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Pregnancy-Associated Deaths Due to Drugs, Suicide, and Homicide in the United States, 2010–2019

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Abstract

Objective: To estimate the prevalence of pregnancy-associated deaths due to drugs, suicide, and homicide nationwide from 2010 to 2019.

Methods: Using U.S. death certificate records from 2010 to 2019 for 33 states plus the District of Columbia, we identified pregnancy-associated deaths using the pregnancy checkbox and ICD-10 codes, calculated pregnancy-associated death ratios, and categorized deaths by cause, timing relative to pregnancy, race or ethnicity, and age.

Results: Of 11,782 pregnancy-associated deaths identified between 2010–2019, 11.4% were due to drugs, 5.4% were due to suicide, and 5.4% were due to homicide, whereas 59.3% were due to obstetric causes and the remaining 18.5% were due to other causes. Drug-related deaths, suicide, and homicide accounted for 22.2% of pregnancy-associated deaths. All three causes of death increased over the study period, with drug-related pregnancy-associated deaths increasing 190%. Homicide during pregnancy and drug-related deaths, suicides, and homicide in the late postpartum period (43 to 365 days) accounted for a larger proportion of all deaths in these time periods than the contribution of these causes to all deaths among women of reproductive age. Pregnant and postpartum people identified as non-Hispanic American Indian or Alaska Native were at highest risk of drug-related and suicide death, whereas people identified as non-Hispanic Black were at highest risk of homicide.

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Conclusions: Deaths due to drug use, suicide, and homicide constitute over one-fifth of all deaths during pregnancy and the first year postpartum. Drug-related deaths and homicides have increased over the past decade. Substantial racial and ethnic inequities in these deaths exist.

Precis

Drug-related deaths, suicide, and homicide accounted for 22% of pregnancy-associated deaths in the United States from 2010 through 2019, with drug-related deaths increasing almost two-fold over that period.

Introduction

In the United States, pregnant and birthing persons die at a higher rate (>20 per 100,000 live births) than in other high-income countries (1), and this rate has increased by an estimated 27% from 2000 to 2014 (2). Reducing these deaths has thus become a public health and clinical priority, and substantial research, public health, and quality improvement efforts now focus on reducing the primary causes of pregnancy-related mortality, including hemorrhage, hypertension, and venous thromboembolism (Box 1) (3–5). However, recent evidence from several states suggests that drug use (illicit or prescription), suicide, and homicide, which are not typically included in estimates of maternal or pregnancy-related mortality (6)—but which fall under the broader definition of pregnancy-associated (Box 1) mortality—are prevalent and increasing causes of death during pregnancy and the first year postpartum (7–12).

To date, few national estimates of the burden of pregnancy-associated deaths due to drugs, suicide, or homicide exist. Wallace and colleagues have provided some of the only national estimates of mortality during pregnancy and postpartum due to homicide, suicide, and injury using death certificates from 2005 to 2010, including a range of estimates adjusted for underreporting (9). Our objective was to estimate pregnancy-associated mortality ratios (i.e., deaths per 100,000 live births) in the United States overall and those attributable to drug use, suicide, and homicide from 2010 to 2019 and compare this to mortality among non-pregnant or postpartum women of reproductive age.

Methods

We used U.S. death certificate records from 2010 to 2019, with state identifiers obtained from the National Center for Health Statistics. We obtained the count of live births in each state for each year overall and by race and ethnicity from the Centers for Disease Control and Prevention WONDER database. Race was included in our study because prior research indicates substantial disparities in pregnancy-associated death by race and ethnicity (9,10). We emphasize that race is not a biological variable, but a social construct. To create a comparison group of women of reproductive age, we restricted our study population to deaths identified as female and between the ages of 15–44 years old, acknowledging that we have excluded birthing persons identified as male on the death certificate. We only included data from states (and the District of Columbia [DC]) that had adopted the 2003 Revised Death Certificate by January 1, 2010 (AR, AZ, CT, DC, DE, FL, GA, ID, IL, IN, KS, MI, MO, MT, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, RI, SC, SD, TX, UT, VT, WA,

excluded deaths in California, for which we did not have data on specific timing of death relative to pregnancy information.

