Non-Obstetric Maternal Mortality Trends by Race in the United States

Ryan S. Huang[1] · Andrea R. Spence[2] · Haim A. Abenhaim[3]

Abstract

Objectives Public health interventions to reduce maternal mortality have largely focused on obstetric causes of death. However, previous studies have noted that non-obstetrics factors, such as motor vehicle accidents, substance overdoses, homicides, and suicides, may account for a large proportion of maternal deaths. The study objective was to examine trends in maternal deaths from non-obstetric causes across races in the United States (US).

Methods A population-based cross-sectional study was conducted on 80,710,348 live births using data from the "Birth Data" and "Mortality Multiple Cause" files compiled by the Centers for Disease Control and Prevention from 2000 to 2019. The annual incidence of maternal deaths attributed to non-obstetric causes (/100,000 live-births) during pregnancy and up to 42 days postpartum were calculated across racial groups. Then the effects of race on the risk of non-obstetric maternal mortality and temporal changes over the study period were examined using logistic regression models.

Results From 2000 to 2019, a total 7,334 women died during pregnancy, childbirth, and within 42 days postpartum from non-obstetric causes, representing 34.5% (7,334/21,241) of all maternal mortality. Of non-obstetric deaths, 31.3% were caused by transport accidents and 27.3% by accidental poisoning. American Indian women were found to have the highest risk of non-obstetric maternal mortality (OR 2.20,95% CI 1.90–2.56), and 46.1% (176/382) of all deaths among pregnant American Indian women were caused by non-obstetric complications. Risk of non-obstetric maternal mortality increased overall during the 20-year study period, with a greater increase among Black (1.15, 1.13–1.17) and American Indian women (1.17, 1.13–1.21).

Conclusion Non-obstetric causes of death have become increasingly prevalent in the US, especially in American Indian women. Novel interventions to address these non-obstetric factors should especially target American Indian women to improve maternal outcomes.

Significance

What is Already Known on this Subject? Black women and American Indian women have the highest maternal mortality rates in the United States. Few studies have considered non-obstetric causes of maternal death.

What this Study adds? Non-obstetric causes of maternal mortality have become increasingly prevalent in the US within the past two decades, with more than one-third of all deaths in pregnant women being non-obstetric in nature. American Indian women and Black women were found to be at the highest risk of non-obstetric mortality, with an upward trend over time. Maternal deaths due to non-obstetric causes was also elevated among Black women compared to white women.

Keywords Non-obstetric · Maternal Mortality · race · United States

✉ Haim A. Abenhaim
    haim.abenhaim@mcgill.ca

1   Division of Experimental Medicine, McGill University, Montreal, QC, Canada

2   Center for Clinical Epidemiology, Lady Davis Institute, Jewish General Hospital, Montreal, QC, Canada

3   Department of Obstetrics and Gynecology, Jewish General Hospital, McGill University, 5790 Cote-Des Neiges, Pav. H 325, Montreal, QC H3S 1Y9, Canada

Introduction

Maternal mortality is a key indicator of nationwide maternal and infant health (Say et al., 2014), and remains a serious medical concern with more than 300,000 women worldwide dying from complications during pregnancy or childbirth each year (World Health Organization, 2022). Over the past two decades, maternal mortality has decreased in most high-income countries, but an upward trend has been observed in

the United States (US) (Callaghan, 2012; Declercq, 2020; MacDorman et al., 2016; World Health Organization, 2019). Specifically, between 2000 and 2020, the maternal mortality ratio in the US increased by an estimated 78% from 12 to 21 maternal deaths/100,000 live births (World Health Organization, 2023).

Globally, direct and indirect obstetric causes of maternal mortality have continued to receive attention from healthcare providers and policy makers, whereas non-obstetric causes have not received the same level of attention (Kong et al., 2021). Non-obstetric causes of mortality are those unrelated to pregnancy or the postpartum, such as motor vehicle accidents, substance overdoses, homicides, and suicides. It is believed that these specific non-obstetric causes may account for a large proportion of maternal deaths in the US, (Campbell et al., 2021; Mangla et al., 2019; Margerison et al., 2022; Sakamoto et al., 2019; Wallace et al., 2021). Maternal mortality, whether due to non-obstetric or obstetric complications, are equally important to discern and deserve national attention. The World Health Organization's (WHO) definition of maternal death, which is the most commonly referenced, does not include accidental and incidental causes of death (World Health Organization, 2022); hence, it is not surprising that studies examining non-obstetric causes of death during pregnancy and childbirth are limited. A recently published study that collectively considered both obstetric and non-obstetric causes of maternal death found that Black women, followed by American Indian women, had the highest maternal mortality rates in the US (Huang et al., 2023).

