Short Communication

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Economic burden of maternal mortality in the USA, 2018–2020

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Aim: To evaluate the economic burden of age- and race/ethnicity-based US maternal mortality disparities. Economic burden is estimated by years of potential life lost (YPLL) and value of statistical life (VSL). **Methods:** Maternal mortality counts (2018–2020) were obtained from the CDC Wide-ranging Online Data for Epidemiologic Research database. Life-expectancy data were obtained from the Social Security actuarial tables. YPLL and VSL were calculated and stratified by age (classified as under 25, 25–39, and 40 and over) and race/ethnicity (classified as Hispanic, non-Hispanic White, non-Hispanic Black). **Results:** Economic measures associated with maternal mortality increased by an estimated 30%, from a YPLL of 32,824 and VSL of US$7.9 billion in 2018 to a YPLL of 43,131 and VSL of US$10.4 billion in 2020. **Conclusion:** Our findings suggest that age, race and ethnicity are major drivers of the US maternal mortality economic burden.

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In the USA, nearly 700 women die annually due to pregnancy and related complications [1–3]. As defined by the WHO, maternal mortality is death from any cause related to or aggravated by pregnancy or its management during pregnancy and childbirth, or within 42 days of termination of pregnancy [4]. Since implementation of standardized surveillance, maternal mortality has been uptrending, from 7.2 deaths per 100,000 live births in 1987 to more than 17 deaths per 100,000 live births from 2017 onwards. There is a gap in national maternal mortality data between 2007 and 2018 [3,5]. Since 2018, however, maternal mortality has risen, with 17.4 deaths per 100,000 live births in 2018 (658 deaths), 20.1 in 2019 (754 deaths) and 23.8 in 2020 (861 deaths) [1–3]. This increase may be partly secondary to an artifact of changes in surveillance and increased identification of maternal deaths rather than a true uptick [3,5–8]. Nevertheless, these rates are dramatically higher for the USA compared with most other high-income countries, despite having higher overall medical spending. According to a Commonwealth Fund study, the rate of maternal mortality in the USA is more than twice that compared with ten other wealthy countries (17.4 vs, e.g., 3.2 in Germany, 6.5 in the United Kingdom, 8.6 in Canada and 8.7 in France) [9].

Maternal mortality rates and risk factors are not distributed evenly across populations and vary by age and race/ethnicity. In 2020, maternal mortality rates were 13.8 deaths per 100,000 live births for women under age 25, 22.8 for those aged 25–39 and 107.9 for those aged 40 and over. The difference in rate for women aged 40 to the rate for women under age 25 was 7.8-times higher and statistically significant [1]. In 2020, the maternal mortality rate for non-Hispanic Black women was 55.3 deaths per 100,000 live births, 19.1 for non-Hispanic White women and 18.2 for Hispanic women. The difference in rates for non-Hispanic Black women and non-Hispanic White women was 2.9-times higher compared with rates for non-Hispanic White and Hispanic women. Additionally, non-Hispanic Black and Hispanic women experienced significant increases in maternal mortality from 2019 to 2020, whereas for non-Hispanic White women this increase from 2019 to 2020 was not significant [1,2].

A better understanding the financial value of maternal mortality can help to highlight the magnitude of this public health crisis and the role of age and racial and ethnic disparities. O'Neil *et al.* estimated the 2019 economic impact of maternal mortality at US$30.8 million annually (all dollar values in the current paper refer to US dollars).

However, these findings are only estimations in terms of medical costs due to hospitalization and nonmedical costs due to funerals, and do not account for the long-term physical and psychological burden that each premature death imposes on society in the years thereafter. The aim of this paper is to estimate years of potential lost life and the value of a statistical life, two economic measures that describe the societal impact and monetary valuation of premature deaths, to better understand the economic cost of maternal mortality in the USA and its age- and race/ethnicity-based disparities.

