OBSTETRICS

Maternal drug-related death and suicide are leading causes of postpartum death in California

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BACKGROUND: Reducing maternal mortality is a priority in the United States and worldwide. Drug-related deaths and suicide may account for a substantial and growing portion of maternal deaths, yet information on the incidence of and sociodemographic variation in these deaths is scarce.

OBJECTIVE: We sought to examine incidence of drug-related and suicide deaths in the 12 months after delivery, including heterogeneity by sociodemographic factors. We also explored maternal decedents' health care utilization prior to death.

STUDY DESIGN: This retrospective, population-based cohort study followed up 1,059,713 women who delivered a live-born infant in California hospitals during 2010–2012 to ascertain maternal death. Analyses were conducted using statewide, all-payer, longitudinally-linked hospital and death data.

RESULTS: A total of 300 women died during follow-up, a rate of 28.33 deaths per 100,000 person-years. The leading cause of death was obstetric-related problems (6.52 per 100,000 person-years). Drug-related deaths were the second leading cause of death (3.68 per 100,000 person-years), and suicide was the seventh leading cause (1.42 per 100,000 person-years); together these deaths comprised 18% of all maternal deaths. Non-Hispanic white women, Medicaid-insured women, and women residing in micropolitan areas were especially likely to die from drugs/suicide. Two thirds of women who died, including 74% of those who died by drugs/suicide, made ≥1 emergency department or hospital visit between their delivery and death.

CONCLUSION: Deaths caused by drugs and suicide are a major contributor to mortality in the postpartum period and warrant increased clinical attention, including recognition by physicians and Maternal Mortality Review Committees as a medical cause of death. Importantly, emergency department and inpatient hospital visits may serve as a point of identification of, and eventually prevention for, women at risk for these deaths.

Key words: accidental death, depression, maternal morbidity, maternal mortality, opioid overdose, poisoning

Reducing maternal mortality is a public health and clinical priority in the United States and worldwide.[1,2] However, maternal mortality increased by 26.6% from 2000 to 2014 in 48 US states and Washington, DC.[1]

These concerning trends have resulted in the development of targeted action plans and safety bundles for clinical care that focus on common causes of pregnancy-related mortality, namely obstetric hemorrhage, severe hypertension in pregnancy, and peripartum venous thromboembolism.[3] Moreover, in December 2018, the US Congress passed the Preventing Maternal Deaths Act (https://www.congress.gov/bill/115th-congress/house-bill/1318/text), standardizing definitions of maternal mortality and providing funding for state review committees to track and review maternal deaths.

On the other hand, despite growing evidence that maternal deaths from drug-related causes (eg, overdose) and suicide may be nearly as common as these pregnancy-related causes, published estimates of maternal mortality typically exclude these types of accidental deaths.[1,4,5] Opioid use during pregnancy increased 4- to 8-fold from 2004 through 2013,[6] and opioid overdose deaths among women aged 25–44 years increased by 6.7% between 2014 and 2015 alone.[7] Suicide rates, including suicide via drug poisoning, also increased substantially between 2003 and 2015, with some of the largest rate increases among women.[8]

Only a few publications report incidence of maternal deaths caused by drug use or suicide, with most studies limited to a single state.[5,9–13] A recent review, published in this Journal, highlighted the critical need for more epidemiological evidence on incidence of maternal drug-related and suicide deaths,[4] particularly in light of the current opioid epidemic, rising rates of suicide among women, and the devastating consequences of these deaths for infants, children, and families.

To expand this limited evidence base, we utilized a unique statewide, all-payer, longitudinally linked hospital and death database from California. Our first objective was to examine incidence of drug-related deaths and suicide in the 12 months after delivery among women with an index delivery in 2010–2012 and to describe heterogeneity in death rates by key sociodemographic factors.

Our second objective was to examine the incidence of emergency department (ED) visits and hospitalization between delivery and postpartum death to examine whether these health care encounters may serve as opportunities to identify women at risk of drug-related death or suicide.

