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Critical Illness Among Patients Hospitalized With Acute COVID-19 With and Without Congenital Heart Defects

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Keywords

COVID-19; heart defects, congenital; risk factors

Given the increased risk for severe COVID-19 illness in individuals with cardiac disease, individuals with congenital heart defects (CHDs) might have increased risk of severe illness from COVID-19 as well.¹ Most publications on CHD and COVID-19 illness have been restricted to patients at congenital cardiology centers, limiting generalizability, because many individuals with CHD do not receive specialized cardiology care.^{2–4} Furthermore, the studies did not include comparison groups without CHD or adjust for differences in established risk factors for critical COVID-19,⁴ and comparisons to general population estimates may be confounded.

We compared the period prevalence of critical COVID-19 illness (intensive care unit [ICU] admission, invasive mechanical ventilation [IMV], or death) among hospitalized patients with COVID-19 with and without CHD. Among patients with CHD, we examined characteristics associated with critical COVID-19 illness.

We used data on inpatient encounters from March 2020 through January 2021 from the Premier Healthcare Database Special COVID-19 Release, an all-payor database representing ≈20% of US hospital admissions. Data and study materials will not be provided because of licensing restrictions. All 1- to 64-year-old patients with COVID-19 (identified by

1 inpatient *ICD-10-CM* [International Classification of Diseases, 10th revision, Clinical Modification] code of U07.1 or, from March to April 2020, B97.29 [the recommended code before U07.1]) were included. Patients missing classification of sex were excluded (<0.1%). CHD was identified by 1 inpatient *ICD-10-CM* code between Q20.x and Q26.x

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Disclosures
None.

(excluding nonspecific codes) at any time in the study period and categorized by anatomic complexity using a published algorithm.⁵ ICU admission, IMV, and death were defined as 1 inpatient code for the outcome in the same encounter as COVID-19 diagnosis. Other characteristics included other known comorbidities (ie, 1 inpatient diagnosis of pulmonary hypertension, heart failure, Down syndrome, type 1 or 2 diabetes, or obesity), age group, sex, race/ethnicity, payor type, and hospital urbanicity.

Among hospitalized patients with COVID-19, characteristics and critical COVID-19 outcomes were assessed by CHD status. Using modified Poisson regression accounting for within-hospital correlation, adjusted prevalence ratios (aPRs) and 95% CIs were calculated for each outcome comparing patients with versus those without CHD, adjusting for age group, sex, race/ethnicity, and payor type. Among patients with COVID-19 with CHD, critical COVID-19 outcomes were assessed by characteristics using crude prevalence ratios (cPRs; accounting for within-hospital correlation). Deemed public health surveillance by the US Centers for Disease Control and Prevention as defined in 45 CFR 46.102(l) (2), this activity was exempt from institutional review board review and written informed consent.

Of 235 638 hospitalized patients with COVID-19 who were 1 to 64 years of age, 421 (0.2%) had CHD (consistent with CHD prevalence in non-COVID-19-related health care data sets⁵). Overall, 68.4% with and 58.8% without CHD had 1 comorbidity and 12.8% with CHD were 1 to 17 years of age compared with 1.4% without CHD (Table). More than half of the patients with COVID-19 with CHD were admitted to the ICU, 24.0% required IMV, and 11.2% died during hospitalization. After adjustment, ICU admission (aPR=1.4), IMV (aPR=1.8), and death (aPR=2.0) were more prevalent among patients with COVID-19 with CHD than without CHD. When stratified by high-risk characteristics, prevalence estimates for ICU admissions, IMV, and death remained higher among patients with COVID-19 with CHD than without CHD across nearly all strata, including younger age groups and those without heart failure, pulmonary hypertension, Down syndrome, diabetes, or obesity.

Among the 421 patients with CHD, critical COVID-19 outcomes were associated with having comorbidities (1 comorbidity: IMV, cPR=2.5; 2 comorbidities: ICU, cPR=1.3; IMV, cPR=3.3; death, cPR=4.0), male sex (ICU, cPR=1.3), and age 50 to 64 years compared with 18 to 29 years (IMV, cPR=3.0; data not shown; all $P<0.05$).

