

# **Risk Factors for COVID-19-associated hospitalization: COVID-19-Associated Hospitalization**

## **Surveillance Network and Behavioral Risk Factor Surveillance System**

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**Summary:** Severe obesity, chronic kidney disease, diabetes, obesity, hypertension, asthma, age  $\geq 45$ , male sex, and non-Hispanic black and other race/ethnicity are associated with increased risk of COVID-19-associated hospitalizations.

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## **ABSTRACT**

**Background:** Data on risk factors for COVID-19-associated hospitalization are needed to guide prevention efforts and clinical care. We sought to identify factors independently associated with COVID-19-associated hospitalizations.

**Methods:** U.S. community-dwelling adults ( $\geq 18$  years) hospitalized with laboratory-confirmed COVID-19 during March 1–June 23, 2020 were identified from the COVID-19-Associated Hospitalization Surveillance Network (COVID-NET), a multi-state surveillance system. To calculate hospitalization rates by age, sex, and race/ethnicity strata, COVID-NET data served as the numerator and Behavioral Risk Factor Surveillance System estimates served as the population denominator for characteristics of interest. Underlying medical conditions examined included hypertension, coronary artery disease, history of stroke, diabetes, obesity [BMI  $\geq 30$  kg/m<sup>2</sup>], severe obesity [BMI  $\geq 40$  kg/m<sup>2</sup>], chronic kidney disease, asthma, and chronic obstructive pulmonary disease. Generalized Poisson regression models were used to calculate adjusted rate ratios (aRR) for hospitalization.

**Results:** Among 5,416 adults, hospitalization rates were higher among those with  $\geq 3$  underlying conditions (versus without) (aRR: 5.0; 95% CI: 3.9, 6.3), severe obesity (aRR: 4.4; 95% CI: 3.4, 5.7), chronic kidney disease (aRR: 4.0; 95% CI: 3.0, 5.2), diabetes (aRR: 3.2; 95% CI: 2.5, 4.1), obesity (aRR: 2.9; 95% CI: 2.3, 3.5), hypertension (aRR: 2.8; 95% CI: 2.3, 3.4), and asthma (aRR: 1.4; 95% CI: 1.1, 1.7), after adjusting for age, sex, and race/ethnicity. Adjusting for the presence of an individual underlying medical condition, higher

hospitalization rates were observed for adults aged  $\geq 65$ , 45-64 (versus 18-44 years), males (versus females), and non-Hispanic black and other race/ethnicities (versus non-Hispanic whites).

**Conclusion:** Our findings elucidate groups with higher hospitalization risk that may benefit from targeted preventive and therapeutic interventions.

**Keywords:** COVID-19; risk factors; hospitalization; epidemiology; surveillance

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## INTRODUCTION

As of June 26, 2020, >9 million cases of Coronavirus Disease 2019 (COVID-19), the disease caused by SARS-CoV-2, have been reported worldwide (1); over 2 million cases, including >120,000 deaths, have been reported in the United States (2). Older age and underlying medical conditions are prevalent among cases (3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13). Preliminary estimates indicate approximately 30% of U.S. laboratory-confirmed COVID-19 cases were among adults aged  $\geq 65$  years (7, 8), and about one third had underlying medical conditions (9). Among U.S. hospitalized cases, diabetes mellitus (8, 9, 10, 11, 12, 13, 14), hypertension (10, 11, 12, 13, 14), cardiovascular disease (8, 9, 10, 14) obesity (10, 11, 13, 14), and chronic lung disease (8, 9, 10) were common. However, the risk of hospitalization imparted by underlying medical conditions is not clear; many of these conditions (e.g., obesity (15), hypertension (16), and diabetes (17)) are also prevalent in the general U.S. population.

Similarly, the risk of hospitalization related to sex and race/ethnicity is unclear. An estimated 60% of New York patients hospitalized for COVID-19 were male (11); however, other studies have found the male-female distribution among COVID-19 hospitalizations was similar to the general U.S. population (50%) (10,18). Non-Hispanic black adults comprised a greater proportion of hospitalized COVID-19 cases compared to the community population in 14 states (10) and to overall hospitalizations in Georgia (18).

To better understand the independent association of age, sex, race/ethnicity, and underlying medical conditions with COVID-19-associated hospitalization relative to the non-hospitalized community-dwelling population, we calculated rate ratios for adults with and without select underlying medical conditions, adjusted for age, sex, and race/ethnicity, using data from the Coronavirus Disease 2019-Associated Hospitalization Surveillance Network

(COVID-NET) and the Behavioral Risk Factor Surveillance System (BRFSS), two large multi-state surveillance systems.

## **METHODS**

### **COVID-19-associated hospitalization surveillance**

COVID-NET is an all age population-based surveillance system of laboratory-confirmed COVID-19-associated hospitalizations (10, 19). Patients must have a positive SARS-CoV-2 test no more than 14 days before admission or during hospitalization; be a resident of the pre-identified surveillance catchment area; and be admitted to a hospital where residents of the surveillance catchment area receive care. Trained surveillance officers use a standard case report form to abstract additional data, such as patient demographics, underlying medical conditions, clinical course, and outcomes data, from medical charts. Community-dwelling adults ( $\geq 18$  years) were identified from 70 counties in 12 states (California, Colorado, Connecticut, Georgia, Maryland, Michigan, Minnesota, New Mexico, New York, Oregon, Tennessee, and Utah) participating in COVID-NET; herein referred to as the COVID-NET catchment area. As of June 23, 2020, 5,715 adult COVID-19-associated hospitalizations were eligible for inclusion in our analysis; 5,416 adults had underlying medical condition data and were included as hospitalized cases for this study (Figure 1).