Materials and Methods

Data and study population

We obtained nonpublic ED and inpatient discharge data from the California Office of Statewide Health Planning and

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AJOG at a Glance

Why was this study conducted?

- To describe the incidence of and sociodemographic heterogeneity in postpartum drug-related and suicide deaths.

Key findings

- Among >1 million women who delivered a live-born infant in California 2010–2012, drug-related deaths were the second leading cause of death (incidence rate of 3.68 per 100,000) over 12 months of follow-up, and suicide was the seventh leading cause.
- Medicaid-insured women, those of non-Hispanic white race, and those residing in micropolitan areas were especially likely to die from drug/suicide causes.

What does this add to what is known?

- Our study is one of only a few to calculate incidence rates for drug-related and suicide deaths in the first year after delivery in a large, diverse state.
- This investigation also sheds light on sociodemographic variation in postpartum drug-related and suicide death rates and potential opportunities for prevention.

Development on all patient visits to all California-licensed hospitals that included a unique identifier (encrypted Social Security number [SSN]) and a California residential ZIP code.[14] We then identified all women aged ≥10 years who delivered a live infant in 2010–2012.

The California Office of Statewide Health Planning and Development provided information on women in this cohort to the California Department of Public Health Vital Records, which assessed vital status in California death records and provided information on date, underlying cause, and manner of death for all matching decedents who died in the first 12 months after delivery. (decedents who died out of state, <1% of the total, are excluded.)

Hospital and death record data sets were deterministically linked using patient SSN and birthdate, with linkage rates of approximately 98%[15,16]; all data obtained and used by the study team were deidentified. This study was approved by the Institutional Review Boards of the California Health and Human Services Agency and the University of California, Merced.

Delivery hospitalizations were identified using Diagnosis-Related Group codes, a patient classification system that categorizes hospital admissions into groups based on *International Classification of Diseases* diagnoses, procedures, patient characteristics, and presence of complications; these groups are clinically homogeneous in terms of resource use.[17]

Consistent with prior literature, delivery admissions were identified using Diagnosis-Related Group codes 767–768 and 774–775 (vaginal delivery) or 765–766 (cesarean delivery).[17] To simplify calculations, if a woman delivered more than once during the study period, only the first observed delivery, henceforth referred to as the index delivery, was retained for analysis.

Measures

Causes of death

Primary outcomes of interest were drug-related deaths and suicide within the 12 months after an index delivery. We also assessed several other leading causes of death, using both the World Health Organization's definition of maternal deaths[18] and prior research[19] as guides for classifying major causes of death. Underlying causes of death were ascertained using *International Classification of Diseases*, tenth revision (ICD-10) codes.

Drug-related deaths comprised those with ICD-10 codes indicating unintentional drug overdose, drug overdose of undetermined intent, drug-induced diseases, drugs present in the blood, and mental/behavioral disorders caused by drugs (see Supplemental Table 1).[19]

Suicide deaths comprised those with codes X60 to X84, Y87.0, or U03, including intentional self-poisoning.[20] All other deaths were categorized into obstetric deaths (O00–O99, encompassing obstetric complications and pregnancy-related disease, as defined by the World Health Organization[18]), circulatory system disease deaths (I00–I99), cancer (C00–C97), other unintentional injuries (V01–V99), homicide (X85–X90, X91, X93–X95, Y00–Y09, or Y87.1), and an all other causes category.

Follow-up began on each woman's date of index delivery and ended at death or 365 days after delivery, whichever came first. The last possible follow-up date was Dec. 31, 2013. Women whose hospital record did not link to state mortality records were presumed alive.

Emergency department and inpatient hospital utilization

We also examined ED and inpatient hospital utilization among women who died during follow-up. ED/inpatient utilization was defined as the woman's total number of ED and/or inpatient visits made subsequent to the index delivery but prior to death.

