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Has the first year of the COVID pandemic impacted the trends in obesity-related CVD mortality between 1999 and 2019 in the United States?

Afifa Qamar [f], Dmitry Abramov [a], Vijay Bang [b], Nicholas WS. Chew [c], Ofer Kobo [d,e], Mamas A. Mamas [e,*]

[a] *Division of Cardiology, Department of Medicine, Loma Linda Health, Loma Linda, CA, USA*
[b] *Lilavati Hospital and Research Center, Mumbai, India*
[c] *Department of Cardiology, National University Heart Centre, National University Health System, Singapore*
[d] *Department of Cardiology, Hillel Yaffe Medical Center, Israel*
[e] *Keele Cardiovascular Research Group, Centre for Prognosis Research, Institute for Primary Care and Health Sciences, Keele University, United Kingdom*
[f] *Lancashire Teaching Hospitals, Preston, England, United Kingdom*

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ABSTRACT

Background: During the covid-19 pandemic there was a marked rise in the number of cardiovascular deaths. Obesity is a well-known modifiable risk factor for cardiovascular disease and has been identified as a factor which leads to poorer covid-19 related outcomes. In this study we aimed to analyse the impact of covid-19 on obesity-related cardiovascular deaths compared to trends seen 20 years prior. We also analysed the influence different demographics had on mortality.

Methods: Multiple Cause of Mortality database was accessed through CDC WONDER to obtain the obesity-related and general cardiovascular crude mortality and age adjusted mortality rates (AMMR) between 1999 and 2020 in the US. The obesity-related sample was stratified by demographics and cardiovascular mortality was subdivided into ischemic heart disease, heart failure, hypertension and cerebrovascular disease. Joinpoint Regression Program (Version 4.9.1.0) was used to calculate the average annual percent change (AAPC) in AAMR, and hence projected AAMR. Excess mortality was calculated by comparing actual AAMR in 2020 to projected values.

Results and discussion: There were an estimated 3058 excess deaths during the early stages of the pandemic impacting all cohorts. The greatest excess mortalities were seen in men, rural populations and in Asian/Pacific Islander and Native Americans. Interestingly the greatest overall mortality was seen in the Black American population. Our study highlights important, both pre and during the pandemic, in obesity related cardiovascular disease mortality which has important implications for ongoing public health measures.

1. Introduction

The rising prevalence of obesity worldwide is well documented with the prevalence of obesity affecting over 40% of the adult population in the United States (US) in 2020 [1,2]. This trend is of particular concern as obesity is a known modifiable risk factor for a multitude of diseases including cardiovascular disease (CVD) [2–5]. During the COVID pandemic, obesity was noted to be one of the most important risk factors for hospitalization and fatal outcomes particularly in patients with CVD [6–8]. Previous studies have reported an increase in non-COVID related mortality during the pandemic, largely attributed to the restrictive public health measures, decreases in provision of healthcare for the management of chronic conditions, exacerbation of health inequalities, and decreases in hospitalisations for acute presentations [9–13]. However, there is limited data around obesity-related CVD mortality over a 20-year period prior to the COVID pandemic and the trends in obesity-related CVD mortality during the early phase of the pandemic.

Therefore, we aimed to analyse the effects of the COVID pandemic on obesity-related CVD mortality using the Centers for Disease Control and Prevention (CDC) dataset. We also sought to examines the influence of urbanization, ethnicity, race, age, and gender on these trends.

* Corresponding author.
E-mail address: mamasmamas1@yahoo.co.uk (M.A. Mamas).