### **Denominator Estimation**

The BRFSS is a nationwide cross-sectional telephone survey that collects state-based data on health-related risk behaviors, chronic health conditions, and use of preventive services from more than 400,000 community-dwelling adults ( $\geq 18$  years) annually (20). BRFSS data were used to calculate weighted population estimates of community-dwelling adults with and without individual underlying medical conditions by age, sex, and race/ethnicity strata for the COVID-NET catchment area and served as the analytic

denominators. Responses from adults residing in the COVID-NET catchment area were weighted using the BRFSS iterative proportional fitting method, which incorporates a number of factors to improve the degree and extent to which the weighted BRFSS sample reflects the sociodemographic make-up of the COVID-NET catchment area (20). Weights also account for survey design, probability of selection, nonresponse bias, and non-coverage error (20).

### **Variable definitions**

In COVID-NET, underlying medical conditions were ascertained if the condition (hypertension; history of myocardial infarction, coronary artery disease, coronary artery bypass grafting; stroke; diabetes mellitus; chronic kidney disease; asthma; chronic obstructive pulmonary disease [COPD]) was present in the patient's medical chart that detailed their COVID-19-associated hospitalization. In BRFSS, underlying medical conditions were based on self-report to the question: "Has a doctor, nurse, or other health professional ever told you that you had..." (high blood pressure; heart attack also called myocardial infarction, angina or coronary heart disease; stroke; diabetes, chronic kidney disease; asthma; COPD, emphysema, or chronic bronchitis). For BRFSS, 2018 data was used for each underlying medical condition except for hypertension, where 2017 was the most recent year of available data.

Histories of myocardial infarction, coronary artery disease, and coronary artery bypass grafting (only available in COVID-NET) were categorized as coronary artery disease. In BRFSS, adults who self-reported having high blood pressure and answered "yes" to the subsequent question "are you currently taking medication for your high blood pressure?" were categorized as having hypertension.

In COVID-NET, body mass index (BMI) was calculated using height and weight listed in medical charts; if these data were not available, recorded BMI was used. In BRFSS, self-

reported height and weight were used to calculate BMI. BMI was categorized as obese ( $\geq 30$  kg/m<sup>2</sup>) or severely obese ( $\geq 40$  kg/m<sup>2</sup>).

For both COVID-NET and BRFSS data, we created an “any condition” variable and “number of conditions” variable (0; 1; 2; 3+). Hypertension was not included in the “any condition” or “number of conditions” variables because COVID-NET catchment estimates for hypertension were derived from 2017 BRFSS estimates and could not be integrated with the other 2018 estimates of underlying medical conditions. Although hypertension is not included in these composite variables, in 2017, 14% of adults with treated hypertension also had at least one other underlying medical condition examined in this analysis. Additional details are available in Supplemental Table 1. The following categories were defined for age (18-44; 45-64;  $\geq 65$  years), sex (male; female), and race/ethnicity (non-Hispanic white; non-Hispanic black; other). Other race/ethnicity groups were aggregated due to small cell sizes once these data were stratified by age, sex and underlying medical conditions.

### **Statistical analysis**

Demographic characteristics were tabulated among hospitalized COVID-19 cases overall and by underlying medical condition. The percentage of adults with select underlying medical conditions was calculated among COVID-19-associated hospitalizations and residents of the COVID-NET catchment area. To understand if the prevalence of underlying medical conditions in the COVID-NET catchment area was different from national estimates, nationwide BRFSS weighted data were compared to estimates obtained for the COVID-NET catchment area.

Hospitalization rates by underlying medical condition and age, sex, race/ethnicity strata were calculated. For each rate, the numerator was the number of hospitalized adults from COVID-NET in the strata of interest; the denominator was the estimated number of adults from the community in the strata of interest, derived from BRFSS data for the COVID-



NET catchment area. Generalized Poisson regression models with a scaled deviance term to account for overdispersion were used to calculate unadjusted and adjusted rate ratios and 95% confidence intervals (CIs) associated with hospitalization. Multivariable models included an individual underlying medical condition, age, sex, and race/ethnicity. Model goodness of fit was assessed by evaluating standardized deviance residual plots. Rate ratios with 95% CIs that excluded 1 were considered statistically significant. We also assessed the prevalence of co-occurring conditions in hospitalized cases (Supplemental Table 2); however, due to the analytic design of this study and small cell counts of BRFSS estimates from the COVID-NET catchment area, we were unable to account for combinations of underlying medical conditions in our adjusted models. SAS v.9.4 (SAS Institute, Cary, NC) was used for analyses.

No personal identifiers were included in either COVID-NET or BRFSS data submitted to CDC. This analysis was exempt from CDC's Institutional Review Board, as it was considered part of public health surveillance and emergency response. Participating sites obtained approval for COVID-NET surveillance from their respective state and local IRBs, as required.

## **RESULTS**

Of 5,416 community-dwelling adults with COVID-19-associated hospitalization, 30% were aged 18-44 years, 40% were aged 45-64 years and 31% were aged 65+ years; 53% were male; 34% were non-Hispanic White, 32% were non-Hispanic Black and 34% were of other races/ethnicities (Table 1). Overall, 55% had obesity, 49% had hypertension, 33% had diabetes, 16% had severe obesity, 13% had asthma, 12% had chronic kidney disease, 9% had a history of coronary artery disease, 6% had COPD, and 4% had a history of stroke.

Excluding hypertension, 73% of hospitalized cases had at least one underlying medical

condition. Co-occurring underlying medical conditions were common among hospitalized cases (Supplemental Table 2).

