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Authors

Raphael, Eva
Azar, Kristen MJ
Gu, Dian
et al.

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Racial and sociodemographic predictors of COVID-19 compared with influenza, appendicitis, and all-cause hospitalization: retrospective cohort analysis

Eva Raphael, MD, MPH[a,b,*], **Kristen M.J. Azar, RN, MSN/MPH**[a,c], **Dian Gu, PhD**[d,e], **Zijun Shen, MS**[c,f], **Anna Rubinsky, PhD**[a], **Michael Wang, MD**[g], **Matthew Pantell, MD, MS**[h], **Courtney R. Lyles, PhD**[a,g], **Alicia Fernandez, MD**[g], **Kirsten Bibbins-Domingo, MD, PhD**[a,g], **Alice Pressman, PhD**[a,c,f], **Catherine Nasrallah, MPH**[c], **Rita Hamad, MD, PhD**[b,i]

[a]Department of Epidemiology & Biostatistics, University of California San Francisco (UCSF), San Francisco, California

[b]Department of Family & Community Medicine, UCSF, San Francisco, California

[c]Institute for Advancing Health Equity, Sutter Health, Walnut Creek, California

[d]Institute for Health & Aging, UCSF, San Francisco, California

[e]Center for Tobacco Control Research and Education, UCSF, San Francisco, California

[f]Center for Health Systems Research, Sutter Health, Walnut Creek, CA

[g]Department of Medicine, UCSF, San Francisco, California

[h]Department of Pediatrics, UCSF, San Francisco, California

[i]Philip R. Lee Institute for Health Policy Studies, UCSF, San Francisco, California

Abstract

Objective: To determine whether inequities in COVID-19 infection and hospitalization differ from those for common medical conditions: influenza, appendicitis, and all-cause hospitalization.

Design: Retrospective study based on electronic health records of three healthcare systems in San Francisco (university, public, and community) examining (1) racial/ethnic distribution in cases and hospitalization among patients with diagnosed COVID-19 (March-August 2020) and patients with diagnosed influenza, diagnosed appendicitis, or all-cause hospitalization (August 2017-March 2020), and (2) sociodemographic predictors of hospitalization among those with diagnosed COVID-19 and influenza.

Results: Patients 18 years or older with diagnosed COVID-19 (N=3,934), diagnosed influenza (N=5,932), diagnosed appendicitis (N=1,235), or all-cause hospitalization (N=62,707) were included in the study. The age-adjusted racial/ethnic distribution of patients with diagnosed COVID-19 differed from that of patients with diagnosed influenza or appendicitis for all

*corresponding author.

DECLARATION OF INTEREST

The authors report there are no competing interests to declare.

healthcare systems, as did hospitalization from these conditions compared to any cause. For example, in the public healthcare system, 68% of patients with diagnosed COVID-19 were Latine, compared with 43% of patients with diagnosed influenza, and 48% of patients with diagnosed appendicitis ($p<0.05$). In multivariable logistic regressions, COVID-19 hospitalizations were associated with male sex, Asian and Pacific Islander race/ethnicity, Spanish language, and public insurance in the university healthcare system, and Latine race/ethnicity and obesity in the community healthcare system. Influenza hospitalizations were associated with Asian and Pacific Islander and other race/ethnicity in the university healthcare system, obesity in the community healthcare system, and Chinese language and public insurance in both the university and community healthcare systems.

Conclusions: Racial/ethnic and sociodemographic inequities in diagnosed COVID-19 and hospitalization differed from those for diagnosed influenza and other medical conditions, with consistently higher odds among Latine and Spanish-speaking patients. This work highlights the need for disease-specific public health efforts in at-risk communities in addition to structural upstream interventions.

Keywords

COVID-19; influenza; race and ethnicity; hospitalizations; health inequities

INTRODUCTION

Racial/ethnic and socioeconomic inequities in COVID-19 infection and outcomes were recognized early in the pandemic.(Azar et al. 2020; Reitsma et al. 2021; Lopez, Hart, and Katz 2021; Tai et al. 2021) In 2020, COVID-19-related case and hospitalization rates were more than double among Black and Latine populations compared with White populations, and mortality was more than double among Black individuals.(Khazanchi, Evans, and Marcelin 2020) These inequities are thought to be driven by socioeconomic factors—for example, a higher percentage of minoritized individuals with low-wage essential work due, in part, to structural racism in employment opportunities.(Rogers et al. 2020) While sobering, these findings are nevertheless unsurprising as several decades of social epidemiology research have identified racial/ethnic and socioeconomic inequities for many health conditions, rooted in structural and historical discrimination and disenfrachisement. (Bailey et al. 2017; CDC 2016; Adler and Newman 2002)

Over the course of the pandemic, many have compared COVID-19 to influenza in terms of mechanism of spread, virulence, and mitigation strategies. However, there has been little work to determine whether patterns of COVID-19 inequities are unique, or rather a manifestation of longstanding inequities that function similarly across disease domains. Understanding this key comparison would help public health officials develop effective prevention and mitigation strategies to close potentially unique equity gaps. One prior study compared sociodemographic characteristics associated with COVID-19 to those associated with influenza during the 2019–2020 season, finding differing trends in risk factors, although influenza incidence was low during this period and may not reflect pre-pandemic inequities.(Trick et al. 2021)

To address this gap, we examined the racial/ethnic distributions of those diagnosed and hospitalized with COVID-19 to capture factors associated with disease severity at the beginning of the pandemic and compared them with corresponding pre-pandemic distributions in those with diagnosed influenza (i.e., another respiratory infection), diagnosed appendicitis (i.e., a non-communicable disease), and all-cause hospitalization. While there are recognized inequities in influenza infection and outcomes, we used appendicitis to establish a baseline for racial/ethnic distribution as inequities have not been identified in incidence. We used electronic medical record (EMR) data from three major healthcare systems in San Francisco, California, which is a well-defined, diverse region that was lauded for early and effective action to reduce COVID-19 infection and mortality while targeting health equity.(Ho and Allday 2020) We tested the hypothesis that differences in racial/ethnic distribution of COVID-19 infections and hospitalizations were similar to existing disparities in comparator conditions to inform strategies to decrease inequities in COVID-19.

