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Severe Maternal Morbidity Among Stillbirth and Live Birth Deliveries in California

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Abstract

OBJECTIVE: To assess the prevalence and risk of severe maternal morbidity among delivery hospitalization for stillbirth compared with live birth deliveries.

METHODS: Using data from the Office of Statewide Health Planning and Development in California, we performed a population-based cross-sectional study of 6,459,842 deliveries between 1999 and 2011. We identified severe maternal morbidity using an algorithm comprising diagnoses and procedures developed by the Centers for Disease Control and Prevention and used log-binomial regression models to examine the relative risk (RR) of severe maternal morbidity for stillbirth compared with live birth deliveries, adjusting for maternal demographic, medical, and obstetric characteristics. We also examined severe maternal morbidity prevalence by cause of fetal death among stillbirth deliveries.

RESULTS: The prevalence of severe maternal morbidity for stillbirth and live birth was 578 and 99 cases per 10,000 deliveries, respectively. After adjusting for maternal demographic, medical, and obstetric characteristics, the risk of severe maternal morbidity among stillbirth deliveries was more than fourfold higher (adjusted RR 4.77; 95% CI 4.53–5.02) compared with live birth deliveries. The severe maternal morbidity prevalence was highest among stillbirths caused by hypertensive disorders and placental conditions (24 and 19 cases/100 deliveries, respectively), and lowest among stillbirths caused by fetal malformations or genetic abnormalities (1 case per 100 deliveries).

CONCLUSION: Women who have stillbirths are at substantially higher risk for severe maternal morbidity than women who have live births, regardless of cause of fetal death. The prevalence of severe maternal morbidity varies by cause of fetal death.

Reducing the national rates of maternal mortality and severe maternal morbidity is an obstetric priority in the United States. Recent data indicate that the rate of maternal mortality in the United States is substantially higher than other well-resourced developed countries.¹ Furthermore, the prevalence of severe maternal morbidity has increased steadily in the

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United States over the past few decades, reaching a peak of 1,470 events per 10,000 deliveries in 2015.² Severe maternal morbidity is an important indicator of the quality of maternal care in the United States^{3,4}; however, population-based studies of severe maternal morbidity have not accounted for whether women experienced a live birth or stillbirth.

The prevalence of stillbirth in the United States has remained steady at approximately 6 per 1,000 births⁵; however, more than 15% of maternal deaths within 42 days of delivery in well-resourced countries occur in women who experience a stillbirth delivery.^{6–8} In contrast, scarce data exist examining the prevalence of severe maternal morbidity among women with stillbirth deliveries. In a recent U.S. single-center study, 6% of women with stillbirth deliveries experienced serious medical complications, including severe postpartum hemorrhage, disseminated intravascular coagulation, shock, and hypotension.⁹ To determine whether current approaches for surveillance and maternal quality care improvement should differentiate women who experience stillbirth from live birth, there is a need for population-level studies examining maternal morbidity associated with each delivery type. Therefore, our primary aim was to compare the prevalence of severe maternal morbidity among women who had stillbirth versus live birth deliveries in California. Our secondary aims were to explore whether the prevalence of severe maternal morbidity varies by cause of fetal death among stillbirth deliveries and by gestational age.

METHODS

We performed a population-based cross-sectional study using data from the Office of Statewide Health Planning and Development, under the California Health and Human Services Agency. For this study, we used information from vital statistics of birth and fetal death files, and maternal hospital discharge records (linked by a unique, encrypted alphanumeric code) for live birth and stillbirth deliveries in California between 1999 and 2011. We identified stillbirths from death records in the fetal death file, and live births from birth records. We excluded deliveries with gestational ages less than 20 weeks (because the definition of stillbirth in both sets of records was a fetal death delivered at or after 20 weeks of gestation)¹⁰ and gestational ages greater than 45 weeks (owing to concern of inaccurate data entry). We also excluded deliveries that did not have successful linkages between the fetal or neonatal vital records and the maternal hospital discharge records (see Appendix 1, available online at <http://links.lww.com/AOG/B446>, for characteristics of linked and unlinked deliveries). After these exclusions, our population included 6,459,842 deliveries, of which 25,997 (0.4%) were stillbirths and 6,433,845 (99.6%) were live births (Fig. 1).