Among hospitalized cases, the prevalence of underlying medical conditions was greatest among adults aged 65+ years except for obesity, severe obesity, and asthma (Table 1). The prevalence of obesity (63%) and severe obesity (25%) was greatest among adults aged 18-44 years. Males and females had similar prevalences of history of stroke, diabetes, and COPD. The prevalence of underlying medical conditions was highest among non-Hispanic black adults, except for coronary artery disease and COPD.

The overall prevalence of selected underlying medical conditions was greater among hospitalized cases compared to the COVID-NET catchment area population (Figure 2). COVID-NET catchment area estimates were similar or slightly lower than nationwide estimates: hypertension (21% vs. 25%), coronary artery disease (5% vs. 7%), history of stroke (3% vs. 3%), diabetes (9% vs. 11%), obesity (28% vs. 31%), severe obesity (4% vs. 5%), chronic kidney disease (2% vs. 3%), asthma (10% vs. 9%), and COPD (5% vs. 7%).

Unadjusted rate ratios for COVID-19-associated hospitalizations of adults 45-64 years of age and 65 years and older, versus 18-44 years, were 2.0 (95%CI: 1.8, 2.1) and 2.7 (95%CI: 2.5, 2.9), respectively (Table 2). The unadjusted rate ratio for hospitalization comparing males to females was 1.2 (95%CI: 1.1, 1.3) and for non-Hispanic black to non-Hispanic white adults was 3.9 (95%CI: 3.7, 4.2). Adults with, versus without, specified underlying medical conditions had higher hospitalization rates; unadjusted rate ratios ranged from 1.2 (95%CI: 0.4, 3.8) for COPD to 5.3 (95%CI: 2.4, 12.1) for chronic kidney disease.

The rate ratios for most underlying medical conditions attenuated after adjustment for age, sex, and race/ethnicity; rate ratios for severe obesity and asthma remained stable (Table 2). The adjusted rate ratios (aRR) for hospitalization by underlying medical condition were as follows: severe obesity (aRR:4.4; 95%CI: 3.4, 5.7), chronic kidney disease (aRR:4.0; 95%CI:

3.0, 5.2), diabetes (aRR:3.2; 95%CI: 2.5, 4.1), obesity (aRR:2.9; 95%CI: 2.3, 3.5), hypertension (aRR:2.8; 95%CI: 2.3, 3.4), asthma (aRR:1.4; 95%CI: 1.1, 1.7), coronary artery disease (aRR:1.3; 95%CI:0.99, 1.8), COPD (aRR: 0.9; 95%CI: 0.7, 1.4), and history of stroke (aRR: 0.9; 95%CI: 0.6, 1.4) (Table 2; Figure 3).

Across individual underlying medical condition models, adjusted rate ratios for hospitalization were significantly higher for adults  $\geq 65$  years and 45-64 years (versus 18-44 years), males (versus females), and non-Hispanic black and other race/ethnicities (versus non-Hispanic whites) (Table 2). For example, in the severe obesity model, adults  $\geq 65$  years (aRR: 4.6; 95%CI: 3.6, 5.9), 45-64 years (aRR: 2.7; 95%CI 2.1, 3.4) versus 18-44 years; males versus females (aRR: 1.4; 95%CI: 1.1, 1.7); and non-Hispanic blacks (aRR: 4.7; 95%CI: 3.8, 5.9) and other race/ethnicities (aRR: 3.5; 95%: 2.8, 4.3) versus non-Hispanic whites had higher hospitalization rates. These associations were similar in models adjusting for any condition (Table 2).

In a separate model, after adjustment for age, sex, and race/ethnicity, rate ratios for hospitalization increased with the number of underlying conditions, with the greatest rate ratio for adults with 3+ conditions (aRR: 5.0; 95%CI:3.9, 6.3) compared to those with no underlying conditions (Table 3).

## DISCUSSION

In this study utilizing two large multi-state surveillance systems to compare hospitalized cases with the community at risk, we found that increasing age, male sex, non-Hispanic black race/ethnicity, and select underlying medical conditions were associated with a significantly greater risk for COVID-19-associated hospitalization relative to the non-hospitalized community-dwelling adult population. Among the underlying medical conditions studied, the magnitude of risk was greatest for severe obesity, chronic kidney

disease, diabetes, obesity, and hypertension; each of these conditions was independently associated with approximately 3 or more times the risk of hospitalization after accounting for age, sex, and race/ethnicity. Our study extends the literature by quantifying the independent association of underlying medical conditions with hospitalization relative to the community population at risk.

The magnitude of risk for COVID-19-associated hospitalization was lower for coronary artery disease, stroke, asthma, and COPD than for other medical conditions (e.g., hypertension) in our analysis. Our prevalence estimates of asthma and/or COPD (18%) was similar to a study among adults who tested positive for SARS-CoV-2 (15%), which found that asthma or COPD was not independently associated with risk for hospitalization (21). However, among hospitalized patients, coronary artery disease and COPD have both been found to be associated with intensive care unit admission, need for mechanical ventilation (22, 23) and mortality (22, 23, 24).

Several hypotheses are under evaluation regarding the linkage between specific underlying conditions and COVID-19. Obesity might predispose persons to severe COVID-19 due to inflammation, altered physiology, and immune dysfunction (25). Diabetes mellitus also imparts a chronic low-grade inflammatory state (26) and predisposes persons to infections in general (27). Impaired T-cell function and increased interleukin-6 are specific factors that increase risk and severity of SARS-CoV-2 infection among persons with diabetes (27). Finally, the interaction of SARS-CoV-2 and the renin-angiotensin aldosterone system might contribute to the overrepresentation of hypertension among severe COVID-19 patients (28).