MATERIALS AND METHODS

Study setting

This is a retrospective observational cohort study drawn from EMR data from three healthcare systems (i.e., hospitals and affiliated clinics) in San Francisco: (A) a university healthcare system including a tertiary care hospital, (B) a public safety-net county healthcare system including the city's largest primary care facility and only level 1 trauma center, and (C) a not-for-profit community healthcare system (Supplemental Table 1). These systems represent three of four major healthcare systems providing care to most San Francisco residents.(Davis and Connolly 2021) Analytic datasets were harmonized with identical dataset structures and definitions for variables (Supplemental Tables 2–4). We did not pool the datasets due to institutional confidentiality rules. Study procedures were approved by Institutional Review Boards at the authors' institutions.

Comparison group definitions

We created four comparison groups of patients aged 18 years old and older residing in San Francisco in each healthcare system: (1) diagnosed COVID-19: patients with evidence of COVID-19 infection via a positive test, infection flag, and/or diagnosis code, (2) diagnosed influenza: patients with evidence of influenza via a positive test and/or diagnosis code, (3) diagnosed appendicitis: patients with an appendicitis diagnosis code, and (4) all-cause hospitalization: hospitalized patients regardless of diagnosis including the aforementioned conditions (Supplemental Table 2). Appendicitis was included as a comparison group to establish a baseline for racial/ethnic distribution of patients, and we also tabulated all patients receiving care in each healthcare system. We created two cohorts based on the diagnosed COVID-19 and influenza groups, where patients were followed to ascertain hospitalization and length of stay as infection outcomes. Other groups – appendicitis and all-cause hospitalization – were not examined as cohorts due to sample size (appendicitis) and inability to capture outcomes such as intensive care receipt in all healthcare systems.

The diagnosed COVID-19 group included patients diagnosed or hospitalized from March 1, 2020, to August 31, 2020, to capture trends during the most stringent period of protective policies of the early pandemic before vaccine availability. The San Francisco county shelter-in-place orders went into effect on March 16, 2020.("The Bay Area's Battle Against Coronavirus" 2020) The university healthcare system included a manually-entered flagging system to identify patients with COVID-19 infection. The other groups included patients diagnosed or hospitalized between August 1, 2017, and March 31, 2020, to capture trends prior to the COVID-19 pandemic. The index date was based on the first positive test, infection flag, or diagnosis code for the diagnosed COVID-19, influenza, and appendicitis groups, in both outpatient and inpatient services, and on the first hospitalization for the all-cause hospitalization group. San Francisco residence was based on documented address on the index date.

Variables

Independent Variables—Given the focus on racial/ethnic inequities, the primary independent variable was self-reported race/ethnicity. Categories included non-Hispanic Asian and Pacific Islander, non-Hispanic Black, Hispanic/Latine, non-Hispanic White, and non-Hispanic other. Coefficients for the latter category are difficult to interpret due to its heterogeneity, but small cell sizes and unstable estimates precluded more granular categories. Other covariates included age, sex, self-reported preferred language, health insurance status, housing status, Charlson comorbidity index (CCI) (0, 1, 2+ points),(Quan et al. 2005) and obesity. Housing status was based on EMR documentation from healthcare system screening or ICD-10-CM diagnosis code Z59.0 in the past year (Table 1). CCI and obesity, based on diagnoses documented within 12 months of the index date, were included as possible confounders of the relationship between sociodemographic variables and hospitalization (Supplemental Table 3).

Outcomes—First, for each comparison group, we examined the distribution across race/ethnicity within each healthcare system, including all patients receiving care, and examined the differences in the distribution across comparison groups in cases and hospitalized patients separately. We also assessed differences in length of stay for hospitalized patients in each comparison group. Second, for the diagnosed COVID-19 and influenza cohorts, we examined the association of patient characteristics associated with the outcomes of (1) hospitalization and (2) length of stay above the median for these conditions (Supplemental Table 4).

Statistical analysis

Within each healthcare system, we first tabulated descriptive statistics to summarize the distribution of race/ethnicity and other variables across the four groups.

Next, within each healthcare system, the age-adjusted racial/ethnic distribution in the diagnosed COVID-19 group (reference group) was compared with the distribution in the diagnosed influenza and appendicitis groups and to all patients receiving care within the healthcare system using chi-squared tests. We then evaluated differences in the age-adjusted racial/ethnic distribution in hospitalized patients among the diagnosed COVID-19 group

compared to hospitalized patients in the diagnosed influenza and appendicitis groups and to patients with all-cause hospitalization chi-squared tests. Direct age standardization was conducted based on the age distribution of San Francisco residents.(2020) We also evaluated differences in median length of stay for each comparison group by race/ethnicity in each healthcare system using Kruskal-Wallis test.

We performed multivariable logistic regressions separately for the diagnosed COVID-19 and influenza cohorts by healthcare system to assess which sociodemographic characteristics predicted the outcomes of (1) hospitalization and (2) length of stay above the median. Median length of stay was assessed separately for the diagnosed COVID-19 and influenza cohorts for each healthcare system. These analyses were not conducted in the diagnosed appendicitis group due to small cell sizes and unstable estimates. Independent variables included race/ethnicity, age, sex, preferred language, and insurance, adjusting for CCI and obesity status. Reference groups were those with the lowest hospitalization prevalence. We report odds ratios with 95% confidence intervals to characterize uncertainty in effect estimates.

Data cleaning was conducted by Stata 16 for the university healthcare system and SAS version 9.4 for the public healthcare system. Data analyses were conducted by SAS version 9.4 for the university and public healthcare systems. Data cleaning and analyses were conducted by R version 3.6.3 for the community healthcare system.

RESULTS

Characteristics of the study patients

Overall, the plurality of patients in each comparison group in all healthcare systems were 35–64 years of age (Table 1). However, appendicitis was more commonly diagnosed among those age 18–34 in the university and public healthcare systems, and all-cause hospitalization was more common among those age 65+ in the community healthcare system. Depending on the healthcare system and comparison group, the percentages of women and men also differed, e.g., they were roughly equally represented among diagnosed COVID-19 patients in the university and community healthcare systems, but men were overrepresented in the public healthcare system (Table 1). Similarly, race/ethnicity and insurance type varied across comparison group and healthcare systems. Most patients spoke English, except those with diagnosed COVID-19 in the public healthcare system, where most spoke Spanish. The plurality of patients in each comparison group had a CCI of zero, except for hospitalized individuals in the university and community healthcare systems, where the largest percentage had a CCI of 2+. Length of stay differed by race/ethnicity significantly across healthcare systems for hospitalizations for any cause (Supplemental table 5).