The primary outcome was severe maternal morbidity during the delivery hospitalization. We identified deliveries with severe maternal morbidity using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes corresponding to a list of 18 indicators identified by the Centers for Disease Control and Prevention (Appendix 2, available online at <http://links.lww.com/AOG/B446>, lists relevant ICD-9-CM codes).^{11,12} These codes have since been validated using California data.³ In addition to examining severe maternal morbidity as a composite measure, we examined individual indicators of severe maternal morbidity. Of note, the indicator responsible for the greatest number of severe maternal morbidity cases is blood transfusion.¹¹ Guidelines for

defining severe maternal morbidity require a woman to receive at least 4 units of blood if no other diagnosis or procedure is indicated³; however, the ICD-9-CM code for transfusion does not specify number of units transfused. Therefore, to account for potential overestimation of the prevalence of severe maternal morbidity, we performed additional analysis in which deliveries with transfusion as the only morbidity indicator were not classified as severe maternal morbidity.

We first calculated the severe maternal morbidity prevalence per 10,000 delivery hospitalizations among stillbirths and live births, respectively. We used log-binomial regression models to calculate the overall relative risk (RR) of severe maternal morbidity between stillbirth compared with live birth deliveries. We also separately calculated the RR for each indicator of severe maternal morbidity and severe maternal morbidity excluding cases with blood transfusion as the only indicator. We adjusted for the effects of demographic factors, pregnancy factors, plus delivery-related factors in sequential regression models. Maternal demographic information extracted from the birth certificate dataset included maternal race–ethnicity, age at delivery, parity, payment type at delivery, and education level. Prepregnancy medical conditions (preexisting diabetes and preexisting hypertension) and obstetric characteristics (preeclampsia, gestational diabetes, and gestational hypertension) were defined using ICD-9-CM diagnosis codes in the delivery hospitalization (Appendix 3 available online at <http://links.lww.com/AOG/B446>, lists specific ICD-9-CM codes).^{13–15}

We conducted two sensitivity analyses. The first examined whether mode of delivery affected the relationship between fetal outcome and severe maternal morbidity by including mode of delivery (vaginal or caesarean) as a covariate in the adjusted model. We did this because there is an established relationship between mode of delivery and severe maternal morbidity; however, the timing of these outcomes in relation to fetal outcomes is not well established.^{16,17} To account for women who had more than one delivery during the study period, our second sensitivity analysis included one randomly selected delivery for each woman to address any potential clustering effect by the woman.

Finally, we performed exploratory analyses to examine whether the severe maternal morbidity prevalence among stillbirth deliveries varies according to the cause of fetal death and gestational age at delivery. The cause of fetal death was classified using ICD-10 codes in the fetal death files; these causes were categorized into 10 groups, as previously described by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development–sponsored Stillbirth Collaborative Research Network (Appendix 4, available online at <http://links.lww.com/AOG/B446>, lists the specific ICD-10 codes used to define each category).¹⁸ Given that the gestational age at delivery differs between live births and stillbirths,¹⁹ we also calculated the prevalence of severe maternal morbidity among stillbirth and live birth deliveries, respectively, according to number of completed weeks of gestation in 2-week intervals. Finally, we conducted an exploratory stratified analysis to examine whether the RR of severe maternal morbidity between stillbirth compared with live birth deliveries differed by gestational age (before 30 weeks and at or after 30 weeks).

All statistical tests were conducted using SAS 9.4. Stanford University Institutional Review Board and the California State Committee for the Protection of Human Subjects reviewed and approved this study.

RESULTS

Compared with women with live births, women with stillbirths were more likely to be non-Hispanic black, advanced maternal age, have preexisting diabetes and hypertension, gestational diabetes, preeclampsia, and undergo vaginal delivery (Table 1). Women with stillbirths were less likely to have private insurance, a college education, and gestational hypertension.