The frequency of critical COVID-19 illness among patients with CHD is similar to previous reports, yet most, but not all,⁴ previous publications concluded that outcomes among patients with CHD did not differ from those of the general population.^{2–4} However, previous reports did not include a comparison group without CHD or adjust for differences in age, comorbidities, race/ethnicity, sex, payor type, or location. Instead, authors compared their findings with published reports of older populations with more comorbidities than their patients with CHD or compared crude estimates. The current analyses compared period prevalence of critical COVID-19 between patients with and without CHD at the same hospitals, adjusted for and stratified by established high-risk factors for severe COVID-19 infection, and found up to 2 times higher adjusted prevalence of critical COVID-19 among patients with CHD, although results are specific to hospitalized patients.

ICU admission (aPR=1.4), IMV (aPR=1.8), and death (aPR=2.0) were more prevalent among patients hospitalized with COVID-19 with CHD than without CHD after adjusting for patient characteristics. Results held among younger patients and patients without comorbidities. Among patients hospitalized with COVID-19 with CHD, comorbidities, older age, and male sex were associated with higher adjusted prevalence for critical COVID-19. Targeted strategies to increase awareness of CHD as a risk factor for critical COVID-19 illness and emphasize the critical importance of prevention of COVID-19 illness for people with CHD and their families through vaccination, masking, and physical distancing are needed.

Nonstandard Abbreviations and Acronyms

| | |
|------------------|--|
| aPR | adjusted prevalence ratio |
| CHD | congenital heart defect |
| ICD-10-CM | International Classification of Diseases, 10th revision, Clinical Modification |
| ICU | intensive care unit |
| IMV | invasive mechanical ventilation |

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Table.

Period Prevalence of Intensive Care Unit Admission, Invasive Mechanical Ventilation, and Death Among Patients Hospitalized With COVID-19 With and Without CHDs, Overall and by Patient Characteristics

| Characteristics | Total | | | Intensive care unit admission | | | | | | Invasive mechanical ventilation | | | | | | Death | | | |
|----------------------------|-------|----------|------|-------------------------------|----------|------|------|-------|---------------|---------------------------------|-------|----------|--------|-------|---------------|-------|-------|--------|---------------|
| | CHD | | | No CHD | | | CHD | | | CHD | | | No CHD | | | CHD | | No CHD | |
| | N | Column % | | N | Column % | | N | Row % | aPR (CI) | N | Row % | aPR (CI) | N | Row % | aPR (CI) | N | Row % | N | aPR (CI) |
| Total | 421 | 100 | | 235 | 100 | | 227 | 53.9 | 1.4 (1.2–1.6) | 101 | 24.0 | 14.5 | 34 | 11.1 | 1.8 (1.3–2.6) | 47 | 11.2 | 16 | 2.0 (1.3–3.2) |
| CHD severity* | | | | | | | | | | | | | | | | | | | |
| Complex | 80 | 19.0 | | NA | | | 43 | 53.8 | 1.4 (1.1–1.8) | 15 | 18.8 | NA | NA | | 1.9 (1.1–3.3) | NR | | NA | 1.5 (0.4–6.1) |
| Not complex | 341 | 81.0 | | | | | 184 | 54.0 | 1.3 (1.1–1.6) | 86 | 25.2 | | | | 1.8 (1.2–2.7) | 43 | 12.6 | | 2.1 (1.3–3.4) |
| Other known comorbidities† | | | | | | | | | | | | | | | | | | | |
| Heart failure | 132 | 31.4 | 22 | 9.4 | 83 | 62.9 | 13 | 59.1 | 1.0 (0.9–1.2) | 38 | 28.8 | 5922 | 26.8 | | 1.0 (0.7–1.5) | 18 | 13.6 | 3390 | 15.3 |
| Pulmonary hypertension | 67 | 15.9 | 5405 | 2.3 | 33 | 49.3 | 3474 | 64.3 | 0.8 (0.6–1.0) | 20 | 29.9 | 1745 | 32.3 | | 0.9 (0.6–1.5) | 13 | 19.4 | 1015 | 18.8 |
| Down syndrome‡ | 47 | 11.2 | 923 | 0.4 | 29 | 61.7 | 497 | 53.8 | 1.1 (0.9–1.4) | 17 | 36.2 | 236 | 25.6 | | 1.4 (0.9–2.1) | 10 | 21.3 | 124 | 13.4 |
| Diabetes§ | 127 | 30.2 | 87 | 37.1 | 79 | 62.2 | 44 | 51.2 | 1.2 (1.0–1.5) | 41 | 32.3 | 17 | 20.0 | | 1.6 (1.0–2.6) | 21 | 16.5 | 8974 | 10.3 |
| Obesity | 134 | 31.8 | 86 | 36.8 | 68 | 50.7 | 42 | 48.7 | 1.2 (0.9–1.5) | 37 | 27.6 | 16 | 18.6 | | 1.5 (0.9–2.5) | 18 | 13.4 | 7502 | 8.7 |
| Any of the above | 288 | 68.4 | 138 | 58.8 | 166 | 57.6 | 67 | 49.1 | 1.2 (1.1–1.4) | 83 | 28.8 | 25 | 18.5 | | 1.6 (1.1–2.3) | 41 | 14.2 | 12 | 1.8 (1.1–3.3) |
| None of the above | 133 | 31.6 | 138 | 41.2 | 61 | 45.9 | 32 | 33.4 | 1.5 (1.2–1.7) | 18 | 13.5 | 8553 | 8.8 | | 1.7 (1.0–2.7) | NR | | 3612 | 1.8 (0.8–3.8) |