Age-adjusted racial/ethnic distribution of diagnosed patients, by comparison group and healthcare system

When examining differences by race/ethnicity, for each healthcare system, the distribution of patients with diagnosed COVID-19 was different from the distribution for the other

comparison groups and for all patients in the given healthcare system ($p<0.05$ for all) (Figure 1). In particular, the percent of patients in the diagnosed COVID-19 group who were Latine was disproportionately and consistently high across all healthcare systems. Otherwise, there were inconsistent differences in percent of each racial/ethnic group across comparison groups and healthcare system. For example, with respect to diagnosed influenza, Asian and Pacific Islander patients were overrepresented compared to all patients in the university healthcare system, while Black patients were overrepresented in the public and community healthcare systems.

Age-adjusted racial/ethnic distribution of hospitalized patients, by comparison group and healthcare system

In comparisons of age-adjusted racial/ethnic distributions among hospitalized patients (Figure 2), across all healthcare systems, the proportion of hospitalized patients with diagnosed COVID-19 who were Latine was disproportionately high compared with hospitalized patients with diagnosed influenza, diagnosed appendicitis, or from any cause. This pattern was more pronounced among hospitalized patients than for the diagnosed comparison groups shown in Figure 1. With respect to diagnosed influenza hospitalizations, Black patients were overrepresented compared with all-cause hospitalization in all healthcare systems, and Asian and Pacific Islander patients were overrepresented in the university healthcare system.

Association between sociodemographic characteristics and COVID-19 or influenza hospitalization, by healthcare system

Findings from multivariable logistic regressions examining predictors of diagnosed COVID-19 and influenza hospitalization, in particular race/ethnicity, were roughly similar across healthcare systems, with some differences (Table 2 and 3).

In the university healthcare system, hospitalization for patients with diagnosed COVID-19 was associated with ages 35–64 and 65+ years (compared with 18–34 years), male sex, Asian and Pacific Islander race/ethnicity (compared with White), Spanish as a preferred language (compared with English), public insurance (compared with commercial insurance), and CCI of 2+ (compared with 0). Hospitalization for patients with diagnosed influenza was associated with age 65+ years, Chinese as a preferred language, public insurance, and CCI of 1 and 2+. Asian and Pacific Islander and other/unknown race/ethnicities were associated with lower odds of influenza hospitalization. Length of stay above the median for diagnosed COVID-19 had an association with public insurance and an inverse association with Chinese as a preferred language (Supplemental table 6). Length of stay above the median for diagnosed influenza was associated with CCI of 1 and 2+ (Supplemental table 7).

In the public healthcare system, predictors of hospitalization for patients with diagnosed COVID-19 or influenza included ages 35–64 and 65+ years, male sex, and CCI of 1 and 2+. Other/unknown race/ethnicity was associated with lower odds of COVID-19 hospitalization. Length of stay above the median for diagnosed COVID-19 was associated with age 65+.

In the community healthcare system, hospitalization for patients with diagnosed COVID-19 was associated with ages 35–64 and 65+ years, male sex, Latine race/ethnicity, CCI of 1

and 2+, and obesity. Hospitalization for patients with diagnosed influenza was associated with ages 35–64 and 65+ years, Chinese as a preferred language, public insurance, CCI of 1 and 2+, and obesity. Other/unknown insurance was associated with lower odds of hospitalization. Length of stay above the median for diagnosed influenza was associated with CCI of 2+.

DISCUSSION

We assessed whether racial/ethnic and sociodemographic inequities in COVID-19 infection, hospitalization, and length of stay are unique, or whether they are similar to those seen in other common health conditions. While racial/ethnic distribution varied by comparison group and healthcare system, the age-adjusted racial/ethnic distribution of patients with diagnosed COVID-19 consistently differed from that of all patients in each healthcare system, which, in turn, differed from those with diagnosed influenza or appendicitis, suggesting that there may be different mechanisms driving differences for each condition. Findings were similar among hospitalized patients, with consistent differences in the age-adjusted racial/ethnic distribution and length of stay of patients hospitalized with diagnosed COVID-19 compared to those with diagnosed influenza, appendicitis, or all-cause hospitalization. Multivariable regression models of hospitalizations confirmed these findings for patients with diagnosed influenza and COVID-19. While older age and more comorbidities were associated with hospitalization for both COVID-19 and influenza, Latine and Spanish-speaking patients were more likely to experience hospitalization for COVID-19 but not influenza, whereas Chinese-speaking patients were more likely to experience hospitalization for diagnosed influenza but not COVID-19. Moreover, length of stay above the median had an inverse association with Chinese as a preferred language for patients hospitalized for COVID-19. Asian and Pacific Islander race/ethnicity was associated with greater or less odds of hospitalization depending on the comparison group and healthcare system, likely reflecting differences in the specific populations served by each system.

Our study is consistent with prior work that has found racial/ethnic inequities in COVID-19 infection and outcomes, in particular the disproportionately greater risk among Latine and Spanish-speaking individuals.(Azar et al. 2020; Lopez, Hart, and Katz 2021; Reitsma et al. 2021) In the public healthcare system, for example, Latine individuals represented 68% of all patients with diagnosed COVID-19, whereas they represented 36% of all patients within the healthcare system, and 43%, 48%, and 32% of those with diagnosed influenza, diagnosed appendicitis, and all-cause hospitalization, respectively. Latine race/ethnicity and Spanish language are highly collinear in our data, and each was associated with hospitalization in different healthcare systems after adjusting for other covariates. These inequities, in that patients with specific sociodemographic characteristics were more likely to be hospitalized with an infection after adjusting for common drivers of disease severity, may be due to increased risk of infectious exposure due to occupational factors or crowded living conditions; miscommunication or discrimination due to linguistic or cultural discordance with healthcare providers; or lack of access to or knowledge of safety-net programs—and thus, testing—due to immigration status (among those who are also immigrants).(Lopez, Hart, and Katz 2021; Pérez-Stable and El-Toukhy 2018; Feinberg et al. 2021; Khullar and Chokshi 2019)

As in prior studies,(Azar et al. 2020; Kim et al. 2021; Soares, Mattos, and Raposo 2020; Ingraham et al. 2020; Mude et al. 2021; Jin et al. 2020) our results also found that male sex was associated with increased odds of hospitalization for diagnosed COVID-19. This contrasts with influenza. This may be due to differences by sex in occupational exposures and health-seeking behaviors, but also differences in immune response.(Takahashi et al. 2020; Brodin 2021) Our study also examined the association between markers of socioeconomic status and hospitalization in robust multivariable models, finding that public insurance coverage resulted in higher odds of COVID-19 hospitalization in the university healthcare system and of influenza hospitalization in the university and community systems. Of note, there were fewer statistically significant predictors of hospitalization in the public system, possibly because race/ethnicity, language, and insurance status do not serve as proxies for socioeconomic status to the same degree in this less resourced population as in the other systems.

