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Trends and Disparities in Severe Maternal Morbidity Indicator Categories during Childbirth Hospitalization in California from 1997 to 2017

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Abstract

Objective—Severe maternal morbidity (SMM) is increasing and characterized by substantial racial and ethnic disparities. Analyzing trends and disparities across time by etiologic or organ system groups instead of an aggregated index may inform specific, actionable pathways to equitable care. We explored trends and racial and ethnic disparities in seven SMM categories at childbirth hospitalization.

Study Design—We analyzed California birth cohort data on all live and stillbirths ≥ 20 weeks' gestation from 1997 to 2017 (n = 10,580,096) using the Centers for Disease Control and Prevention's SMM index. Cases were categorized into seven nonmutually exclusive indicator

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Authors' Contributions

A.M.E. played a key role in conceptualization, formal analysis, investigation, methodology, visualization, and contributed to both the original draft and the subsequent review and editing. A.L. contributed significantly to conceptualization, investigation, methodology, and was involved in both the original draft and review and editing stages, providing supervision. P.K. took on responsibilities in data curation, formal analysis, investigation, methodology, visualization, and participated in writing—both the original draft and the review and editing process. M.S.M. focused on writing and reviewing. S.A.L. participated in the writing and reviewing stages. E.K.M. played a vital role in conceptualization, methodology, and contributed to the review and editing. S.L.C. took on multiple roles, including conceptualization, data curation, investigation, funding acquisition, methodology, resources, writing—both original draft and review/editing, supervision, project administration, and additional funding acquisition.

Conflict of Interest

None declared.

categories (cardiac, renal, respiratory, hemorrhage, sepsis, other obstetric, and other medical SMM). We compared prevalence and trends in SMM indicator categories overall and by racial and ethnic group using logistic and linear regression.

Results—SMM occurred in 1.16% of births and nontransfusion SMM in 0.54%. Hemorrhage SMM occurred most frequently (27 per 10,000 births), followed by other obstetric (11), respiratory (7), and sepsis, cardiac, and renal SMM (5). Hemorrhage, renal, respiratory, and sepsis SMM increased over time for all racial and ethnic groups. The largest disparities were for Black individuals, including over 3-fold increased odds of other medical SMM. Renal and sepsis morbidity had the largest relative increases over time (717 and 544%). Sepsis and hemorrhage SMM had the largest absolute changes over time (17 per 10,000 increase). Disparities increased over time for respiratory SMM among Black, U.S.-born Hispanic, and non-U.S.-born Hispanic individuals and for sepsis SMM among Asian or Pacific Islander individuals. Disparities decreased over time for sepsis SMM among Black individuals yet remained substantial.

Conclusion—Our research further supports the critical need to address SMM and disparities as a significant public health priority in the United States and suggests that examining SMM subgroups may reveal helpful nuance for understanding trends, disparities, and potential needs for intervention.

Keywords

health equity; racial and ethnic disparities; severe maternal morbidity; maternal health; pregnancy complications; obstetric complications

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Severe maternal morbidity (SMM) comprises serious complications during labor and childbirth that can have both short- and long-term effects on health. It includes conditions such as hemorrhage, eclampsia, cardiovascular events, and sepsis, which place birthing people at high risk of death.[1] SMM rates are 50 to 100 higher than maternal mortality;[2] thus, it is an important metric for assessment of the health of birthing people, the quality of obstetric care, and an important proxy for maternal mortality whose rarity makes it less feasible to study.

SMM incidence in the United States has been increasing for several decades.[3] Current national data (2019) reported SMM excluding transfusion-only cases in 79.7 per 10,000 childbirth hospitalizations.[4] Of further high concern are the substantial and persistent racial and ethnic disparities observed within these rates, with racially or ethnically minoritized individuals, particularly Black individuals, experiencing significantly higher maternal morbidity and mortality than White people.[5–12]

Prior research on SMM drivers has implicated the sociodemographic characteristics of the obstetric population,[13,14] preexisting comorbidities,[14–18] cesarean birth,[18,19] and poor obstetrical care quality.[20–23] However, increasing trends in SMM remain unexplained by changes in maternal age, prepregnancy obesity, and cesarean birth over time.[18] Racial and ethnic disparities in SMM, which have remained relatively stable over time,[9,23] are attenuated but not resolved in most studies after adjustment for sociodemographic and clinical characteristics.[7,9,10,24,25]

SMM assessment using administrative data are strengthened by the development of a standard 21-item set of indicators based on International Classification of Diseases (ICD) diagnosis and procedure codes.[26,27] Collapsing these indicators into groups representing etiology or affected organ system may help balance the need for understanding underlying causes of SMM for intervention targeting with the challenges inherent to studying rare outcomes, moving us closer toward the elucidation of multilevel pathways shaping racial and ethnic disparities in SMM, which is needed for concrete gains in maternal health equity. Thus, we sought to expand our understanding of population-level SMM patterns through exploring trends and racial and ethnic inequities in seven underlying SMM categories using the California birth cohort data and testing for differential trends in SMM category by racial and ethnic groups.