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2. Methods

2.1. Data source

We used the Multiple Cause of Mortality database accessed through the Centers for Disease Control and Prevention Wide-Ranging, Online Data for Epidemiologic Research (CDC WONDER). This database comprises mortality for US residents and population count from all US counties between 1999 and 2020. Each mortality certificate contains a single underlying cause of mortality, and up to 20 additional contributing causes, along with demographic data. The underlying cause of mortality is selected from conditions entered by the physician on the cause of mortality section of the mortality certificate. The underlying cause of mortality is defined as per the World Health Organization (WHO) definition "the disease or injury which initiated the train of events leading directly to mortality, or the circumstances of the accident or violence which produced the fatal injury". Causes of mortality are recorded in accordance with the International Classification of Disease Tenth Revision (ICD-10). The number of deaths, crude mortality rates, age-adjusted mortality rates can be obtained by cause of mortality, place of residence, age, race, gender, and year.

2.2. Study sample

All records with CVD as the underlying cause of mortality (I00–I99) with obesity (E66) among the contributing causes of mortality were included. The sample was stratified by sex, age group, Hispanic origin, race, and urbanization status. We further sub-categorized CVD into all CVD (I*) as well as ischemic heart disease (IHD, I20–I25), heart failure (I50), hypertensive (HTN) diseases (I10–I15), and cerebrovascular disease (I60–I69). General CVD mortality between 1999 and 2020 was also analysed.

2.3. Outcomes

The outcomes of this analysis for CVD mortality among people with contributing obesity include: (a) the mortality rate in the two decades prior to the pandemic (1999–2019); (b) the mortality rate in the first pandemic year (2020) compared to the year prior (2019); and (c) estimation of the excess mortality during the first year of the pandemic based on the projections from the prior two decades.

2.4. Statistical analysis

Crude mortality and the age-adjusted mortality rates (AAMR) are presented per 100,000 population of respective age, gender, race, ethnicity, and urbanization status; mortality counts are presented as absolute values. Data on absolute number of deaths as well as mortality rates was extracted using the CDC wonder web-based tool. Changes in mortality rate are presented as percentages (%). The Joinpoint Regression Program (Version 4.9.1.0), from the National Cancer Institute was used to calculate the average annual percent change (AAPC) in AAMR and is presented as percentage with 95% confidence interval (CI). The AAPC provided a summary of the trend over the time period prior to the pandemic that was used to estimate the projected AAMR in first year of the pandemic. Excess AAMR was estimated by comparing the projected and the actual AAMR for the first year of the pandemic. This allowed the calculation of the proportion of excess AAMR (presented as percentage) and estimation of the number of excess deaths. Mortality certificates with missing age or ethnicity were included in the overall study but excluded in their respective group analysis.

3. Results

3.1. Baseline characteristics

During the study period (1999–2020), we identified 281,135 cardiovascular mortality records where obesity was listed as a contributor (Supplementary Table 1). Of these, 56.3% were male, 48.5% were aged 55–74, 37.8% aged under 55, and 13.7% aged 75 years or above. Eighty two percent were from urban areas, 78.1% were White, and 19.8% Black/African American. We also identified all cardiovascular mortality records during this period for comparison (Supplementary Tables 2 and 3).

3.2. Changes in mortality from 1999 to 2019 in obese patients

Over the 2 decades prior to the pandemic, the AAMR from CVD among patients with contributing obesity increased from 2.2 per 100,000 US population in 1999 to 5.4 per 100,000 US population in 2020 (Fig. 1 and Table 1). Among individual causes of CVD mortality, the biggest obesity-related increase in AAMR was observed in hypertensive diseases (from 0.3 to 1.4 per 100,000 US population, 366% increase). The AAMR from ischemic heart diseases (from 1.2 to 2.5 per 100,000 US population, 108% increase), cerebrovascular disease (from 0.1 to 0.2 per 100,000 us population, 100% increase) and heart failure (from 0.1 to 0.2 per 100,000 us population, 100% increase) increased to a lesser extent.

The increasing trend in obesity-related CVD AAMR between 1999 and 2019 was generally consistent across racial groups (Fig. 2, sex, urbanization status, and age groups (Supplementary Figs. 1–3). However, bigger increase in AAMR between 1999 and 2019 was observed in men (179.2% increased vs 110.0% in women), American Indian or Alaska native individuals (277% increase vs 114%, 145%, and 225% increase among Black or African American, White, and Asian or pacific islander individuals, respectively) and residents of rural areas (195% increase vs 136% in urban areas). Despite the bigger relative increase in AAMR in American Indian or Alaska native individuals over the study period, the highest AAMR during the entire study period was observed in Black or African American individuals (increased from 4.2 per 100,000 in 1999 to 9.0 per 100,000 in 2020).

