Title
Assessing the Burden of COVID-19 Outcomes Among Healthcare versus Non-Healthcare Workers in 11 U.S. States and the Virgin Islands: A Multilevel Analysis

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Assessing the Burden of COVID-19 Outcomes Among Healthcare versus Non-Healthcare Workers in 11 U.S. States and the Virgin Islands: A Multilevel Analysis

A thesis submitted in partial satisfaction

of the requirements for the degree Master of Science

in Epidemiology

by

Defne Selin Yilmaz

2021

ABSTRACT OF THE THESIS

Assessing the Burden of COVID-19 Outcomes Among Healthcare versus Non-Healthcare Workers in 11 U.S. States and the Virgin Islands: A Multilevel Analysis

by

Defne Selin Yilmaz

Master of Science in Epidemiology

University of California, Los Angeles, 2021

Professor Onyebuchi Aniweta Arah, Chair

Objective/Purpose: More than 16 months after its first detection, the COVID-19 pandemic has resulted in over 159 million cases and 3.3 million deaths worldwide.[1] The purpose of this study is to describe the potential associations between being a healthcare worker and two outcomes of COVID-19 infection: hospitalization and death.

Methods: We conducted detailed descriptive analyses of all incident COVID-19 cases ascertained as part of the passive surveillance system instituted by the CDC from the 50 United States, Puerto Rico, and the US Virgin Islands between 2/1/2020 and 2/28/2021. We modeled the associations between healthcare worker status and two clinical outcomes of COVID-19 infection by individual U.S. state using multivariable multinomial logistic regressions, adjusting for sex, race/ethnicity, age group, and presence of pre-existing conditions.

Results: After adjustment, we observed that healthcare workers in Colorado, Louisiana, Massachusetts, and Ohio had lower odds of both hospitalization and death compared to those who were not healthcare workers. In addition, we noticed a pattern of higher odds of both hospitalization and death in people with unknown healthcare worker status compared to non-healthcare workers in all 12 states/territories assessed. Those with unknown healthcare worker status had the highest odds of hospitalization in the state of Utah (odds ratio, OR 11.73; 95% CI 9.51-14.46) and death in the state of Colorado (OR 13.99; 95% CI 3.12-62.68). The hospitalization ORs for healthcare workers and those with unknown healthcare worker status ranged from 0.27 to 11.73, while the death ORs ranged from 0.19 to 13.99.

Conclusions: The study results demonstrated that being a healthcare worker in the US was associated with less hospitalization and death from COVID-19 infection, while having unknown healthcare worker status is associated with greater hospitalization and death. This study underscores the necessity for additional analyses of COVID-19 infection outcomes among both non-healthcare and healthcare workers, as well as the importance of complete data collection for disease surveillance systems.

The thesis of Defne Selin Yilmaz is approved.

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2021

To my parents, for the unwavering support they have given me throughout my education.

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1. INTRODUCTION

More than 16 months after its first detection, the COVID-19 pandemic has resulted in over 170 million cases and 3.6 million deaths worldwide, with case numbers worldwide continuing to increase.[1] Throughout the pandemic, scientists have studied SARS-CoV-2, its etiology and transmission, risk factors for COVID-19 infection, and various social aspects of the pandemic fallout including the psychological stressors afflicting frontline healthcare workers. Thousands of frontline healthcare workers, including over 3,600 in the United States (US) alone, have died worldwide in the last year in their efforts to preserve and protect the lives of their patients.[2]

Despite the significant death toll among healthcare workers worldwide, there is a scarcity of non-psychosocial research on frontline healthcare workers in the existing literature. Within the limited realm of clinical research conducted on frontline healthcare workers, several studies have evaluated seroprevalence of the virus, risk factors for infection, and exposure patterns in healthcare workers specifically.[3-6] However, the majority of current data on COVID-19 infection within healthcare workers in the US are counts sampled from a few select counties and states. There have been few (if any) large-scale studies conducted with incident COVID-19 case data that evaluate outcome-related differences in COVID-19 infection specifically between healthcare workers and non-healthcare workers in all 50 American states and other US territories. Analyzing incident individual-level COVID-19 infection data will enable researchers to evaluate the possibility of an association between healthcare worker status and the burden of clinical outcomes related to COVID-19 infection. Through such explorative analyses, researchers can shed light on the severity of COVID-19 infection amongst healthcare workers on a broader scale in the US.

The purpose of this study is to describe the potential associations between being a healthcare worker and the severity of two COVID-19 infection outcomes: hospitalization and death. By using incident COVID-19 infection surveillance data reported to the Centers for Disease Control and Prevention (CDC), we hope to provide an analysis of COVID-19 infection burden amongst Americans over a year-long period, as well as fill the gaps of COVID-19-related research on healthcare workers in the US.

2. MATERIALS AND METHODS

2.1 Study Setting and Data

This is a descriptive epidemiological study of the national COVID-19 case surveillance data in the United States. Data of all incident COVID-19 cases reported to the CDC from the 50 United States (US), Puerto Rico, and the US Virgin Islands between 2/1/2020 and 2/28/2021 were obtained from the CDC. Cases occurring outside the designated time period, participants under 19 years of age, and those with missing healthcare worker status were excluded from this analysis. Cases were ascertained as part of the COVID-19 passive surveillance system instituted by the CDC. County health department staff throughout the US conducted interviews of positive cases using a universal case report form and reported the data to the CDC. The CDC's Case Surveillance Task Force previously undertook imputation of the complete dataset; all questions left unanswered (blank) on the case report form were re-coded with 'Missing' and data cells were suppressed for low frequency (<5) records and indirect identifiers, under which suppressed values were re-coded with 'NA' responses. The surveillance study data is restricted and not widely available to the general public; the CDC granted individual official permission and access to this restricted dataset[7] for this research study. IRB exemption was granted by the University of

California, Los Angeles Institutional Review Board for use of the restricted CDC dataset as a secondary data analysis.

2.2 Outcomes

The primary outcomes of interest were measures of COVID-19 infection burden: (I) hospitalization and (II) death. Both outcome variables were ascertained using the case report form and classified with three categories: ‘yes,’ ‘no,’ and ‘unknown.’ By maintaining the ‘unknown’ level for both outcomes in the multinomial logistic regression, more eligible individuals could be included in the analyses. Thus, individuals with ‘unknown’ status for hospitalization and death were not excluded as missing values because their complete exclusion would have resulted in significant missingness, and additional bias incurred in analyses.

