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SARS-CoV-2 Infection Hospitalization Rate and Infection Fatality Rate Among the Non-Congregate Population in Connecticut

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ABSTRACT

BACKGROUND: Infection fatality rate and infection hospitalization rate, defined as the proportion of deaths and hospitalizations, respectively, of the total infected individuals, can estimate the actual toll of coronavirus disease 2019 (COVID-19) on a community, as the denominator is ideally based on a representative sample of a population, which captures the full spectrum of illness, including asymptomatic and untested individuals.

OBJECTIVE: To determine the COVID-19 infection hospitalization rate and infection fatality rate among the non-congregate population in Connecticut between March 1 and June 1, 2020.

METHODS: The infection hospitalization rate and infection fatality rate were calculated for adults residing in non-congregate settings in Connecticut prior to June 2020. Individuals with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) antibodies were estimated using the seroprevalence estimates from the recently conducted Post-Infection Prevalence study. Information on total hospitalizations and deaths was obtained from the Connecticut Hospital Association and the Connecticut Department of Public Health, respectively.

RESULTS: Prior to June 1, 2020, nearly 113,515 (90% confidence interval [CI] 56,758-170,273) individuals were estimated to have SARS-CoV-2 antibodies, and there were 7792 hospitalizations and 1079 deaths among the non-congregate population. The overall COVID-19 infection hospitalization rate and infection fatality rate were estimated to be 6.86% (90% CI, 4.58%-13.72%) and 0.95% (90% CI, 0.63%-1.90%), respectively, and there was variation in these rate estimates across subgroups; older people, men, non-Hispanic Black people, and those belonging to 2 of the counties had a higher burden of adverse outcomes, although the differences between most subgroups were not statistically significant.

CONCLUSIONS: Using representative seroprevalence estimates, the overall COVID-19 infection hospitalization rate and infection fatality rate were estimated to be 6.86% and 0.95%, respectively, among community residents in Connecticut.

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KEYWORDS: COVID-19; Infection fatality rate; Infection hospitalization rate; SARS-CoV-2; Seroprevalence

BACKGROUND

Accurate estimation of the hospitalization and fatality rate is important to guide public health strategies during infectious disease outbreaks. Although the case fatality rate, defined as the proportion of deaths of the confirmed cases, is a commonly used metric, it will be biased based on the availability of testing, especially early in the outbreak.[1] Moreover, because coronavirus disease 2019 (COVID-19) symptoms range widely, mild or asymptomatic infections may be untested. Thus, the number of infections confirmed by testing will underestimate the total infections, inflating the estimated fatality rate.

Infection fatality rate, defined as the proportion of deaths of the total number of infected individuals, can estimate the actual toll of the disease, as the denominator is ideally based on a representative sample of a population, which captures the full spectrum of illness, including asymptomatic and untested individuals. For hospitalizations, the infection hospitalization rate is a comparable measure. Accordingly, with support from the US Centers for Disease Control and Prevention through the Coronavirus Aid, Relief, and Economic Security (CARES) Act,[2] we conducted a statewide severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) seroprevalence study—the Post-Infection Prevalence study (PIP)—in Connecticut,[3] and assessed the SARS-CoV-2 infection hospitalization and fatality rates using the statewide all-payer databases and the statewide mortality data.

METHODS

Based on the PIP study,[3] the seroprevalence of SARS-CoV-2 antibodies was 4.0% (90% confidence interval [CI], 2.0%-6.0%) among a representative population of adults residing in non-congregate settings (ie, excluding adults residing in a long-term care facility, assisted living facility, nursing home, and a prison or jail) in Connecticut prior to June 2020. We used this seroprevalence estimate and the 2018 American Community Survey to calculate the overall population estimates for individuals infected with SARS-CoV-2. Information on the total COVID-19-related hospitalizations and deaths among the non-congregate population in Connecticut between March 1 and June 1, 2020 was provided by the Connecticut Hospital Association and the Connecticut Department of Public Health, respectively. The diagnostic codes used to identify COVID-19-related hospitalizations are listed in Supplementary Methods 1 (available

CLINICAL SIGNIFICANCE

- Using seroprevalence estimates, Connecticut's COVID-19 infection hospitalization rate and infection fatality rate were estimated to be 6.86% (90% confidence interval [CI], 4.58%-13.72%) and 0.95% (90% CI, 0.63%-1.90%), respectively, among the non-congregate population through June 2020, and these estimates varied across subgroups.
- Representative seroprevalence studies provide important information about infections in a community and can provide robust estimates of the infection hospitalization and fatality rate, when combined with hospitalization and death data.

online). Total COVID-19 deaths included both confirmed and probable COVID-19 deaths (details in Supplementary Methods 1).