We found that ages 45-64 years and 65+ years were independently associated with increased risk of hospitalization compared to ages 18-44 years after accounting for underlying medical conditions, sex, and race/ethnicity. Further, the magnitude of risk for

hospitalization was greatest among adults 65 years and older, similar to other studies (21, 29). It is important to note that the additional risk of age groups >45 years is relative to a younger adult age group (18-44 years) and should not be interpreted as absolute risk.

Males were 30% more likely to be hospitalized than females after accounting for age, race/ethnicity, and underlying medical conditions, similar to another study (21). Non-biological factors may lead to a greater proportion of males being hospitalized (e.g., increased exposure or delays in care seeking). Biological factors could include immune function suppression by testosterone compared to estrogen (30) or lower expression of angiotensin-converting enzyme 2, a receptor that allows entry of SARS-CoV-2 into host cells, due to estrogen, potentially inhibiting severe clinical progression in females compared to males (31).

Over-representation of non-Hispanic black adults among hospitalized COVID-19 patients has been hypothesized to be due, in part, to the higher prevalence of underlying medical conditions (10, 29) such as hypertension, obesity, diabetes, and chronic kidney disease among the non-Hispanic black population (15, 16, 17, 32). While these conditions contributed to the total risk, we found that after accounting for underlying medical conditions, age, and sex, non-Hispanic black adults had four times greater risk of hospitalization than non-Hispanic white adults. Additionally, the magnitude of risk was similar across underlying medical conditions (aRR range: 4.0 to 4.7), suggesting that non-Hispanic black adults experience excess risk regardless of select underlying medical conditions. This association was also observed when controlling for the presence of any condition or the number of conditions. Black race was similarly associated with 3 times the risk of hospitalization in an Atlanta-based study (33). It has been suggested that non-Hispanic black adults might have increased risk of hospitalization due to increased exposures (e.g., related to occupation or housing) that could lead to increased incidence or more severe illness; differences in health care access or utilization; or systemic social inequities, including

racism and discrimination (34, 35, 36). However, we were unable to assess these factors with our data. These factors may also explain similar findings of increased risk for hospitalization among other race/ethnicities compared with non-Hispanic White persons.

Overall, these results have implications for clinical practice, as they identify high-risk patients who require closer monitoring and management of their chronic conditions during the ongoing COVID-19 pandemic. While specific underlying medical conditions imparted higher risk of hospitalization, we were unable to account for the duration of each condition or the degree to which each condition was controlled (e.g., glycemic control in diabetic patients). Nevertheless, clinicians might prioritize more aggressive control of underlying conditions with available treatments and encourage their patients to remain engaged in care for management of their chronic conditions while practicing preventive measures, such as wearing a cloth face covering and social distancing. These groups may also benefit from targeted preventative and therapeutic interventions.

### **Limitations**

This study had several limitations. First, this analysis was based on clinical data available as of June 23, 2020 from COVID-NET, a surveillance system designed first to provide hospitalization rates. Clinical data on underlying medical conditions was reliant on medical chart abstraction; charts from approximately 60% of the total hospitalized cases have yet to be abstracted. Thus, included cases represent a convenience sample of hospitalizations with underlying medical conditions, which may have resulted in biased estimates of risk. However, bi-weekly updates of this analysis over a 2-month period with the most recently available COVID-NET data (i.e., additional chart abstractions) suggested consistent estimates of the frequency and distribution of underlying conditions and resulting rate ratios. Second, this analysis did not include institutionalized adults. Third, estimates of risk are restricted to the COVID-NET catchment area; the interpretation of rate ratios as risk in this analysis

assumes that risk of SARS-CoV-2 infection was consistent across all groups. Fourth, after stratification by age, race/ethnicity, sex, and underlying conditions, each strata from the COVID-NET catchment population became small. Thus, we were unable to assess the association of more granular race/ethnicity categories or co-occurring underlying health conditions on risk of COVID-19-associated hospitalization; further investigation on both aspects is important. Fifth, COVID-NET likely under-ascertains COVID-19 cases as testing for SARS-CoV-2 was performed at treating health care providers' discretion and was subject to clinician bias as well as variability in testing practices and capabilities across providers and facilities. However, this probably had minimal impact on our findings as hospitalized individuals are more likely to be tested than those in the community. Finally, we used BRFSS to obtain estimates for underlying medical conditions in the COVID-NET catchment area. As the ascertainment of underlying medical conditions was different across the two data systems (self-report vs. medical chart abstraction), we may have introduced bias in the rate ratio estimation. Self-reported diabetes (37) and hypertension (38) have high correlation with medical examination estimates. Self-report has been found to underestimate prevalence of chronic kidney disease (32) and obesity (38); thus, our rate ratios for these conditions may be overestimated.

## **CONCLUSION**

This analysis quantifies associations of age, sex, race/ethnicity, and underlying medical conditions with risk of COVID-19 hospitalization relative to the non-hospitalized community-dwelling population. These data may aid clinicians in identifying individuals at higher risk for hospitalization who may require more vigilant care and monitoring, and groups that may benefit from targeted preventive and therapeutic interventions.