Sociodemographic characteristics

Sociodemographic factors of interest were measured at each woman's index delivery and included age (<20 years, 20–35 years, ≥35 years), race/ethnicity (non-Hispanic (NH) white, NH black, Hispanic, NH Asian/Pacific Islander, or NH other; American Indians were included in the other category because of small numbers), insurance status (private, Medicaid, self-pay, or other), and urbanicity of residential ZIP code.[21]

Urbanicity was categorized as metropolitan (≥10% of commuting flow was to an urbanized area of ≥50,000 residents), micropolitan (≥10% of

commuting flow was to a large urban center of 10,000−49,999 residents), or small town/rural (≥10% of commuting flow was to a small urban center of 2500−9,9999 residents or to areas outside urban centers).

Statistical analysis

We first examined the data descriptively using frequency statistics. For our first aim, we calculated person-years of follow-up (i.e., the total accumulated time at risk experienced by all individuals in the cohort), number of deaths from each cause of interest, and mortality rates per 100,000 person-years of follow-up (along with associated 95% confidence intervals [CIs]) for the cohort. This approach allowed us to accurately calculate death rates despite differing observation start and end times for each individual.

We then calculated death rates for overall mortality, as well as for combined drug-related/suicide mortality, according to maternal age, race/ethnicity, insurance status, and urbanicity. Combining drug and suicide deaths accounted for these causes' overlapping premorbid factors (eg, psychiatric disorder and substance use) and difficulty in determining intent among overdose decedents[22]; it also increased the precision of estimates for these subgroup analyses.

For our second aim, we calculated the percentage of decedents with any ED or hospital visit between index delivery and death as well as descriptive statistics about the frequency of these visits. All statistical analyses were conducted using Stata 14.0 (StataCorp LP, College Station, TX).

Results

Sample characteristics

During the study period (2010−2012), 1,516,073 live births were recorded in California.[23−25] Our study, which excluded births that were not the mother's index delivery during the observation period (n = 93,464) and hospital births that lacked a valid patient SSN (n = 308,786), included a final population of 1,059,713 births (69.9% of all births), leaving 54,110 births (3.6% of all births) unaccounted for. These births likely occurred outside of state-licensed hospitals (eg, at home, in a birth center, or in a federal hospital).

TABLE 1
Sociodemographic characteristics of study population at index delivery hospitalization, among 1,059,714 women in California, 2010−2012

Characteristic	n, %
Age, y	
<20	82,986 (7.8%)
20−35	817,198 (77.1%)
>35	159,529 (15.1%)
Race/ethnicity	
Non Hispanic white	390,901 (36.9%)
Non-Hispanic black	74,405 (7.0%)
Hispanic	408,205 (38.5%)
Non-Hispanic Asian/Pacific Islander	136,519 (12.9%)
Non-Hispanic other	49,683 (4.7%)
Insurance/payer	
Private	599,980 (56.6%)
Medicaid	420,954 (39.7%)
Self-pay	11,172 (1.1%)
Other	27,607 (2.6%)
Urbanicity	
Metropolitan	999,966 (94.4%)
Micropolitan	42,5497 (4.0%)
Small town/rural	17,248 (1.6%)

Goldman-Mellor and Margerison. Drug-related and suicide death as causes of postpartum maternal death. Am J Obstet Gynecol 2019.

Demographic characteristics of excluded deliveries are shown in Supplemental Table 2; in general, excluded deliveries were more likely than included deliveries to be for younger and Hispanic women and those covered by Medicaid.

Descriptive statistics of the study population are shown in Table 1. On average, mothers were in their late 20s at index delivery and largely of NH white or Hispanic race/ethnicity. Nearly 60% of deliveries were covered by private insurance, with the majority of the rest covered by Medicaid. Most deliveries (94%) were to mothers living in a metropolitan ZIP code.

Postpartum death rates

A total of 300 women died within 1 year of follow-up, for an overall mortality rate of 28.33 deaths per 100,000 person-years. Cause-specific deaths and corresponding incidence rates are shown in Table 2. The leading cause of postpartum death was obstetric-related disease, with a total of 69 women dying from direct or indirect obstetric causes (23% of all maternal deaths).