A key novel finding from our work is how risk factors for COVID-19 hospitalization compare with those for influenza hospitalization, another common respiratory infection. While multiple studies have compared clinical characteristics of patients with COVID-19 and influenza, only one study to our knowledge compared sociodemographic risk factors of hospitalizations for these infections. It found that Latine patients made up a greater proportion of COVID-19 hospitalizations than influenza hospitalizations, and that Latine patients hospitalized with COVID-19 compared to those with influenza were more likely to live in census tracts with overcrowding, limited English proficiency, and high employment in construction.(Trick et al. 2021) We too found that Latine patients made up a greater proportion of diagnosed COVID-19 cases than diagnosed influenza in all healthcare systems. This may be because the shelter-in-place and social distancing orders—unique to the COVID-19 pandemic—were not as easily followed by Latine individuals who are overrepresented among low-wage essential workers relative to other racial/ethnic groups, and who are more likely than White individuals to live in crowded housing.(Lopez, Hart, and Katz 2021) Also, while prior work has also shown racial/ethnic inequities in influenza hospitalizations,(Lu et al. 2015; Kini et al. 2021; Dee et al. 2011; Quinn and Kumar 2014; Sloan et al. 2015) we found novel associations of influenza hospitalization with Chinese language and public health insurance. This may be due to historically lower influenza vaccine uptake in the U.S. among Black, Asian, and Latine patients compared with White patients.(Yoo et al. 2011; Lu et al. 2015; Coupland et al. 2007) Alternately, it may be due to upstream socioeconomic inequities, or differential access to care and outreach and educational efforts,(Crouse Quinn et al. 2017) leading to inequities in influenza hospitalization and mortality.(Dee et al. 2011; O'Halloran et al. 2021) Such drivers may explain the differences in our study, and may hint towards the future of COVID-19 disparities as it becomes endemic.

Similarly, our study found racial/ethnic disparities among patients with appendicitis hospitalizations and all-cause hospitalization, with Black patients overrepresented in all-cause hospitalizations compared with the underlying racial/ethnic distribution of the patient population. This is consistent with prior work finding higher rates of hospitalization among Black patients in California(Raphael, Gaynes, and Hamad 2019) and differences by race/ethnicity and socioeconomic status in appendicitis clinical management, complications, and

hospitalizations.(Lee, Shekherdimian, and Chiu 2011; Lee et al. 2011; Zogg et al. 2016) Nevertheless, these disparities were different from those for COVID-19, suggesting that the mechanism of transmission and possible differential societal barriers to adherence to mitigating policy recommendations drove the specific inequities we observe for COVID-19.

Our study has several strengths and weaknesses. Strengths included the examination of racial/ethnic and other sociodemographic inequities in multiple medical conditions in a large diverse U.S. city by leveraging rich clinical data from three healthcare systems. In terms of limitations, first, we were not able to assess in-hospital mortality and intensive care utilization due to the small number of events and subsequent unstable estimates. Second, comparison groups were identified in slightly different ways in each healthcare system due to differential workflows and available EMR data (see Supplement), although every effort for data harmonization was attempted and identical case definitions were used whenever possible. Third, diagnoses for each condition may be biased by differential access to healthcare by insurance status or other socioeconomic factors. Fourth, there may have been overlap of patients between healthcare systems, given their geographic proximity and ubiquitous use of emergency departments. We are unable to identify these patients due to our inability to pool the datasets due to institutional restrictions; this is a limitation of most research done in the U.S. in the absence of national or state-wide EMR databases. Lastly, analyses were conducted by two different analytic programs which could partially explain differences in findings between healthcare systems.

In summary, in this multicenter study across three healthcare systems in a well-defined diverse urban city, we found that racial/ethnic and other sociodemographic inequities in diagnosed COVID-19 differed meaningfully from those for diagnosed influenza, diagnosed appendicitis, and all-cause hospitalization during the early phase of the pandemic. We found that Latine and Spanish-speaking individuals had disproportionate odds of severe COVID-19 outcomes (i.e., hospitalization) even after adjusting for a range of sociodemographic characteristics and comorbidities available in EMR data. These findings have important clinical and public health implications, in particular for other multi-ethnic urban spaces. Specifically, while social and economic policies to address upstream risk factors like poverty and unstable housing will likely reduce underlying inequities for all four conditions, public health educational messages and clinical interventions may need to be disease-specific and incorporate differentiated cultural and linguistic messaging and outreach.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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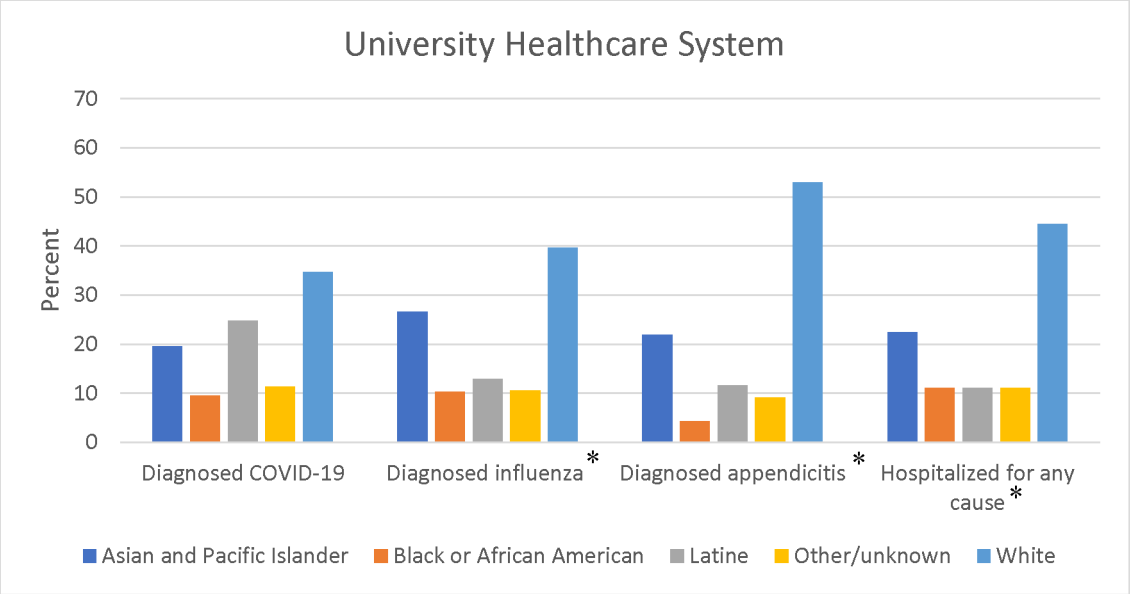
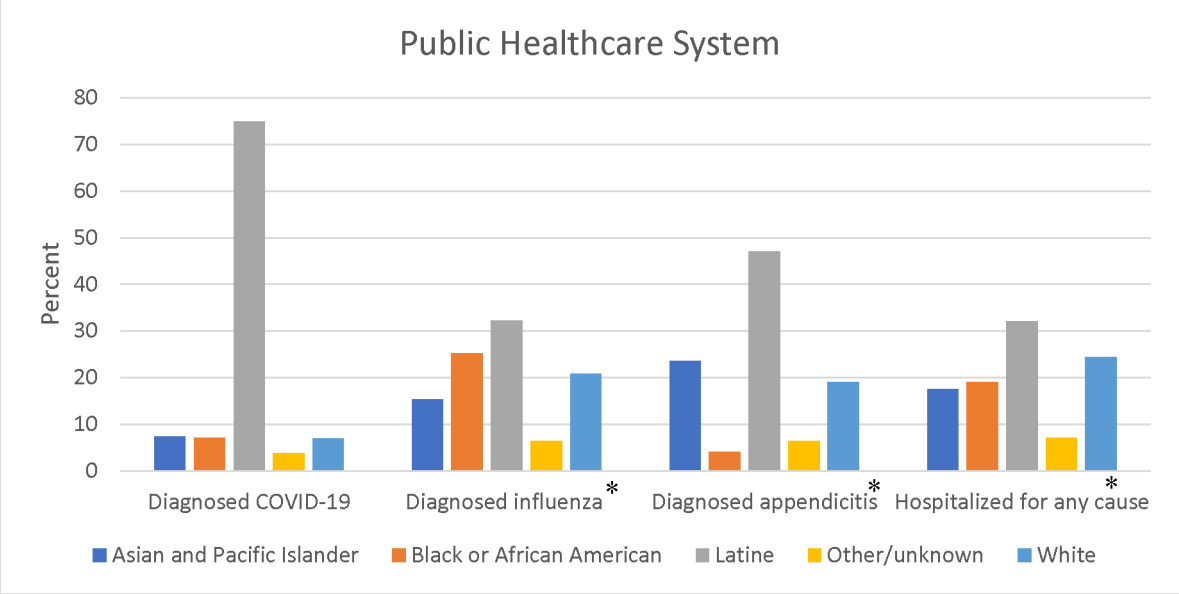