3.3. Trends in mortality during the first year of the pandemic in obese patients

In comparison to 2019, obesity-related CVD AAMR increased by 22.2% (from 5.4 to 6.6 per 100,000) during the first year of the pandemic (2020) (Table 1). The biggest absolute increase in AAMR was in IHD mortality (increased by 0.5 per 100,000, from 2.5 to 3.0 per

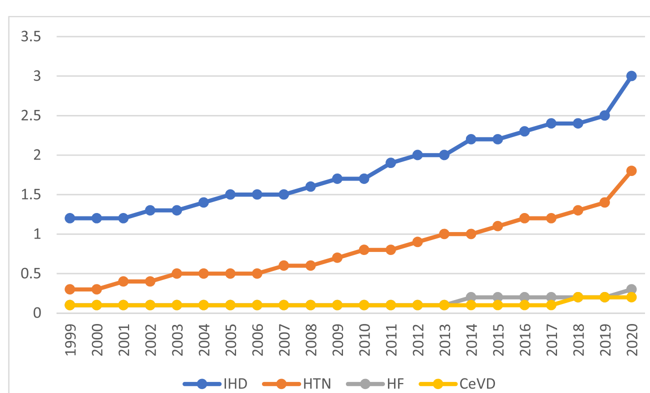

Fig. 1. Trend of cardiovascular Age-Adjusted Mortality Rate (AAMR) by cause of death in obese patients per 100,000 population.

Table 1
Age-adjusted cardiovascular Mortality Rate (AAMR) in obese patients per 100,000 population.

Main causes of death	AAMR				
	1999	2019	Δ% 1999–2019	2020	Δ% 2019–2020
All cardiovascular disease	2.2	5.4	145.45	6.6	22.22
Ischemic heart disease	1.2	2.5	108.33	3.0	20
Hypertensive disease	0.3	1.4	366.67	1.8	28.57
Heart failure	0.1	0.2	100	0.3	50
Cerebrovascular disease	0.1	0.2	100	0.2	0
Sex					
Male	2.4	6.7	179.17	8.7	29.85
Female	2.0	4.2	110	5.1	21.43.
Age					
Under 55	1.2	2.9	141.67	3.5	20.69
55–74	6.1	14.7	140.98	18.3	24.49
75 and above	6.0	14.1	135	17.3	22.70
Hispanic Origin					
Hispanic or Latino	1.3	3.4	161.54	4.4	29.41
Not Hispanic or Latino	2.3	5.7	147.82	7.0	22.81
Race					
White	2.1	5.1	145.86	6.2	21.42
Black or African American	4.2	9.0	114.29	11.6	28.89
Asian or Pacific Islander	0.4	1.3	225	1.6	23.08
American Indian or Alaska Native	1.3	4.9	276.92	6.7	36.73
Urbanization					
Urban	2.2	5.2	136.36	6.5	25
Rural	2.2	6.5	195.45	7.7	18.46

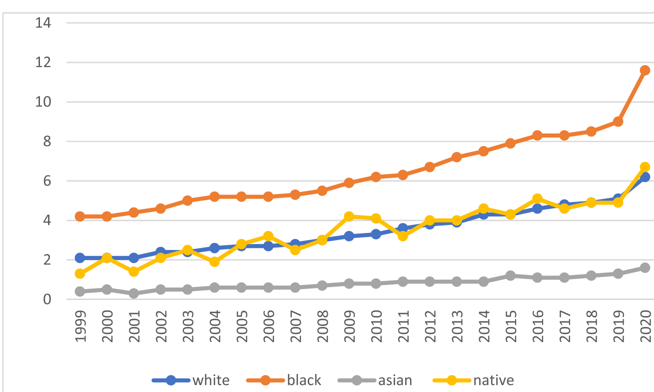

Fig. 2. Trend of cardiovascular Age-Adjusted Mortality Rate (AAMR) by race in obese patients per 100,000 population.