Materials & methods

Data sources & population

Maternal mortality counts in the USA by individual year (2018–2020), age in years, total births, birth rates, fertility rates and race/ethnicity (classified as Hispanic, non-Hispanic White, non-Hispanic Black) were obtained from the CDC Wide-ranging Online Data for Epidemiologic Research database, which provides access to CDC public-health-related data sets. Consistent with previous National Center for Health Statistics (NCHS) (US), Division of Vital Statistics reports, maternal death count only includes deaths assigned to International Statistical Classification of Diseases, 10th Revision (ICD–10) code numbers A34, O00–O95 and O98–O99; maternal death count does not include all deaths occurring to pregnant or recently pregnant women exclusive of these codes, and maternal deaths refer to only those that occur while pregnant or within 42 days of being pregnant [1,2]. Data were unavailable prior to 2018.

The US Social Security actuarial life table was based on the mortality experience of the complete country's population, composed of residents of the 50 States and the District of Columbia (adjusted for net census undercount); civilian residents of Puerto Rico, the Virgin Islands, Guam, American Samoa and the Northern Mariana Islands; federal civilian employees and persons in the US Armed Forces abroad and their dependents; non-citizens living abroad who are insured for Social Security benefits; and all other US citizens abroad [10]. Period life expectancy is the average number of additional years a person would live if she experienced the age-specific mortality rates of the given area and time period for the rest of her life; data for females from age 0 to 119 years old were obtained from the 2019 Social Security actuarial life table [10].

All extracted data were publicly available and did not require approval from the Institutional Review Board.

Statistical analysis

The primary outcome of this study was to measure excess mortality and its economic impact using a) years of potential lost life (YPLL) and b) the value of a statistical life (VSL) due to maternal mortality from 2018 through to 2020 [11–14]. YPLL estimates premature mortality and the number of years lost from a predefined life expectancy age, with higher values indicative of premature mortality. VSL measures financial costs and is useful in cost–benefit analysis to estimate how much one group (e.g., government, society, a corporation/company) is willing to pay for reductions in their risk of dying from adverse health conditions.

Secondary outcomes were YPLL and VSL further stratified by race and ethnicity (classified [unordered] as non-Hispanic White, non-Hispanic Black and Hispanic to correlate with NCHS Health E-Stats reports) and age (classified as under 25, 25–39, and 40 and over to correlate with NCHS Health E-Stats reports) [1,2]. To estimate YPLL for each age bin, the number of maternal deaths for each individual age within each age bin was multiplied by the average period female life expectancy for the corresponding individual age. The YPLL were then summed for the total YPLL for each age bin.

VSL for each age range was calculated by multiplying the YPLL by the population average value of statistical life year, which was set to $240,676 based on previous literature [15–17]. Total YPLL and total VSL for each year from 2018 through 2020 were computed by summing the YPLL and VSL for each age range and race/ethnicity, respectively.

Results

CDC Wide-ranging Online Data for Epidemiologic Research data extraction shows that 2018–2020, White mothers had the highest percentage of births at about 57% as compared with Hispanic (25%) and Black births (16%). The Hispanic population had the highest birth and fertility rates as compared with White and Black populations (Table 1).

National Center for Health Statistics data report that there were an estimated 658 maternal mortality cases in 2018 (total YPLL 32,824; total VSL $7.9 billion), 754 in 2019 (total YPLL 37,998; total VSL $9.1 billion) and 861 in 2020 (total YPLL 43,131; total VSL $10.4 billion). This represents 2273 cases of maternal mortality

Table 1. Birth and fertility rates by Hispanic origin and race across 2018–2020.

Year	Hispanic or Latino	Births	Total population	Birth rate	Female population	Fertility rate	% of total births
2018	Hispanic or Latino	854,377	55,494,785	15.4	12,458,783	68.58	25.21
	Black or African American	552,029	40,902,223	13.5	8,972,311	61.53	16.29
	White	1,956,413	197,546,407	9.9	35,128,528	55.69	57.72
2019	Hispanic or Latino	853,201	56,139,966	15.2	12,569,294	67.88	25.51
	Black or African American	548,075	41,147,488	13.32	9,005,247	60.86	16.39
	White	1,915,912	197,309,822	9.71	35,063,576	54.64	57.28
2020	Hispanic or Latino	832,704	56,640,105	14.7	12,715,840	65.49	25.76
	Black or African American	529,811	41,427,341	12.79	9,040,160	58.61	16.39
	White	1,843,432	196,773,390	9.37	35,022,798	52.64	57.03

Note: Data obtained from CDC Wide-ranging Online Data for Epidemiologic Research database.