2.3 Exposure/Predictor

The exposure or predictor of interest was healthcare worker status, characterized according to the definition given in the CDC Morbidity and Mortality Weekly Reports[8] as those expected to have direct patient contact including nurses, CNA/nursing assistant/nurse aides, patient aides/care aides/caregivers/patient care assistants, home health personnel, phlebotomists/technicians, social workers/behavioral health/counseling, physicians, physical therapists/occupational therapists/chiropractors, dentists/dental hygienists, emergency medical services personnel/paramedics, medical assistants, nursing home/long-term care/assisted living staff members, and respiratory therapists. Healthcare worker status was classified into three categories according to the case report form: 1) healthcare worker, 2) non-healthcare worker, and 3) unknown. Individuals without any of these three responses for healthcare worker status were considered as missing data and were excluded from the study sample.

2.4 Covariates

Based on existing studies of COVID-19 infection in healthcare workers and the general population, as well as generalized healthcare worker occupational trends, we included covariates expected to be associated with healthcare worker status and the burden of COVID-19 infection. These variables included sex, age group, race/ethnicity, and presence of pre-existing medical conditions.

Demographic covariates were all classified categorically and included sex, age group, and race/ethnicity. Sex was classified into four categories: male, female, unknown, or other. Age group was classified into 10 categories: 0-9 years, 10-19 years, 20-29 years, 30-39 years, 40-49 years, 50-59 years, 60-69 years, 70-79 years, 80+ years, and unknown. Only age groups over 19 years of age were included in this analysis, per IRB regulations regarding studies conducted on minors and children. Race and ethnicity were combined as a single variable and categorized over eight levels: American Indian/Alaska Native, Non-Hispanic; Asian, Non-Hispanic; Black, Non-Hispanic; Multiple/Other, Non-Hispanic; Native Hawaiian/Other Pacific Islander, Non-Hispanic; White, Non-Hispanic; Hispanic/Latino; and Unknown. The presence of pre-existing medical conditions was also classified categorically with three levels: 1) 'yes,' 2) 'no,' or 3) 'unknown.' The CDC case report form did not specify which conditions qualified as pre-existing conditions. As with other categorical variables included in this dataset, the 'unknown' level for pre-existing conditions was maintained as a third, separate category because individuals in this category could not be definitively attributed as 'yes' or 'no', but their exclusion would have resulted in significant missingness in the analyses. Also included were continuous state-specific data on total hospital beds and the total number of healthcare workers (by state), obtained from the Kaiser Family Foundation.[9-11]

2.5 Statistical Analysis

We first conducted a descriptive analysis of the entire population sample, stratifying participants by healthcare worker status into healthcare workers, non-healthcare workers, and unknown. In a secondary descriptive analysis of the population sample, we summarize COVID-19 infections by state, according to healthcare worker status, including total hospital beds, and total state healthcare workers.

We modeled the associations between healthcare worker status and burden of COVID-19 infection as captured by two specific clinical outcomes, hospitalization and death, using multivariable multinomial logistic regressions adjusted for covariates. We conducted stratified analysis (stratified by state) and estimated two different sets of odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) fusing non-healthcare workers as the reference exposure group. The Model 1 outcome was hospitalization, and the Model 2 outcome was death. We adjusted for the same set of covariates in both models. All analyses were performed using Python 3.9.2 and R for Windows 4.1.0 software.

2.6 Sensitivity Analysis

To check the robustness of our results, we excluded all cases with unknown healthcare worker status and repeated our analysis. We again modeled the associations between healthcare worker status and COVID-19 infection hospitalization and death using multivariable multinomial logistic regressions of healthcare workers versus non-healthcare workers, stratified by state. We sought to check whether the over-representation of healthcare worker cases influenced the associations between exposure and outcomes in the dataset.

3. RESULTS

About 18 million individual COVID-19 cases in the US, Puerto Rico, and the Virgin Islands were documented in the CDC case records between February 2020 and February 2021. Of those, we excluded 150,082 individuals because they did not meet the minimum age requirement (18 years of age). After the age exclusion and restriction of our dataset to individuals with complete, analyzable study data, we identified 1,623,677 total individuals that had complete records for healthcare worker status, age, sex, race/ethnicity, presence of pre-existing conditions, presence of pneumonia, hospitalization, and death.

Table 1 displays descriptive characteristics of the study population as well as the two main outcomes of interest, stratified by healthcare worker status. Of the 1,623,677 individuals included, 102,733 were healthcare workers, 839,277 were non-healthcare workers, and 681,717 had unknown healthcare worker status. The majority of individuals (51.7%) were not healthcare workers, while only a small number (6.3%) were healthcare workers. In both the healthcare worker and non-healthcare worker groups, the majority of individuals were female (84% and 51.3%, respectively), aged 20-39 (48% and 37.8%), White (52.3% and 47.6%), and had pre-existing medical conditions (46.1% and 44.1%). More than 75% of both healthcare workers and non-healthcare workers were not hospitalized and did not die due to COVID-19 infection. Of those with unknown healthcare worker status, the majority (53.2%) were female and 20-39 years of age (37.3%).

Table 2 shows the population breakdown of healthcare workers, non-healthcare workers, and unknown individuals with recorded COVID-19 infection in each US state included in our regression analysis, as well as Kaiser Family Foundation state-wide healthcare provider information[9-11] on total hospital beds and healthcare workers. The 12 states and territories included in Table 2 were the only states with sufficiently robust data to be used in regression analyses (shown in Table 3). The state of New Hampshire had the highest incidence of COVID-19 cases amongst healthcare workers (0.56% of the total state population) and non-healthcare workers (5.89% of the total state population), while Pennsylvania had the highest incidence of COVID-19 cases amongst those with unknown healthcare worker status (4.60% of the total state population). According to Kaiser Family Foundation data, of these 12 states, Colorado has the greatest number of hospital beds (178,899 beds).

Table 3 shows the adjusted association between healthcare worker status and COVID-19 infection outcomes by state: hospitalization and death. The states included in Table 3 are comprised of the same sub-population of 12 states included in Table 2, which were the only states with sufficiently complete data for regression analyses. The full multivariable multinomial model was run on each state individually to yield results by state for hospitalization and death.