Methods

This passive prospective cohort study[28] included all live births and stillbirths occurring in California at ≥20 weeks' gestation from 1997 to 2017. Vital statistics records were linked to hospital discharge records from California Department of Health Care Access and Information, resulting in over 95% successful linkage for live births and 85% for stillbirths.[29] We limited the analysis to successfully linked records and included only the first birth for multifetal gestations to avoid duplicates, leaving an analytic sample of 10,580,096 births.

Our outcome of SMM during childbirth hospitalization was defined using the Severe Maternal Morbidity Index, a validated measure developed by the U.S. Centers for Disease Control and Prevention (CDC).[30] Diagnosis and procedure codes specified in the ICD 9th (ICD-9) and 10th (ICD-10) editions were used to identify SMM cases overall and categorize them based on expert feedback into seven nonmutually exclusive indicator categories generally representing etiologic or affected organ system category (cardiac, renal, respiratory, hemorrhage, sepsis, other obstetric, and other medical SMM; ►Table 1, ►Supplementary Table S1, available in the online version). About half of SMM occurrences are solely based on blood transfusion codes without transfusion quantity to inform severity. We therefore examined nontransfusion SMM (SMM cases excluding cases for which transfusion was the only SMM indicator), which the CDC now commonly reports. Hemorrhage SMM excludes transfusion-only cases for this reason (►Table 1).

We used race and ethnicity as a proxy for exposure to racism and related social and structural factors, recognizing race as a social construct and the lack of granular data on social and structural determinants of health a limit of our study dataset.[31] Race and Hispanic ethnicity data are based on self-reported information in the vital record and categorized by the state as Hispanic and non-Hispanic: White, Black, Asian, Pacific Islander, American Indian and Alaska Native, other, and unknown following federal standards.[32,33] Given the large Hispanic population and substantial proportion of first-generation Hispanic immigrants, we included the birthing parent's birthplace (U.S.-born vs. non-U.S.-born) as a proxy for acculturation. Due to limited sample sizes, Asian and Pacific Islander categories were combined, and individuals self-reporting non-Hispanic American Indian and Alaska

Native (n = 46,535; 0.4%), other (n = 6,088; 0.1%), and unknown (n = 149,880; 1.4%) were excluded from race- and ethnicity-disaggregated analyses.

Analysis

We first computed annual prevalence in SMM, nontransfusion SMM, and each of the seven SMM indicator categories among the whole population and for each racial and ethnic group for 1997 to 2017. We then estimated the association of race and ethnicity with each SMM outcome using logistic regression. To determine annual rate change over time, we calculated crude rates and estimated linear trends using linear regression, visually displaying smoothed trend lines from crude prevalence data. Disparity analyses in SMM outcomes employed logistic regression modeling to test for annual differences and trends over time. We modeled disparity analyses using non-Hispanic White as the reference group, given this group has the lowest prevalence of SMM nationally and within California.[8,9] Odds ratios (ORs) were considered appropriate approximations for relative risk as SMM is a rare outcome. To investigate differences in SMM trends by race and ethnicity, we estimated models including main effects for race and ethnicity and year and their interaction. As the intent of the current analysis was to describe patterns of SMM categories experienced at the population level by racial and ethnic groups, we included no adjustments to prevent masking of temporal effects and magnitude.

We further calculated the percent increase in SMM overall and by indicator categories in 1997 and 2017 using crude prevalence data. To accommodate the ICD-9 to ICD-10 transition, we performed trends sensitivity analyses using data from 1997 to October 1, 2015 (transition date) and compared these with our main 1997 to 2017 results.

Statistical analyses were performed using SAS version 9.4 (SAS Institute Inc, Cary, NC), and differences where $p < 0.05$ were considered statistically significant. The State of California Committee for the Protection of Human Subjects and the Stanford University Research Compliance Office approved this project.

Language

People across the gender spectrum have capacity for pregnancy,[34,35] yet gender identity is unavailable within this administrative dataset. We limit gendered language to “maternal” in reference to SMM by convention where it is intended to inclusively refer to all pregnant or birthing individuals.