We calculated the pregnancy-associated death ratio by year for each cause and generated 95% confidence intervals for pregnancy-associated death ratios assuming a chi-squared distribution: $\frac{\# \text{ pregnancy-associated deaths}}{\# \text{ live births}} \times 100,000$ To compare pregnancy-associated death ratios at the start of the study period (2010) to the end (2019), we used the incidence rate (ir) command in stata to calculate rate ratios (RRs) and 95% confidence intervals (CIs).

We also calculated the proportion of deaths due to drug-related causes, suicide, homicides, and obstetric causes occurring during pregnancy, in the first 42 days postpartum, and within 43–365 days postpartum. We then calculated the number of pregnancy-associated deaths and pregnancy-associated death ratios by age category and race or ethnicity, as prior research indicates substantial disparities in pregnancy-associated death by these factors (9,10). We calculated RRs and 95% CIs using the incidence rate command in stata. We chose the referent group as the group with the largest number of births (ages 25–29 and non-Hispanic White).

To account for under-reporting of pregnancy-associated death on the death certificate, we relied on one of the few published studies that quantifies the magnitude of under-reporting by cause of death. Specifically, Horon and Cheng (16) used Maryland death certificate data from 2001 to 2008 to combined with a comprehensive review of medical records and a linkage to birth and fetal death certificate to identify pregnancy-associated deaths due to a variety of causes. The authors then calculated the proportion of these pregnancy-associated deaths (overall and by cause) that were identified on the death certificate. The authors found that 35.1%, 42.9%, and 42.5% of pregnancy-associated deaths due to substance use, suicide, and homicide, respectively, were reported as such on the death certificate. We used these proportions (p) and built on the procedure developed by Wallace and colleagues (9) to calculate the expected pregnancy-associated death ratio for drug-related deaths, suicide, and homicide, assuming that these proportions were applied to our data. We used the following equation, where p is the proportion of deaths due to cause c identified from the death certificate alone and $\left(\frac{PAD_c}{p}\right)$ yields the expected number of ‘true’ deaths due to cause c if only p of those deaths are marked as such on the death certificate.

$$\text{expected } PAD \text{ ratio}_c = \left(\frac{\# PAD_c / p}{\# \text{ live births}} \right) \times 100,000$$

We conducted robustness checks excluding the two states that did not adopt the 2003 Revised Death Certificate by January 1, 2010, i.e., California and Maryland. We also conducted an analysis excluding women over the age of 40 because prior research finds plausible overreporting of maternal deaths among this age group (17). Finally, we considered a definition of suicide where we assigned ICD-10 codes Y10-Y19 (poisoning deaths of undetermined intent) as suicide instead of drug-related.

This research was approved by the Institutional Review Board at Michigan State University. Analyses were conducted using Stata MP.

Results

We identified 11,782 pregnancy-associated deaths from 2010 to 2019 using U.S. death certificate data for all 33 states plus DC. Of these deaths, 11,354 (96.4%) were identified using the pregnancy checkbox, and an additional 428 (3.6%) were identified using ICD-10 codes. The majority of deaths (6,561 or 55.7%) had both the pregnancy checkbox and an obstetric ICD-10 code.

Of people who died during pregnancy, 54.6% died due to maternal or obstetric causes, 10.5% due to drug-related causes, 4.9% due to suicide, and 8.0% due to homicide (Table 1 and Appendix 3, available online at <http://links.lww.com/xxx>). In comparison, over three-quarters of deaths within 42 days postpartum were due to maternal or obstetric causes. During the late postpartum period (43–365 days postpartum), drug-related deaths and suicide made up 17.0% and 8.3%, respectively, of all deaths, compared to 16.5% and 8.1% of all deaths to women of reproductive age. Moreover, homicide accounted for 8.0% of all deaths during pregnancy and 5.9% of deaths in the late postpartum period, compared to 3.4% of deaths to women of reproductive age. The number and proportion of all deaths to females 15–44 stratified by timing relative to pregnancy and by age, race or ethnicity, educational attainment, and marital status is presented in Appendix 2, <http://links.lww.com/xxx>.

Of the 11,782 pregnancy-associated deaths from 2010 to 2019, 11.4% were due to drugs, 5.4% were due to suicide, and 5.4% were due to homicide, whereas 59.3% were due to obstetric causes and 18.5% were due to other causes (Table 2). For the entire period of 2010–2019, the pregnancy-associated death ratio due to drug-related causes was 4.7/100,000 live births (95% confidence interval [CI]: 4.4–4.9). For both suicide and homicide, the pregnancy-associated death ratio was 2.2/100,000 live births (Table 1) (95% CI: 2.2–2.4 for both).