Drug-related deaths (n = 39) were the second leading cause of mortality. All but 2 of these deaths were coded as accidental drug overdoses, mostly to unspecified substances (n = 20) but some to opioids or other narcotics (n = 8) and some to sedatives/hypnotics (n = 8). Additional details on the drugs involved were not available from the death records.

Postpartum suicides were less common (n = 15) but ranked as the seventh leading cause of death. Only 1 suicide death involved drug poisoning; the rest included hanging/strangulation (n = 9)

TABLE 2
Causes and associated 12 month incidence rates of postpartum death, ranked in descending order, among women delivering in California, 2010–2012

Underlying cause	Deaths, n	Incidence rate (per 100,000 person-years)	95% CI around incidence rate
Obstetric complications/disease	69	6.52	5.15–8.25
Drug related	39	3.68	2.69–5.04
Circulatory system disease	36	3.40	2.45–4.71
Cancer	34	3.21	2.29–4.49
Other unintentional injuries	33	3.12	2.22–4.38
Homicide	17	1.61	1.00–2.58
Suicide	15	1.42	0.85–2.35
All other causes	57	5.38	4.15–6.98

Goldman-Mellor and Margerison. Drug-related and suicide death as causes of postpartum maternal death. Am J Obstet Gynecol 2019.

or firearms (n = 3). Together, drug-related and suicide deaths comprised 18% of all postpartum deaths. Two thirds of these deaths occurred between 6 months and 1 year postpartum.

Heterogeneity by maternal sociodemographic factors

There was evidence of heterogeneity by maternal sociodemographic factors in the incidence of deaths overall and from drug-related/suicide causes, although precision of these estimates was low because of small numbers of cases in each subgroup (Table 3). Maternal older age, NH black race, nonprivate insurance, and residence in a micropolitan ZIP code were all associated with substantially higher overall mortality risk.

For drug/suicide deaths, maternal age and mortality risk were not associated. Compared with NH white women, Hispanic women had significantly lower risk of drug/suicide death (risk ratio [RR], 0.35, 95% confidence interval [CI], 0.18–0.70), but associations with other race categories were not significant. Women who used Medicaid to pay for their index deliveries were approximately 3 times more likely to die by drugs/suicide than women who used private insurance (RR, 3.36 [95% CI, 1.80–6.28]), and women with other insurance had a 7-fold increased risk (RR, 7.76 [(95% CI, 2.80–21.56]), although this estimate was based on just 5 deaths. Residence in a micropolitan (vs metropolitan) area was associated with a 3-fold higher risk of drug/suicide death (RR, 3.74 [95% CI, 1.69–8.31]).

Emergency department/inpatient utilization

Of all 300 women who died during follow-up, two thirds (66%) had at least 1 ED or inpatient visit between their index delivery and death (mean, 2.2, SD, 3.9). These metrics were higher among the 54 women who died of drug-related causes or suicide. As shown in the Figure, 74% made at least 1 ED or hospital visit, and 39% made ≥3 visits (mean, 3.5, SD, 6.4).

Comment

Principal findings of the study

Among more than 1 million women delivering a live infant in the state of California from 2010 through 2012, we found that drug-related deaths were the second leading cause of postpartum mortality and that suicide was the seventh leading cause. Together, drug-related causes and suicide were responsible for more than 1 in 6 postpartum deaths.

NH white women, and women who were socioeconomically disadvantaged (ie, had their deliveries covered by Medicaid or self-paid), appeared to be at an especially elevated risk for dying from these causes within the year after delivery. We note, however, that NH black women had the highest overall rates of postpartum mortality, a finding consistent with national data showing very high maternal mortality rates in this group, particularly from cardiovascular causes and homicide.[26,27]

In line with reports that drug and suicide rates are rising faster in nonmetropolitan areas compared with metropolitan ones,[28,29] we also found that women who lived in micropolitan areas had an elevated risk of drug/suicide mortality risk compared with those in urban areas.