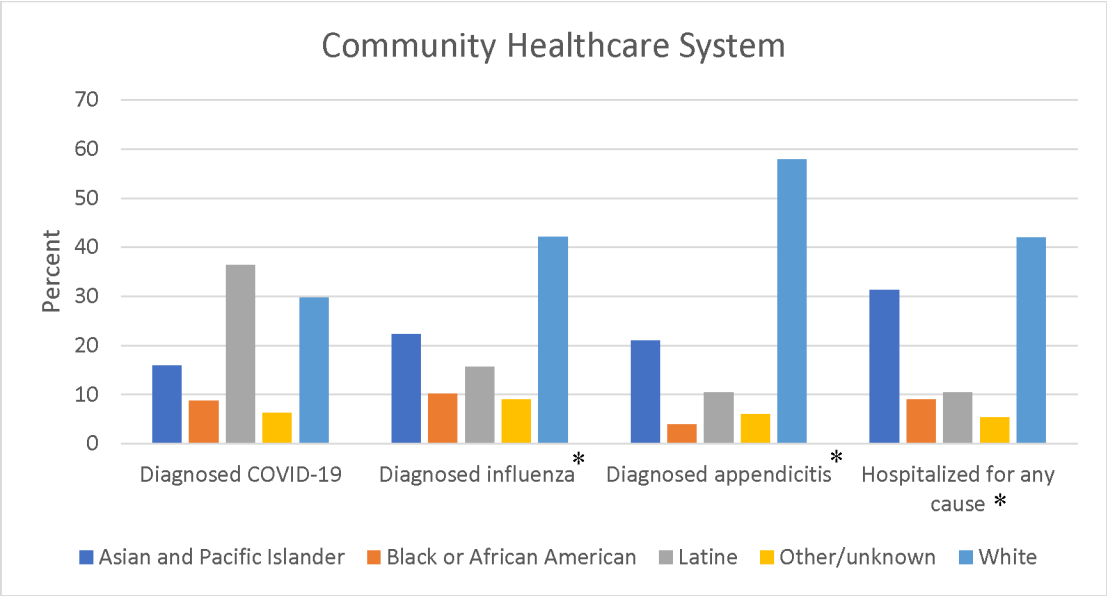
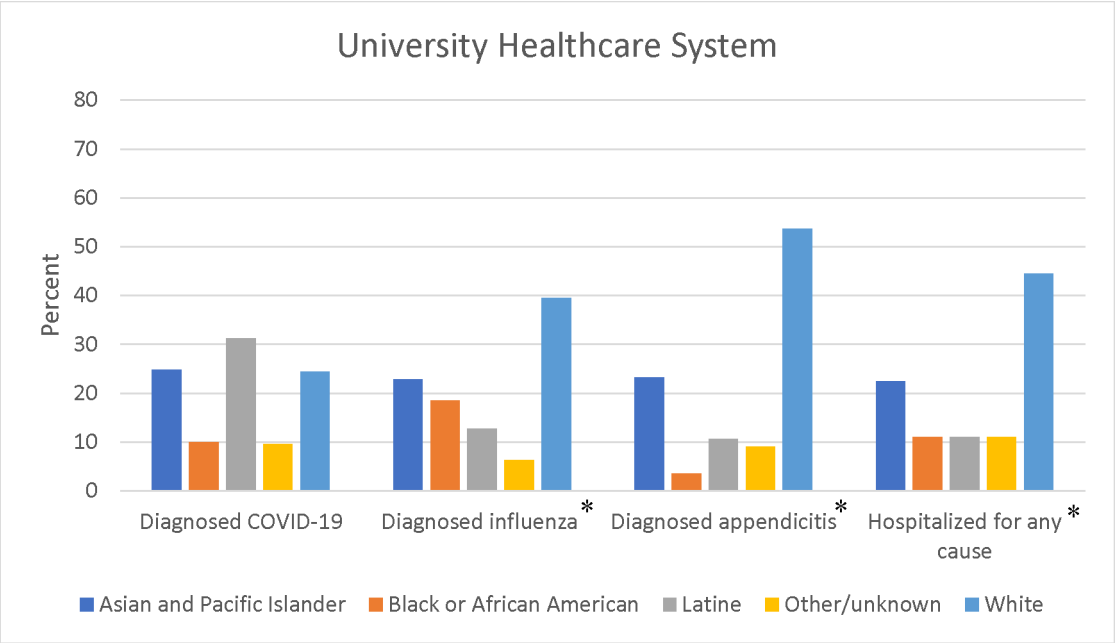