Currently, there is a need for greater understanding of non-obstetric causes of death and racial disparities in maternal mortality in the US. Hence, the purpose of our study was to conduct a nationwide population-based study to estimate maternal mortality rates arising from non-obstetrical causes in the US and to examine associations between race and risk of non-obstetric maternal mortality.

Materials and Methods

Study Design and Data Sources

We conducted a 20-year retrospective population-based cross-sectional study on all non-obstetric maternal deaths during pregnancy, childbirth, and within 42 days of childbirth occurring in the US from 2000 to 2019 using the birth and mortality records compiled by the National Center for Health Statistics (NCHS) at the Centers for Disease Control and Prevention (CDC). This observation period of pregnancy and postpartum is in concordance with the time-frame employed in the WHO's definition of maternal death (World

Health Organization, 2022). The birth data were extracted from the "Birth Data" files, which are developed by the NCHS annually by taking information from the birth certificates for all births to residents and non-residents occurring in the US. Birth certificates are required by state laws and the data are collected and merged by the NCHS to create the "Birth Data" files (National Center for Health Statistics. Vital Statistics Online Data Portal). The mortality data used in the study were obtained from the "Mortality Multiple Cause" files from the CDC (Kong et al., 2021). These mortality data files contain information collected directly from official death certificates for every recorded death in the US (Hoyert & Miniño, 2020). The medical portion of each death certificate is completed by a physician and a medical examiner indicating the primary cause of death and additional contributing causes. Subsequently, this information is filed in vital statistics offices in each state and compiled into national data through the National Vital Statistics System (NVSS) creating the "Mortality Multiple Cause" data files. In this way, the NVSS captures all deaths across every state in the US with medically certified death certificate information. Although the WHO definition of maternal mortality does not include accidental and incidental deaths (World Health Organization, 2022), we defined maternal mortality as the death of a woman during pregnancy, childbirth, or within 42 days of childbirth, from any cause including direct obstetric, indirect obstetric, and non-obstetric causes. Specifically, the non-obstetric causes that have contributed to these deaths were examined in this study.

Data Extraction

We created the study cohort by extracting all 80 million live births occurring in the US between 2000 and 2019 from the "Birth Data" files. Then, the International Classification of Diseases (ICD)-10 codes A34, O00-O95, and O98-O99 were used to identify all deaths during pregnancy, childbirth, and within 42 days of childbirth from the "Mortality Multiple Cause" data files according to the WHO application of ICD-10 codes to pregnancy-related deaths (World Health Organization, 2012). The same ICD-10 codes have been used to code cause-of-death data in the US since 1999 (World Health Organization, 2010), and therefore we used the same codes for the entire study period. The "Mortality Multiple Cause" files contain a "Record-Axis" conditions column highlighting the ICD-10 code for the primary cause of death and up to 20 contributing causes. Within the column, all records where the maternal death ICD-10 codes were identified as either the medically certified primary or 1–20 contributing causes of death were extracted from the data files. After extraction, the data were segmented by primary cause-of-death into deaths occurring from direct obstetric causes,

indirect obstetric causes, or non-obstetric causes of death using the appropriate ICD-10 codes. All records where A34, O00-O95, and O98-O99 were not the primary cause of death but listed as a contributing condition were sorted into the non-obstetric cohort to identify women dying from non-obstetric conditions. The ICD codes for these non-obstetric causes are list in Table 1. These include the following causes of death: Transport accidents (any accident involving a device designed primarily for transporting persons or goods from one place to another); Accidental poisoning (accidental poisoning by drugs and biological substances including unintentional overdose from noxious substances); Assault/homicide (injuries inflicted by another person with intent to injure or kill, by any means); Intentional self-harm (suicide, regardless of the causal factors); Accidental exposure to physical forces (mechanical and external causes of injury); Complications of medical care (surgical and medical procedures resulting in abnormal reaction of the patient or due to complication); Legal interventions (injuries inflicted by law-enforcing agents); and other unspecified non-obstetric causes during pregnancy, childbirth and 42 days postpartum. Further stratification of the data by race was achieved using a combination of the "Race Recode" and "Hispanic Origin" variables to identify women as either White, Black, Hispanic, American Indian, or Asian/Pacific Islander in the study.