100,000, a20% increase) followed by hypertensive diseases mortality (0.4 per 100,000, from 1.4 to 1.8, a28.6% increase), and HF (0.1 per 100,000 from 0.2 to 0.3 per 100,000, a50% increase). We did not observe an increase in cerebrovascular diseases mortality rate between 2019 and 2020.

The relative increase in obesity-related CVD AAMR between 2019 and 2020 was higher in men compared to women (29.8% vs 21.4%), and similar across the different age groups studied (20.7%–24.5%). Higher increase in AAMR between 2019 and 2020 was also observed among those of Hispanic origin (29.4% vs 22.8% among those not of Hispanic origin) and among American Indian or Alaska native individuals (36.7% vs 28.9%, 23.1%, and 21.4% among black or African American, Asian, or pacific islander, and White individuals, respectively). There was a greater increase in urban populations (25.0%) than rural (18.5%).

The crude CVD mortality rates and number of obesity-related CVD deaths in 1999, 2019, and 2020 with their respective changes in mortality proportions are presented in Supplementary Tables 4 and 5

3.4. Estimated excess mortality in 2020 in obese patients

Yearly AAMR data from 1999 to 2019 were used to model the estimated average annual percent change (AAPC) in order to generate a projection for the expected AAMR in 2020 in various demographic groups (Table 2). This model estimated 3058 excess obesity-related CVD mortality in 2020. More than these deaths were due IHD (1,622), followed by hypertensive diseases (1,104), and HF (332). Our model estimated there was no excess obesity-related cerebrovascular mortality patients during the first pandemic year. Excess death among males accounted for almost two thirds of overall excess mortality (2800 vs. 1449). The largest portion of excess mortality was among the 55-74-year age group (2172), followed by those between under 55 years of age (1157) and those 75 and above 55–74-year age group (7178), and those under 55 years of age (1,564). A third of the excess mortality were amongst the Black or African American community [1,025]. The results for other demographics in the estimate of excess mortality are shown in Table 2.

Estimation of the proportion of excess AAMR out of the actual 2020 AAMR allows analysis of the impact of the first pandemic year on each demographic group/cause of mortality independent of their distribution in the population and these results are shown in Table 2.

3.5. Cardiovascular mortality in general population

Between 1999 and 2019 there was an overall decreasing trend in cardiovascular mortality with a 38.8% (from 350.8 to 214.6 per 100.000) decrease in AAMR (Supplementary Table 2). This trend was reversed in 2020, with a 4.6% (from 214.6 to 224.4 per 100,000 population) increase in AAMR. The same model was used to predict estimated mortality. The model estimated 63,154 excess CVD during the pandemic (Supplementary Table 3).

4. Discussion

Our analysis of CVD mortality trends attributed to obesity between 1999 and 2019, as well as between 2019 and the first year of the COVID pandemic in 2020, demonstrates several important findings. In the 20 years prior to the COVID pandemic, CVD mortality attributed to obesity almost tripled. Mortality increases were more notable among males, among rural communities, and among Asian/Pacific Islander and Native Americans compared to other race groups, although mortality in Black Americans remained highest throughout the study period. The first year of the COVID pandemic resulted in a further rise in obesity-related CVD mortality in the US across all cohorts, with most prominent increases in Hispanic, Black, Native American, and urban populations. These results highlight the trends in obesity-related CVD mortality prior to and during the first year of the COVID pandemic and have important implications for ongoing public health efforts that focus on CVD risk reduction in the growing number of obese patients in the US.