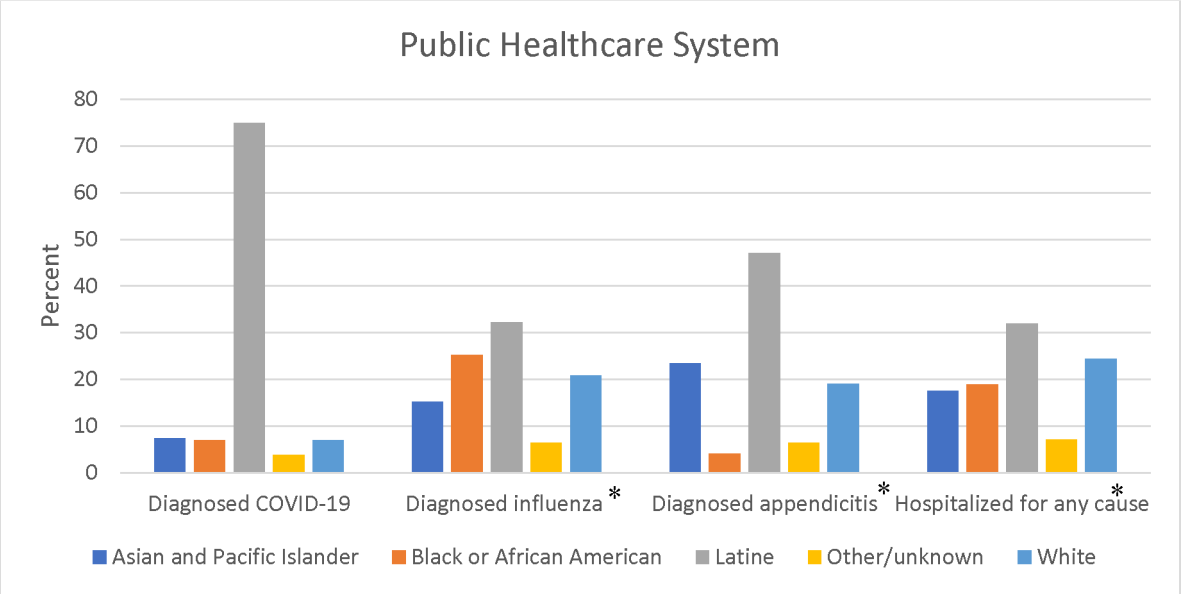
Figure 1.

Age-adjusted racial/ethnic distribution of patients for each comparison group, by healthcare system

3-part bar graphs representing racial/ethnic distribution of patients within the diagnosed COVID-19, diagnosed influenza, and diagnosed appendicitis groups, and all patients receiving care for the three healthcare systems (university, public, community). Asterisks denote a racial/ethnic distribution for a comparison group that is statistically significantly different from that of COVID-19 by chi-square test

Note: Asterisks (*) denote a racial/ethnic distribution for a comparison group that is statistically significantly different from that of COVID-19 by chi-square test.





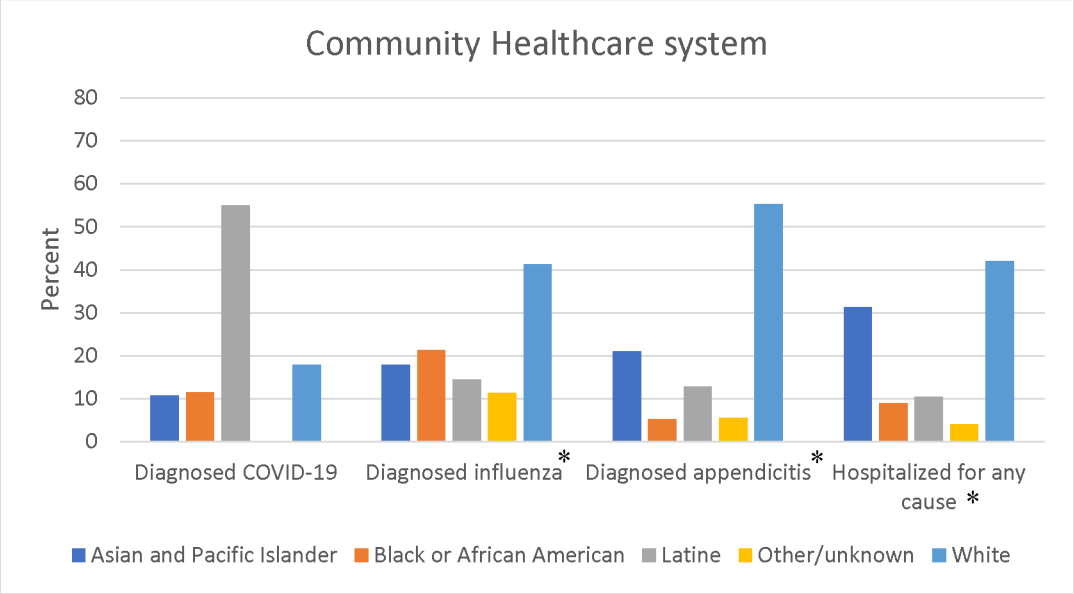


Figure 2.

Age-adjusted racial/ethnic distribution of hospitalized patients in each comparison group, by healthcare system

3-part bar graphs representing racial/ethnic distribution of hospitalized patients within the diagnosed COVID-19, diagnosed influenza, and diagnosed appendicitis groups, and patients with all-cause hospitalization for the three healthcare systems (university, public, community). Asterisks denote a racial/ethnic distribution for a comparison group that is statistically significantly different from that of patients hospitalized with COVID-19 by chi-square test

Note: Asterisks (*) denote a racial/ethnic distribution for a comparison group that is statistically significantly different from that of COVID-19 by chi-square test. Some percentages for the community healthcare system are not presented due to small number of patients (less than 10).

Table 1.