## ACKNOWLEDGEMENTS

Erin Parker, Jeremy Roland, Gretchen Rothrock (California Emerging Infections Program); Isaac Armistead, Rachel Herlihy, Sarah McLafferty (Colorado Department of Public Health and Environment); Paula Clogher, Hazal Kayalioglu, Amber Maslar, Adam Misiorski, Linda Niccolai, Danyel Olson, Christina Parisi (Connecticut Emerging Infections Program, Yale School of Public Health); Emily Fawcett, Katelyn Lengacher, Jeremiah Williams (Emerging Infections Program, Georgia Department of Health, Veterans Affairs Medical Center, Foundation for Atlanta Veterans Education and Research); Jim Collins, Kimberly Fox, Sam Hawkins, Shannon Johnson, Libby Reeg, Val Tellez Nunez (Michigan Department of Health and Human Services); Erica Bye, Richard Danila, Nagi Salem (Minnesota Department of Health); Kathy Angeles, Lisa Butler, Cory Cline, Kristina G. Flores, Caroline Habrun, Emily B. Hancock, Sarah Khanlian, Meaghan Novi, Erin C. Phipps (New Mexico Emerging Infections Program); Alison Muse, Adam Rowe (New York State Department of Health); Sophrena Bushey, Maria Gaitan, RaeAnne Kurtz, Marissa Tracy (Rochester Emerging Infections Program, University of Rochester Medical Center); Ama Owusu-Dommey, Lindsey Snyder (Oregon Health Authority); Katherine Michaelis, Kylie Seeley (Oregon Health & Science University School of Medicine); Kathy Billings, Katie Dyer, Melinda Eady, Anise Elie, Gaily Hughett, Karen Leib, Tiffanie Markus, Terri McMinn, Danielle Ndi, Manideepthi Pemmaraju, John Ujwok (Vanderbilt University Medical Center); Ryan Chatelain, Andrea George, Keegan McCaffrey, Jacob Ortega, Andrea Price, Ilene Risk, Melanie Spencer, Ashley Swain (Salt Lake County Health Department); Rainy Henry, Sonja Nti-Berko, Bob Pinner, Alvin Shultz (Emerging Infections Program); Mimi Huynh, Monica Schroeder (Council for State and Territorial Epidemiologists); Junling Ren, Bill Bartoli, Liegi Hu (CDC Division of Population Health, Northrup Grumman); Gayle Langley, Melissa Rolfes, Carrie Reed (CDC)



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**Funding**

This work was supported by the Centers of Disease Control and Prevention through an Emerging Infections Program cooperative agreement (#CK17-1701) and through a Council of State and Territorial Epidemiologists cooperative agreement (#NU38OT000297-02-00).

**Potential conflicts:**

Additionally, E.Anderson reports consulting for AbbVie, Pfizer and clinical trials research funding from Pfizer, Merck, Micron, Paxvax, Sanofi Pasteur, Novavax, MedImmune, Regeneron, and Glaxo Smith Kline. R. Lynfield reports royalties from a book on infectious disease surveillance and compensation for AAP Red Book (Report from Committee on Infectious Disease) donated to Minnesota Dept of Health. W. Schaffner reports consulting with VBI Vaccines. H.K. Talbot reports serving on Seqirus' Data Safety Monitoring Board. N. Alden reports grants from CDC, outside the submitted work. All other authors have no potential conflicts.

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## FIGURE LEGENDS

Figure 1: Analytic Population Flow Diagram, Coronavirus Disease 2019-Associated Hospitalization Surveillance Network, March 1-June 23, 2020

Figure 2: Prevalence of Underlying Medical Conditions: Community Dwelling Adults with COVID-19-associated Hospitalizations, \* COVID-NET Catchment Population, † and Nationwide BRFSS Estimates‡

Figure 3: Adjusted\* Rate Ratios for COVID-19-Associated Hospitalization by Underlying Medical Condition, COVID-NET, March 1-June 23, 2020

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**Table 1: Prevalence of Specific Underlying Medical Conditions among Community Dwelling Adults with COVID-19-associated Hospitalizations by Age, Sex, and Race/Ethnicity, COVID-NET\* (N=5,416)**

	<b>Overall</b> N=5,416	<b>Age 18-44</b> n=1,601 (30%)	<b>Age 45-64</b> n=2,162 (40%)	<b>Age 65+</b> n=1,653 (31%)	<b>Males</b> n=2,847 (53%)	<b>Females</b> n=2,569 (47%)	<b>Non-Hispanic White</b> n=1,758 (34%)	<b>Non-Hispanic Black</b> n=1,663 (32%)	<b>Other Race/Ethnicity Groups†</b> n=1,798 (34%)
<b>Presence of Underlying Medical Condition‡</b>	<b>n(%)</b>	<b>n(%)</b>	<b>n(%)</b>	<b>n(%)</b>	<b>n(%)</b>	<b>n(%)</b>	<b>n(%)</b>	<b>n(%)</b>	<b>n(%)</b>
Hypertension	2,658 (49%)	272 (17%)	1,146 (53%)	1,240 (75%)	1,469 (52%)	1,189 (46%)	956 (55%)	1,026 (62%)	594 (33%)
Coronary Artery Disease	506 (9%)	11 (1%)	145 (7%)	350 (21%)	337 (12%)	169 (7%)	255 (15%)	155 (9%)	73 (4%)
History of Stroke	227 (4%)	12 (1%)	70 (3%)	145 (9%)	134 (5%)	93 (4%)	79 (5%)	99 (6%)	41 (2%)
Diabetes	1,793 (33%)	300 (19%)	798 (37%)	695 (42%)	984 (35%)	809 (32%)	528 (30%)	654 (39%)	548 (31%)
Obesity	2,674 (55%)	801 (63%)	1,238 (60%)	635 (41%)	1,315 (49%)	1,359 (62%)	879 (54%)	929 (60%)	785 (51%)
Severe Obesity	769 (16%)	312 (25%)	353 (17%)	104 (7%)	316 (12%)	453 (21%)	240 (15%)	329 (21%)	191 (12%)
Chronic Kidney Disease	640 (12%)	54 (3%)	201 (9%)	385 (23%)	387 (14%)	253 (10%)	206 (12%)	285 (17%)	125 (7%)
Asthma	702 (13%)	211 (13%)	295 (14%)	196 (12%)	243 (9%)	459 (18%)	236 (13%)	276 (17%)	171 (10%)