Figures 1 and 2 show the adjusted association by state between healthcare worker status and hospitalization, comparing healthcare workers and unknown healthcare workers to non-healthcare workers; Figures 3 and 4 show the adjusted association by state between healthcare worker status and death, comparing healthcare workers and unknown healthcare workers to non-healthcare workers. The overall pattern in the data is increased odds of both hospitalization and death among those with unknown healthcare worker status, compared to those who were not healthcare workers. Those with unknown healthcare worker status had the highest odds of hospitalization in the state of Utah (OR 11.73; 95% CI 9.51-14.46) and the highest odds of death in the state of Colorado (OR 13.99; 95% CI 3.12-62.68). Colorado, Louisiana, Massachusetts, Nevada, and Ohio all had non-null significantly different odds of hospitalization and death in healthcare workers compared to those who were not healthcare workers. Among those five states, healthcare workers in Colorado, Louisiana, Massachusetts, and Ohio had lower odds of both hospitalization and death compared to those who were not healthcare workers. Healthcare workers in the state of Louisiana had the lowest odds of hospitalization and death (OR 0.39; 95% CI 0.30-0.52 and OR 0.28; 95% CI 0.11-0.69, respectively). Additional sub-analyses conducted on a smaller, more complete dataset with four different COVID-19 infection burden outcomes (hospitalization, admission to the ICU, use of a mechanical ventilator, and death) displayed similar patterns of decreased odds of hospitalization and death among healthcare workers and increased odds among those with unknown healthcare worker status, using non-healthcare workers as the reference group (results of analyses included in Appendix).

The results were not significantly changed by the exclusion of cases with unknown healthcare worker status and showed similar patterns to those observed in the full model (results of analyses included in Appendix). There was only one exception to the similarity in pattern: healthcare workers in Nevada had decreased odds of hospitalization in the sensitivity analysis, compared to previously having increased odds of hospitalization in the full model. In these analyses, several states had too few individuals in the healthcare worker group, which produced non-calculable regression results (denoted as “not calculated” in the table).

4. DISCUSSION

Our study attempts to describe the association between healthcare worker status and hospitalization and death outcomes related to COVID-19 infection in the US. In examining 18 million unique cases of COVID-19 infection over one year, this study demonstrates that being a healthcare worker in the US is associated with less hospitalization and death due to COVID-19 infection while having unknown healthcare worker status is associated with greater hospitalization and death. Because a significant proportion of the total study population had unknown healthcare worker status, it is difficult to determine whether the patterns observed in both hospitalization and death would remain if all unknown individuals had been attributed as either healthcare workers or non-healthcare workers. Throughout this study, the large proportion of unknown values across the exposure, outcomes, and covariates underscores the need for better data collection systems in epidemiologic surveillance to avoid potential misclassification bias.

4.1 Limitations

Our study has several limitations. Primarily, we had to exclude a significant proportion of the 18 million cases recorded in our time frame due to missing data for our exposure, outcomes, and covariates of interest. As a result of these exclusions, only 12 states are represented in the regression analyses, which may be an under-representative sample of COVID-19 infection burden among healthcare workers and non-healthcare workers in the US and may not reflect a broader range of age, sex, and race/ethnicity demographics present in other states. In addition, a large proportion of the study sample included individuals in the unknown category (42%), which makes this study prone to misclassification bias; the findings produced could have been altered significantly if a higher proportion of the unknown category was attributable to healthcare workers, or conversely, if a higher proportion was attributable to non-healthcare workers. Because we do not know the differences in how exposure data (being a healthcare worker) was obtained using the case report form, we cannot definitively establish whether the exposure misclassification was non-differential or differential. Furthermore, there appears to be differential missingness across the three healthcare categories within the outcome variables. While the healthcare worker and non-healthcare worker categories had a modest proportion of unknown for hospitalization (5.6% and 5.4%, respectively) and death (4.8% and 2.7%, respectively), the unknown healthcare worker exposure had a significant proportion of unknown for both outcomes (78% for hospitalization and 78.3% for death). The differential missingness likely resulted in differential misclassification of individuals with unknown healthcare worker status; however, the analyses conducted in this study cannot be used to extrapolate this missingness to bias estimates. Further extended quantitative bias analyses are needed to determine the magnitude and direction of bias due to differential (or non-differential) misclassification in this study sample. Finally, we cannot distinguish the source of infection in the reported COVID-19 cases, which does not allow us to directly attribute being a healthcare worker in the US to definitive infection with COVID-19 in a healthcare setting. It is indeed possible that some of the COVID-19 infections among healthcare workers resulted from infection outside a healthcare setting.

4.2 Main Findings

Our results demonstrate a pattern that, compared to non-healthcare workers, being a healthcare worker is associated with a decrease in the odds of both hospitalization and death due to COVID-19 infection, while having unknown healthcare worker status is associated with an increase in the odds of both hospitalization and death due to COVID-19 infection. Two states were an exception to these patterns. In Nevada, being a healthcare worker was associated with increased odds of hospitalization (OR 1.15; 95% CI 1.04-1.28), and in New Hampshire, being a healthcare worker was associated with increased odds of death (OR 1.42; 95% CI 0.24-8.21), though the association in New Hampshire was non-significant. Therefore, with the exception of Nevada and New Hampshire, being a healthcare worker in the US is associated with less hospitalization and death due to COVID-19 infection, while having unknown healthcare worker status is associated with greater hospitalization and death.

Many studies on healthcare workers have been conducted internationally and within the US[12-25] throughout the COVID-19 pandemic. Of the studies conducted in the US, most pertain to seroprevalence and have been conducted on smaller, hospital-based samples of healthcare workers.[17-18] In an observational study conducted on 1743 healthcare workers at Boston Medical Center, Kataria et al found that only 5.5% of participants tested positive for COVID-19 antibodies and seropositivity was not associated with occupation, gender, hand hygiene, and personal protective equipment (PPE) practices in healthcare workers.[17] Another study conducted by Purswani et al at an inner-city teaching hospital in New York City from May to June 2020 found that compared to hospital administrative staff, the odds ratios were compatible with a strong increase in seropositivity for nurses (adjusted OR 2.54) and nonclinical healthcare workers (adjusted OR 2.5); moderate increase for allied HCWs such as patient care technicians, social workers, registration clerks and therapists (adjusted OR between 1.70 and 1.83); and a moderate decrease for physicians (adjusted OR 0.80).[18]

In the CDC Morbidity and Mortality Weekly Report (MMWR) released in October 2020 by Kambhampati et al, hospitalization data from the COVID-NET surveillance study provide cross-sectional, count-based analyses of COVID-19 infection among healthcare workers in 13 select states: California, Colorado, Connecticut, Georgia, Maryland, Michigan, Minnesota, New Mexico, New York, Ohio, Oregon, Tennessee, and Utah.[12] Findings from the MMWR demonstrate that of the 438 healthcare workers in the 6,760 patient study, 71.9% were female and 52.0% were non-Hispanic Black. 67.4% of those hospitalized due to COVID-19 infection worked in healthcare occupations with direct patient contact, and 89.8% of hospitalized healthcare workers had at least one pre-existing condition, where the most reported conditions included obesity (body mass index ≥30 kg per m^2) (72.5%), hypertension (40.6%), and diabetes (30.9%).