Table 2. Total years of potential life lost and total value of statistical life by year.

	2018		2019		2020		2018–2020	
Deaths	658		754		861		2273	
	Total YPLL	Total VSL (USD)	Total YPLL	Total VSL (USD)	Total YPLL	Total VSL (USD)	Total YPLL	Total VSL (USD)
	32,824	7,899,886,448	37,998	9,145,319,766	43,131	10,380,574,895	113,953	27,426,000,000

USD: US dollars; VSL: Value of statistical life; YPLL: Years of potential life lost.

Table 3. Total years of potential life lost and total value of statistical life by age group and year.

	Under 25		25–39		40 and over	
Total deaths	321		1609		342	
	Total YPLL	Total VSL (USD)	Total YPLL	Total VSL (USD)	Total YPLL	Total VSL (USD)
2018	5815	1,399,497,245	22,750	5,475,494,524	4258	1,024,894,678
2019	6741	1,622,375,255	27,254	6,559,479,974	4003	963,464,536
2020	6916	1,664,560,944	30,564	7,356,062,179	5651	1,359,951,772
2018–2020	19,472	4,686,433,445	80,569	19,391,036,678	13,912	3,348,310,986

USD: US dollars; VSL: Value of statistical life; YPLL: Years of potential life lost.

Table 4. Total years of potential life lost and total value of statistical life by race/ethnicity and year.

	Non-Hispanic White		Non-Hispanic Black		Hispanic	
Total deaths	986		740		375	
Year	Total YPLL	Total VSL (USD)	Total YPLL	Total VSL (USD)	Total YPLL	Total VSL (USD)
2018	14,506	3,491,347,140	10,161	2,445,569,005	5384	1,295,717,754
2019	17,304	4,164,578,081	12,149	2,923,907,741	5721	1,376,953,124
2020	17,424	4,193,473,641	14,854	3,574,905,034	7950	1,913,311,624
2018–2020	49,234	11,849,398,862	37,164	8,944,381,780	19,055	4,585,982,503

USD: US dollars; VSL: Value of statistical life; YPLL: Years of potential life lost.

2018–2020 with a total YPLL of 113,953 and total VSL of $27.4 billion. Table 2 shows the total YPLL and VSL by year and overall.

During this 3-year period from 2018 to 2020, mothers under 25 accounted for 321 deaths (total YPLL 19,472; total VSL $4.7 billion), 25–39 year-old mothers for 1609 deaths (total YPLL 80,569; total VSL $19.4 billion) and 40-and-over mothers 342 deaths (total YPLL 13,912; total VSL $3.3 billion). Table 3 shows the total YPLL and VSL by age group classification bin and year.

Additionally, from 2018 to 2020, Non-Hispanic White mothers accounted for 986 deaths (total YPLL 49,234; total VSL $11.8 billion), Non-Hispanic Black mothers for 740 deaths (total YPLL 37,164; total VSL $8.9 billion) and Hispanic mothers 375 deaths (total YPLL base case 19,055; total VSL $4.6 billion). Table 4 shows the total YPLL and VSL by race/ethnicity and year.

Discussion

This study assesses the relationship between age and race/ethnicity and the financial burden of maternal mortality in the USA from 2018 to 2020, as estimated by economic cost-benefit measures: YPLL and VSL. Estimations of YPLL represent the sum of years of life lost annually by persons who suffered early deaths, and VSL represents the amount of additional spending that would be commonly accepted as justifiable to prevent excess maternal mortality. We found that there was a dramatic increase in both YPLL and VSL due to maternal mortality over the time studied, increasing more than 30% from an estimated YPLL of 32,824 and VSL of $7.9 billion to 43,131 and $10.4 billion, respectively. Overall, during 2018–2020, the economic burden of maternal mortality was estimated at a total YPLL of 113,953 and total VSL of $27.4 billion. We also observed significant racial and ethnic disparities in the economic metrics of maternal mortality.