The pregnancy-associated death ratio due to drug-related causes rose 190% from 2.7/100,000 in 2010 to 7.8/100,000 in 2019 (Figure 1) (RR: 2.9, 95% CI: 2.2–3.8). The pregnancy-associated death ratio due to suicide increased approximately 30% from 2010 to 2019 from 1.9/100,000 to 2.5/100,000, but this increase was not statistically significant (RR: 1.3, 95% CI: 0.9–1.9). The homicide pregnancy-associated death ratio increased 63% (RR: 1.6, 95% CI: 1.1–2.3) from 1.8/100,000 to 3.0/100,000 in 2019.

For deaths due to drug-related causes, 34.3% occurred during pregnancy, 19.2% occurred in the first 42 days postpartum, and 46.4% occurred between 43–365 days postpartum. For deaths due to suicide, these percentages were 36.2, 12.9, and 50.9, respectively, and for homicides, the percentages were 56.8, 8.3, and 34.9. For obstetric causes of deaths, the percentages were 35.9, 35.0, and 26.1, with 3.4% having unknown timing. (Figure 2)

The pregnancy-associated death ratio for drug-related causes was highest among decedents identified as Non-Hispanic American Indian or Alaska Native (10.1/100,000), followed by

Non-Hispanic White (7.2/100,000), and Non-Hispanic Black (3.4/100,000) (Table 3). The pregnancy-associated death ratio for suicide was also highest among decedents identified as non-Hispanic American Indian or Alaska Native (7.7/100,000), followed by Non-Hispanic White (2.8/100,000), and Non-Hispanic Asian and Pacific Islander (2.0/100,000). Homicide was most prevalent among Non-Hispanic Black decedents (7.0/100,000), followed by Non-Hispanic American Indian or Alaska Native (2.1/100,000).

Drug-related deaths were most common among people ages 35 (6.1/100,000), followed by those 25–29 (5.2/100,000) and those 20–24 and 30–34 (4.3/100,000 (Table 3)). Suicide was most common among people in the youngest age category (15–19, pregnancy-associated death ratio: 3.5/100,000), followed by 35 (2.9/100,000) and 20–24 (2.4/100,000). The pregnancy-associated death ratio for homicide was highest among people aged 15–19 (4.9/100,000), followed by those aged 20–24 (3.7/100,000).

When applying the Horon and Cheng (16) estimated proportion of ‘true’ pregnancy-associated deaths identified by the death certificate to our data, we found that the pregnancy-associated death ratio per 100,000 for drug-related causes would be 13.0 (vs. 4.7 in the observed data); for suicide, the pregnancy-associated death ratio would be 5.1 (vs. 2.2); and for homicide, the pregnancy-associated death ratio would be 5.2 (vs. 2.2) (Appendix 4, available online at <http://links.lww.com/xxx>). If we add the misclassified deaths due to these causes to the total 11,782 deaths found based on the death certificate, there would be a total of 15,895 pregnancy-associated deaths. Of these, drug-related deaths would account for 23.6%, suicide for 9.3%, and homicide for 9.4%, compared to the percentages calculated from the observed data of 11.4, 5.4, and 5.4 (Table 2).

Compared to our main analyses, when we excluded California and Maryland, we found slightly higher pregnancy-associated death ratios due to drugs, suicide, and homicide, and when excluding women over 40 years, we found slightly smaller pregnancy-associated death ratios for drug-related deaths, suicides, and homicides (Appendixes 5 and 6, available online at <http://links.lww.com/xxx>). When we assigned ICD-10 codes Y10-Y19 (poisoning deaths of undetermined intent) as suicide instead of drug-related, the pregnancy-associated mortality ratio due to suicide changed from 2.2 to 2.5 per 100,000 live births, and the ratio due to drug-related causes changed from 4.7 to 4.4 per 100,000 live births (Appendix 7, available online at <http://links.lww.com/xxx>).

Discussion

Using U.S. death certificate records from 2010 to 2019 from 33 states and the District of Columbia, we found that drug-related deaths, suicide, and homicide accounted for 22.2% of all deaths during pregnancy and the first year after pregnancy (i.e., pregnancy-associated death). All three causes of death increased over the study period, with drug-related pregnancy-associated death increasing 190%.