Patient characteristics for each comparison group, by San Francisco healthcare system

Panel A. University Healthcare System				
	Diagnosed COVID-19 No. (%)	**Diagnosed influenza No. (%)**	**Diagnosed appendicitis No. (%)**	**All-cause hospitalization No. (%)**
Total	588	1621	303	18731
Age (years)				
18–34	174 (30)	355 (22)	135 (45)	3826 (20)
35–64	284 (48)	796 (49)	119 (39)	7958 (43)
65+	130 (22)	470 (29)	49 (16)	6947 (37)
Sex				
Male	281 (48)	973 (60)	145 (48)	11102 (59)
Female	307 (52)	648 (40)	158 (52)	7629 (41)
Other/Missing	<10	<10	<10	<10
Race/Ethnicity				
Asian and Pacific Islander	116 (20)	455 (28)	61 (20)	4590 (25)
Black or African American	56 (10)	160 (10)	13 (4)	1978 (11)
Latine	145 (25)	197 (12)	39 (13)	1879 (10)
Other/Multi-Race/Ethnicity	45 (8)	30 (2)	<10	339 (2)
Unknown/Declined	21 (4)	135 (8)	26 (9)	1622 (9)
White	205 (35)	644 (40)	160 (53)	8323 (44)
Preferred Language				
Chinese	12 (2)	121 (8)	16 (5)	1773 (10)
English	511 (87)	1388 (86)	275 (91)	15499 (83)
Other	20 (3)	75 (5)	<10	889 (5)
Spanish	45 (8)	34 (2)	<10	525 (3)
Unknown	<10	<10	<10	45 (0)
Insurance Type				
Commercial	325 (55)	701 (43)	191 (63)	6437 (34)
Public	226 (38)	863 (53)	101 (33)	11628 (62)
Patient Pay/Uninsured	33 (6)	46 (3)	10 (3)	558 (3)
Other/Unknown	<10	11 (0.7)	<10	108 (1)
Homeless/Marginally Housed	14 (2)	17(1)	<10	638 (3)
Patient clinical characteristics				
Obesity	50 (9)	96 (6)	<10	1641 (9)
Charlson co-morbidity index				
0	388 (66)	905 (56)	251 (83)	7542 (40)
1	72 (12)	258 (16)	19 (6)	3064 (16)
2+	128 (22)	458 (28)	33 (11)	8125 (43)
Panel B. Public Healthcare System				

	Diagnosed COVID-19 No. (%)	Diagnosed influenza No. (%)	Diagnosed appendicitis No. (%)	All-cause hospitalization No. (%)
Total	2601	1932	375	18169
Age				
18–34	855 (33)	479 (25)	185 (49)	4312 (24)
35–64	1492 (57)	1039 (54)	163 (44)	8884 (49)
65+	253 (10)	414 (21)	27 (7)	4973 (27)
Missing	<10	<10	<10	<10
Sex				
Male	1492 (57)	956 (50)	147 (39)	8520 (47)
Female	1100 (42)	976 (51)	228 (61)	9649 (53)
Other/Missing	<10	<10	<10	<10
Race/Ethnicity				
Asian and Pacific Islander	169 (6)	357 (19)	71 (19)	3471 (19)
Black or African American	187 (7)	303 (16)	16 (4)	3416 (19)
Latine	1821 (70)	816 (42)	201 (54)	5515 (30)
Other/Multi-Race/Ethnicity	119 (5)	110 (6)	21 (6)	931 (5)
White	166 (6)	318 (17)	65 (17)	4516 (25)
Unknown/Declined	139 (5)	28 (1)	<10	320 (2)
Preferred Language				
Chinese	32 (1)	14 (1)	28 (8)	1444 (8)
English	896 (34)	1126 (58)	197 (53)	12576 (69)
Other	54 (2)	212 (11)	12 (3)	611 (3)
Spanish	1604 (62)	563 (29)	137 (37)	3184 (18)
Unknown	15 (1)	17 (1)	<10	354 (1)
Insurance Type				
Commercial	65 (2)	86 (5)	41 (11)	1140 (6)
Public	1518 (58)	1463 (76)	280 (75)	14202 (78)
Patient Pay/Uninsured	100 (4)	353 (18)	44 (12)	2088 (12)
Other/Unknown	918 (35)	30 (2)	10 (3)	739 (4)
Homeless/Marginally Housed	203 (8)	211 (11)	17 (5)	3161 (17)
Patient clinical characteristics				
Obesity	96 (4)	88 (5)	15 (4)	1350 (7)
Charlson co-morbidity index				
0	2056 (79)	1487 (77)	320 (85)	7917 (44)
1	247 (9)	182 (9)	29 (8)	3439 (19)
2+	298 (11)	263 (14)	26 (7)	6813 (38)
Panel C. Community Healthcare System				
	Diagnosed COVID-19 No. (%)	**Diagnosed influenza No. (%)**	**Diagnosed appendicitis No. (%)**	**All-cause hospitalization No. (%)**
Total	745	2379	557	25807

Age				
18–34	153 (21)	565 (24)	208 (37)	5267 (20)
35–64	380 (51)	1065 (45)	267 (48)	9430 (37)
65+	212 (28)	749 (31)	82 (15)	11110 (43)
Sex				
Male	361 (48)	1032 (43)	301 (54)	9383 (36)
Female	384 (52)	1347 (57)	256 (46)	16420 (64)
Other/Missing	<10	<10	<10	<10
Race/Ethnicity				
Asian and Pacific Islander	121 (16)	549 (23)	110 (20)	8092 (31)
Black or African American	65 (9)	239 (10)	21 (4)	2259 (9)
Latine	265 (36)	355 (15)	60 (11)	2967 (11)
Other/Multi-Race/Ethnicity	<10	30 (1)	<10	290 (1)
White	246 (33)	1025 (43)	326 (59)	11151 (43)
Unknown/Declined	44 (6)	181 (8)	36 (6)	1048 (4)
Preferred Language				
Chinese	29 (4)	137 (6)	30 (5)	3571 (14)
English	530 (71)	1979 (83)	487 (87)	19267 (75)
Other	28 (4)	99 (4)	15 (3)	1471 (6)
Spanish	153 (21)	142 (6)	25 (4)	1341 (5)
Unknown	<10	22 (1)	<10	157 (1)
Insurance Type				
Commercial	279 (37)	1031 (43)	384 (69)	9376 (36)
Public	340 (46)	1045 (44)	151 (27)	15588 (60)
Self-pay/Unknown/Other	126 (17)	303 (13)	22 (4)	843 (3)
Homeless/Marginally Housed	<10	11 (0)	<10	479 (2)
Patient clinical characteristics				
Obesity	157 (35)	212 (9)	45 (8)	2964 (12)
Charlson co-morbidity index				
0	458 (61)	1361 (57)	420 (75)	10743 (42)
1	94 (13)	383 (16)	74 (13)	3913 (15)
2+	193 (26)	635 (27)	63 (11)	11151 (43)

Note: Diagnosed COVID group from 03/2020 to 08/2020, all other comparison groups from 08/2017 to 03/2020. Based on EMR data from a San Francisco university healthcare system. COVID-19 and influenza cohorts based on testing positive, a diagnosis, and/or presence of an infection flag.