COPD	328 (6%)	---	§ 104 (5%)	219 (13%)	179 (6%)	149 (6%)	189 (11%)	102 (6%)	29 (2%)
Any Condition	3,938 (73%)	978 (61%)	1,660 (77%)	1,300 (79%)	2,071 (73%)	1,867 (73%)	1,302 (74%)	1,338 (80%)	1,168 (65%)

CVD: Cardiovascular Disease; COPD: Chronic obstructive pulmonary disease

\*COVID-NET: Coronavirus Disease 2019-Associated Hospitalization Surveillance Network (California, Colorado, Connecticut, Georgia, Maryland, Michigan, Minnesota, New Mexico, New York, Oregon, Tennessee, and Utah), March 1-June 23, 2020

†197 hospitalizations missing race/ethnicity information; Other race/ethnicity includes Alaskan Native/American Indian, Asian/Pacific Islander, Hispanic or Latino, multiple races

‡Variables with missing observations: Hypertension (n=8; 0.1%); Coronary Artery Disease (n=11; 0.2%), History of Stroke (n=11; 0.2%), Diabetes (n=14; 0.3%), Obesity (n=518; 10%), Severe Obesity (n=518; 10%), Chronic Kidney Disease (n=16; 0.3%), Asthma (n=12; 0.2%), COPD (n=12; 0.2%)

§ Data suppressed due to small cell sizes

||Any underlying medical condition excludes hypertension to align with 2018 BRFSS community estimates of underlying medical conditions; the most recent year of available BRFSS data for hypertension was 2017.

**Table 2. Unadjusted and Adjusted\* Rate Ratios for COVID-19-Associated Hospitalizations by Underlying Condition among Community Dwelling Adults, COVID-NET, March 1-June 23, 2020**

	Unadjusted RR (95% CI)	Adjusted Models* aRR (95%CI)									
		Hypertension	Coronary Artery Disease	History of Stroke	Diabetes	Obesity	Severe Obesity	Chronic Kidney Disease	Asthma	COPD	Any Condition
<b>Age 45-64 years†</b>	2.0 (1.8, 2.1)	1.6 (1.3, 1.9)	2.3 (1.9, 2.9)	2.4 (2.0, 2.9)	1.9 (1.4, 2.4)	2.5 (2.0, 3.3)	2.7 (2.1, 3.4)	2.2 (1.8, 2.7)	2.3 (2.0, 2.8)	2.4 (1.9, 2.9)	2.0 (1.6, 2.3)
<b>Age 65+ years†</b>	2.7 (2.5, 2.9)	2.2 (1.7, 2.7)	3.7 (2.9, 4.6)	3.8 (3.1, 4.7)	2.5 (1.9, 3.4)	4.5 (3.4, 5.9)	4.6 (3.6, 5.9)	3.4 (2.7, 4.2)	3.8 (3.1, 4.6)	3.8 (3.0, 4.8)	2.9 (2.4, 3.5)
<b>Male‡</b>	1.2 (1.1, 1.3)	1.2 (1.1, 1.4)	1.2 (1.03, 1.4)	1.2 (1.1, 1.4)	1.2 (0.98, 1.5)	1.4 (1.1, 1.7)	1.4 (1.1, 1.7)	1.2 (1.02, 1.4)	1.2 (1.1, 1.5)	1.2 (1.03, 1.5)	1.2 (1.1, 1.4)
<b>Non-Hispanic black §</b>	3.9 (3.7, 4.2)	4.0 (3.3, 4.8)	4.7 (3.8, 5.8)	4.7 (3.9, 5.7)	4.0 (3.1, 5.2)	4.4 (3.4, 5.7)	4.7 (3.8, 5.9)	4.5 (3.7, 5.6)	4.7 (3.9, 5.6)	4.7 (3.8, 5.9)	4.0 (3.4, 4.8)
<b>Other race/ethnicity §</b>	2.6 (2.4, 2.7)	3.5 (2.9, 4.2)	3.3 (2.7, 4.0)	3.3 (2.7, 4.0)	3.0 (2.3, 3.9)	3.5 (2.8, 4.5)	3.5 (2.8, 4.3)	3.3 (2.7, 4.1)	3.2 (2.7, 4.0)	3.3 (2.7, 4.1)	3.3 (2.8, 4.0)
<b>Hypertension</b>	3.6 (2.3, 5.8)	2.8 (2.3, 3.4)	-----	-----	-----	-----	-----	-----	-----	-----	-----
<b>Coronary Artery Disease</b>	1.9 (0.7, 4.7)	-----	1.3 (0.99, 1.8)	-----	-----	-----	-----	-----	-----	-----	-----
<b>History of Stroke</b>	1.6 (0.4, 6.1)	-----	-----	0.9 (0.6, 1.4)	-----	-----	-----	-----	-----	-----	-----
<b>Diabetes</b>	4.8 (2.9, 8.0)	-----	-----	-----	3.2 (2.5, 4.1)	-----	-----	-----	-----	-----	-----
<b>Obesity</b>	3.2 (1.8, 5.6)	-----	-----	-----	-----	2.9 (2.3, 3.5)	-----	-----	-----	-----	-----
<b>Severe obesity</b>	4.5 (2.0, 10.0)	-----	-----	-----	-----	-----	4.4 (3.4, 5.7)	-----	-----	-----	-----