The infection hospitalization rate and the infection fatality rate were calculated as the number of individuals who were hospitalized and died, respectively, due to COVID-19, divided by the total estimated number of individuals who had SARS-CoV-2 antibodies using the seroprevalence estimates (details in Supplementary Methods 2, available online). We estimated the infection hospitalization and fatality rates for the overall population and by age, sex, race/ethnicity, and region subgroups. The margin of error for our estimates was calculated at the 90% confidence level in accordance with the design of the PIP study; however, estimates at 95% CI have also been provided. Due to sample size limitations, the upper end of the CI was non-estimable when stratifying by some sociodemographic characteristics. Statistical analyses were performed using R version 4.0.2. This study was exempted from review by the Institutional Review Board at Yale University because of the public health surveillance activity exclusion.

RESULTS

Of the 2.8 million individuals residing in the non-congregate settings in Connecticut, 113,515 (90% CI, 56,758-170,273) had SARS-CoV-2 antibodies (Table 1). Between March 1 and June 1, 2020, there were a total of 9425 COVID-19-related hospitalizations and 4071 COVID-19-related deaths in Connecticut, of which 7792 hospitalizations and 1079 deaths occurred among the non-congregate population.

The overall COVID-19 infection hospitalization rate and infection fatality rate were estimated to be 6.86% (90% CI, 4.58%-13.72%) and 0.95% (90% CI, 0.63%-1.90%) among the non-congregate population. There was variation in infection hospitalization rate and infection fatality rate estimates across subgroups and older people, men, non-Hispanic Black people, and those belonging to New Haven and Litchfield counties had a higher burden of adverse outcomes, though the differences between most subgroups were not statistically significant (Table 2). Population estimates and the estimates for the infection hospitalization and fatality rates at the 95% CI are presented in Supplementary Tables 1 and 2 (available online).

Table 1 Estimated Number of Individuals with SARS-CoV-2-Specific Antibodies Among the Non-Congregate Population in Connecticut, between March 1 and June 1, 2020, by Sociodemographic Characteristics

Characteristics	Total Population* n	Seroprevalence[†] of SARS-CoV-2 Antibodies % (± MOE at 90% CI)	Estimated Number of Individuals with Antibodies n (90% CI)
State total	2,837,877	4.0% (± 2.0)	113,515 (56,758-170,273)
Sex			
Men	1,365,019	2.5% (± 2.4%)	34,125 (1365-66,886)
Women	1,472,858	5.3% (± 2.9%)	78,061 (35,349-120,774)
Age group, years			
18-29	564,738	6.4% (± 7.7%)	36,143 (NE-79,628)
30-44	649,874	4.9% (± 4.6%)	31,844 (1950-61,738)
45-54	496,628	6.6% (± 4.7%)	32,777 (9436-56,119)
55-64	513,656	2.6% (± 2.4%)	13,355 (1027-25,683)
≥65	612,981	0.8% (± 1.2%)	4904 (NE-12,260)
Race/ethnicity			
Non-Hispanic Black	278,112	6.4% (± 5.5%)	17,799 (2503-33,095)
Non-Hispanic White	1,969,487	2.7% (± 1.7%)	53,176 (19,695-86,657)
Latino/Hispanic	408,654	19.9% (± 6.7%)	81,322 (53,942-108,702)
County			
New Haven	683,928	3.4% (± 3.2%)	23,254 (1368-45,139)
New London	215,679	1.7% (± 3.3%)	3667 (NE-10,784)
Middlesex	133,380	—	—
Fairfield	732,172	5.7% (± 5.4%)	41,734 (2197-81,271)
Hartford	706,631	4.0% (± 3.6)	28,265 (2827-53,704)
Litchfield	147,570	1.6% (± 3.2%)	2361 (NE-7083)

Source: 2018 American Community Survey. Source: Post-Infection Prevalence Study.

CI = confidence interval; MOE = margin of error; NE = non-estimable; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2.

*Source: 2018 American Community Survey.

†Source: Post-Infection Prevalence Study.