To our knowledge, few—if any—studies have evaluated incident COVID-19 infection outcomes such as hospitalization, admission to the intensive care unit, use of a mechanical ventilator, and death among healthcare workers versus non-healthcare workers in a large population-based sample from all 50 United States. As a result, direct comparisons of our study outcomes to results in the existing literature are currently inconsequential, though research on COVID-19 infection is rapidly evolving. One of the main findings in this study is that compared to non-healthcare workers, having unknown healthcare worker status increases the odds of both hospitalization and death from COVID-19 infection, while being a healthcare worker generally decreases the odds of both outcomes.

Our study has several strengths. The results are derived using individual-level data from a considerably large population-based sample, which is likely the largest study (by sheer sample size) conducted in the US on COVID-19 infection outcomes to date. So far, only one other study conducted by Goodman et al has reported on COVID-19 associated hospitalization on a larger scale, but this study only analyzed data from 66,646 inpatients across 613 US hospitals without classification by healthcare worker status.[22] The large random population drawn from states across the US for our study enables the generalization of results to an extended group of people outside of a clinical setting, including both healthcare workers and non-healthcare workers. Furthermore, the analysis of a large sample of individual-level data with a multinomial logistic regression enabled us to derive odds ratios that aim to describe associations, not merely report count data, between healthcare worker status and hospitalization and death due to COVID-19 infection.

4.3 Implications

Our study highlights, through both its strengths and limitations, various important implications for future research and areas of further exploration. The limitations related to missing data in this study, and how that might have affected the patterns observed among healthcare workers and non-healthcare workers, underscore the necessity for centralized and consistent infectious disease data surveillance in reducing misclassification biases in epidemiologic data analyses. In addition, in surveying the extant literature of COVID-19 and healthcare workers, though there are studies that evaluate nosocomial COVID-19 infection of healthcare workers,[26] we noticed a clear gap in infection outcome-based research conducted on a national scale of healthcare personnel working on the frontlines. Several studies conducted both in the US and internationally[27-29] have assessed the availability—and lack thereof—of personal protective equipment (PPE) throughout the COVID-19 pandemic. However, none to our knowledge have attempted to estimate and describe the association between availability/stock of PPE and risk/odds of adverse COVID-19 infection outcomes specifically among healthcare personnel on a large, multi-site scale. This emphasizes the need for further larger-scale research performed with the purpose of describing associations related to healthcare worker status and the risk and etiology of COVID-19 transmission—particularly concerning the availability of PPE—in order to inform and set precedents for hospital emergency preparedness policies in the event of a future global pandemic.

4.4 Conclusions

The study results demonstrated that being a healthcare worker in the US was associated with less hospitalization and death from COVID-19 infection while having unknown healthcare worker status is associated with greater hospitalization and death. This study underscores the necessity for additional analyses of COVID-19 infection outcomes among both non-healthcare and healthcare workers, as well as the importance of complete data collection for disease surveillance systems.

5. TABLES

Table 1. Characteristics of the entire study population.

	Healthcare Worker Status							
	Healthcare Worker		Non-Healthcare Worker		Unknown		Total	
	n	%	n	%	n	%	n	%
Total individuals	102,733	6.3	839,277	51.7	681,717	42.0	1,623,677	100.0
Sex								
Female	86,346	84.0	430,369	51.3	362,694	53.2	879,409	54.2
Male	16,332	15.9	408,438	48.7	315,884	46.3	740,654	45.6
Unknown	55	0.1	420	0.1	3,139	0.5	3,614	0.2
Age Group (years)								
20-29	24,265	23.6	172,285	20.5	136,861	20.1	333,411	20.5
30-39	25,025	24.4	144,886	17.3	117,339	17.2	287,250	17.7
40-49	22,426	21.8	144,897	17.3	106,614	15.6	273,937	16.9
50-59	20,438	19.9	148,321	17.7	118,739	17.4	287,498	17.7
60-69	9,990	9.7	114,546	13.6	91,242	13.4	215,778	13.3
70-79	562	0.5	69,360	8.3	54,809	8.0	124,731	7.7
80+	27	0.0	44,915	5.4	55,908	8.2	100,850	6.2
Race/Ethnicity								
American Indian/Alaska Native, Non-Hispanic	134	0.1	2,982	0.4	197	0.0	3,313	0.2
Asian, Non-Hispanic	2,746	2.7	14,010	1.7	4,712	0.7	21,468	1.3
Black, Non-Hispanic	16,720	16.3	85,866	10.2	18,984	2.8	121,570	7.5
Hispanic/Latino	7,924	7.7	143,247	17.1	42,598	6.2	193,769	11.9
Multiple/Other, Non-Hispanic	1,916	1.9	16,797	2.0	14,492	2.1	33,205	2.0
Native Hawaiian/Other Pacific Islander, Non-Hispanic	206	0.2	2,419	0.3	225	0.0	2,850	2.0
Unknown	19,395	18.9	174,393	20.8	457,631	67.1	651,419	40.1
White, Non-Hispanic	53,692	52.3	399,513	47.6	142,878	21.0	596,083	36.7
Pneumonia								
Yes	3,531	3.4	41,897	5.0	8,927	1.3	54,355	3.3
No	74,816	72.8	609,806	72.7	90,737	13.3	775,359	47.8
Unknown	24,386	3.4	187,524	22.3	582,053	85.4	793,963	48.9
Pre-existing medical conditions								
Yes	47,336	46.1	370,224	44.1	42,323	6.2	459,883	28.3
No	37,834	36.8	322,208	38.4	55,631	8.2	415,673	25.6
Unknown	17,563	17.1	146,795	17.5	583,763	85.6	748,121	46.1
Hospitalization								
Yes	7,696	7.5	85,935	10.2	35,638	5.2	129,269	8.0
No	89,529	86.9	707,976	84.4	114,258	16.8	911,493	56.1
Unknown	5,769	5.6	45,243	5.4	531,820	78.0	582,832	35.9
Death								
Yes	434	0.4	23,210	2.8	23,416	3.4	47,060	2.9
No	97,415	94.8	793,287	94.5	124,198	18.2	1,014,900	62.5
Unknown	4,884	4.8	22,730	2.7	534,103	78.3	561,717	34.6

Table 2. Population composition of states analyzed in regression models, stratified by healthcare worker status, with healthcare provider data from Kaiser Family Foundation on hospital beds and state healthcare workers.