<b>Chronic kidney disease</b>	5.3 (2.4, 12.1)	-----	-----	-----	-----	-----	-----	4.0 (3.0, 5.2)	-----	-----	-----
<b>Asthma</b>	1.4 (0.6, 3.1)	-----	-----	-----	-----	-----	-----	-----	1.4 (1.1, 1.7)	-----	-----
<b>COPD</b>	1.2 (0.4, 3.8)	-----	-----	-----	-----	-----	-----	-----	-----	0.9 (0.7, 1.4)	-----
<b>Any condition  </b>	3.9 (2.3, 6.7)	-----	-----	-----	-----	-----	-----	-----	-----	-----	3.2 (2.7, 3.8)

aRR: adjusted Rate Ratios; CI: Confidence Interval; COPD: chronic obstructive pulmonary disease; COVID-NET: Coronavirus Disease 2019-Associated Hospitalization Surveillance Network; RR: Rate Ratio

\*Each adjusted model for underlying medical condition includes the select underlying medical condition, age, sex, and race/ethnicity

†Reference group is 18-44 years

‡Reference group is female

§Reference group is non-Hispanic white

|| Any underlying medical condition excludes hypertension to align with 2018 BRFSS community estimates of underlying medical conditions; the most recent year of available BRFSS data for hypertension was 2017.

**Table 3. Unadjusted and Adjusted\* Rate Ratios for Number of Underlying Medical Conditions and Hospitalization for COVID-19, COVID-NET, March 1-June 23, 2020**

	Unadjusted Rate Ratio (95%CI)	Adjusted Rate Ratio* (95%CI)
Number of conditions†		
1	2.8 (2.7, 3.1)	2.5 (2.1, 3.0)
2	5.6 (5.2, 6.1)	4.5 (3.7, 5.5)
3+	7.2 (6.6, 7.9)	5.0 (3.9, 6.3)
Age 45-64 years‡	-----	1.8 (1.5, 2.2)
Age 65+ years‡	-----	2.6 (2.1, 3.1)
Male§	-----	1.2 (1.1, 1.4)
Non-Hispanic black	-----	3.9 (3.3, 4.7)
Other race/ethnicity	-----	3.3 (2.8, 3.9)

CI: Confidence Interval; COVID-NET: Coronavirus Disease 2019-Associated Hospitalization Surveillance Network

\*Model for number of conditions (variable) is adjusted for age, sex, and race/ethnicity

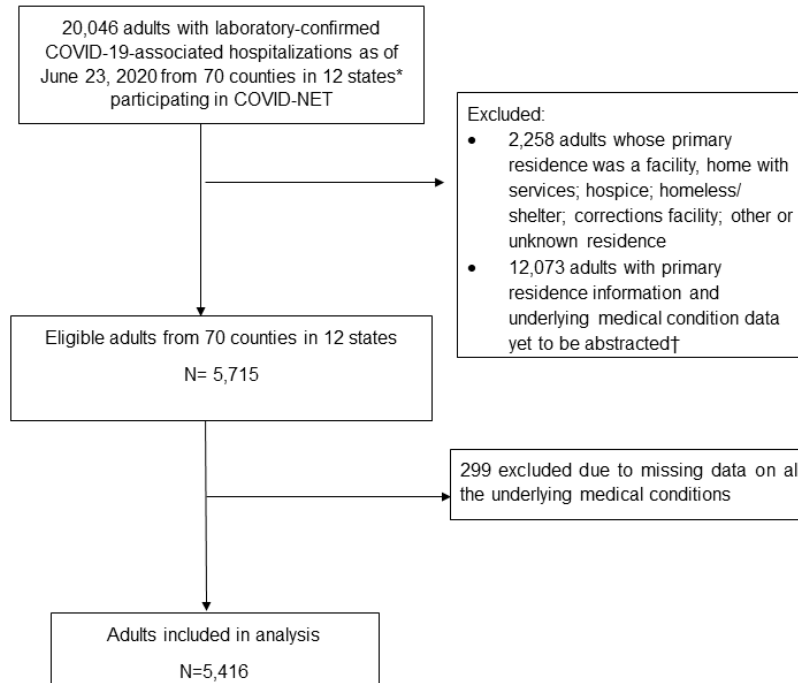
†Reference group is no underlying medical condition; Number of conditions is a sum of underlying medical conditions excluding hypertension; the most recent year of available BRFSS data for hypertension was 2017.