Table 2 Infection Hospitalization Rate and Infection Fatality Rate Among the Non-Congregate Population in Connecticut between March 1 and June 1, 2020, by Sociodemographic Characteristics

	COVID-19-Related Hospitalizations n (%)	Infection Hospitalization Rate % (90% CI)	Total* COVID-19-Related Deaths n (%)	Total Infection Fatality Rate % (90% CI)
State Total	7792 (100%)	6.86 (4.58-13.72)	1079 (100%)	0.95 (0.63-1.90)
Sex				
Men	4166 (53.47%)	12.21 (6.23-NE)	815 (75.53%)	2.39 (1.22-59.71)
Women	3625 (46.52%)	4.64 (3.00-10.25)	264 (24.47%)	0.34 (0.22-0.75)
Age group, years				
18-29	288 (3.70%)	0.80 (0.36-NE)	5 (0.46%)	0.01 (0.01-NE)
30-44	855 (10.97%)	2.68 (1.38-43.85)	34 (3.15%)	0.11 (0.06-1.74)
45-54	1013 (13.00%)	3.09 (1.81-10.74)	59 (5.47%)	0.18 (0.11-0.63)
55-64	1660 (21.30%)	12.43 (6.46-NE)	174 (16.13%)	1.30 (0.68-16.94)
≥65	3918 (50.28%)	79.89 (31.96-NE)	807 (74.79%)	16.46 (6.58-NE)
Race/ethnicity				
Non-Hispanic Black	1762 (22.61%)	9.90 (5.32-70.40)	259 (24.00%)	1.46 (0.78-10.35)
Non-Hispanic White	3948 (50.67%)	7.42 (4.56-20.05)	593 (54.96%)	1.12 (0.68-3.01)
Latino/Hispanic	845 (10.84%)	1.04 (0.78-1.57)	190 (17.61%)	0.23 (0.17-0.35)
County				
New Haven	2101 (26.96%)	9.04 (4.65-NE)	270 (25.02%)	1.16 (0.60-19.74)
New London	148 (1.90%)	4.04 (1.37-NE)	21 (1.95%)	0.57 (0.19-NE)
Middlesex	231 (2.96%)	NE	32 (2.97%)	NE
Fairfield	2665 (34.20%)	6.39 (3.28-NE)	399 (36.98%)	0.96 (0.49-18.16)
Hartford	1755 (22.52%)	6.21 (3.27-62.08)	294 (27.25%)	1.04 (0.55-10.40)
Litchfield	195 (2.50%)	8.26 (2.75-NE)	39 (3.61%)	1.65 (0.55-NE)

CI = confidence interval; NE = non-estimable.

*Total COVID-19-related deaths includes both confirmed and probable COVID-19 deaths.

DISCUSSION

Using seroprevalence estimates, we estimated that, through June 2020, Connecticut's COVID-19 infection hospitalization rate and infection fatality rate were 6.86% and 0.95%, respectively, and these estimates varied across subgroups. Our estimates are distinctive because they reflect people living in the community and are based on a methodology that sought to obtain a representative estimate for the denominator and brought together multiple streams of data.

There has been continued controversy about the infection fatality rate, and the literature is replete with widely varied estimates.[4-8] However, most studies do not have a representative sample or separate out special populations, such as those in nursing homes.[5,9] Moreover, infection fatality rate is not an inherent characteristic of the disease, but rather a confluence of the pathogen virulence, sociodemographic and clinical characteristics of the population, health care availability and quality, therapeutic availability, and accurate counting and reporting of COVID-19-related deaths. As such, an overall infection fatality rate may not be very informative, given the heterogeneity across regions.

The COVID-19 infection hospitalization rate is not well described, and most studies report the case hospitalization rate, which also varies widely in the literature.[10-12] The Centers for Disease Control and Prevention estimated a US COVID-19 case hospitalization rate of 14.0% for infections prior to June 2020.[12] As expected, this case hospitalization rate estimate was higher than Connecticut's estimated infection hospitalization rate in our study (6.9%), as infection hospitalization rate includes the total estimated infections rather than detected positive cases only. Moreover, our estimate excluded individuals from congregate settings, which had a higher burden of adverse outcomes.