Approximately half of all drug-related and suicide deaths occurred between 6 weeks and one year postpartum and another 20% of drug-related deaths occurred during the first 6 weeks postpartum, consistent with reports from Utah (8) and Massachusetts (12). Indeed,

drug-related and suicide deaths account for a larger proportion of deaths between 43 and 365 days postpartum than among all deaths to women of reproductive age. The high risk of drug-related and suicide death in the late postpartum period may be due to lack of continuous postpartum care, lack of specialized mental health and substance use services, increasing stress of caring for a newborn, lack of structural supports (e.g., stable housing), stigma or fear of punitive consequences, hormonal changes, and decreased tolerance after abstinence during pregnancy (18,19). Pregnancy-associated homicides, on the other hand, occurred disproportionately during pregnancy (56.8%), and homicide made up a substantially larger share of deaths during pregnancy (8.0%) than among all women of reproductive age (3.4%).

These data also demonstrate unacceptable racial and ethnic inequities in pregnancy-associated deaths. Pregnant and birthing people identified as American Indian or Alaska Native had much higher rates of drug-related death and suicide compared to all other racial or ethnic groups. Non-Hispanic White people had the second highest rates of pregnancy-associated drug and suicide death. Non-Hispanic Asian and Pacific Islander people, who had the lowest pregnancy-associated death ratio for both drug-related deaths and homicide, had the third highest ratio for suicide. Non-Hispanic Black people had disproportionately high pregnancy-associated death ratios due to homicide, consistent with data from 2005 to 2010 (9). Pregnancy-associated drug-related deaths were most common among those 35 years, while suicide and homicide were most common among youngest birthing people.

Our findings are consistent with those of Wallace and colleagues, who used death certificate data from 2005 to 2010 and reported a pregnancy-associated suicide mortality ratio of 1.6/100,000 live births and a homicide ratio of 2.2/100,000 live births (9). Our study indicates that these pregnancy-associated death ratios have increased over time, and in 2019, were 2.5 and 3.0, respectively. Our findings also comport with those of Gemmill and colleagues, who identified increases in opioid-related deaths during pregnancy and postpartum using national death certificate data from 2010 to 2016, with particularly steep increases from 2014 to 2016 (20). Our study builds on this previous research by using the most recent 10 years of national data available, by estimating mortality due to all drug types, and by examining disparities among multiple racial or ethnic and age groups and trends over time from 2010 to 2019, a key time period during which the U.S. experienced the Great Recession, declines in fertility rates (14), and an escalating opioid epidemic (13). Our findings are also congruent with those from in-depth maternal mortality reviews of pregnancy-related deaths conducted in 14 states (21), which found that pregnancy-related deaths due to mental health conditions were particularly common among non-Hispanic white people and during the late postpartum period. This study also found that 100% of these mental-health related deaths were considered preventable (21).

We also demonstrate that the contribution of drug-related deaths, suicide, and homicide to overall pregnancy and postpartum mortality is likely much higher than our unadjusted estimates due to under-use of the pregnancy checkbox for these causes of death. After adjustment for under-reporting, these deaths may account for over 40% of all pregnancy-associated deaths (compared to 22.2%). We note that the data used in this study were not collected explicitly for this purpose. Because only one study—using Maryland data from 2001 to 2008—has validated the death certificate against an in-depth review of pregnancy-

associated deaths, estimates of underreporting are uncertain and underreporting remains a major barrier to producing valid estimates of the burden of these deaths nationwide. Another potential limitation is that some suicides may be misclassified as unintentional drug-related deaths. Indeed, the California Pregnancy Associated Mortality Review report found that about half of accidental deaths during pregnancy or postpartum were identified as suicides upon review (22). Prior research also suggests potential underestimation and misclassification of overdose mortality, especially for deaths involving opioids (23,24). Thus, our analyses may underestimate the relative contribution of suicides and drug use to pregnancy-associated death. Overall, our findings are limited by inconsistent uptake of the 2003 Revised Death Certificate by states in the United States, resulting in our inclusion of only 33 states and D.C.