Table 1 Primary causes of death in all death certificates with a non-obstetric maternal death diagnosis from 2000–2019 in the US

Record Axis Code	Condition	Frequency (% subset)	% of Total
All Maternal Deaths		21,241	100
Obstetric Deaths		13,907	65.5
Non-Obstetric Deaths		7,334 (100)	34.5
V01-V99	Transport Accidents	2,295 (31.3)	10.8
X40-X49	Accidental Poisoning/ Overdose	2,002 (27.3)	9.4
X85-Y09	Assault/Homicide	1,380 (18.8)	6.5
X60-X84	Intentional Self-Harm/ Suicide	897 (12.2)	5.1
Y10-Y34	Events of Undetermined Intent	203 (2.8)	1.0
W00-X59	Accidental Exposure to Physical Forces	201 (2.7)	0.9
Y40-Y84	Complications of Medical Care	56 (0.8)	0.3
Y35-Y36	Legal Intervention/Injury from Law-Enforcer	8 (0.1)	0.0
Y84-Y98	Other Non-Obstetric Unspecified Cause	292 (4.0)	1.4

Statistical Analyses

First, we calculated the overall and annual maternal mortality rates attributed to non-obstetric causes per 100,000 live births from 2000 to 2019. Second, the individual non-obstetrical causes of death were enumerated. Third, race-specific mortality rates attributed to non-obstetric causes were calculated and logistic regression models were used to estimate associations between race and risk of maternal mortality from non-obstetric causes through the estimation of odds ratios (OR) and 95% confidence intervals (CI). White individuals were used as the reference group since they were the largest racial group. Next, the frequencies of specific non-obstetric causes were examined by race. Lastly, we examined the temporal trends of non-obstetric maternal mortality across each race stratum by calculating the annual change in maternal mortality rates from 2000 to 2019 using the slope within logistic regression models, with year of maternal death entered as a continuous independent variable.

The analyses were conducted using SAS 9.4 statistical software and graphs were developed with Excel 2019. P-values < 0.05 were considered statistically significant.

Ethical Approval

According to the Tri-Council Policy of 2018, institutional ethics approval was not required for this study as it was only based on data from a publicly available database (Canadian Institutes of Health Research, December 2018). Our study adhered to the Declaration of Helsinki and followed the STROBE guidelines.

Results

Over the study period of 2000–2019, 80,710,348 live births were extracted, with births ranging from 3.7 to 4.3 million annually. In total, 7,334 maternal deaths had a primary cause of death labeled as a non-obstetric cause, comprising 34.5% of all 21,241 deaths occurring during pregnancy, childbirth, or 42 days postpartum throughout the study period. Table 1 shows the most common causes-of-death for all deaths in pregnant women from non-obstetric causes. Transport accidents were the most common cause of death, making up 31.3% of all non-obstetric deaths, while the second was accidental poisoning (27.3%), and third was assault (18.8%).

Table 2 shows the distribution of non-obstetric maternal deaths, total number of live births, and non-obstetric maternal mortality rate by race, as well as the association between race and risk of non-obstetric maternal mortality. The

Table 2 Non-obstetric maternal death incidence in the US stratified by race

Cohort	Non-Obstetric Maternal Deaths N (%)	Livebirths from the General US Population N (%)	Non-Obstetric Maternal Deaths per 100,000 Births (95% CI)	% of Maternal Deaths due to Non-Obstetric Causes	Odds Ratio (95% CI)	P-value
All	7,334	80,710,348	9.1 (6.7–11.8)	34.5[a]		
Race						
White	4,528 (61.7)	44,384,643 (55.0)	10.2 (7.3–13.8)	42.3	Reference	
Black	1,377 (18.8)	11,930,146 (14.8)	11.5 (7.7–15.5)	22.5	1.13 (1.07–1.20)	< 0.0001
Hispanic	1,079 (14.7)	18,748,899 (23.2)	5.6 (4.3–7.2)	33.0	0.56 (0.53–0.60)	< 0.0001
American Indian	176 (2.4)	782,950 (1.0)	22.5 (14.5–32.3)	46.1	2.20 (1.90–2.56)	< 0.0001
Asian/Pacific Islander	172 (2.3)	4,362,792 (5.4)	3.9 (2.5–4.3)	24.3	0.39 (0.33–0.45)	< 0.0001
Other	2 (0.0)	500,918 (0.6)	0.4 (-0.5-1,3)	5.2	0.04 (0.01–0.16)	< 0.0001