Our results clearly indicate that drug-related and suicide deaths are a major contributor to postpartum maternal mortality and warrant increased attention. This work is especially urgent given increasing US maternal mortality rates and related calls for action from the American College of Obstetricians and Gynecologists and the US Congress.[30,31]

Comparison with existing literature

Our study is one of only a few to calculate incidence rates for drug-related and suicide deaths in the first year after delivery in a large, diverse state. Currently data do not exist at the national level linking birth or delivery records with maternal deaths. Individual states often conduct maternal mortality reviews; however, these reviews do not always include deaths caused by drugs and suicide.[4,5]

A handful of published studies using state-specific data have examined pregnancy-associated deaths (ie, during pregnancy or the first year postpartum) from drug-related causes and suicide. Estimates of the percentage of pregnancy-associated deaths from drug-related causes range from 6.1% in Illinois (2002–2013)[5] to 22% in Philadelphia (2010–2014)[12]; for suicide, estimates range from 4% to 5% in Philadelphia[12] and Texas (2011–2012)[10] to 13% in Colorado (2004–2012).[9] Our findings that drug-related deaths and suicides comprised 13% and 5% of all postpartum deaths, respectively, are

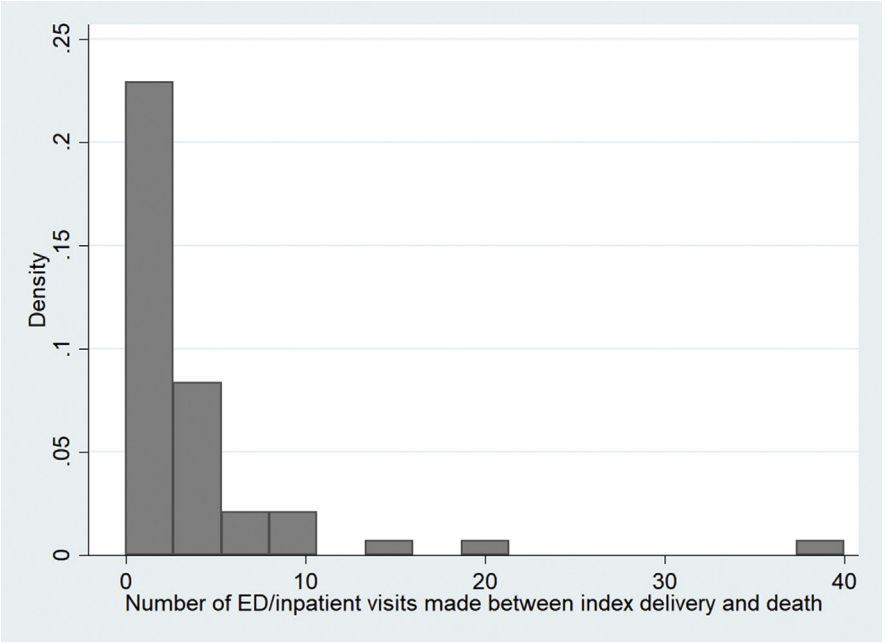
TABLE 3
Twelve month incidence of postpartum death (overall and for drug-related/suicide deaths), according to maternal age, race/ethnicity, insurance status, and urbanicity at index delivery, among women delivering in California, 2010–2012