The overall severe maternal morbidity prevalence was 101 (95% CI 100–102) events per 10,000 deliveries (not shown in Table 2); the prevalence of severe maternal morbidity among these was 578 (95% CI 550–608) and 99 (95% CI 98–100) events per 10,000 deliveries for stillbirths and live births, respectively. After adjusting for maternal demographic, medical, and obstetric characteristics, the risk of severe maternal morbidity was more than fourfold higher among stillbirth compared with live birth deliveries (adjusted RR 4.77; 95% CI 4.53–5.02). For each severe maternal morbidity indicator, the risk was higher among stillbirths compared with live births, with shock incurring the highest RR (adjusted RR 14.65; 95% CI 11.99–17.90). We identified 34,701 deliveries with blood transfusion as the only indicator. After excluding transfusions from cases of severe maternal morbidity, the severe maternal morbidity prevalence remained high among stillbirth compared with live birth deliveries (321 and 46/10,000 deliveries, respectively; adjusted RR 5.48; 95% CI 5.11–5.88; Table 2).

In our first sensitivity analysis, we adjusted for mode of delivery in our models. Compared with live births, the adjusted RR of severe maternal morbidity among women with stillbirths increased to 6.12 (95% CI 5.81–6.44) (Appendix 5, available online at <http://links.lww.com/AOG/B446>). In our second sensitivity analysis of women with one randomly selected delivery (Appendix 6, available online at <http://links.lww.com/AOG/B446>), the risk of severe maternal morbidity associated with stillbirth remained high (adjusted RR 5.37; 95% CI 4.94–5.83).

Among all stillbirth deliveries, 18,468 (71%) had a defined cause of fetal death listed on the fetal death file. The most common specified causes of fetal death were umbilical cord anomalies (18.9%), obstetric complications (15.1%), and placental conditions (12.0%) (Table 3). The severe maternal morbidity prevalence among stillbirth deliveries varied substantially by cause of fetal death, from 1 per 100 deliveries due to fetal major structural malformations or genetic abnormalities to 24 per 100 deliveries due to hypertensive disorders. For each specified cause of fetal death, the severe maternal morbidity prevalence was higher than the overall prevalence among live birth deliveries. We also explored whether severe maternal morbidity rates vary according to the gestational age at delivery. Although deliveries resulting in stillbirths occurred at an earlier gestational age compared with live births (mean 30.7 and 39.0 weeks, respectively; Appendix 7, available online at <http://links.lww.com/AOG/B446>), the gestational-age-specific prevalence of severe maternal morbidity occurring after 29 weeks of gestation was consistently higher among stillbirth

deliveries than live birth deliveries (Fig. 2). We conducted an exploratory analysis in which we stratified women into two delivery cohorts: deliveries before 30 weeks of gestation and deliveries at or after 30 weeks of gestation (Appendix 8, available online at <http://links.lww.com/AOG/B446>). In the stratum who delivered at or after 30 weeks of gestation, the risk of severe maternal morbidity was 5.4-fold higher among women with stillbirths compared with women with live births. In contrast, the risk of severe maternal morbidity was not significantly different between women with stillbirths and live births for deliveries before 30 weeks of gestation.

DISCUSSION

Our findings indicate that nearly 1 in 17 women who deliver a stillbirth in California experience severe maternal morbidity. Furthermore, the risk of severe maternal morbidity was more than fourfold higher for women undergoing stillbirth delivery than live birth delivery.

Minimal attention has been given to maternal outcomes and acute complications experienced by women who have a stillbirth. This is partly because prior population-wide studies of severe maternal morbidity have either excluded stillbirth deliveries,²⁰ combined stillbirths and live births,^{12,21–24} or adjusted for stillbirths as a fetal outcome.^{25,26} One U.S. study has reported maternal morbidity data among 543 women who experienced stillbirth; 6% of women experienced severe morbidity, with the most common morbidities being blood transfusion, disseminated intravascular coagulation, acute renal failure, and respiratory failure requiring intubation.⁹ Despite the small cohort size, the prevalence of these morbidities is consistent with those observed in our study. Given the recent calls to reduce the national rate of severe maternal morbidity,^{4,27} new public health initiatives and practice guidelines are needed to highlight and address the morbidity risk associated with stillbirth identified in this study.