Our findings indicate that deaths due to drug-use, suicide, and homicide are a substantial and increasing contributor to pregnancy-associated mortality. Preventing these deaths could have saved the lives of over 2,600 pregnant and birthing people from 2010 to 2019. Loss of these lives is particularly devastating to infants and families and has long-term repercussions on infants who lose their parent (25,26). Our findings point to the need to generate scientific evidence on risk factors and prevention approaches for pregnancy-associated death due to drugs, suicide, and homicide. Potential avenues include 1) screening for substance use, suicidality, psychological distress, and intimate partner violence, which has been linked to both pregnancy-associated homicide and suicide (27), combined with the ability for health care professionals to connect people with resources (28,29); 2) coordination of obstetric care with other areas such as addiction medicine, behavioral health, and social services (30); and, perhaps most importantly, 3) attention to structural barriers to accessing care and support including housing, transportation, child care, domestic abuse, stigma, and fear of legal ramifications or social service interventions (31).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Box 1.**Definitions of Key Terms**

Maternal death (1): Female death from any cause related to or aggravated by pregnancy or its management (excluding accidental or incidental causes) during pregnancy and childbirth or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy.

Pregnancy-related death (31): Death of a woman while pregnant or within one year of the end of a pregnancy from any cause related to or aggravated by the pregnancy or its management.

Pregnancy-associated death (31): Death of a woman while pregnant or within one year of the end of a pregnancy from any cause.

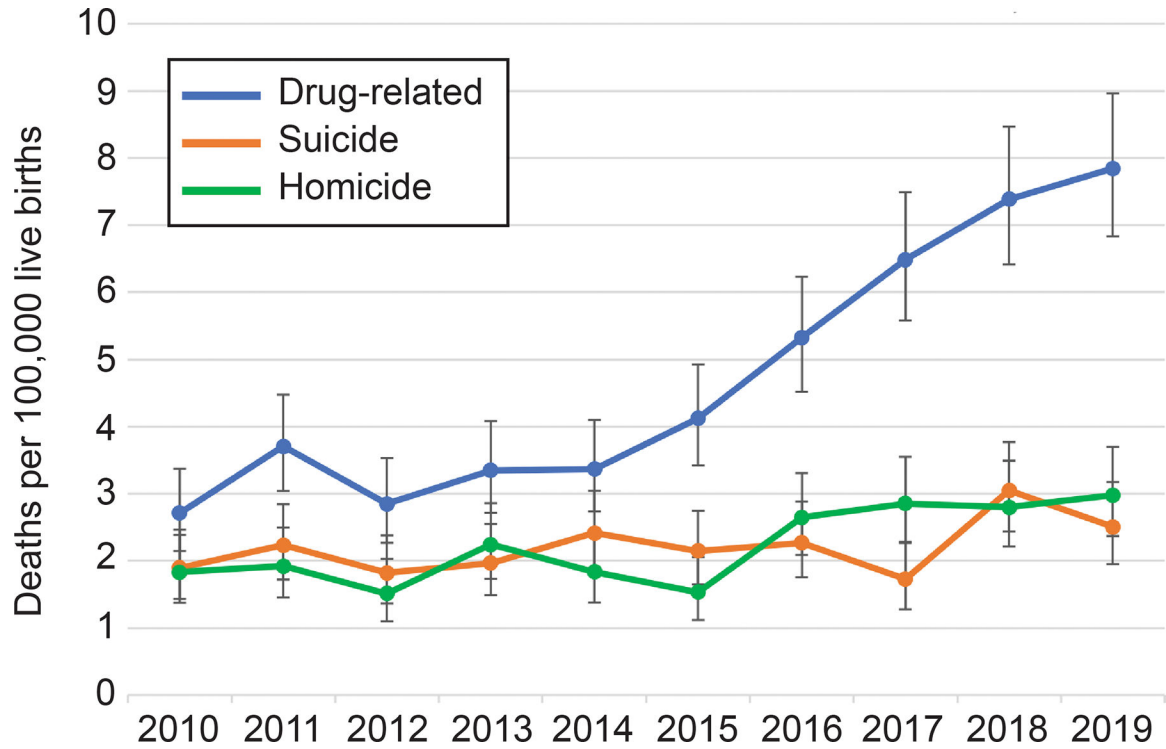


Figure 1.