Our subgroup findings are notable, even though the differences between subgroups were not statistically significant. Prior studies have noted that age and sex are associated with disease severity, however, they have been hampered by including nursing home residents and biased by testing patterns. We had the opportunity to identify hospitalizations and deaths among the non-congregate population in Connecticut and show that, even in the community, these associations remain. Prior studies have shown that Black people have had disproportionately higher infection rates, even as some studies indicate that hospital mortality does not vary by race/ethnicity.[13] Our findings highlight that the burden of COVID-19 among Black subpopulations is not just about infection rates but also worse outcomes. The lower infection hospitalization rate for Latino/Hispanic individuals was in accordance with previously reported low hospital admission rates among Latino/Hispanic individuals testing positive for SARS-CoV-2 in Baltimore/Washington, DC[14] and may be associated with the lower insurance rates among the Latino/Hispanic subpopulation in Connecticut.[15]

Limitations of our study include potential underestimation of COVID-19-related hospitalizations due to limited testing availability; underestimation of total infections due to the decrease in antibody concentration over time or poor sensitivity of serology tests; lack of power to detect statistical differences between subgroups due to the small sample size; and that our findings may not be generalizable to other regions or across time. Nevertheless, this study shows that representative seroprevalence studies provide important information about infections in a community and can provide robust estimates of the infection hospitalization and fatality rates, when combined with hospitalization and death data.

In conclusion, using representative seroprevalence estimates, the COVID-19 infection hospitalization rate and infection fatality rate were estimated to be 6.86% (90% CI, 4.58%-13.72%) and 0.95% (90% CI, 0.63%-1.90%), respectively, among the non-congregate population in Connecticut through June 1, 2020.

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SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjmed.2021.01.020.

SUPPLEMENTARY MATERIAL

Supplementary Methods 1. Coronavirus disease 2019 (COVID-19) case classification criteria used by the Connecticut Department of Public Health and the International Classification of Diseases, Tenth Revision (**ICD-10**) **codes used to identify COVID-19 visits by the Connecticut Hospital Association.**

A. Case classifications criteria −

- Confirmed:
○ Meets confirmatory laboratory evidence.
- Probable:
○ Meets clinical criteria AND epidemiologic evidence with no confirmatory laboratory testing performed for COVID-19.
○ Meets presumptive laboratory evidence AND either clinical criteria OR epidemiologic evidence.
○ Meets vital records criteria with no confirmatory laboratory testing performed for COVID-19.

Source: Standardized surveillance case definition and national notification for 2019 novel coronavirus disease (COVID-19). Council of State and Territorial Epidemiologists. https://cdn.ymaws.com/www.cste.org/resource/resmgr/2020ps/interim-20-id-01_covid-19.pdf

Published 2020. Accessed September 8, 2020.

B. ICD-10 codes used to identify COVID-19 visits

ICD-10 Codes	Description
J1289 and (B9729 or U071)	COVID-related pneumonia
(J208 or J40) and (B9729 or U071)	COVID-related bronchitis
(J988 or J22) and (B9729 or U071)	COVID-related respiratory infection
J80 and (B9729 or U071)	COVID-related acute respiratory distress syndrome (ARDS)
U071	COVID-19

Note: the above diagnosis codes can be in any position, ie, they do not have to be the principal diagnosis code.

Supplementary Methods 2. Details of calculation of the infection hospitalization rate and the infection fatality rate among adults residing in the non-congregate setting in Connecticut

- Assessment of the number of hospitalizations and deaths among the non-congregate populations—residents were identified as living in a congregate facility if they resided in a long-term care facility, assisted living facility, nursing home, and a prison or jail. Information on Coronavirus disease 2019 (COVID-19)-related deaths among the residents from non-congregant settings was provided directly by the Connecticut Department of Public Health. For hospitalizations among the non-congregate population, we excluded patients admitted from skilled nursing facilities using the admission source fields from the hospitalization data obtained from the Connecticut Hospital Association.
- Calculation of infection hospitalization rate (IHR) and infection fatality rate (IFR)—IHR and IFR were calculated as the number of individuals who were hospitalized and died, respectively, due to COVID-19 divided by the total estimated number of individuals who had COVID-19 using the seroprevalence estimates. The lower (upper) bound of the IHR/IFR was calculated by dividing the number of hospitalizations/deaths by the lower (upper) bound of the denominator estimation.

Supplementary Table 1 Estimated Number of Individuals with SARS-CoV-2-Specific Antibodies at 95% Confidence Interval among the Non-Congregate Population in Connecticut, between March 1 and June 1, 2020, by Sociodemographic Characteristics