In our study, compared with live birth deliveries, we observed that the prevalence of major organ dysfunction or failure (including disseminated intravascular coagulation, acute renal failure, adult respiratory distress syndrome, sepsis, shock) and hysterectomy (for presumed major blood loss control) were substantially higher among stillbirth deliveries. These morbidities may be related to specific stillbirth etiologies, such as placental abruption; infection of the fetus, fetal membranes, or placenta; and hypertensive disorders of pregnancy. Based on data from postmortem examinations of the fetus, the aforementioned etiologies have been identified as probable or possible causes in 7.4%, 13.2%, and 9.2% of stillbirths, respectively.¹⁸

Moreover, we observed that, among all categories of fetal death, hypertensive disorders and placental conditions (which include previa and accreta) had the highest prevalence of severe maternal morbidity.¹⁸ Severe complications associated with severe preeclampsia and major hemorrhage, respectively—including disseminated intravascular coagulation, renal failure, and acute respiratory distress syndrome—were among the most common morbidities affecting stillbirth deliveries.^{28,29} In addition, blood transfusion, an important proxy for severe obstetric hemorrhage, occurred nearly seven times more frequently among stillbirth

deliveries than live birth deliveries.³⁰ Taken together, these findings suggest the morbidity associated with obstetric hemorrhage and preeclampsia among women hospitalized for stillbirth delivery is a serious concern. Prospective studies are needed to determine whether women undergoing stillbirth delivery experience a high morbidity burden related to these conditions and to examine whether management practices of these conditions differ for pregnant women carrying a viable compared with nonviable fetus.

In our exploratory analysis, we observed that the prevalence of severe maternal morbidity varied substantially by gestational age for both stillbirths and live births, with a higher risk after 29 weeks of gestation among stillbirths than live births. We are unable to determine reasons for these within and between-group differences with increasing gestational age.

A major strength of this analysis is the large dataset, with linkages between administrative claims, birth and fetal death records. Because stillbirth deliveries occur with very low frequency, these data allowed us to perform detailed analyses of maternal outcomes of this delivery cohort. Our study has a number of limitations. First, linkage between birth records and maternal delivery records was lower for stillbirths than live births (79% vs 97%). However, our concerns about selection bias due to the exclusion of unlinked stillbirths is minimal as the distribution of maternal sociodemographic variables is similar among stillbirth cases that were and were not linked to discharge records. Second, the analyses of severe maternal morbidity by cause of fetal death was limited because fetal death records suffer from missing data, do not differentiate intrapartum fetal deaths from antepartum stillbirths, and 27% stillbirths had an “unspecified” cause of death. Further research is needed to understand how the relations between stillbirth and severe maternal morbidity are modified or explained by identifiable causes of fetal death. Third, as in most observational studies, there may be unobserved covariates that influence the risk of severe maternal morbidity among women with stillbirths. However, our findings remained consistent in our secondary analyses excluding transfusion from severe maternal morbidity and our sensitivity analyses. Given the high risk of severe maternal morbidity among women with stillbirths and the precision of these estimates, a substantial effect from unobserved confounders would be needed to attenuate point estimates towards the null. Lastly, our study included deliveries in California only between 1997 and 2011. Although care practices for women with stillbirths are unlikely to have dramatically changed in subsequent years, our results may not be generalizable outside of this time period and location.