The current study expands on prior publications which describe trends in CVD mortality in the US over the last 20 years. Declines in CVD mortality were noted among the whole US population over the same time frame [14], with smaller declines in CVD mortality noted among patients with high-risk comorbid conditions such as CKD and diabetes [15,16]. However, the role of obesity as a contributor to CVD mortality has not been well characterized. Prior data from the US National Center for Health Statistics demonstrated an increase in obesity-related CV mortality between 2011 and 2017, but the findings were not further characterized based on important patient demographics [17]. Our results validate these trends from a different US dataset, and further extend the results into the early phase of the COVID era.

The rise in obesity-related CVD mortality has important clinical implications. The growing burden of obesity and obesity-related

Table 2
Projected excess Age-Adjusted cardiovascular Mortality Rate (AAMR) in obese patients per 100,000 population based on 1999–2019 trend. (AAPC - Average Annual Percent Change, *percentage excess AAMR of actual 2020 AAMR).

Main causes of death	AAPC 1999–2019 [95% CI]	2020				
		Projected AAMR	Actual AAMR	Estimated excess AAMR	% Excess AAMR*	Estimated excess deaths
All cardiovascular disease	4.8 [4.6, 5.0]	5.7	6.6	0.9	13.6	3058
Ischemic heart disease	4.1 [3.9, 4.4]	2.6	3.0	0.4	13.3	1622
Hypertensive disease	7.5 [7.0, 7.9]	1.5	1.8	0.3	16.7	1.104
Heart failure	5.0 [3.6, 6.5]	0.2	0.3	0.1	33.3	332
Cerebrovascular disease	3.5 [1.9, 5.1]	0.2	0.2	0.0	0.0	0
Sex						
Male	5.6 [5.4, 5.8]	7.1	8.7	1.6	18.4	2800
Female	3.8 [3.6, 4.0]	4.4	5.1	0.7	13.7	1449
Age						
Under 55	4.7 [4.3, 5.0]	3.0	3.5	0.5	14.3	1157
55–74	4.8 [4.6, 5.0]	15.4	18.3	2.9	15.8	2172
75 and above	5.0 [4.5, 5.4]	14.8	17.3	2.5	14.5	573
Hispanic Origin						
Hispanic or Latino	4.7 [4.4, 5.1]	3.6	4.4	0.8	18.2	405
Not Hispanic or Latino	4.9 [4.7, 5.1]	6.0	7.0	1.0	14.3	3.358
Race						
White	4.9 [4.7, 5.1]	5.3	6.2	0.9	14.5	2.859
Black or African American	4.1 [3.8. 4.3]	9.4	11.6	2.2	19.0	1.025
Asian or Pacific Islander	5.8 [5.1, 6.5]	1.4	1.6	0.2	12.5	48
American Indian or Alaska Native	5.1 [3.9. 6.3]	5.1	6.7	1.6	23.9	71
Urbanization						
Urban	4.7 [4.5, 4.9]	5.4	6.5	1.1	16.9	3590
Rural	5.4 [5.1, 5.7]	6.9	7.7	0.8	10.4	473

comorbidities may explain the slowing trend in CVD mortality improvement in the US over the last decade (2010s) compared to the previous decade (2000s) [14]; with the rise in obesity in the US potentially expected to further reduce future life expectancy [18]. Obesity and related comorbidities were further exacerbated in the early COVID era due to worsening socioeconomic conditions, stress, and altered eating behaviour [19], and our results confirm greater relative increases in obesity associated CVD mortality compared to overall CVD mortality in the early COVID era. Although obesity in itself was a known risk factor for COVID complications, these worsening obesity-related conditions risks associated with COVID public health changes may also explain the rise in obesity-related CVD mortality in 2020 which led to thousands of additional CVD deaths. Whether additional public health interventions or novel medication classes for obesity management are able reverse the trends in obesity and obesity-related CVD mortality, particularly at the time of the ongoing COVID pandemic, will require further evaluation. Additional research will also be needed to evaluate differences in aetiology of obesity-related CVD mortality during the pandemic, although delays in revascularization for acute coronary syndrome among patients with risk factors may be one explanation for greater increases in ischemic causes of mortality compared to other causes [20].