Our results should be placed into context of another previous economic analysis of maternal mortality and morbidity. The analysis by O'Neil *et al.* developed cost estimates for all 2019 maternal morbidity conditions, including medical and nonmedical costs associated with outcomes for birthing people and their offspring from pregnancy through post-delivery year five. Their analysis showed that the costs of child outcomes was $24.0 billion, and this was much greater than the costs of maternal outcomes at $8.3 billion (of which $30.8 million is attributed to maternal mortality). Their work, however, was limited by data availability and likely underestimated the costs of maternal outcomes.

Our analysis showed increases in maternal mortality for nearly every category of age over the years studied, aside from 2019 where there was a transient decrease in maternal mortality for births to women aged 40 years and over compared with 2018. During 2018–2020, more than 15% of maternal deaths were among patients aged 40 years or older, though the total number of births by women of the same category was only 3.5% [18]. Comparing the overall increase in maternal mortality from 2018–2020, however, there were significant increases in births by women aged 25–39 years and 40 years and over; therefore, women who give birth at age 40 or over not only continue to have the highest risk of mortality, but experience mortality at higher rates [1–3]. Analysis of 2016–2017 vital statistics mortality data with cause-of-death literal text indicated that the leading causes of death for women aged 35 years and over were obstetric hemorrhage (leading cause; four-times higher than for women <35 years), postpartum cardiomyopathy (three-times higher), obstetric embolism, eclampsia/preeclampsia and other complications of obstetric surgery and procedures [19].

There was an increase in maternal mortality for each category of race/ethnicity in each of the years studied, with an overall increase of 21% for White mothers, 32% for non-Hispanic Black mothers and 35% for Hispanic mothers. However, from 2019 to 2020 non-Hispanic Black and Hispanic women experienced significant increases in maternal mortality, whereas for non-Hispanic White women the increase was not significant. While our findings show total maternal mortality and the economic costs associated to be highest among White deliveries, it must be viewed in the context of the proportion of White births and total births by race/ethnicity as a denominator (Table 1). In this time period, percentages of birth by race/ethnicity were about 57% White, 25% Hispanic and 16% non-Hispanic Black. For comparison, White mothers constitute about 47% of the economic cost measures, while non-Hispanic Black mothers are about 35% of the costs and Hispanic mothers about 18%. Therefore, YPLL and overall rate of maternal mortality remains disparate among women of different racial backgrounds when compared with their respective birth population percentages, with the greatest increases among non-Hispanic Black women. These racial disparities are multifactorial [20] and have previously been attributed to prevalence of preexisting and chronic disease [21], access to prenatal care [22] and pervasive implicit bias that negatively impacts medical care [23]. Non-Hispanic Black women are more likely to experience differences in obstetrical and anesthesia care received, severe maternal morbidity (SMM), failure to rescue (FTR) from SMM to maternal mortality and hospital readmission after birth [20,24–27].

Research has indicated that hospital-level factors and variations in hospital quality can influence obstetrical outcomes, including maternal mortality, FTR and SMM [26,28–30]. National obstetrical care benchmarking systems allow for better promotion of best practices and identification of system-based issues driving disparities [30]. Adoption of enhanced recovery after surgery protocols promotes equality in care provided to all patients and thereby reduces racial and ethnic disparities [20]. Implementation of health information technology also promotes healthcare equity to address disparities via better documenting of patient clinical history and risk factors, minimizing provider bias, improving coordination of clinical care and enhancing adherence to clinical guidelines [31,32]. Using 2017 data from a Turkish tertiary hospital setting, Oğlak *et al.* [33] indicated that adopting maternal near-miss concepts into a health system to evaluate the quality of obstetrical healthcare facilities can serve as a method to prevent maternal mortality. Maternal near miss or FTR have likewise been shown to be associated with hospital-level factors and to be a contributor to healthcare disparities. Friedman *et al.* [34] using National Inpatient Sample data from 1998 to 2010 (n = 50,433,539 delivery hospitalizations) showed that both low and high annualized hospital delivery volume were associated with both SMM and FTR from SMM to mortality. Additionally, FTR was higher among non-Hispanic Black and Hispanic women than non-Hispanic White women. Further analysis by Guglielminotti *et al.* [25] focused on racial and ethnic disparities in FTR, using 1999–2017 National Inpatient Sample data (n = 73,934,559 delivery hospitalizations) which indicated a higher FTR rate ratio for racial and ethnic group mothers compared with White mothers (ratio of FTR in the racial and minority group to FTR rate in White women). For instance, the adjusted FTR rate ratio was 1.79 (95% CI 1.77–1.81) for Black women, 1.39 (95% CI 1.37–1.41) for women of other race and ethnicity, 1.43 (95% CI 1.42–1.45) for women with missing race and ethnicity data and 1.08 (95% CI 1.06–1.09) for Hispanic women.