Sociodemographic characteristic	Total deaths, n	Overall mortality rate (per 100,000 person-years)	Rate ratio (95% CI)	Drug-related/ suicide deaths, n	Drug-related/ suicide mortality rate (per 100,000 person-years)	Rate ratio (95% CI)
Age, y						
<20	27	32.55	1.29 (.85–1.96)	5	6.03	1.23 (0.49–3.11)
20-35	217	26.57	1.0	41	5.02	1.0
≥35	56	35.13	1.40 (1.03–1.90)[a]	8	5.02	1.03 (0.48–2.19)
Race/ethnicity						
Non-Hispanic white	100	25.60	1.0	30	7.68	1.0
Non-Hispanic black	46	61.87	2.37 (1.65–3.42)[a]	5	6.73	0.70 (0.25–1.99)
Hispanic	108	26.47	0.97 (0.73–1.29)	11	2.70	0.35 (0.18–0.70)[a]
Non-Hispanic Asian/Pacific Islander	34	24.92	0.86 (0.57–1.32)	5	3.67	0.48 (0.19–1.23)
Non-Hispanic other	12	24.17	0.93 (0.50–1.74)	3	6.04	0.79 (0.24–2.58)
Insurance/payer						
Private	105	17.51	1.0	14	2.34	1.0
Medicaid	162	38.51	2.20 (1.70–2.85)[a]	34	8.08	3.36 (1.80–6.28)[a]
Self-pay	10	89.60	4.57 (2.22–9.41)[a]	1	8.96	3.84 (0.51–29.19)
Other	23	83.38	4.86 (3.03–7.79)[a]	5	18.13	7.76 (2.80–21.56)[a]
Urbanicity						
Metropolitan	275	27.52	1.0	44	4.40	1.0
Micropolitan	19	44.74	1.63 (1.00–2.67)[a]	8	18.83	3.74 (1.69–8.31)[a]
Small town/rural	6	34.81	1.42 (0.63–3.19)	2	11.60	2.64 (0.64–10.87)

[a] Statistically significant associations ($P<.05$).

Goldman-Mellor and Margerison. Drug-related and suicide death as causes of postpartum maternal death. Am J Obstet Gynecol 2019.

FIGURE
Emergency department/hospital utilization among maternal decedents



Number of emergency department or inpatient hospital visits made between index delivery and death among women who died postpartum from a drug-related cause or suicide, California, 2010–2012.

Goldman-Mellor and Margerison. Drug-related and suicide death as causes of postpartum maternal death. Am J Obstet Gynecol 2019.

consistent with these ranges. Our estimated postpartum mortality rates of 3.7 per 100,000 for drug-related deaths and 1.4 per 100,000 for suicides are also consistent with national estimates.[13,32]

Clinical and research implications

Current research points to a critical need to identify women in the first year (or longer) after delivery who may be at risk of drug overdose or suicide. The overwhelming majority of women in our study who died from drug-related causes or suicide made at least 1 ED or hospital visit between their delivery and death dates. This observation suggests that ED and hospital visits may serve as a point of identification of, and eventually intervention on, women at risk for postpartum death. Although examining details of these visits was beyond the scope of this study, this finding warrants further exploration in other samples, including examining the nature of these interactions to identify predictors of maternal death and/or points of intervention.

An obvious intervention point is screening for depression and anxiety among mothers at postpartum and well-baby visits or other health care encounters. The US Preventive Services Task Force and American College of Obstetricians and Gynecologists recommend routine screening for depression and anxiety using validated instruments at postpartum visits,[33,34] and some studies show that 80% or more of postpartum and well-child visits include a depression screen for the mother.[35,36] However, mothers who die of drugs or suicide in the first year after delivery may not have attended a postpartum or well-baby visit, may not screen positive for depression or anxiety, or may not receive follow-up mental health services because of stigma, lack of access, or time constraints.[37,38]

Moreover, the stigma and potential repercussions (eg, removal of the child) of acknowledging substance use during the postpartum period may prevent women from doing so and thus receiving services or treatment.[39] Although pregnancy appears to be a motivation for many women to decrease substance use,[40] recent research shows that, while perinatal nonfatal opioid overdose rates were lowest in the third trimester, this rate quadrupled by 7–12 months postpartum,[41] suggesting that women may fall back into substance use after delivery and not continue to receive treatment.

Strengths and limitations

We could not examine all mothers in California during the study period because some deliveries occur outside state-licensed hospitals, and not all delivery hospitalizations could be linked to the death record data. This would have primarily affected calculation of mortality rates among low-income Hispanic women because most delivery hospitalizations missing a unique identifier were to Hispanic women covered by Medicaid (some of whom may have been undocumented immigrants). Whether this would have resulted in under- or overestimating drug-related and suicide mortality in this subgroup is unclear because mortality from these causes in our analytic sample was lower for Hispanic women but higher for Medicaid-insured women.

