENT	COVID-19 case numbers	Otolaryngologists ≥ 60 yrs
New York	721	196,146	272
New Jersey	659	64,584	98
Massachusetts	363	26,867	74
Michigan	320	25,635	80
Connecticut	291	13,381	46
Rhode Island	271	2976	11
Louisiana	226	21,016	93
Nevada	202	3031	15
Illinois	187	22,025	118
Pennsylvania	175	24,336	139

^a This table presents the top 10 states with the highest ratios of confirmed COVID-19 cases to ENT providers over 60. Data is accurate as of April 14th, 2020.

3. Results

A total of 9578 practicing U.S. ENT surgeons were identified by AAMC in 2018; 3081 were older than 60 years (32.2%). The states with the highest proportion of ENTs over 60 years were documented along with the total number of ENTs for that state (Table 1). The proportion of ENTs over age 60 ranged from 25.9% in Kansas to 58.8% in Maine (Appendix A). Ratios representing the total state population divided by the number of total ENTs for that state were also documented (Table 1). Of the 20 states with the highest proportion of ENTs over 60 years, state populations per ENT provider ranged from 20,897 to 48,086 (Table 1).

A heat map illustrating the U.S. states with the highest proportion of ENTs over 60 and the current geographic COVID-19 case volume was depicted in Fig. 1. COVID-19 case volume was accurate as of April 14th, 2020. The highest risk states for older ENTs, defined by the ratio of total confirmed COVID-19 case volume to the total number of ENT providers over 60, were New York, New Jersey, Massachusetts, and Michigan, among others (Table 2). The highest number of confirmed COVID-19 cases per ENT over 60 years old was New York (721) and the lowest was Hawaii (28). Data for Vermont, North Dakota, South Dakota, Wyoming, and Alaska were not incorporated into the heat map as there were fewer than 10 ENT providers over 60 in each of these states, which was the AAMC's cut-off for publishing a given state's data.

No statistically significant differences were found in the average proportion of ENTs over 60 by U.S. Census region (Fig. 2). The average percentages within the Midwest, Northeast, South, and West were

32.5%, 38.7%, 33.7%, and 33.4%, respectively ($p = .38$).

Additional demographic data for U.S. otolaryngologists and COVID-19 case counts for all 50 states is documented in the Appendix A.

4. Discussion

The present study illustrates the risk of older otolaryngologists during the COVID-19 pandemic. Our geospatial analysis demonstrates the U.S. states with both high combined confirmed COVID-19 cases and proportions of ENTs over 60 years, highlighting a segment of the healthcare workforce that could be at elevated risk of developing severe complications secondary to nosocomial transmission.

According to our findings, Maine, Delaware, Hawaii, and Louisiana have the highest proportions of ENTs over 60. However, with the exception of Louisiana, reported COVID-19 cases have been relatively low in these states. Therefore, ENT providers in these states may not be experiencing the same extent of viral exposure within healthcare settings as providers serving in New York, New Jersey, Massachusetts, and Michigan, which currently have the highest ratios of confirmed COVID-19 cases to the number of ENT providers over 60 years. These states will likely continue to be vulnerable with anticipated rises in case volumes or in the setting of a COVID-19 re-emergence.

Rates of nosocomial transmission and the susceptibility of all health care providers during this pandemic is frightening [13]. However, with careful precautions, it is possible to limit the risk unto health care workers and curb nosocomial transmission. With the proper personal protective equipment and adequate hand hygiene, a cohort of 41 health care workers was able to avoid nosocomial transmission while treating a confirmed COVID-19 patient with pneumonia despite exposure during ICU intubation and mechanical ventilation [14]. Various safety recommendations for ENTs during the COVID-19 pandemic have been proposed to achieve similarly successful outcomes.

For otolaryngologists specifically, routine, nonurgent appointments and elective surgeries have largely been postponed [10]. Some have recommended deferring all endoscopies unless deemed necessary to reduce 30-day morbidity, such as circumstances pertaining to malignancy and airway risk, among others [15]. For essential urgent and emergent procedures, which must proceed despite the risks, determination of whether to use powered air-purifying respirators (PAPRs) versus N95s should be assessed by each institution as both forms of masks offer distinct advantages and disadvantages [16]. However, at a minimum, otolaryngologists should don a respirator, gown, cap, eye protection, and gloves [17]. Moreover, studies from the Ebola outbreak reported that in some circumstances, up to 79.2% of providers self-

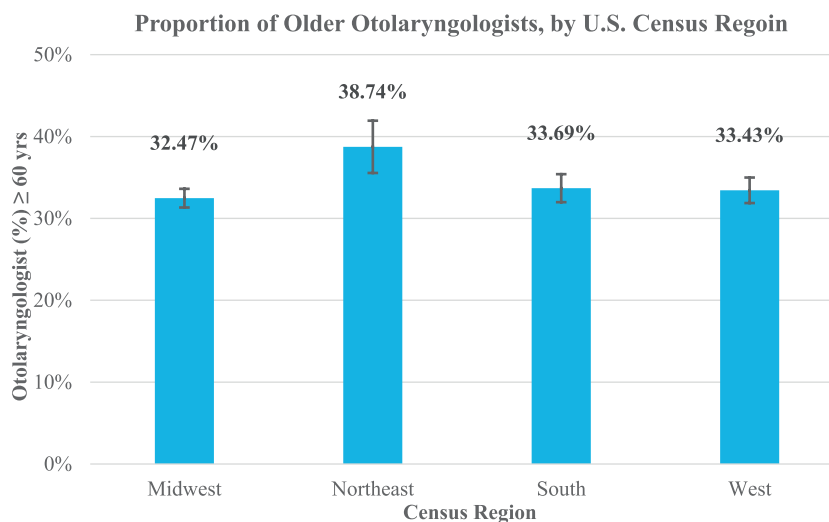


Fig. 2. Average State Proportion of Older Otolaryngologists, by U.S. Census Region.