Our study has several limitations. The use of our economic metrics, including the measure of an entity's willingness to pay for risk reduction (VSL) may not be appropriate for evaluating maternal mortality, considering the inherent age- and race/ethnicity-based disparities [11,15]. VSL was determined from a set actuarial value that did not account for patient-level social determinant of health heterogeneity [12–14]. Additionally, there exist multiple methods to calculate VSL, which may differ based on national wealth and average personal incomes [14]. Official national data on maternal mortality was not available prior to 2018 [1–3], and our study cannot provide a longitudinal assessment of maternal mortality costs and disparities. Our study period also included the height of the COVID-19 pandemic in the USA, which strained healthcare resources and presented particular health risks to pregnant patients. The lack of stratified data limited the scope of our analysis and precluded us from assessing potential economic burden variance, analyzing contributing factors and in ultimately establishing specific population-level interventions to reduce maternal mortality risk. Our analysis focuses on maternal mortality rates, and it should be noted that some types of maternal deaths, such as homicide, suicide and drug-related overdoses, are not automatically included in maternal mortality rate analysis. For example, accidents, suicides and homicides are not converted to ICD-10 O-codes (coding system used for identifying maternal mortality), and as a result, some deaths due to external causes may not be coded as maternal, thereby leading to underreporting. Accurate coding to capture these causes of death requires death certificate certifiers of pregnancy status to be included. Research has shown that homicide, suicide and drug-related overdose represent the three leading causes of pregnancy-associated death [35]. Therefore, our analysis may undercount and underestimate the economic impact of maternal mortality.

This study has several strengths, including external validity for the US population. Our analysis of 2018–2020 maternal mortality data from the CDC Wide-ranging Online Data for Epidemiologic Research database provides national mortality estimates and classifications consistent with those used in previous National Center for Health Statistics, Division of Vital Statistics reports. Furthermore, we used US Social Security Administration actuarial life tables and economic estimates generalizable to the US population. We acknowledge that our economic estimates may not be generalizable to other countries, individual states or cities/communities, considering inherent societal value differences or disparities in race/ethnicity- and age-based maternal mortality.

Conclusion

Maternal mortality and disparities in populations affected by maternal mortality are caused by a multitude of patient-, hospital- and community-level factors [1–3]. Systemic and structural racism, differences in access to care and quality of care received, social determinants of health and co-occurrence of medical comorbidities contribute to these disparities in race/ethnicity- and age-based maternal outcomes [20]. Our study estimated the economic burden associated with these disparities in maternal mortality and showed a substantial increase in years of potential life lost and statistical value of lives lost due to maternal mortality from 2018 to 2020. These economic cost measure increases follow broader trends in increases in national maternal mortality rates over the past two decades. The data presented here suggest that a significant increase in public spending to reduce US maternal mortality risk may be justified according to commonly accepted economic cost–benefit analysis metrics. Addressing maternal mortality will require unparalleled national, state-wide and local initiatives to improve perinatal medical care. Prospective economic estimations from this analysis may additionally inform public health officials on the value of policies aimed at reducing maternal mortality and closing the disparity gap.

Summary points

- The estimated years of potential life lost and statistical value of lives lost due to maternal mortality in the USA from 2018 to 2020 are substantial.
- From 2018 to 2020, the national economic burden of lives lost was US$27.4 billion.
- Age- and race/ethnicity-based analysis demonstrates that the economic burden of maternal mortality was disproportionately concentrated in non-Hispanic Black patients and patients 40 years and older.

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