Relatedly, mortality data for cohort women who died outside California were not available for this study; we expect this biases our absolute mortality rate calculations downward slightly.

We also could not ascertain maternal deaths that occurred during pregnancy because pregnant women who died without first delivering their infants in a hospital would not be observed in the study data set. Second, correctly classifying drug-related deaths as intentional or otherwise is challenging for reasons related to stigma avoidance, legal and religious pressure, and underresourcing of death investigation systems; the result of such misclassification is usually to undercount suicides.[22,42] We view this as an additional rationale for examining drug-related and suicide deaths together as a cause of maternal mortality.

Finally, data from California are not necessarily generalizable to the rest of the United States, although California

generates one sixth of all live births in the United States and is one of the most diverse states in terms of racial/ethnic makeup. However, California is the only state that has experienced a drop in maternal mortality from 2003 through 2014,[1] suggesting that our estimates might provide a lower bound on estimates for the rest of the United States. On the other hand, this decrease in California's maternal mortality rate likely resulted primarily from efforts to reduce deaths caused by obstetric hemorrhage and preeclampsia and may not have translated to declines in drug-related and suicide deaths.[1]

Our study also had important advantages, including its focus on drug and suicide deaths; the use of statewide data from California, a highly diverse and the most populous, US state; and our analysis of maternal decedents' ED/hospital utilization prior to death.

Conclusion

In summary, our findings clearly indicate a need for increased research as well as public health and clinical attention to maternal deaths caused by drugs and suicide. An important first step would be further documentation of this problem across the United States, which will require that all state Maternal Mortality Review Committees categorize deaths caused by drugs, suicide, and other nonobstetric causes as medical deaths that fall within the scope of their review, particularly in wake of Congressional legislation providing funding for all states to form Maternal Mortality Review Committees. Postpartum morbidity from drug abuse, psychological disorder, and suicidal behavior also warrants greater attention because the deaths observed in the current study likely reflect only the tip of the iceberg of the growing health challenges facing women and their families. ■

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SUPPLEMENTAL TABLE 1
ICD-10 codes used to define maternal drug-related deaths

ICD-10 code	Diagnosis
Accidental poisoning	X40–X44
Poisoning of undetermined intent by exposure to drugs	Y10–Y14
Drug-induced diseases	D52.1, D59.0, D59.2, D61.1, D64.2, E06.4, E16.0, E23.1, E24.2, E27.3, E66.1, G21.1, G24.0, G25.1, G25.4, G25.6, G44.4, G62.0, G72.0, I95.2, J70.2–J70.4, K85.3, L10.5, L27.0, L27.1, M10.2, M32.0, M80.4, M81.4, M83.5, M87.1, R50.2
Drugs in the blood	R78.1–R78.5
Mental/behavioral disorders due to drugs	F11.0–F11.5, F11.7–F11.9, F12.0–F12.5, F12.7–F12.9, F13.0–F13.5, F13.7–F13.9, F14.0–F14.5, F14.7–F14.9, F15.0–F15.5, F15.7–F15.9, F16.0–F16.5, F16.7–F16.9, F18.0–F18.5, F18.7–F18.9, F19.0–F19.5, F19.7–F19.9

ICD-10, International Classification of Diseases, tenth revision.

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SUPPLEMENTAL TABLE 2
Sociodemographic characteristics of delivery hospitalizations excluded from analytic sample, California, 2010–2012

Sociodemographic characteristic	n, %
Age, y	
<20	33,056 (8.2%)
20-35	317,199 (78.9%)
≥35	51,995 (12.9%)
Race/ethnicity	
White, non-Hispanic	56,437 (14.0%)
Black, non-Hispanic	10,832 (2.7%)
Hispanic	280,223 (69.7%)
Asian/Pacific Islander	39,113 (9.7%)
Other	15,645 (3.9%)
Insurance/payer	
Private	96,378 (24.0%)
Medicaid	281,063 (69.9%)
Self-pay	20,021 (5.0%)
Other	4,788 (1.2%)

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