[a] A total of 21,241 maternal deaths occurred during the study period

Table 3 Cause of non-obstetric death by maternal race

Cause of death	White	Black	Hispanic	American Indian	Asian/ Pacific Islander
Transport Accidents	1394 (30.8)	369 (26.8)	412 (38.2)	67 (38.3)	52 (30.2)
Accidental Poisoning/Overdose	1508 (33.3)	231 (16.8)	195 (18.1)	45 (25.5)	23 (13.3)
Assault/Homicide	523 (11.5)	581 (42.2)	241 (22.3)	17 (9.7)	18 (10.2)
Intentional Self-Harm/ Suicide	596 (13.2)	100 (7.3)	121 (11.2)	27 (15.4)	54 (31.1)
Events of Undetermined Intent	145 (3.2)	19 (1.4)	22 (2.0)	5 (2.6)	13 (7.5)
Accidental Exposure to Physical Forces	139 (3.1)	29 (2.1)	26 (2.4)	5 (3.1)	2 (1.0)
Complications of Medical Care	25 (0.6)	17 (1.2)	11 (1.0)	1 (0.5)	2 (1.4)
Legal Intervention	3 (0.1)	3 (0.2)	0 (0.0)	2 (0.9)	0 (0.0)
Other	196 (4.3)	28 (2.0)	51 (4.7)	7 (4.0)	9 (5.2)
Total	4528 (100)	1377 (100)	1079 (100)	176 (100)	172 (100)

overall maternal mortality rate from non-obstetric causes over the study period was 9.1 deaths per 100,000 live births. The mortality rate due to non-obstetric causes was highest among American Indian women at a rate of 22.5 maternal deaths per 100,000 live births. Out of all maternal deaths in American Indian women, 46.1% had a primary cause of death labeled as a non-obstetric complication compared to the 34.5% observed for the entire cohort. Compared with white women, American Indian women were found to be at a more than 2-fold greater risk of maternal mortality from non-obstetric causes (2.20, 95% CI 1.90–2.56), while Black women were also found to be at a greater risk (1.13, 95% CI 1.07–1.20). On the other hand, Hispanic (0.56, 95% CI 0.53–0.60) and Asian/Pacific Islander (0.39, 95% CI 0.33–0.45) women showed a lower risk of maternal death from non-obstetric causes compared with white women.

Table 3 shows the distribution of specific non-obstetric causes of maternal mortality for each racial group. White individuals most commonly died from accidental poisoning/overdose, although the frequency of transport accident deaths was just slightly lower. Black individuals more frequently died from assault/homicide. Transport accidents were the most common cause of non-obstetric deaths among Hispanics and American Indians. Suicides were the most frequent cause of death among Asian/Pacific Islanders,

although motor vehicle accidents were almost comparable in terms of frequency in this racial group.

Over the study period, there was an upward trend in annual maternal mortality rates from non-obstetric causes (Fig. 1). The annual increase in maternal mortality rate from non-obstetric causes was the greatest in American Indian women, while Hispanic and Asian/Pacific Islander women showed little annual increase (Table 4).

Discussion

Our analysis revealed that non-obstetric complications were the primary cause of death in 34.5% of women who died during pregnancy, childbirth, or within 42 days postpartum over the past 2 decades in the US, with transport accidents, accidental poisoning, and assault representing the most prevalent causes of death. An upward trend was observed in non-obstetric maternal mortality from 2000 to 2019 in the US, with the greatest annual increase and greatest odds of non-obstetric death observed in American Indian women. Research on accidental and incidental causes of maternal death is notably limited. To our knowledge, this is the first nation-wide study on the trends and characteristics of

Table 4 Annual change in the non-obstetric maternal mortality rate from 2000–2019 in the US population stratified by race