Pregnancy-associated death ratios and 95% CIs for drug-related deaths, suicide, and homicide in 33 U.S. states and the District of Columbia, 2010 to 2019. The pregnancy-associated death ratio due to drug-related causes rose 190% from 2.7/100,000 in 2010 to 7.8/100,000 in 2019 (RR: 2.9, 95% CI: 2.2–3.8). The pregnancy-associated death ratio due to suicide increased approximately 30% from 2010–2019 from 1.9/100,000 to 2.5/100,000, but this increase was not statistically significant (RR: 1.3, 95% CI: 0.9–1.9). The homicide pregnancy-associated death ratio increased 63% (RR: 1.6, 95% CI: 1.1–2.3) from 1.8/100,000 to 3.0/100,000 in 2019.

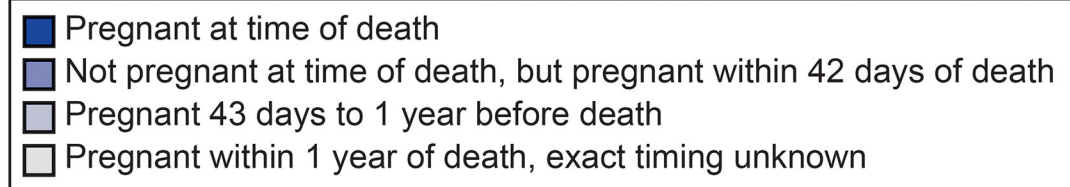
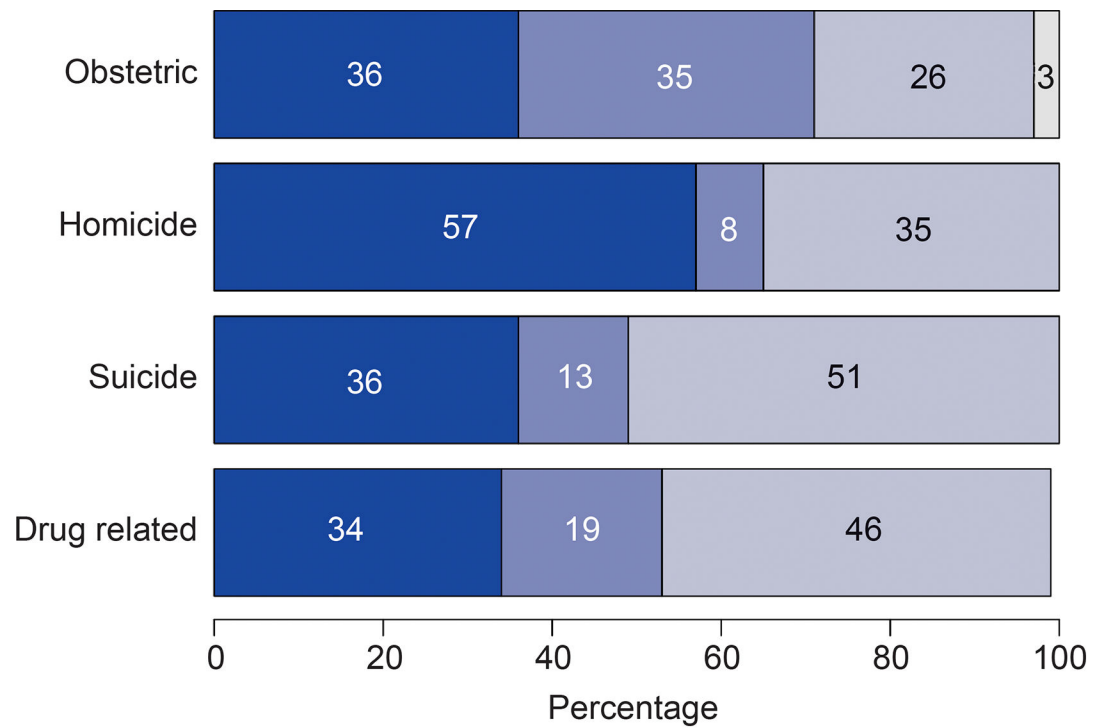


Figure 2. Percentage of cause-specific pregnancy-associated deaths by timing relative to pregnancy in 32 U.S. states* and the District of Columbia, 2010 to 2019. *California data not included in this figure due to lack of specificity of timing relative to pregnancy.

Number and percent of deaths by cause to females of reproductive age (15–44 years) overall and by timing relative to pregnancy in 32 US states and the District of Columbia, 2010–2019.