The prevalence of severe maternal morbidity is substantially higher among stillbirth deliveries than live birth deliveries. With nearly 1 in 17 women hospitalized for stillbirth delivery experiencing severe morbidity, obstetric providers should consider closely monitoring these women for symptoms and signs of severe maternal morbidity. As the causes of stillbirth are heterogeneous,¹⁸ further research is needed to determine the extent to which each cause contributes to maternal morbidity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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REFERENCES

1. GBD 2015 Maternal Mortality Collaborators. Global, regional, and national levels of maternal mortality, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016;388:1775–812. [PubMed: 27733286]
2. Finger K, Hambrick M, Heslin K, Moore J. Trends and disparities in delivery hospitalizations involving severe maternal morbidity, 2006–2015. Available at: <https://www.hcup-us.ahrq.gov/reports/statbriefs/sb243-Severe-Maternal-Morbidity-Delivery-Trends-Disparities.jsp>. Retrieved January 5, 2019.
3. Main EK, Abreo A, McNulty J, Gilbert W, McNally C, Poeltler D, et al. Measuring severe maternal morbidity: validation of potential measures. *Am J Obstet Gynecol* 2016;214:643.e1–10. [PubMed: 26582168]
4. D'Alton ME, Bonanno CA, Berkowitz RL, Brown HL, Copel JA, Cunningham FG, et al. Putting the “m” back in maternal-fetal medicine. *Am J Obstet Gynecol* 2013;208:442–8. [PubMed: 23211544]
5. Gregory E, MacDorman M, Martin J. Trends in fetal and perinatal mortality in the United States, 2006–2012. *NCHS Data Brief* 2014;1–8.
6. Ray JG, Park AL, Dzakpasu S, Dayan N, Deb-Rinker P, Luo W, et al. Prevalence of severe maternal morbidity and factors associated with maternal mortality in Ontario, Canada. *JAMA Netw Open* 2018;1:e184571. [PubMed: 30646359]
7. Nair M, Knight M, Kurinczuk JJ. Risk factors and newborn outcomes associated with maternal deaths in the UK from 2009 to 2013: a national case-control study. *BJOG* 2016;213: 1654–62.
8. Macdorman MF, Kirmeyer S. The challenge of fetal mortality. *NCHS Data Brief* 2009;16:1–8.
9. Gold K, Mozurkewich E, Puder K, Treadwell M. Maternal complications associated with stillbirth delivery: a cross-sectional analysis. *J Obstet Gynaecol* 2016;36:208–12. [PubMed: 26479679]
10. MacDorman M, Gregory E. Fetal and perinatal mortality: United States, 2013. *Natl Vital Stat Rep* 2015;64:1–24.
11. Centers for Disease Control and Prevention. Severe maternal morbidity in the United States. Available at: <https://www.cdc.gov/reproductivehealth/maternalinfanthealth/severematernalmorbidity.html>. Retrieved December 15, 2018.
12. Callaghan WM, Creanga AA, Kuklina EV. Severe maternal morbidity among delivery and postpartum hospitalizations in the United States. *Obstet Gynecol* 2012;120:1029–36. [PubMed: 23090519]
13. Carmichael SL, Blumenfeld YJ, Mayo JA, Profit J, Shaw GM, Hintz SR, et al. Stillbirth and live birth at periviable gestational age: a comparison of prevalence and risk factors. *Am J Perinatol* 2019;36:537–544. [PubMed: 30208499]
14. Guendelman S, Thornton D, Gould J, Hosang N. Obstetric complications during labor and delivery: assessing ethnic differences in California. *Womens Health Issues* 2006;16:189–97. [PubMed: 16920523]
15. Lydon-Rochelle MT, Holt VL, Cárdenas V, Nelson JC, Easterling TR, Gardella C, et al. The reporting of pre-existing maternal medical conditions and complications of pregnancy on birth certificates and in hospital discharge data. *Am J Obstet Gynecol* 2005;193:125–34. [PubMed: 16021070]
16. Cham M, Sundby J, Vangen S. Fetal outcome in severe maternal morbidity: too many stillbirths. *Acta Obstet Gynecol Scand* 2009;88:343–9. [PubMed: 19172420]