Cohort	Annual Increase per 100,000 Births	Odds Ratio (95% CI)	*P*-Value
All	1.0	1.12 (1.12–1.13)	<0.0001
Race			
White	1.2	1.13 (1.12–1.14)	<0.0001
Black	1.3	1.15 (1.13–1.17)	<0.0001
Hispanic	0.5	1.09 (1.08–1.10)	<0.0001
American Indian	2.7	1.17 (1.13–1.21)	<0.0001
Asian/Pacific Islander	0.2	1.03 (1.01–1.07)	<0.0001

non-obstetric causes of maternal deaths in the US, although such studies have been conducted in individual states.

Our study found that American Indian women were at a two-fold greater risk of maternal death from non-obstetric causes compared with white women, with the mortality rates increasing the most over time among the former group. Maternal mortality and severe maternal morbidity have previously been reported to be higher in American Indian women than in white women (Heck et al., 2021; Kozhimannil et al., 2020), but there is little literature on the contribution of accidental and incidental causes of mortality. This current study found that 46.1% of all maternal deaths in American Indian women were caused by non-obstetric complications, which is the highest of all racial groups. We also observed that Black women had a greater risk of maternal death due to non-obstetric factors, compared with white women. Although it is well known that Black women in the US have a significantly higher rate of pregnancy-related

deaths than white women, largely due to cardiomyopathy, thrombotic pulmonary embolism, and hypertensive disorders of pregnancy (Petersen et al., 2019), less is known about the non-obstetric factors of maternal death of this racial group. These racial disparities in maternal mortality have been attributed to marginalization of racialized groups and structural racism within the healthcare system, healthcare encounters, and society at large. This has a multitude of possible ramifications including inadequate access to healthcare, dismissal of health concerns by the healthcare system, living in food deserts, poor housing, disadvantaged economic status, among others (LoGiudice, 2022). Further, living with chronic and daily exposure to microaggressions negatively impacts overall health (Geronimus, 1992). These are complex factors that need to be addressed to improve the health of childbearing American Indian and Black women. We also observed that Hispanic and Asian/Pacific Islander women were at a lower risk of non-obstetric causes of
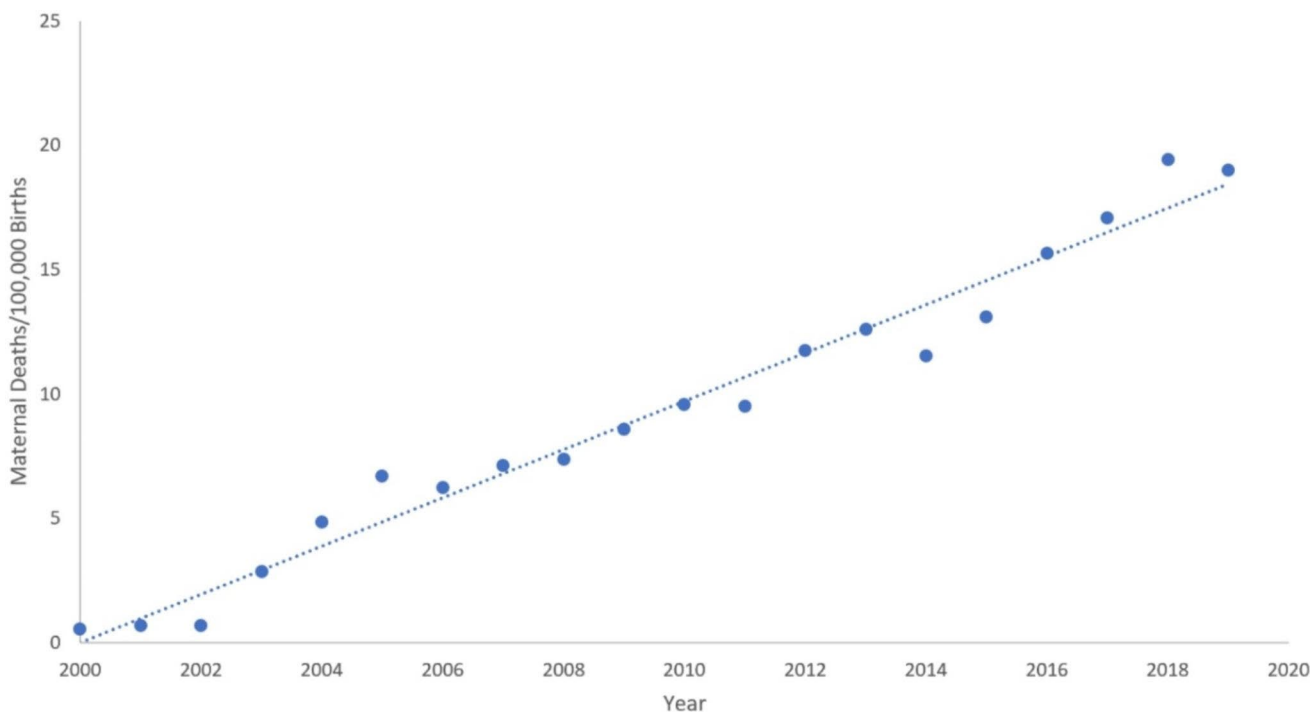
Fig. 1 Annual incidence of non-obstetric maternal mortality per 100,000 deliveries from 2000–2019 in the US