‡Reference group is 18-44 years

§Reference group is female

||Reference group is non-Hispanic white

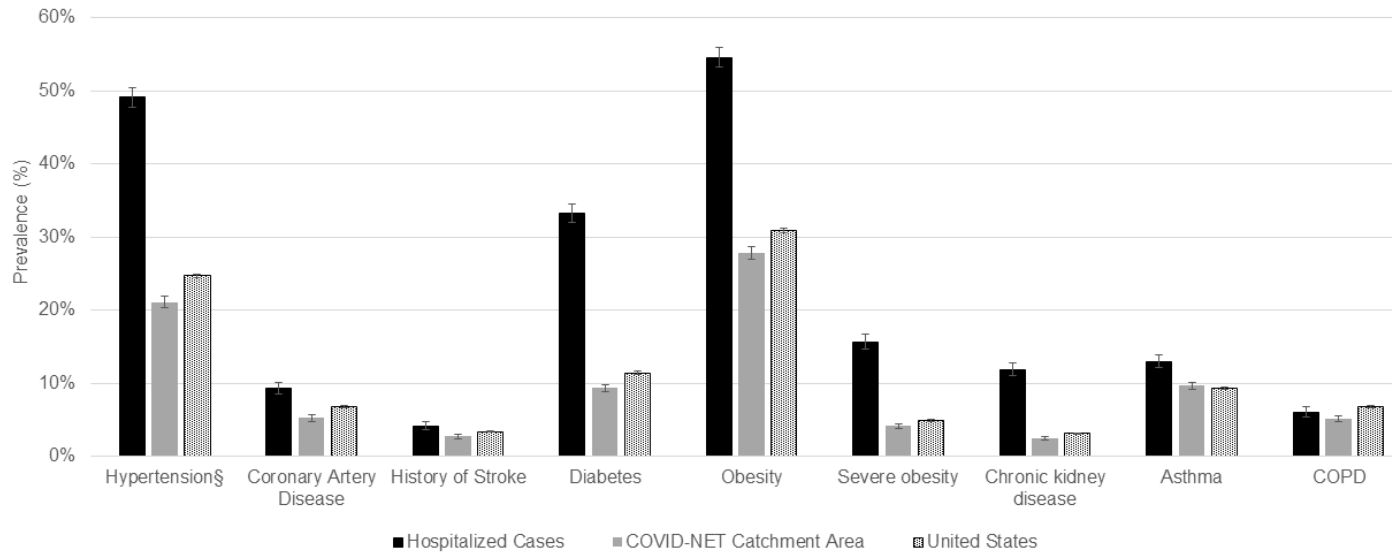
Figure 1



\*California, Colorado, Connecticut, Georgia, Maryland, Michigan, Minnesota, New Mexico, New York, Oregon, Tennessee, and Utah.

†Additional data beyond the minimum required data elements (Case Identification Number, state, case type [pediatric vs. adult], age, admission date, sex, and SARS-CoV-2 test result [test type, test date, test result]) to calculate age-stratified COVID-19-associated hospitalization rates may be subject to a time lag for submission to CDC.

Figure 2



COPD: Chronic obstructive pulmonary disease

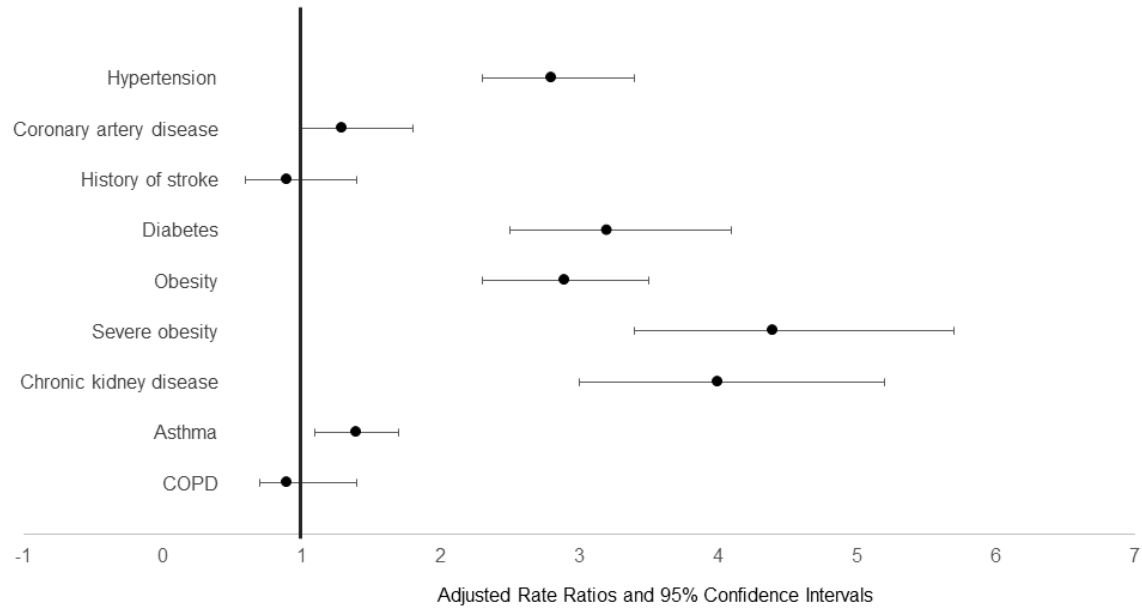
\*Prevalence of underlying medical conditions among community-dwelling hospitalized cases from COVID-NET: Coronavirus Disease 2019-Associated Hospitalization Surveillance Network (COVID-NET), March 1-June 23, 2020; error bars represent 95% confidence interval surrounding estimates

†Catchment population estimates from direct Behavioral Risk Factor Surveillance System estimates of underlying medical conditions aggregated from counties participating in COVID-NET, providing community level data on underlying health conditions, 2018; error bars represent 95% confidence interval surrounding estimates

‡Nationwide estimates from Behavioral Risk Factor Surveillance System (BRFSS), 2018; error bars represent 95% confidence interval surrounding estimates

§Estimates for hypertension from COVID-NET Catchment Area and Nationwide BRFSS estimates are from 2017, the latest year of available data.

Figure 3



COPD: Chronic obstructive pulmonary disease; COVID-NET: Coronavirus Disease 2019-Associated Hospitalization Surveillance Network  
\*Adjusted for age, sex, race/ethnicity; also shown in Table 2