17. Lazariu V, Nguyen T, McNutt LA, Jeffrey J, Kacica M. Severe maternal morbidity: a population-based study of an expanded measure and associated factors. *PLoS One* 2017;12:1–13.
18. The Stillbirth Collaborative Research Network Writing Group. Causes of death among stillbirths. *JAMA* 2011;306:2459–68. [PubMed: 22166605]
19. MacDorman MF, Reddy UM, Silver RM. Trends in stillbirth by gestational age in the United States, 2006–2012. *Obstet Gynecol* 2015;126:1146–50. [PubMed: 26551188]
20. Grobman WA, Bailit JL, Rice MM, Wapner RJ, Reddy UM, Varner MW, et al. Racial and ethnic disparities in maternal morbidity and obstetric care. *Obstet Gynecol* 2015;125: 1460–7. [PubMed: 26000518]
21. Creanga AA, Bateman BT, Kuklina EV, Callaghan WM. Racial and ethnic disparities in severe maternal morbidity: a multistate analysis, 2008–2010. *Am J Obstet Gynecol* 2014; 210:435.e1–8.
22. Creanga AA, Shapiro-Mendoza CK, Bish CL, Zane S, Berg CJ, Callaghan WM. Trends in ectopic pregnancy mortality in the United States: 1980–2007. *Obstet Gynecol* 2011;117:837–43. [PubMed: 21422853]
23. Martin AS, Monsour M, Kissin DM, Jamieson DJ, Callaghan WM, Boulet SL. Trends in severe maternal morbidity after assisted reproductive technology in the United States, 2008–2012. *Obstet Gynecol* 2016;127:59–66. [PubMed: 26646124]
24. Howell E, Mora P, Horowitz C, Leventhal H. Racial and ethnic differences in factors associated with early postpartum depressive symptoms. *Obstet Gynecol* 2005;105:1442–50. [PubMed: 15932842]
25. Bauer ME, Bateman BT, Bauer ST, Shanks AM, Mhyre JM. Maternal sepsis mortality and morbidity during hospitalization for delivery: temporal trends and independent associations for severe sepsis. *Anesth Analg* 2013;117:944–50. [PubMed: 24023020]
26. Acosta CD, Harrison DA, Rowan K, Lucas DN, Kurinczuk JJ, Knight M. Maternal morbidity and mortality from severe sepsis: a national cohort study. *BMJ Open* 2016;6:e012323.
27. Council on patient safety in women's health care. Alliance for innovation in maternal health (AIM). Available at: <https://safehealthcareforeverywoman.org/aim-program/>. Retrieved February 24, 2019.
28. Bateman BT, Berman MF, Riley LE, Leffert LR. The epidemiology of postpartum hemorrhage in a large, nationwide sample of deliveries. *Anesth Analg* 2010;110:1368–73. [PubMed: 20237047]
29. Steegers EA, von Dadelszen P, Duvekot JJ, Pijnenborg R. Preeclampsia. *Lancet* 2010;376:631–44. [PubMed: 20598363]
30. Patterson JA, Roberts CL, Bowen JR, Irving DO, Isbister JP, Morris JM, et al. Blood transfusion during pregnancy, birth, and the postnatal period. *Obstet Gynecol* 2014;123:126–33. [PubMed: 24463672]

Fig. 1. Study population selection process.

Wall-Wieler. Severe Maternal Morbidity and Stillbirths. *Obstet Gynecol* 2019.

Fig. 2. Prevalence (estimate and 95% CI) of severe maternal morbidity per 10,000 deliveries by gestational age, California, 1999–2011.

Wall-Wieler. Severe Maternal Morbidity and Stillbirths. *Obstet Gynecol* 2019.

Maternal Characteristics Among All Deliveries, Live Birth Deliveries, and Stillbirth Deliveries, California, 1999–2011

Table 1.