maternal death relative to white women. To our knowledge, there is no literature examining accidental and incidental causes of death among Hispanic and Asian/Pacific Islander communities; however, lower maternal mortality rates overall have been reported among these racial groups (Guendelman & Abrams, 1995; Marcus & Crane, 1985).

Our study observed that transport accidents were the overall leading non-obstetric cause of maternal mortality, comprising 31.3% of all non-obstetric deaths, which is consistent with previous studies indicating motor vehicle accidents to be the leading cause of maternal mortality related to injury (Sakamoto et al., 2019; Vladutiu & Weiss, 2012). A multi-state study found that about 92,500 pregnant women were hurt annually by motor vehicle accidents in the United States (Sirin et al., 2007), which surpassed all other non-obstetric complications. It has been shown that physiologic changes of pregnancy increase fatigue and sleep deprivation in pregnant women (Rodriguez et al., 2001). These characteristics, along with everyday maternal stressors, may be associated with an increased risk of motor vehicle accidents (McCall & Bhattacharya, 2014; Taylor & Dorn, 2006). Despite the proven efficacy of seatbelt use at reducing injuries and deaths due to motor vehicle accidents, decreased seatbelt use during pregnancy has been observed, placing these women at an even greater risk of injury (Lam et al., 2016). In addition, the use of illicit substances and alcohol may significantly increase the risk of fatal crash involvement (Li et al., 2013), making substance and alcohol use during pregnancy an even greater concern. Counseling pregnant women regarding the connection between alcohol and substance use on the greater risk of accidents, as well as the importance of seatbelt use, is necessary to address the large number of maternal deaths caused by transport accidents. However, it should be noted that the data sources used for our study were limited in that they did not allow us to delve deeper into the circumstances surrounding these deaths related to transport accidents. For instance, we were not able to determine if the pregnant/postpartum individuals were driving the vehicles during the accident or whether were they were passengers. We were also not able to determine if transport accidents were more common during pregnancy or during the postpartum. Further, what percentage of fatal transport accidents involved substances or were suicides? These are all questions that need to be studied in forthcoming research in order to address the high proportion of maternal deaths caused by transport accidents.

Although a large proportion of non-obstetric deaths were attributable to motor-vehicle accidents among all racial groups in our study, they were the most common cause of non-obstetric death among American Indian and Hispanic women during pregnancy and post-partum, comprising 38% of maternal deaths in each group. Previous studies have shown that higher proportions of Hispanic and American Indian pregnant women are killed in motor vehicle crashes, compared with non-Hispanic white women (Schiff et al., 1997). For American Indian women, rates of driver alcohol impairment assessed by the police are much higher among American Indian drivers and highest among rural American Indian drivers, resulting in a greater risk of motor vehicle accidents among these women (Gross et al., 2007; Grossman et al., 1997). Additionally, this racial group has lower reported rates of seatbelt usage (Crump et al., 2019). To address the disparity in transport accidents leading to deaths among American Indian women, motor vehicle injury prevention programs should continue to be implemented targeting American Indian communities (Letourneau et al., 2008). In particular, the CDC employed road safety interventions among four American Indian tribes between 2004 and 2009 that led to an increase in seat belt usage, as well as a decrease in alcohol-impaired driving (West & Naumann, 2014), providing support for the continued use of these programs in the future. If true progress is to be made at reducing maternal mortality due to transport accidents, the factors noted above must be examined in the context of historical injustices committed against American Indian individuals and injustices that are continued to be perpetuated (Centers for Disease Control and Prevention (CDC), 2017). Further research must be done to examine the reasons accounting for the high rate of traffic accidents among Hispanic women.

