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Prevalence of cardiovascular diseases in COVID-19 related mortality in the United States

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Abstract

Background: Several cardiovascular disease (CVD) risk factors and sequelae have been associated with COVID-19. Little is known about the distribution of CVD conditions in COVID-19 related deaths in the US population.

Methods: The public-use dataset by CDC, “Conditions Contributing to COVID-19 Deaths, by State and Age, Provisional 2020-2021”, was abstracted as of August 1, 2021. A descriptive analysis was conducted to explore the overall and age-specific prevalence of various CVD and risk factors grouped by pre-specified ICD-10 codes amongst COVID-19 patient deaths. Respective trends over the duration of the pandemic were analyzed using the Mann-Kendall method, including time-periods before and after the introduction of vaccines in January 2021. All time-related analysis was conducted between March 2020 and June 2021.

Results: A total of 600,241 COVID-19 related deaths were reported between March 2020 and June 2021. Hypertensive diseases were the most prevalent (19.6%), followed by diabetes (15.9%), ischemic heart disease (IHD; 10.9%), heart failure (7.7%), cardiac arrhythmias (7.5%), other diseases of the circulatory system (6.6%), cerebrovascular diseases (5%), and obesity (4.1%). While a significant downward trend was noted for hypertensive diseases over the course of the pandemic, cardiac arrhythmias, heart failure (HF), obesity, and other circulatory system diseases demonstrated a significant upward trend. Since the introduction of vaccines, the trends for heart failure and cardiac arrhythmias remained steady while having demonstrated a significant rise in the pre-vaccination time-period. While obesity and other diseases of the circulatory system predominated (>50%) amongst the CVD burden in the younger population (0–24 years and 25–34 years), the percentage occurrence of cardiac arrhythmias, hypertensive diseases, HF, and IHD increased with age.

Conclusion: Hypertensive diseases, diabetes, and IHD were the most prevalent cardiovascular conditions amongst COVID-19 related deaths. These patterns varied by age. While the trend for hypertensive diseases declined over the course of the pandemic, cardiac arrhythmias, HF, obesity, and other diseases of the circulatory system demonstrated an upward trend. An important limitation is the source of the data being limited to death certificates.

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Abbreviations: CVD, cardiovascular disease; DM, diabetes mellitus; HF, heart failure; IHD, ischemic heart disease.
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Introduction

COVID-19, caused by SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus-2), was the third leading cause of death in the U.S. in 2020. As the number of COVID-19 patients increased, an association was quickly observed between cardiovascular disease (CVD) and COVID-19. Analysis of patients with COVID-19 in critical condition demonstrated that 20–35% of COVID-19 mortalities occurred in those with pre-existing CVD and risk factors.

Understanding the burden of CVD amongst COVID-19 mortality can help predict risks and outcomes in specific populations and encourage thoughtful allocation of resources. This descriptive analysis uses national-level data to highlight the patterns of various CVD that contribute to mortality in patients with COVID-19 by age and investigates their respective trends over the course of the pandemic.

Methods

The public-use data available for researchers by the National Center of Health Statistics (NCHS), CDC, “Conditions Contributing to COVID-19 Deaths, by State and Age, Provisional 2020-2021”, was abstracted as of August 1, 2021. This dataset compiles data from death certificates and is stratified by age group and pre-specified health conditions.

Using this dataset, we conducted a descriptive analysis to investigate the prevalence of underlying CVD and their risk factors grouped by respective ICD-10 codes (see Supplementary Table 1) amongst COVID-19 deaths, listed as the underlying cause of death. We studied their trends over the duration of the pandemic and reported distributions stratified by pre-specified age groups. Time-related analysis was conducted between March 2020 and June 2021, and trend analysis was performed using the Mann-Kendall method. The trend patterns were compared for the time period before (pre-vaccination) and after January 2021 (post-vaccination), which served as a surrogate for estimating any effect of vaccines on these trends. Overall age-group differences were compared using chi-squared analysis.

Results

A total of 600,241 COVID-19 related deaths were reported between March 2020 and June 2021. COVID-19 related mortality trends showed a peak in January 2021. A declining trend in reported COVID-19 related mortality was noted since January 2021. Amongst CVD conditions reported amongst COVID-19-related deaths for the duration of the pandemic across all ages (Fig. 1), hypertensive diseases were most prevalent (19.6%), followed by diabetes mellitus (DM;15.9%), ischemic heart disease (IHD;10.9%), heart failure (HF;7.7%), cardiac arrhythmias (7.5%), other diseases of the circulatory system (6.6%), cerebrovascular diseases (5%), and obesity (4.1%).

The trends of CVD in COVID-19 related deaths over the course of the pandemic are presented in Fig. 2. Hypertensive diseases noted a significant downward trend (20% in March 2020 to 16.4% in June 2021, \( p < 0.001 \)). Several other CVD-related diseases demonstrated a significant upward trend, including cardiac arrhythmias (4.7% to 7.9%, \( p = 0.005 \)), HF (5.5% to 8.1%, \( p = 0.006 \)), obesity (3.6% to 5.5%, \( p = 0.042 \)), and other diseases of the circulatory system (5.0% to 9.4%, \( p < 0.001 \)). Since the introduction of vaccines, the trends for HF (7.7% to 8.1%, \( p = 0.133 \)) and cardiac arrhythmias (8.0% to 7.9%, \( p = 0.452 \)) remained steady while having demonstrated a significant rise in the pre-vaccination time period. Underlying cerebrovascular diseases, DM, or IHD did not show significant trends.