Characteristic	All (N = 6,459,842)	Live Birth (n=6,433,845)	Stillbirth (n=25,997)	P (Difference χ^2)
Race-ethnicity				
Non-Hispanic white	1,876,065 (29.04)	1,869,313 (29.05)	6,752 (25.97)	<.001
Non-Hispanic black	371,147 (5.75)	368,088 (5.72)	3,059 (11.77)	
Hispanic	3,306,251 (51.18)	3,293,139 (51.18)	13,112 (50.44)	
Asian or Pacific Islander	801,561 (12.41)	798,834 (12.42)	2,727 (10.49)	
Other	31,182 (0.48)	31,060 (0.48)	122 (0.47)	
Missing	73,636 (1.14)	73,411 (1.14)	225 (0.87)	
Age at delivery (y)				
Younger than 20	613,689 (9.50)	610,861 (9.49)	2,828 (10.88)	<.001
20–34	4,737,403 (73.34)	4,719,842 (73.36)	17,561 (67.55)	
35 or older	1,108,750 (17.16)	1,103,142 (17.15)	5,608 (21.57)	
Primiparous	2,500,963 (38.72)	2,490,897 (38.72)	10,066 (38.72)	.989
Payment type at delivery				
Government-assisted	2,939,951 (45.51)	2,928,036 (45.51)	11,915 (45.83)	<.001
Private	3,250,063 (50.31)	3,238,687 (50.34)	11,376 (43.76)	
Other	256,857 (3.98)	255,263 (3.97)	1,594 (6.13)	
Missing	12,971 (0.20)	11,859 (0.18)	1,112 (4.28)	
Education level				
High school or less	3,474,813 (53.79)	3,459,881 (53.78)	14,932 (57.44)	<.001
Some college	1,329,070 (20.57)	1,323,335 (20.57)	5,735 (22.06)	
Completed college	1,493,813 (23.12)	1,489,893 (23.16)	3,920 (15.08)	
Missing	162,146 (2.51)	160,736 (2.50)	1,410 (5.42)	
Medical or obstetric comorbidity				
Preexisting diabetes	45,618 (0.71)	44,966 (0.70)	652 (2.51)	<.001
Preexisting hypertension	71,595 (1.11)	70,762 (1.10)	833 (3.20)	<.001
Preeclampsia	198,534 (3.07)	197,172 (3.06)	1,362 (5.24)	<.001
Gestational diabetes	430,722 (6.67)	428,775 (6.66)	1,947 (7.49)	<.001
Gestational hypertension	132,940 (2.06)	132,452 (2.06)	488 (1.88)	.040

Characteristic	All (N = 6,459,842)	Live Birth (n=6,433,845)	Stillbirth (n=25,997)	P (Difference χ^2)
Mode of delivery				
Vaginal	4,590,502 (71.06)	4,568,633 (71.01)	21,869 (84.12)	<.001
Caesarean	1,869,340 (28.94)	1,865,212 (28.99)	4,128 (15.88)	

Data are n (%) unless otherwise specified.

Table 2.

Prevalence and Relative Risk of Severe Maternal Morbidity and Its Specific Indicators per 10,000 Delivery Hospitalizations Among Women With Stillbirth and Live Birth Deliveries, California 1999–2011 (N=6,459,842)