Accidental poisoning/overdose, assault/homicide, and intentional self-harm/suicide were found to be the second, third, and fourth most prevalent causes of non-obstetric maternal mortality in our study, representing 27.3%, 18.8%, and 12.2% of deaths, respectively. Substance overdose was found to be the cause of death among 33% of white women in our study, the highest percentage of all the racial groups. Maternal death due to substance overdose are more common among white women in the US (Schiff et al., 2018). In the US, perinatal substance use is a major public health dilemma with 40% of individuals with a lifetime drug disorder being women (Prince et al., 2023). In fact, between 2007 and 2016, pregnancy-associated mortality due to substance overdoses more than doubled in the USA (Gemmill et al., 2019). Although our data source did not provide the specific substances associated with the overdose-related deaths, there is currently a public health crisis in the US due to opiates, including synthetic opioids, such as fentanyl, in the general population and pregnant women (Martin et al., 2019). A recent study found that the majority of drug-related deaths during pregnancy and the postpartum may be due to prescription or illicit opioids (Cleveland et al., 2020). Further, an estimated 30% of opioid dependent individuals in the US are women of child-bearing age (Unger et al., 2010). State-level studies that examined the incidence of substance

overdoses and injuries as causes of maternal death also found concerningly high numbers of cases. For instance, a study in Colorado (Metz et al., 2016), found 30% of maternal deaths were related to suicide or substance overdose, while another study in Philadelphia found 40% of non-obstetric causes of maternal death to be attributed to suicide, overdose and assault (Mehta et al., 2016). Prevention of substance overdoses should involve individualized, non-judgemental, comprehensive treatment by a multi-disciplinary team providing pharmacotherapy, trauma-informed mental health treatment, obstetric care, and parenting support (Campbell et al., 2021). Care providers should also consider that substance users may feel stigma or have fear of prosecution, psychiatric comorbidities, and maternal stress due to an infant with neonatal abstinence syndrome. They may also be experiencing intimate partner violence (IPV), defined as physical or sexual violence, stalking or psychological aggression by a current or former partner (Chaves et al., 2019). Also, women at risk of substance overdose should be provided with naloxone to take home and be educated on its administration. Lastly, it is important to consider structural and monetary barriers to accessing care and support, such as health care, housing, transportation, and child care, experienced by low-income women or racialized women (Ruderman et al., 2021).

Our study observed that pregnancy and the post-partum period are times of great homicide risk. Studies have shown that during these periods pregnant women have about twice the risk of homicide compared to non-pregnant women (Campbell et al., 2021). A review of 465,000 death certificates in the US between 2005 and 2010 found that homicide during pregnancy or the postpartum was most common among women who were young, non-Hispanic Black, and with less education (Wallace et al., 2016). Further, it is believed that the largest proportion, up to two-thirds, of homicides during pregnancy or the postpartum may be linked to IPV (Campbell et al., 2021; Cliffe et al., 2019). IPV is associated with young age, single relationship status, and poverty (Campbell, 2002; Ikossi et al., 2005; Shah & Shah, 2010; Vest et al., 2002). In our study, the proportion of deaths due to homicide was disproportionately higher for Black women than any of other racial groups. Other studies have noted that non-Hispanic Black women who were pregnant or postpartum were the most frequent victims of homicide (Wallace et al., 2016). This high risk of homicide has been attributed to the greater incidence of IPV among Black women. In fact, a US study found that Black women had an intimate partner homicide rate more than three-fold higher than that of white and Hispanic women (Kivisto et al., 2022). The US Preventive Services Task Force recommends routine screening for IPV during pregnancy and the post-partum (US Preventative Services Task Force, 2018).

However, it has been shown that such screening takes places less than 50% of the time (Halpern-Meekin et al., 2019). Targeted interventions including home visitation programs, such as the "nurse-family partnership", have proven to help intervene with women experiencing abuse (Olds et al., 1993) and should be routinely implemented to address risk factors contributing to the high number of non-obstetric maternal deaths in the US.