State	Population	HCP	HCP %	Non-HCP	Non-HCP %	Unknown HCP	Unknown HCP %	Total Hospital Beds	Total State HCW
COLORADO	5,758,736	181	0.00%	1,058	0.02%	37	0.00%	73,109	178,899
LOUISIANA	4,648,794	926	0.02%	4,092	0.09%	8,651	0.19%	14,151	21,263
MASSACHUSETTS	6,892,503	309	0.00%	3,074	0.04%	1,557	0.02%	10,894	38,275
NEVADA	3,080,156	36	0.00%	255	0.01%	80,123	2.60%	6,038	9,579
NEW HAMPSHIRE	1,359,711	7,604	0.56%	80,123	5.89%	17,997	1.32%	6,309	10,580
NEW YORK	19,453,561	265	0.00%	3,239	0.02%	120	0.00%	3,765	9,031
OHIO	11,689,100	25,567	0.22%	164,930	1.41%	5,593	0.05%	3,323	3,258
PENNSYLVANIA	12,801,989	3,935	0.03%	89,846	0.70%	588,498	4.60%	6,975	18,868
UTAH	3,205,958	2,368	0.07%	28,957	0.90%	535	0.02%	65,187	111,031
VERMONT	623,989	440	0.07%	5,380	0.86%	5	0.00%	5,664	10,896
WYOMING	578,759	5	0.00%	240	0.04%	111	0.02%	11,894	25,323
VIRGIN ISLANDS	106,631	31	0.03%	755	0.71%	33	0.03%	*	*
Total		41667	1.01%	381,949	10.70%	703,260	8.85%	207,309	437,003

*U.S. Virgin Islands data unavailable for Total Hospital Beds and Total State Healthcare Workers from Kaiser Family Foundation

Table 3. Crude and adjusted ORs (95% CIs) from multivariate multinomial logistic regressions by state for the association between healthcare worker status and COVID-19 infection outcomes hospitalization and death.

	Hospitalization		Death	
	Crude[a]	Adjusted[b]	Crude[a]	Adjusted[b]
State				
Colorado				
Healthcare worker	0.096 (0.05-0.18)*	0.27 (0.13-0.54)*	-	-
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	1.52 (0.71-3.27)	3.68 (1.35-10.05)*	1.44 (0.49-4.25)	13.99 (3.12-62.68)*
Louisiana				
Healthcare worker	0.18 (0.14-0.23)*	0.39 (0.30-0.52)*	0.07 (0.27-0.16)*	0.28 (0.11-0.69)*
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	4.84 (3.70-6.34)*	4.33 (3.12-6.00)*	13.5 (10.54-17.28)*	-
Massachusetts				
Healthcare worker	0.35 (0.28-0.45)*	0.62 (0.47-0.82)*	0.03 (0.02-0.05)*	0.19 (0.10-0.35)*
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	3.46 (2.82-4.25)*	3.13 (2.52-3.87)*	3.08 (2.60-3.65)*	4.48 (3.51-5.72)*
Nevada				
Healthcare worker	0.66 (0.60-0.73)*	1.15 (1.04-1.28)*	0.16 (0.11-0.23)*	0.53 (0.37-0.78)*
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	4.40 (4.11-4.71)*	4.23 (3.87-4.62)*	4.57 (4.17-5.00)*	4.81 (4.23-5.47)*
New Hampshire				
Healthcare worker	0.36 (0.17-0.74)*	0.87 (0.36-2.11)	0.16 (0.04-0.69)	1.42 (0.24-8.21)
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	-	-	-	-
New York				
Healthcare worker	0.51 (0.38-0.67)*	0.90 (0.66-1.24)	0.12 (0.05-0.27)*	0.40 (0.17-0.92)*
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	9.38 (5.13-17.15)*	11.68 (6.05-22.57)*	5.78 (3.99-8.37)*	12.65 (7.86-20.35)*
Ohio				
Healthcare worker	0.36 (0.34-0.39)*	0.77 (0.72-0.83)*	0.11 (0.09-0.14)*	0.52 (0.41-0.66)*
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	1.81 (1.59-2.05)*	2.80 (2.44-3.22)*	2.28 (1.88-2.77)*	5.25 (4.23-6.52)*
Pennsylvania				
Healthcare worker	0.71 (0.61-0.83)*	1.12 (0.96-1.31)	0.31 (0.19-0.53)*	0.92 (0.54-1.57)
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	6.35 (6.16-6.54)*	3.31 (3.19-3.45)*	22.64 (21.26-24.11)*	5.87 (5.46-6.31)*
Utah				
Healthcare worker	0.36 (0.27-0.48)*	0.72 (0.53-0.98)*	0.07 (0.02-0.23)*	0.37 (0.11-1.13)
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	10.92 (9.11-13.10)*	11.73 (9.51-14.46)*	6.89 (5.22-9.07)*	6.07 (4.36-8.46)*
Vermont				
Healthcare worker	0.44 (0.20-0.93)*	0.97 (0.44-2.14)	-	-
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	-	-	-	0.47 (0.4719-0.4719)*
Wyoming				
Healthcare worker	-	-	-	0.54 (0.53662-0.53664)*
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	2.00 (0.90-4.43)	2.07 (0.53-8.14)	11.07 (1.2-100.87)*	1.81 (0.12-27.51)
Virgin Islands				
Healthcare worker	0.48 (0.06-3.60)	1.16 (0.14-9.79)	-	-
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	4.2 (1.73-10.24)*	2.04 (0.15-27.58)	53.29 (11.05-256.93)*	-

* p value < 0.05
[a] Crude association between healthcare worker status and COVID-19 infection hospitalization and death.
[b] Adjusted ORs are adjusted for sex, race/ethnicity, age group, and pre-existing conditions.
Cells denoted with - represent values that were not calculated.