Table 1.

Cause of death	All female deaths ages 15–44		Not pregnant or postpartum		Pregnant at time of death		Timing relative to pregnancy				Pregnant within a year, but exact timing unknown*	
	n	%	n	%	n	%	n	%	n	%	n	%
Drug-Related	52047	16.5	50789	16.7	432	10.5	242	8.5	584	17.0	0	0.0
Suicide	25,492	8.1	24,934	8.2	202	4.9	72	2.5	284	8.3	0	0.0
Homicide	10,824	3.4	10,248	3.4	327	8.0	48	1.7	201	5.9	0	0.0
Obstetric	6,244	2.0	--	0.0	2,241	54.6	2,161	76.0	1,628	47.5	214	100.0
Other causes	220932	70.0	218977	71.8	903	22.0	322	11.3	730	21.3	0	0.0
Total	315,539	100	304,948	100	4,105	100	2,845	100	3,427	100	214	100

* Deaths identified by ICD-10 codes associated with death from obstetric causes, but without substantial information to assign timing

Table 2.

Number of pregnancy-associated deaths by cause and year, pregnancy-associated death ratios by cause, and percent of all deaths by cause in 33 US states and the District of Columbia, 2010–2019.

Measure	Pregnancy-associated deaths					Total	Number of births
	Drug-Related	Suicide	Homicide	Obstetric	Other		
Number of deaths							
Year							
2010	80	56	54	618	263	1071	2,954,034
2011	108	65	56	679	269	1177	2,914,824
2012	83	53	44	660	182	1022	2,915,408
2013	97	57	65	728	213	1160	2,898,700
2014	99	71	54	716	227	1167	2,943,675
2015	121	63	45	686	242	1157	2,936,361
2016	155	66	77	718	189	1205	2,911,965
2017	184	49	81	711	203	1228	2,838,136
2018	206	85	78	703	224	1296	2,789,355
2019	216	69	82	770	162	1299	2,753,979
All years	1349	634	636	6989	2174	11782	28,856,437
Pregnancy-associated death ratio *	4.7	2.2	2.2	24.2	7.5	--	--
Percent of all deaths	11.4%	5.4%	5.4%	59.3%	18.5%	--	--

* Pregnancy-associated death ratio = $\frac{\text{pregnancy-associated deaths}_c}{\text{live births}} \times 100,000$

Table 3.

Pregnancy-associated deaths due to drugs, homicide, and suicide by race and ethnicity and age: counts, pregnancy-associated mortality rate, and rate ratios in 33 US states and the District of Columbia, 2010 to 2019.

Race or ethnicity	Drug-related			Suicide			Homicide		
	Count	Pregnancy-associated death ratio* Rate ratio [†]	95% CI	Count	Pregnancy-associated death ratio* Rate ratio [†]	95% CI	Count	Pregnancy-associated death ratio* Rate ratio [†]	95% CI
Hispanic	129	1.6	0.2–0.3	105	1.3	0.5–0.6	127	1.6	0.9–1.4
Non Hispanic American Indian or Alaska Native	29	10.1	0.9–2.0	22	7.7	1.7–4.2	<10	2.1	0.5–3.1
Non Hispanic Asian or Pacific Islander	12	0.6	0.0–0.1	42	2.0	0.5–1.0	<10	0.2	0.1–0.4
Non Hispanic Black	140	3.4	0.4–0.6	64	1.6	0.4–0.7	285	7.0	4.0–5.7
Non Hispanic White	1039	7.2	Referent	401	2.8	Referent	213	1.5	Referent
Age (years)									
15–19	34	1.8	0.2–0.5	64	3.5	1.4–2.5	90	4.9	1.9–3.3
20–24	261	4.3	0.7–1.0	146	2.4	1.0–1.6	226	3.7	1.9–2.3
25–29	427	5.2	Referent	152	1.8	Referent	160	1.9	Referent
30–34	334	4.3	0.7–1.0	136	1.7	0.7–1.2	97	1.2	0.5–0.8
35	293	6.1	1.0–1.4	136	2.9	1.2–2.0	63	1.3	0.5–0.9

* Count per 100,000 live births in that racial and ethnic group from 2010 to 2019.

[†] Rate ratio = Pregnancy-associated death ratio in group divided by pregnancy-associated death ratio in reference group

CI: Confidence interval