Suicides were the fourth most common non-obstetric cause of maternal death in our study. Studies have found that psychiatric depression, IPV, and substance use disorders were the most significant risk factors for suicide during pregnancy and the postpartum, which are also risk factors for substance overdoses and homicide (Devries et al., 2013; Mangla et al., 2019; Mehta et al., 2016; Metz et al., 2016). Previous studies have reported higher maternal deaths from suicide and overdose among white and American Indian women (Mangla et al., 2019). However, in our study, Asian/Pacific Islanders had the greater proportion of suicides. To our knowledge, there is little research regarding suicides among Asian/Pacific Islanders in the US. However, it has been shown that suicide is the leading cause of death among Asian American women between the ages of 15–24 years (Centers for Disease Control and Prevention, 2019). A recent study concluded that gendered racial microaggression stress, leading to internalized self-negativity, were associated with increased risk of suicidal ideation in Asian American women (Keum et al., 2023). All women should be screened for suicidality during pregnancy and postpartum (Campbell et al., 2021). Further, as many of the risk factors for suicide overlap with the factors associated with deaths due to substance overdose and homicide, proposed approaches to prevent suicides are similar as noted above.

Although our study observed disparities in maternal mortality by race, it is important to consider the impact of racism on adverse events. Bailey et al. consider racism as a root cause of racial health disparities (Bailey et al., 2017). They defined structural racism as "the totality of ways in which societies foster racial discrimination through mutually reinforcing systems of housing, education, employment, earnings, benefits, credit, media, health care, and criminal justice." Further, Lett et al. stress that race should be considered a proxy for systemic racism and the structural and individual components of racism impact the outcomes observed (Lett et al., 2022). Hence, it is important to consider study findings involving race in the context of the components of systemic racism, including historical and societal forces.

Future research studies should aim to examine the reasons for the temporal rise in non-obstetric causes of maternal mortality in the US. Further, research-driven public health interventions should be developed to address the conditions associated with maternal death from non-obstetric

causes. Ideally, research should be participatory in-nature and racially-centered as the main non-obstetric causes vary according to race.

Death records are a desirable source of pregnancy-related mortality data as they are routinely collected by each state and capture the official death details of every resident in the nation. However, limitations arise with this data as it is possible that medical practitioners who completed the death certificates may have unknowingly failed to report women as pregnant or postpartum, resulting in the underestimation of maternal deaths among these women. Further, the pregnancy checkbox on death certificates was only introduced in 2003 on a voluntary basis and its use was only slowly and gradually adopted by the individual states, which also impacted accurate measures of maternal mortality. In our study, we addressed this possibility by examining all ICD-10 codes listed under the contributing causes of death in addition to the primary cause of death. Therefore, even if the primary cause of death failed to report the woman was pregnant or postpartum, this information was retrieved from contributing causes of death. Another limitation of our study was the lack of more detailed data in the "Mortality Multiple Cause" files pertaining to subject demographics and also data pertaining to the deaths. For instance, information on the timing of the maternal death would have allowed for additional analyses and provided further context to our findings.

Our study has several strengths. This study, to our knowledge, represents the largest population-based evaluation of the contribution of non-obstetric causes of death to maternal mortality in the US, providing ample statistical power to examine longitudinal trends. Non-obstetric causes of death have received much less attention compared with obstetric complications, and the findings from this study provide strong evidence supporting the need to address these causes of death. All 80 million births in the US over the past two decades were captured in the study and all maternal deaths were verified by medical practitioners through official death certificates, allowing the study findings to be generalized to the American population and attesting to the validity of the data.

In conclusion, most studies have focused their attention on obstetric causes of maternal mortality, while ignoring accidental and incidental causes. Non-obstetric causes of maternal mortality, including transport accidents and assault, have become more prevalent in the US, representing more than one-third of all maternal mortality. Risk is especially high in American Indian women and Black women and therefore, public health interventions should especially target these racial groups in order to have the greatest impact on improving maternal outcomes. The high proportion of deaths in pregnant and postpartum women attributed to non-obstetric causes emphasizes the importance of acknowledging and addressing their role in maternal mortality.

Declarations

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