The overall difference in distribution of CVD over its total burden in COVID-19 mortality by age, shown in Fig. 3, was statistically significant \( (p < 0.001) \). While obesity and other diseases of the circulatory system predominated (>50%) amongst the CVD burden in the younger...
population (0–24 years and 25–34 years), percentage of cardiac arrhythmias, hypertensive diseases, HF, and IHD was noted to increase with age and was greater in the elderly population, especially above 65 years of age.

**Discussion**

Using publicly available data of COVID-19 related mortality in the U.S., we found that hypertensive diseases, DM, and IHD were the most prevalent CVD-related diseases in COVID-19 deaths. Obesity and other diseases of the circulatory system were predominant amongst younger individuals. While the occurrence of hypertensive diseases amongst COVID-19 deaths showed a downward trend over the course of the pandemic, several other conditions, including cardiac arrhythmias, obesity, and other diseases of the circulatory system, demonstrated an upward trend. The rising trend for cardiac arrhythmias and HF was noted to be stable since the introduction of vaccines effective against COVID-19 in January 2021.

The distribution of CVD risk factors and sequelae relating to COVID-19 severity has been studied. Our findings in the U.S. population demonstrate comparatively higher rates of hypertensive diseases (19.6%) and DM (15.9%). The predominance of hypertension in COVID-19-related mortality carries clinical importance as studies have demonstrated an association of hypertension with up to 2.5 times the increased risk of severe or fatal COVID-19. Prior studies demonstrated that CVD complications were prevalent in patients with COVID-19, including myocardial injury (27.8%) and HF (23%). The prevalence of these complications in our analysis was lower. This may be explained by the difference in the data collection method, whereby our analysis is limited to data collected from death certificates versus data collected from in-hospital records in other studies.

Our analysis allowed unique estimation of trends of CVD burden amongst COVID-19 related mortality over the course of the pandemic. Cardiac arrhythmias, obesity, and other diseases of the circulatory diseases demonstrated a rising trend in the background of a declining trend in hypertensive diseases contributing to COVID-19 mortality. In the months following the availability of the vaccine, trends of HF and cardiac arrhythmias were noted to remain steady. With limited ability to derive specific conclusions, this finding may demonstrate the early benefit that vaccines effective against COVID-19 may have amongst vulnerable groups, such as the elderly with comorbid conditions. This should be interpreted with caution, especially since the uptake of the vaccine was a gradual process and the age demographic of patients with COVID-19 has been evolving. It is also important to recognize that frequently changing state-wide and national policies relating to lockdown and public-space use interfere with the interpretation of the trend analysis.

The overall distribution of CVD-related diseases varies significantly with age. Obesity was a major contributor to COVID-19 related mortality in children. It showed a general upward trend in contribution to COVID-19 mortality during the pandemic for all ages. This supports studies demonstrating that the COVID-19 pandemic was associated with weight gain amongst adults and children. Other age-related findings indicate that younger individuals with COVID-19 had greater occurrences of other diseases of the circulatory system. Of note is that this umbrella diagnosis includes myocarditis and cardiomyopathies, which may have contributed to mortality. Additionally, our finding of an increased occurrence of IHD, hypertensive diseases, and cerebrovascular diseases with age amongst COVID-19 mortality correlate with the increased national burden of IHD and cerebrovascular diseases in the elderly.

Analysis using the CDC’s public-use dataset has several limitations. Even though the data may be gauged as accurate since they are based on death certificates, it is subject to variability given the physician filling out the respective form. It is estimated that about 20–30% of death certificates “have issues with completeness.” Additionally, specific

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**Fig. 2.** Trends of cardiovascular diseases contributing to COVID-19 mortality, March 2020 – June 2021, United States. The respective p-values for trend are presented next to the legend (a = overall p-value for trend, b = p-value for trend in the pre-vaccination period, c = p-value for trend in the post-vaccination period). The dashed vertical line roughly estimates the time vaccines against COVID-19 became publicly available in a graduated fashion.

*Other diseases of the circulatory system*.
conditions like myocarditis fall under a broader diagnosis listed in the dataset, such as “Other diseases of the circulatory system” could not be analyzed individually. The CDC reports from previous analyses of provisional data that about 54% of mortality data was complete within four weeks, though this has been improving in recent years.\textsuperscript{10} For this reason, the month of July was excluded for time-related analysis to minimize missing entries. Thus, interpretation of findings for later months of the analysis should be undertaken with caution. Even though the data presented with its limitations might underestimate the actual CVD burden amongst COVID-19 deaths, it is a valuable tool to investigate trends and patterns of disease distribution.

Investigating the CVD burden in COVID-19 mortality may help respective stakeholders prioritize healthcare resources in CVD conditions most associated with COVID-19 mortality. This also provides insight for future researchers to target methods to mitigate risks and the occurrence of prevalent CVD amongst COVID-19 deaths. An examination of cardiovascular disease trends and their changes with novel vaccines may provide early indications of potential CVD protection relating to its use. Further studies, possibly with access to individual-level data, are needed to more accurately determine the CVD burden in COVID-19 mortality and assess any impact vaccines effective against COVID-19 may have on the CVD burden.

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**Declaration of Competing Interest**

None.

**Appendix A. Supplementary data**

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pcad.2022.09.002.
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