contaminated while removing PPE [18]; therefore, careful consideration must be applied to doffing PPE during the COVID-19 pandemic.

Even after exercising adequate precautions, it is sensible to recommend that vulnerable demographics limit their exposure to possible COVID-19 infection as much as possible [19]. As rates of new cases start to decrease, otolaryngologists who are highly susceptible to severe complications from nosocomial transmission should exercise caution in their “return-to-work” planning in the coming weeks.

5. Limitations

The present study assesses the comparative risk of older otolaryngologists developing severe symptoms from COVID-19. However, there are many other variables that would need to be factored into this discussion to adequately predict the risks to ENTs in the United States. First, in addition to age, clinical comorbidities, male sex, and smoking history also play significant roles in the risk of developing severe complications secondary to COVID-19 infection [20]. Furthermore, risk of exposure is also highly dependent on local institutional practices, availability of resources such as personal protective equipment, and the scope of the hospital staff available to assist in the care for COVID-19 patients [21], which are not factored into our model. Although the provider data from 2018 was the most recent data available from the

AAMC, it may not exactly reflect the current workforce in each state, since there may have been movement or retirements since the data was released in 2018.

6. Conclusions

Across the world, countries have reported the disproportionate impact of COVID-19 on older individuals and health care workers. With otolaryngologists at increased susceptibility due to the nature of their work and the type of procedures they perform, protocols must be implemented to protect otolaryngologists, especially those most vulnerable. It is vital that, as the nation starts to recover from the COVID-19 pandemic, we evaluate how best older ENTs can serve while limiting their risk of exposure.

Funding

None.

Declaration of competing interest

None.

Appendix A

State	Otolaryngologists ≥60 yrs. [n (%)]	Total ENTs	COVID-19 cases	COVID-19 cases per older ENT (> 60 years)
New York	272 (37.6)	723	196,146	721
New Jersey	98 (38.3)	256	64,584	659
Massachusetts	74 (28.5)	260	26,867	363
Michigan	80 (33.2)	241	25,635	320
Connecticut	46 (40)	115	13,381	291
Rhode Island	11 (39.3)	28	2976	271
Louisiana	93 (41.7)	223	21,016	226
Nevada	15 (31.3)	48	3031	202
Illinois	118 (33.8)	349	22,025	187
Pennsylvania	139 (35.8)	389	24,336	175
District of Columbia	13 (27.7)	47	1955	150
Delaware	12 (48)	25	1761	147
Indiana	60 (35.3)	170	8368	139
Washington	77 (34.8)	221	10,725	139
Georgia	105 (34.4)	305	13,621	130
Colorado	61 (33.2)	184	7696	126
Maryland	71 (29.5)	241	8936	126
Texas	116 (31.3)	722	14,505	125
Mississippi	28 (35.9)	78	2942	105
Florida	210 (36)	584	21,019	100
Utah	24 (26.4)	91	2363	98
Idaho	16 (38.1)	42	1464	92
Tennessee	65 (35.1)	185	5610	86
Virginia	72 (29.5)	244	5828	81
New Hampshire	13 (31.7)	41	1020	78
Arizona	48 (31.6)	152	3705	77
South Carolina	46 (32.6)	141	3439	75
Missouri	61 (33.5)	182	4531	74
Oklahoma	30 (36.6)	82	2069	69
Arkansas	22 (30.8)	72	1480	67
New Mexico	20 (38.5)	52	1345	67
Kansas	21 (25.9)	81	1391	66
Wisconsin	52 (31.7)	164	3428	66
Ohio	109 (33.1)	330	6975	64
Iowa	27 (30.7)	88	1710	63
California	388 (32.6)	1189	24,372	63
North Carolina	85 (26.5)	321	5007	59
Alabama	69 (40.4)	171	3803	55
Kentucky	39 (34.8)	112	2048	53
Oregon	38 (27.1)	140	1584	42
Montana	10 (30.3)	33	394	39
Minnesota	43 (28.5)	151	1650	38
Maine	20 (58.8)	34	698	35
Nebraska	25 (39.1)	64	871	35
West Virginia	21 (37.5)	56	633	30

Hawaii	18 (43.9)	41	504	28
Vermont	*	21	752	*
South Dakota	*	28	868	*
North Dakota	*	14	331	*
Wyoming	*	16	275	*
Alaska	*	31	277	*

*The is stratified by the highest ratios of confirmed COVID-19 cases to ENT providers over 60 years in descending order. Data is accurate as of April 14th, 2020.

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