6. FIGURES

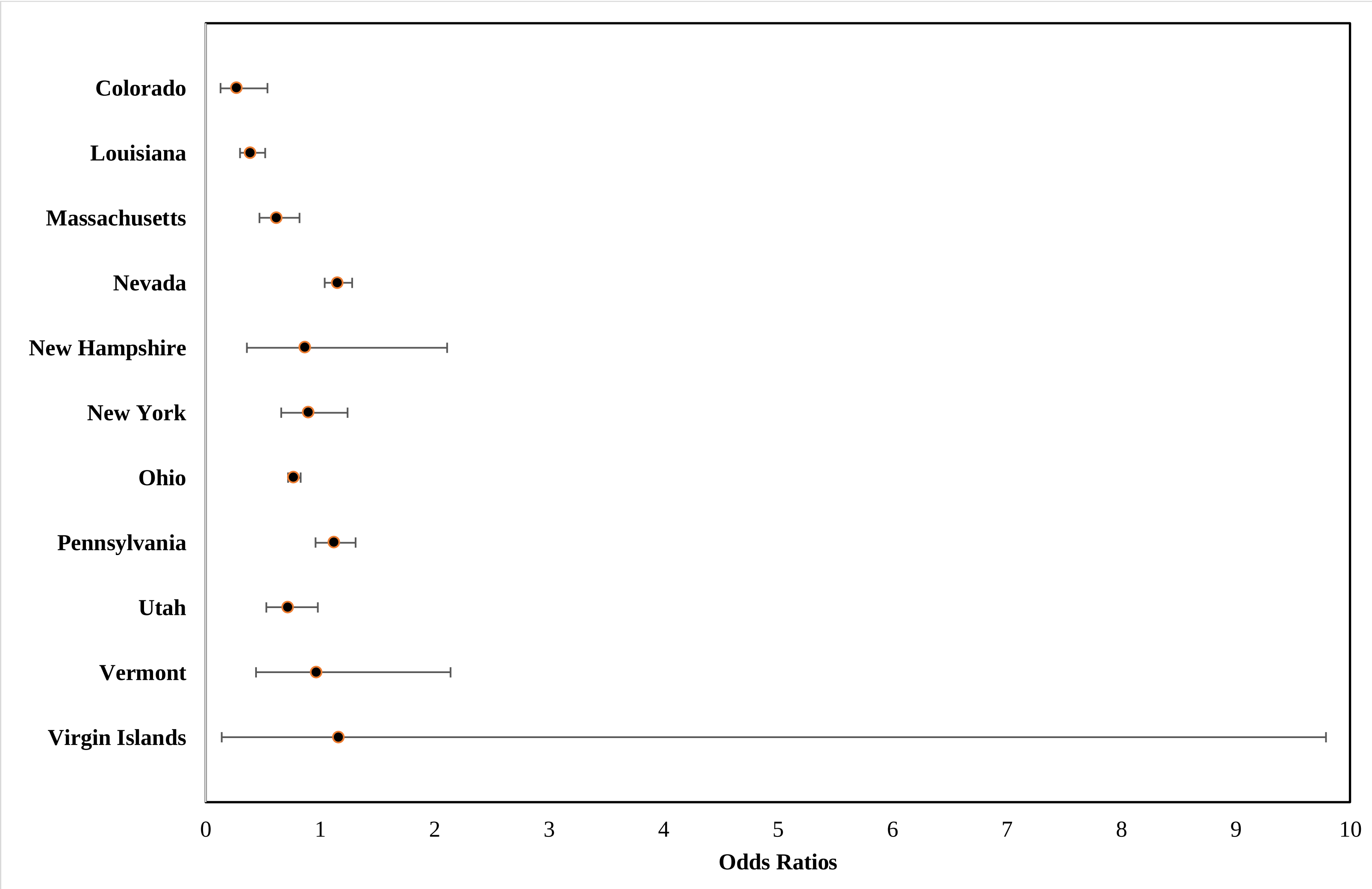

Figure 1. Results from multinomial logistic regressions by state computing adjusted odds ratios for the association between healthcare worker status and hospitalization, comparing healthcare workers to non-healthcare workers.

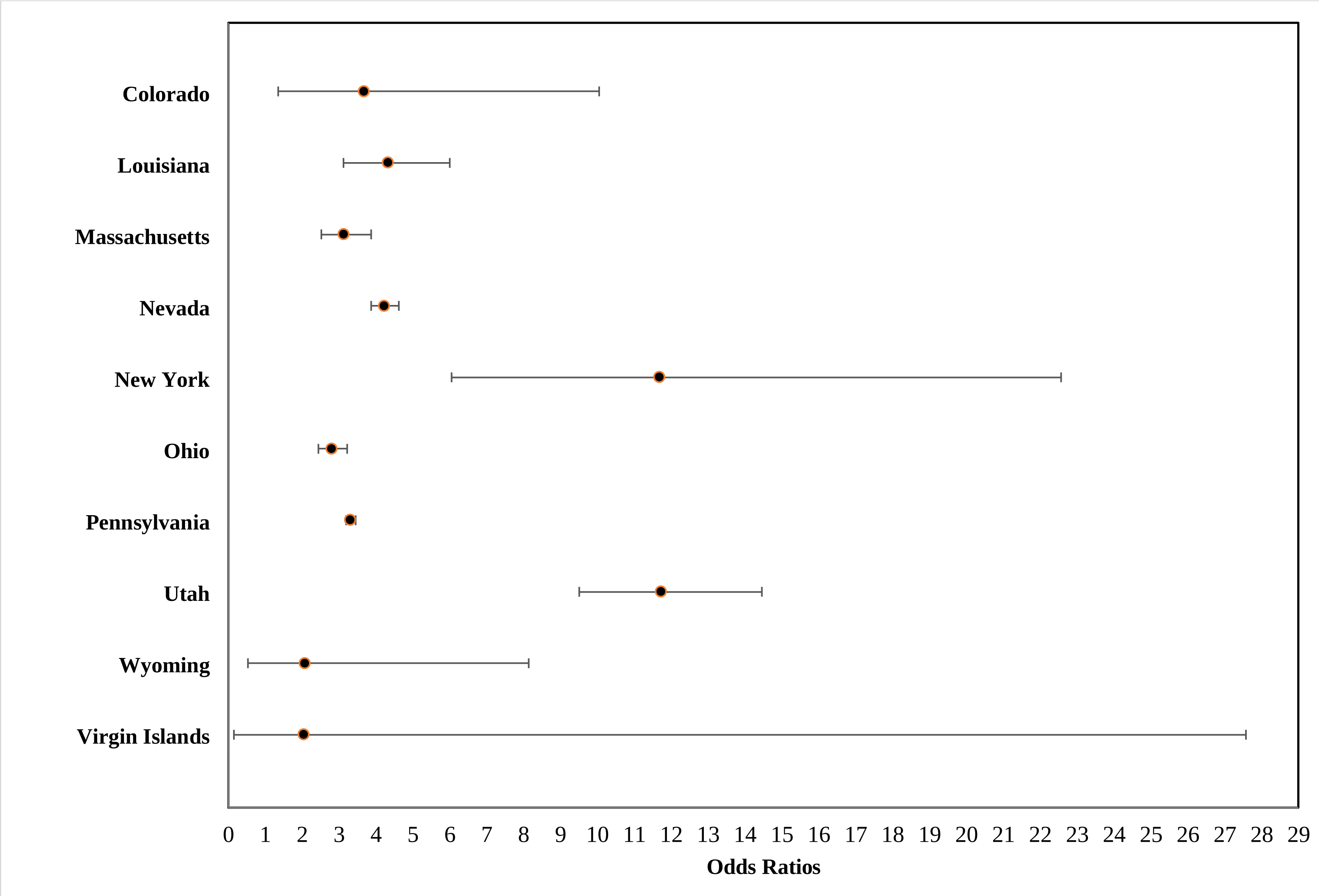

Figure 2. Results from multinomial logistic regressions by state computing adjusted odds ratios for the association between healthcare worker status and hospitalization, comparing unknown healthcare workers to non-healthcare workers.