| Characteristics | Total | | | Intensive care unit admission | | | | | | Invasive mechanical ventilation | | | | | | Death | | | |
|-----------------------------|-------|----------|---------|-------------------------------|-----|-------|--------|-------|---------------|---------------------------------|-------|--------|--------|---------------|--------|-------|---|--------|----------------|
| | CHD | | | No CHD | | | CHD | | | CHD | | | No CHD | | | CHD | | No CHD | |
| | N | Column % | N | Column % | N | Row % | N | Row % | aPR (CI) | N | Row % | N | Row % | aPR (CI) | N | Row % | N | Row % | aPR (CI) |
| Age group, y | | | | | | | | | | | | | | | | | | | |
| 1–17 | 54 | 12.8 | 3281 | 1.4 | 30 | 55.6 | 1048 | 31.9 | 1.6 (1.1–2.3) | 10 | 18.5 | 214 | 6.5 | 2.7 (1.5–5.1) | 28 | 0.9 | | | # |
| 18–29 | 59 | 14.0 | 22 469 | 9.6 | 30 | 50.8 | 5976 | 26.6 | 1.5 (1.2–2.0) | 10 | 16.9 | 1363 | 6.1 | 2.2 (1.2–4.1) | 280 | 1.2 | | | 4.0 (1.6–10.1) |
| 30–49 | 135 | 32.1 | 79 014 | 33.6 | 68 | 50.4 | 31 667 | 40.1 | 1.3 (1.1–1.6) | 30 | 22.2 | 9156 | 11.6 | 1.8 (1.1–2.9) | 3249 | 4.1 | | | 2.2 (1.1–4.5) |
| 50–64 | 173 | 41.1 | 130 453 | 55.5 | 99 | 57.2 | 61 579 | 47.2 | 1.3 (1.1–1.5) | 51 | 29.5 | 23 378 | 17.9 | 1.6 (1.1–2.4) | 12 680 | 9.7 | | | 1.9 (1.1–3.1) |
| Sex | | | | | | | | | | | | | | | | | | | |
| Male | 255 | 60.6 | 123 395 | 52.5 | 148 | 58.0 | 58 245 | 47.2 | 1.3 (1.2–1.5) | 67 | 26.3 | 21 172 | 17.2 | 1.7 (1.2–2.4) | 10 402 | 8.4 | | | 1.9 (1.1–3.2) |
| Female | 166 | 39.4 | 111 822 | 47.5 | 79 | 47.6 | 42 025 | 37.6 | 1.4 (1.1–1.7) | 34 | 20.5 | 12 939 | 11.6 | 2.0 (1.2–3.2) | 5835 | 5.2 | | | 2.2 (1.2–3.8) |
| Race/ethnicity [¶] | | | | | | | | | | | | | | | | | | | |
| Non-Hispanic White | 233 | 55.3 | 98 894 | 42.0 | 124 | 53.2 | 42 828 | 43.3 | 1.3 (1.1–1.5) | 54 | 23.2 | 13 927 | 14.1 | 1.7 (1.2–2.4) | 6301 | 6.4 | | | 2.0 (1.2–3.2) |
| Non-Hispanic Black | 69 | 16.4 | 55 900 | 23.8 | 43 | 62.3 | 23 270 | 41.6 | 1.5 (1.2–1.9) | 19 | 27.5 | 7978 | 14.3 | 2.2 (1.5–3.1) | 3948 | 7.1 | | | 1.6 (0.7–3.5) |
| Hispanic | 80 | 19.5 | 56 464 | 24.0 | 40 | 50.0 | 24 204 | 42.9 | 1.3 (1.0–1.8) | 17 | 21.3 | 8117 | 14.4 | 1.8 (0.7–4.4) | 3969 | 7.0 | | | 1.6 (0.5–5.8) |
| Payor type | | | | | | | | | | | | | | | | | | | |
| Any public | 227 | 53.9 | 98 914 | 42.1 | 126 | 55.5 | 42 336 | 42.8 | 1.4 (1.2–1.6) | 56 | 24.7 | 16 163 | 16.3 | 1.8 (1.3–2.4) | 8509 | 8.6 | | | 2.0 (1.3–3.1) |
| Private, no public | 164 | 39.0 | 104 314 | 44.3 | 84 | 51.2 | 43 882 | 42.1 | 1.3 (1.1–1.5) | 35 | 21.3 | 13 605 | 13.0 | 1.7 (1.0–2.7) | 5742 | 5.5 | | | 1.7 (0.8–3.5) |