SMM	SMM Cases (Prevalence ^a)					
	Stillbirths (n=25,997)	Live Births (n=6,433,845)	RR (95% CI)	Adjusted [†] RR (95% CI)	Adjusted [‡] RR (95% CI)	
All	1,503 (578)	63,819 (99)	5.83 (5.54–6.13)	4.94 (4.69–5.20)	4.77 (4.53–5.02)	
Specific SMM indicator						
Blood transfusion	1,080 (415)	41,233 (64)	6.48 (6.11–6.88)	5.59 (5.25–5.94)	5.38 (5.06–5.72)	
Disseminated intravascular coagulation	402 (155)	9,818 (15)	10.13 (9.18–11.19)	9.30 (8.40–10.29)	8.78 (7.93–9.72)	
Acute renal failure	169 (65)	1,820 (3)	22.98 (19.64–26.89)	14.70 (12.45–17.35)	13.22 (11.20–15.62)	
Adult respiratory distress syndrome	143 (55)	2,791 (4)	12.68 (10.72–14.99)	9.11 (7.66–10.84)	8.68 (7.29–10.33)	
Sepsis	137 (53)	1,863 (3)	18.20 (15.30–21.65)	14.31 (11.95–17.14)	14.15 (11.81–16.95)	
Shock	110 (42)	1,515 (2)	17.97 (14.81–21.80)	15.04 (12.31–18.37)	14.65 (11.99–17.90)	
Hysterectomy	82 (32)	5,175 (8)	3.92 (3.15–4.88)	3.31 (2.66–4.13)	3.29 (2.64–4.10)	
Pulmonary edema or acute heart failure	74 (29)	2,745 (4)	6.67 (5.30–8.40)	4.41 (3.48–5.58)	4.16 (3.28–5.27)	
Eclampsia	52 (20)	5,156 (8)	2.50 (1.90–3.28)	2.11 (1.60–2.78)	2.11 (1.60–2.77)	
Conversion of cardiac rhythm	30 (12)	518 (1)	14.33 (9.92–20.71)	10.45 (7.11–15.37)	10.17 (6.91–14.97)	
Puerperal cerebrovascular disorders	29 (11)	1,660 (3)	4.32 (3.00–6.24)	3.55 (2.45–5.15)	3.36 (2.31–4.87)	
Cardiac arrest or ventricular Fibrillation	25 (10)	377 (1)	16.41 (10.95–24.60)	10.81 (7.01–16.66)	10.44 (6.75–16.14)	
Ventilation or temporary tracheostomy	20 (8)	446 (1)	11.10 (7.09–17.37)	6.95 (4.38–11.03)	6.78 (4.27–10.77)	
All, excluding “blood transfusion only” cases	834 (321)	29,787 (46)	6.93 (6.48–7.41)	5.68 (5.29–6.09)	5.48 (5.11–5.88)	

RR, relative risk; SMM, severe maternal morbidity.

Data are n (%) unless otherwise specified.

Six of the 19 SMM indicators included in the index—acute myocardial infarction or aneurysm, amniotic fluid embolism, heart failure or arrest during surgery or procedure, severe anesthesia complications, sickle cell anemia with crises, and air and thrombotic embolism—had fewer than 15 cases among live births or stillbirths; information for these specific indicators is not presented.

^a Per 10,000 delivery hospitalizations.

[†] Adjusted for maternal race–ethnicity, age at delivery, parity, payment type at delivery, education level, preexisting diabetes, preexisting hypertension.

[‡] Adjusted for maternal race–ethnicity, age at delivery, parity, payment type at delivery, education level, preexisting diabetes, preexisting hypertension, preeclampsia, gestational diabetes, gestational hypertension.

Table 3.

Prevalence of Severe Maternal Morbidity Among Stillbirths by Cause of Fetal Death, California 1999–2011 (n=25,997)

Cause of Fetal Death	Stillbirths	SMM Cases	SMM Prevalence per 100 Deliveries (95% CI)*
Hypertensive disorders	709 (2.73)	167 (11.11)	24 (21–27)
Placental conditions	3,111 (11.97)	596 (39.65)	19 (18–21)
Infections	661 (2.54)	60 (3.99)	9 (7–12)
Maternal medical conditions	608 (2.34)	51 (3.39)	8 (6–11)
Other	1,840 (7.08)	98 (6.52)	5 (4–6)
Obstetric complications	3,920 (15.08)	164 (10.91)	4 (4–5)
Missing	433 (1.67)	18 (1.20)	4 (3–7)
Not otherwise specified	7,096 (27.30)	235 (15.64)	3 (3–4)
Umbilical cord anomalies	4,923 (18.94)	79 (5.26)	2 (1–2)
Fetal major structural malformations or genetic abnormalities	2,696 (10.37)	35 (2.33)	1 (1–2)

SMM, severe maternal morbidity.

Data are n (%) unless otherwise specified.

* Ranked from highest to lowest prevalence.