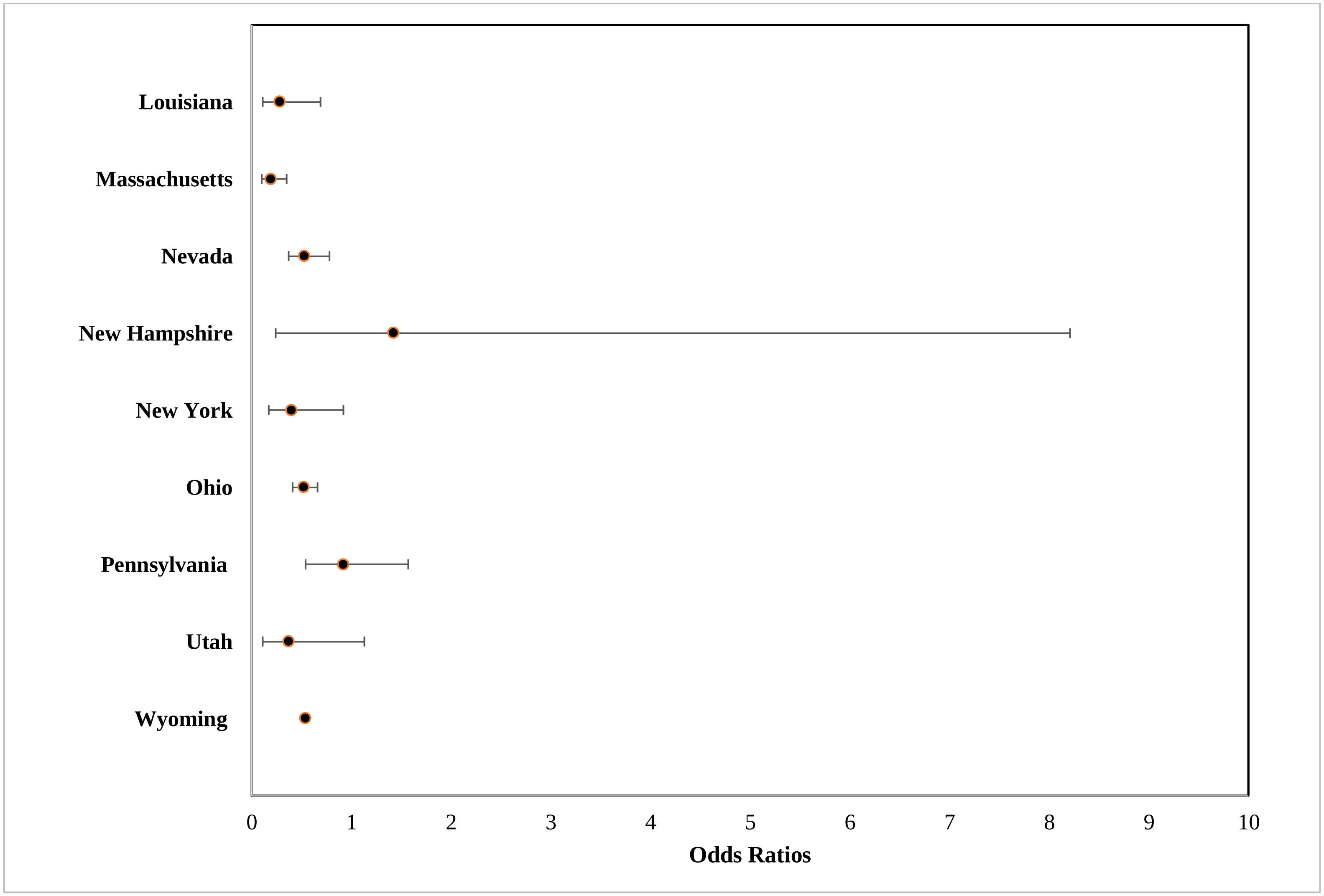

Figure 3. Results from multinomial logistic regressions by state computing adjusted odds ratios for the association between healthcare worker status and death, comparing healthcare workers to non-healthcare workers.