| Characteristics | Total | | | Intensive care unit admission | | | | Invasive mechanical ventilation | | | | Death | | | |
|-----------------|-------|------|----------|-------------------------------|------|----------|------|---------------------------------|-------|---------------|-------|-------|-------|--------|---------------|
| | CHD | | Column % | No CHD | | aPR (CI) | | CHD | | No CHD | | CHD | | No CHD | |
| | N | % | | N | % | Row % | N | N | Row % | N | Row % | N | Row % | N | aPR (CI) |
| Other/none | 30 | 7.1 | | 31 | 13.6 | 17 | 56.7 | 14 | 43.9 | 1.5 (1.1–2.1) | 10 | 33.3 | 4343 | 13.6 | 2.5 (1.2–5.1) |
| Location¶ | | | | | | | | | | | | | | | |
| Rural‡ | 44 | 10.5 | | 25 | 11.0 | 23 | 52.3 | 11 | 42.5 | 1.3 (0.9–1.8) | NR | | 3678 | 14.2 | 1.1 (0.5–2.4) |
| Urban | 377 | 89.5 | | 209 | 89.0 | 204 | 54.1 | 89 | 42.6 | 1.4 (1.2–1.6) | 95 | 25.2 | 30 | 14.5 | 1.9 (1.3–2.7) |

Data from the US Premier Healthcare Database Special COVID-19 Release (March 2020–January 2021). aPR indicates adjusted prevalence ratio (models included age group, sex, race/ethnicity, and payor type, and accounted for within-hospital correlation); CHD, congenital heart defect; NA, not applicable; and NR, not reported because cell has <10 observations.

* To estimate aPRs for CHD severity, patients with CHD in each stratum of CHD severity were compared with those without CHD overall: 100 270 (42.6%) for intensive care unit admission, 34 111 (14.5%) for invasive mechanical ventilation, and 16 237 (6.9%) for death.

‡ Comorbidity frequencies are not mutually exclusive.

§ For convergence of the model for death outcome, age categories were collapsed (<29, 30–49, and 50–64 years) and payor type was not included.

¶ Type 1 or type 2 diabetes.

‖ A total of 39 patients with CHD and 23 959 patients without CHD were of other or unknown non-Hispanic race.

¶ Location refers to the location of the patient’s health care provider, not the patient’s residence.

No deaths occurred among 1- to 17-year-old patients with CHD.