Characteristics	Total Population* n	Seroprevalence[†] of SARS-CoV-2 Antibodies % ($\pm$ MOE at 95% CI)	Estimated Number of Individuals with Antibodies n (95% CI)
State total	2,837,877	4.0% ($\pm$ 2.3)	113,515 (48,244-178,786)
Sex			
Men	1,365,019	2.5% ($\pm$ 2.9%)	34,125 (NE-73,711)
Women	1,472,858	5.3% ($\pm$ 3.5%)	78,061 (26,511-129,612)
Age group, years			
18-29	564,738	6.4% ($\pm$ 9.2%)	36,143 (NE-88,099)
30-44	649,874	4.9% ($\pm$ 5.5%)	31,844 (NE-67,587)
45-54	496,628	6.6% ($\pm$ 5.6%)	32,777 (NE-60,589)
55-64	513,656	2.6% ($\pm$ 2.9%)	13,355 (NE-28,251)
$\geq$65	612,981	0.8% ($\pm$ 1.4%)	4904 (NE-13,486)
Race/ethnicity			
Non-Hispanic Black	278,112	6.4% ($\pm$ 6.5%)	17,799 (NE-35,876)
Non-Hispanic White	1,969,487	2.7% ($\pm$ 2.0%)	53,176 (13,786-92,566)
Latino/Hispanic	408,654	19.9% ($\pm$ 8.0%)	81,322 (48,630-114,015)
County			
New Haven	683,928	3.4% ($\pm$ 3.8%)	23,254 (NE-49,243)
New London	215,679	1.7% ($\pm$ 4.0%)	3667 (NE-12,294)
Middlesex	133,380	—	—
Fairfield	732,172	5.7% ($\pm$ 6.4%)	41,734 (NE-88,593)
Hartford	706,631	4.0% ($\pm$ 4.3%)	28,265 (NE-58,650)
Litchfield	147,570	1.6% ($\pm$ 3.8%)	2361 (NE-7969)

Source: 2018 American Community Survey.Source: Post-Infection Prevalence Study.
CI = confidence interval; MOE = margin of error; NE = non-estimable; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2.
*Source: 2018 American Community Survey.
†Source: Post-Infection Prevalence Study.

Supplementary Table 2 Estimates for Infection Hospitalization Rate and Infection Fatality Rate at 95% Margin of Error Among the Non-Congregate Population in Connecticut between March 1 and June 1, 2020, by Sociodemographic Characteristics

	COVID-19-Related Hospitalizations n	Infection Hospitalization Rate % (95% CI)	Total* COVID-19-related Deaths n	Total Infection Fatality Rate % (95% CI)
State total	7792 (100%)	6.86 (4.36-16.15)	1079 (100%)	0.95 (0.60-2.24)
Sex				
Men	4166 (53.47%)	12.21 (5.67-NE)	815 (75.53%)	2.39 (1.11-NE)
Women	3625 (46.52%)	4.64 (2.80-14.21)	264 (24.47%)	0.34 (0.20-1.00)
Age group, years				
18-29	288 (3.70%)	0.80 (0.33-NE)	5 (0.46%)	0.01 (0.01-NE)
30-44	855 (10.97%)	2.68 (1.27-NE)	34 (3.15%)	0.11 (0.05-NE)
45-54	1013 (13.00%)	3.09 (1.67-NE)	59 (5.47%)	0.18 (0.10-NE)
55-64	1660 (21.30%)	12.43 (5.88-NE)	174 (16.13%)	1.30 (0.62-NE)
$\geq$65	3918 (50.28%)	79.89 (29.05-NE)	807 (74.79%)	16.46 (5.98-NE)
Race/ethnicity				
Non-Hispanic Black	1762 (22.61%)	9.90 (1.90-NE)	259 (24.00%)	1.46 (0.72-NE)
Non-Hispanic White	3948 (50.67%)	7.42 (11.00-28.64)	593 (54.96%)	1.12 (0.64-4.30)
Latino/Hispanic	845 (10.84%)	1.04 (0.74-1.74)	190 (17.61%)	0.23 (0.17-0.39)
County				
New Haven	2101 (26.96%)	9.04 (4.27-NE)	270 (25.02%)	1.16 (0.55-NE)
New London	148 (1.90%)	4.04 (1.20-NE)	21 (1.95%)	0.57 (0.17-NE)
Middlesex	231 (2.96%)	NE	32 (2.97%)	NE
Fairfield	2665 (34.20%)	6.39 (3.01-NE)	399 (36.98%)	0.96 (0.45-NE)
Hartford	1755 (22.52%)	6.21 (2.99-NE)	294 (27.25%)	1.04 (0.50-NE)
Litchfield	195 (2.50%)	8.26 (2.45-NE)	39 (3.61%)	1.65 (0.49-NE)

CI = confidence interval; COVID-19 = Coronavirus disease 2019; NE = non-estimable.
*Total COVID-19-related deaths includes both confirmed and probable COVID-19 deaths.