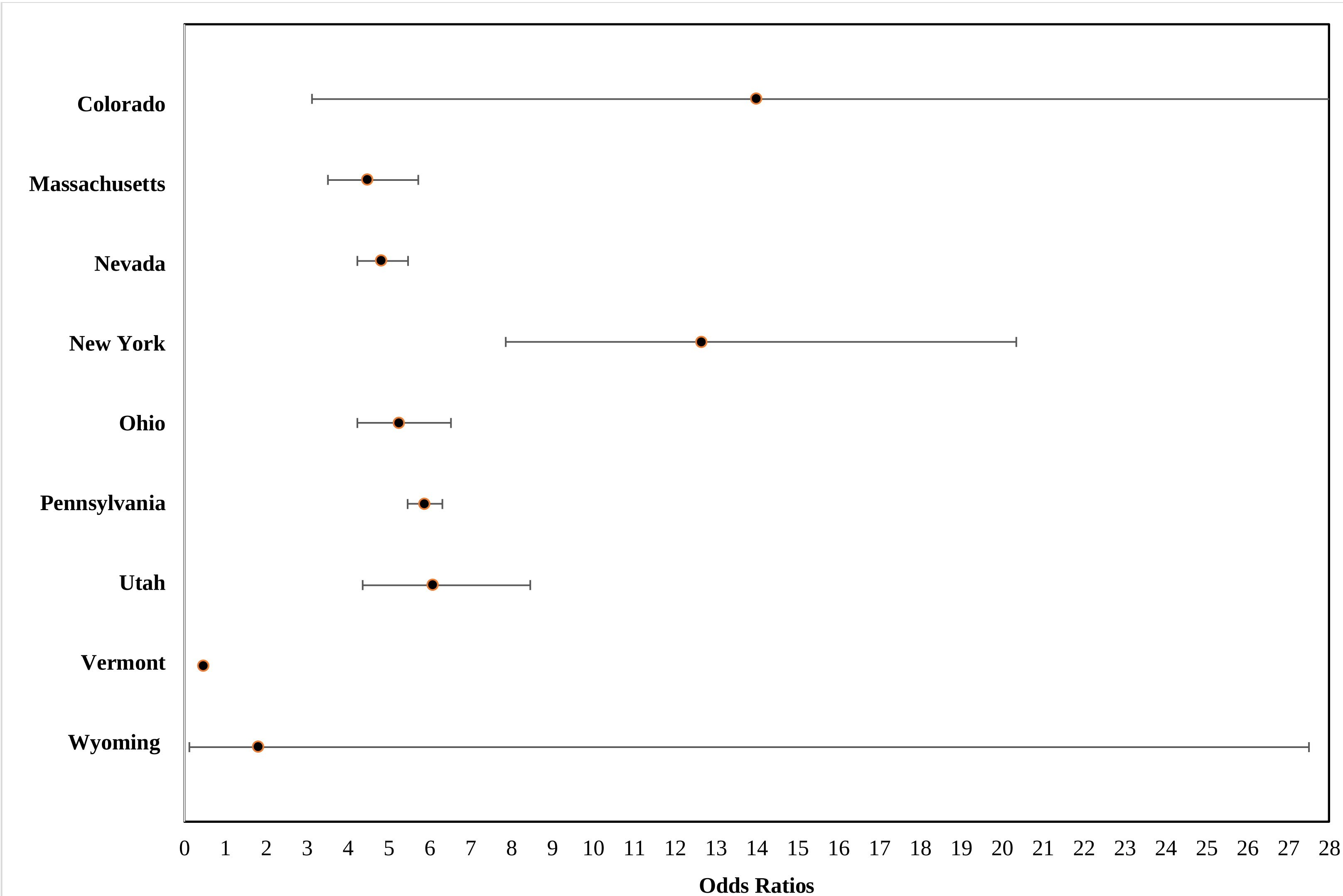

Figure 4. Results from multinomial logistic regressions by state computing adjusted odds ratios for the association between healthcare worker status and death, comparing unknown healthcare workers to non-healthcare workers.

7. APPENDIX

Table 4. Adjusted ORs (95% CIs) from multivariate multinomial logistic regressions by state for the association between healthcare worker status and COVID-19 infection outcomes hospitalization and death, unknown healthcare workers removed.

State	Hospitalization[b]	Death[b]
Colorado		
Healthcare worker	0.13 (0.06-0.28)*	-
Non-Healthcare Worker	Reference	Reference
Louisiana		
Healthcare worker	-	0.25 (0.01-0.73)*
Non-Healthcare Worker	Reference	Reference
Massachusetts		
Healthcare worker	0.33 (0.19-0.58)*	0.07 (0.02-0.22)*
Non-Healthcare Worker	Reference	Reference
Nevada		
Healthcare worker	0.67 (0.59-0.75)*	0.21 (0.14-0.32)*
Non-Healthcare Worker	Reference	Reference
New Hampshire		
Healthcare worker	-	-
Non-Healthcare Worker	Reference	Reference
New York		
Healthcare worker	-	-
Non-Healthcare Worker	Reference	Reference
Ohio		
Healthcare worker	0.42 (0.39-0.46)*	0.15 (0.12-0.19)*
Non-Healthcare Worker	Reference	Reference
Pennsylvania		
Healthcare worker	-	-
Non-Healthcare Worker	Reference	Reference
Utah		
Healthcare worker	0.42 (0.30-0.59)*	0.12 (0.04-0.38)*
Non-Healthcare Worker	Reference	Reference
Vermont		
Healthcare worker	-	-
Non-Healthcare Worker	Reference	Reference
Wyoming		
Healthcare worker	-	-
Non-Healthcare Worker	Reference	Reference
Virgin Islands		
Healthcare worker	-	-
Non-Healthcare Worker	Reference	Reference

* p value < 0.05

[b]Adjusted ORs are adjusted for sex, race/ethnicity, age group, and pre-existing conditions.

Cells denoted with - represent values that were not calculated.

Table 5. Adjusted ORs (95% CIs) from multivariate multinomial logistic regressions by state for the association between healthcare worker status and COVID-19 infection outcomes hospitalization, admission to ICU, mechanical ventilation, and death.

State	Hospitalization[a]	Admission to ICU[a]	Mechanical Ventilator[a]	Death[a]
Colorado				
Healthcare worker	0.26 (0.11-0.59)*	-	-	-
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	5.00 (1.53-16.35)*	3.75 (1.02-13.72)*	8.66 (2.32-32.42)*	20.77 (4.08-105.74)*
Louisiana				
Healthcare worker	-	1.00 (0.50-2.01)	1.07 (0.47-2.48)	0.78 (0.26-2.35)
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	-	6.01 (3.13-11.55)*	10.49 (5.38-20.42)*	9.57 (4.60-19.91)*
Massachusetts				
Healthcare worker	0.33 (0.18-0.63)*	0.60 (0.31-1.15)	0.37 (0.16-0.82)*	0.20 (0.06-0.69)*
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	2.78 (1.28-6.01)*	1.96 (1.29-2.98)*	1.78 (1.17-2.69)*	2.43 (1.44-4.10)*
Nevada				
Healthcare worker	1.02 (0.90-1.15)	1.51 (0.30-7.60)	0.81 (0.59-1.12)	0.55 (0.36-0.84)*
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	2.47 (2.16-2.81)*	-	5.77 (4.81-6.92)*	7.40 (6.11-8.95)*
New Hampshire				
Healthcare worker	-	1.97 (0.42-9.27)	2.18 (0.37-12.77)	-
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	-	-	-	-
Ohio				
Healthcare worker	0.78 (0.72-0.85)*	0.18 (0.13-0.25)*	0.73 (0.54-0.97)*	0.56 (0.44-0.73)*
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	2.04 (1.66-2.51)*	30.27 (24.18-37.90)*	5.31 (3.59-7.85)*	3.25 (2.24-4.72)*
Utah				
Healthcare worker	0.72 (0.51-1.02)*	0.56 (0.31-1.02)*	0.46 (0.17-1.27)	0.50 (0.17-1.59)
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	10.84 (8.20-14.33)*	4.11 (3.03-5.57)*	4.78 (3.28-6.98)*	5.05 (3.47-7.35)*
Vermont				
Healthcare worker	-	2.25 (0.11-44.80)	-	-
Non-Healthcare Worker	Reference	Reference	Reference	Reference
Unknown	-	-	-	-

* p value < 0.05

[a]ORs for hospitalization, admission to ICU, use of mechanical ventilator, and death adjusted for sex, race/ethnicity, age group, and pre-existing conditions.

Cells denoted with - represent values that were not calculated.

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