We also identify that the rise in obesity-related CVD mortality varied based on important patient characteristics, particularly race and ethnicity. A rise in obesity-related CVD mortality over the last 20 years was more prominent in Hispanic as well as in Asian/Pacific Islander and Native American patients. Although Black patients demonstrated a smaller relative increase in obesity-related CVD mortality over time, the absolute rates in the Black population remained highest of any racial or ethnic group during the study period. Therefore, while the first year of the COVID pandemic resulted in similar relative increases in CV mortality among racial and ethnic groups, one third of the excess obesity-related CV mortality occurred in the Black patients despite Black Americans comprising less than 15% of the US population. These findings are consistent with known racial and ethnic disparities in obesity trends in the US [21], which have been attributed to socioeconomic inequality, food insecurity, less access to areas for physical activity, reduced access to healthcare, and lower utilization of self-management resources [22]. Additionally, racial disparities have been identified in obesity treatment [23], which would further exacerbate baseline racial inequalities. Racial disparities were further exacerbated during the COVID pandemic, with greater CV mortality increases among racial and ethnic minorities in 2020 [14]; an effect which may be partly explained by racial and ethnic differences in obesity. In light of our findings, ongoing efforts to understand and address racial and ethnic inequality in obesity-related care will be required as part of efforts reduce the burden of obesity-related complications in these populations.

Additionally, we show that obesity-related CVD mortality increased to a greater extent in rural areas compared to urban areas between 1999 and 2019, with absolute mortality rates in 2019 higher in rural compared to urban areas. These findings expand on the previously known trends of greater obesity burden in rural regions, which has been attributed to differences in diet, education, and physical activity among other factors [24]. The first year of the COVID pandemic saw some reversal of the prior trends, with greater relative and absolute excess diabetes-related CVD mortality in urban regions. There may be several explanations for this observation. The burden of COVID itself was greater in urban communities due to higher population density and greater number of people employed in exposed occupations [25]. A greater urban burden of COVID may in turn contribute to unhealthy lifestyle choices in urban communities, which may be particularly detrimental to the high-risk obesity population and lead to increase in CVD complications [26,27]. Further attention to predisposing risk factors for obesity and obesity-related mortality is required in both urban and rural areas to reduce pre-pandemic and pandemic trends in mortality.

This study has limitations, including those inherent to analyses of large datasets and determination of cause of mortality. The underlying cause of mortality may be multifactorial and coding accuracy is important to determine whether mortality was primarily CVD in nature. Contributors to mortality, including obesity, may also be difficult to determine and classification of obesity-related CVD mortality is dependent on physician coding on the mortality certificate. Therefore, our analysis may significantly underestimate the contribution of obesity to CVD mortality. Important information about severity of obesity, concomitant comorbid conditions, and obesity risk factors are not available in this dataset. Additionally, other important clinical characteristics about delivery of care and cardiac treatments are not available for analysis. We did not examine whether changes in mortality trends in

2020 were due to COVID infection or were associated with indirect effects of COVID on the healthcare or public health system. Estimation of excess mortality was based on predicted mortality using historical data, which can be difficult to model.

In conclusion, we report that obesity-related CVD mortality in the US has increased between 1999 and 2019. Increases were most prominent in racial and ethnic minorities and in rural populations, with Black patients having the highest mortality rates of any racial group. Obesity-related CV mortality further increased in the first year of the COVID pandemic, with absolute increases most prominent among Black patients and in urban areas. As the prevalence of obesity in the US continues to rise, these findings can have important implications for targeting population interventions to improve CV mortality.

Credit author statement

Afifa Qamar – data curation, investigation, writing - original draft preparation, Dmitry Abramov - writing - original draft preparation, Ofer Kobo – methodology, writing - original draft preparation, Vjay Bang writing – reviewing and editing, Nicholas WS Chew – writing reviewing and editing, Mamas A Mamas – supervision, conceptualization, writing reviewing and editing.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijcrp.2024.200248.

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