Note: COVID comparison group from 03/2020 to 08/2020, all other comparison groups from 08/2017 to 03/2020. Based on EMR data from a San Francisco public healthcare system. COVID-19 and influenza cohorts based on testing positive and/or a diagnosis.

Note: Diagnosed COVID group from 03/2020 to 08/2020, all other comparison groups from 08/2017 to 03/2020. Based on EMR data from a San Francisco community healthcare system. COVID-19 and influenza cohorts based on testing positive and/or a diagnosis.

Table 2.

Association between patient characteristics and hospitalization among patients diagnosed with COVID-19, by healthcare system

	University Healthcare System		Public Healthcare System		Community Healthcare System	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Age group (ref 18–34)						
35–64	2.56 (1.27, 5.17)	<.01	2.51 (1.71, 3.68)	<.0001	2.57 (1.2, 6.11)	0.02
65+	3.48 (1.58, 7.66)	<.01	4.48 (2.71, 7.39)	<.0001	7.31 (3.16, 18.5)	<.0001
Male sex	2.78 (1.69, 4.58)	<.0001	1.88 (1.41, 2.5)	<.0001	1.61 (1.04, 2.53)	0.03
Race/ethnicity (ref White)						
Asian and Pacific Islander	2.36 (1.16, 4.82)	0.02	1.36 (0.63, 2.94)	0.43	1.46 (0.63, 3.26)	0.36
Black/African American	1.48 (0.65, 3.38)	0.35	1.00 (0.51, 1.95)	0.99	1.86 (0.84, 4.05)	0.12
Latine	1.34 (0.62, 2.86)	0.46	1.4 (0.75, 2.6)	0.29	3.78 (1.95, 7.42)	<.0001
Other/Unknown	1.81 (0.74, 4.44)	0.19	0.32 (0.12, 0.85)	0.02	0.74 (0.21, 2.23)	0.61
Language (ref English)						
Chinese	1.4 (0.34, 5.83)	0.64	0.98 (0.31, 3.1)	0.97	1.84 (0.61, 5.63)	0.28
Spanish	3.58 (1.51, 8.49)	<.01	1.05 (0.7, 1.6)	0.80	1.00 (0.52, 1.94)	0.99
Insurance (ref commercial)						
Public	2.1 (1.27, 3.49)	<.01	0.96 (0.42, 2.19)	0.92	1.17 (0.66, 2.07)	0.60
Other/Unknown	0.21 (0.03, 1.62)	0.13	0.62 (0.27, 1.46)	0.27	1.59 (0.77, 3.26)	0.21
CCI (ref 0)						
1	1.74 (0.86, 3.52)	0.12	2.35 (1.62, 3.4)	<.0001	7.77 (4.27, 14.33)	<.0001
2+	2.49 (1.41, 4.37)	<.01	2.47 (1.74, 3.51)	<.0001	6.66 (3.94, 11.48)	<.0001
Obesity	1.25 (0.6, 2.63)	0.55	1.01 (0.53, 1.91)	0.98	1.66 (1.01, 2.71)	0.04

Note: COVID-19 cohort based on positive test, infection flag, and/or presence of diagnosis code. Multivariable logistic regression models included all covariates listed in Table 1 above. CI: confidence interval, CCI: Charlson comorbidity index, OR: odds ratio.

Table 3.

Association between patient characteristics and hospitalization among patients diagnosed with influenza, by healthcare system

	University Healthcare System		Public Healthcare System		Community Healthcare System	
	OR (95% CI)	**p-value**	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Age group (ref 18–34)						
35–64	1.59 (0.95, 2.66)	0.08	2.4 (1.59, 3.62)	<.0001	2.49 (1.38, 4.84)	<.01
65+	1.81 (1.05, 3.11)	0.03	4.13 (2.59, 6.6)	<.0001	5.40 (2.92, 10.71)	<.0001
Male sex	1.27 (0.94, 1.74)	0.12	1.38 (1.05, 1.81)	0.02	1.09 (0.83, 1.44)	0.53
Race/ethnicity (ref White)						
Asian and Pacific Islander	0.45 (0.27, 0.73)	<.01	0.69 (0.42, 1.13)	0.14	0.78 (0.5, 1.22)	0.28
Black/African American	1.37 (0.86, 2.19)	0.19	1.36 (0.93, 1.99)	0.11	1.36 (0.89, 2.07)	0.16
Latine	0.64 (0.35, 1.17)	0.15	0.67 (0.43, 1.04)	0.07	0.82 (0.46, 1.42)	0.50
Other/Unknown	0.45 (0.23, 0.86)	0.02	0.6 (0.33, 1.1)	0.10	1.38 (0.71, 2.59)	0.33
Language (ref English)						
Chinese	6.44 (3.62, 11.44)	<.0001	0.3 (0.04, 2.41)	0.25	3.50 (2.01, 6.16)	<.0001
Spanish	2.16 (0.84, 5.56)	0.11	0.82 (0.54, 1.25)	0.35	1.03 (0.51, 2.09)	0.94
Insurance (ref commercial)						
Public	4.71 (3, 7.38)	<.0001	0.75 (0.41, 1.39)	0.36	2.83 (1.91, 4.25)	<.0001
Other/Unknown	2.28 (0.81, 6.41)	0.12	0.60 (0.31, 1.19)	0.14	0.23 (0.08, 0.55)	<.01
CCI (ref 0)						
1	1.87 (1.2, 2.93)	<.01	2.91 (1.98, 4.28)	<.0001	2.56 (1.70, 3.85)	<.0001
2+	3.34 (2.32, 4.81)	<.0001	3.09 (2.24, 4.26)	<.0001	6.51 (4.57, 9.38)	<.0001
Obesity	0.96 (0.54, 1.7)	0.89	1.28 (0.74, 2.22)	0.39	2.18 (1.47, 3.24)	<.01

Note: Influenza cohort based on positive test and/or presence of diagnosis codes. Multivariable logistic regression models included all covariates listed in Table 1 above. CI: confidence interval, CCI: Charlson comorbidity index, OR: odds ratio.