Results

Severe Maternal Morbidity Prevalence and Disparity from 1997 to 2017: Overall and by Severe Maternal Morbidity Indicator Category

SMM and nontransfusion SMM occurred in 116.1 and 53.7 per 10,000 births, respectively (►Table 2). Across indicator categories, rates were highest for hemorrhage SMM (27.2 per 10,000 births), followed by other obstetric (11.2), respiratory (7.0), sepsis (5.2), cardiac (5.1), and renal SMM (4.5), and other medical SMM (3.0). All racial and ethnic groups experienced elevated odds of SMM compared with non-Hispanic White individuals,

ranging from 19% elevated odds for non-U.S.-born Hispanic individuals (OR = 1.19, 95% confidence interval [CI] = 1.17–1.21) to a nearly 2-fold increased odds among Black individuals (OR = 1.97, 95% CI = 1.93–2.02). Disparities in nontransfusion SMM were slightly attenuated among most racial and ethnic groups and similar for Black individuals.

Racial and ethnic disparities were evident for most groups compared with non-Hispanic White individuals across many but not all categories, with the most pronounced disparities for Black individuals (►Table 2). Elevated SMM odds ranged from 8% for respiratory SMM (OR = 1.08, 95% CI = 1.01–1.16) to 55% for sepsis SMM (OR = 1.55, 95% CI = 1.43–1.67) for U.S.-born Hispanic individuals, 18% for other obstetric SMM (OR = 1.18, 95% CI = 1.13–1.25) to 23% for sepsis SMM (OR = 1.23, 95% CI = 1.14–1.34) for non-U.S.-born Hispanic individuals, 60% for hemorrhage SMM (OR = 1.60, 95% CI = 1.53–1.68) to over 3-fold for other medical SMM (OR = 3.48, 95% CI = 3.13–3.86) for Black individuals, and 25% for cardiac SMM (OR = 1.25, 95% CI = 1.14–1.37) to 2-fold for sepsis SMM (OR = 2.02, 95% CI = 1.85–2.20) for Asian or Pacific Islander individuals.

Severe Maternal Morbidity Trends Over Time: Overall and by Severe Maternal Morbidity Indicator Category

SMM prevalence increased 170%, from 67.2 per 10,000 births in 1997 to 182 in 2017 (►Table 3). Much of this rise was driven by blood transfusions (280% increase from 31.8 per 10,000 births to 120.7); yet nontransfusion SMM increased 89.4% from 42.5 per 10,000 births in 1997 to 80.5 in 2017. Renal SMM had the largest relative increase (717%) from 1.6 per 10,000 births in 1997 to 13.0 in 2017, whereas sepsis and hemorrhage SMM had the largest absolute increase of 17 per 10,000 births.

All SMM categories increased in prevalence over time for all race and ethnicity groups except cardiac and other medical SMM, which did not increase or decrease (►Fig. 1A–C, Group A). Nontransfusion SMM meaningfully increased after 2008 to 2009: from 42.5 to 47.8 per 10,000 births during 1997 to 2008 and from 56.0 to 80.5 per 10,000 births during 2009 to 2017. Renal and sepsis SMM increased substantially after 2008 to 2009 and 2011 to 2012, respectively.

Severe Maternal Morbidity Disparity and Trends Over Time: Overall and by Severe Maternal Morbidity Indicator Category

Minimal variation over time was observed in relative racial and ethnic differences for SMM overall and nontransfusion SMM; however, changes in disparity level compared with non-Hispanic White individuals were notable within certain SMM indicator categories (►Fig. 1, Group B). Respiratory SMM disparity increased over time for Black individuals from OR of 1.92 (95% CI = 1.62–2.28) in 1997 to 2.67 (95% CI = 2.30–3.10) in 2017. U.S.-born and non-U.S.-born Hispanic individuals initially had 15 and 14% lower odds of respiratory SMM (OR = 0.85 [95% CI = 0.72–0.99] and OR = 0.86 [95% CI = 0.75–0.98], respectively); however, this reversed by 2017 to increased odds of 19% among U.S.-born Hispanic individuals (OR = 1.19, 95% CI = 1.06–1.35) and 29% among non-U.S.-born Hispanic individuals (OR = 1.29, 95% CI = 1.14–1.46). Elevated sepsis SMM decreased among Black individuals from OR of 3.27 (95% CI = 2.52–4.25) in 1997 to OR of 2.09

(95% CI = 1.77–2.46) in 2017 but increased among Asian or Pacific Islander individuals from OR of 1.34 (95% CI = 1.04–1.73) in 1997 to OR of 2.01 (95% CI = 1.77–2.29) in 2017.

Sensitivity Analyses

Our sensitivity analysis using data from 1997 to 2015 found that the transition from ICD-9 to ICD-10 years (2016–2017) had minimal impact on estimated trend (►Supplementary Table S2, available in the online version).

Discussion

This study revealed variation in trends and disparities by disaggregated SMM indicator category across the period 1997 to 2017, which presents a view of SMM that may be more actionable than the overall SMM index more commonly presented. Disparities in SMM were largest for Black individuals across all SMM indicator categories, with elevated odds for nearly all indicator categories 2-fold or higher and reaching a high of three-and-a-half-fold elevated odds for other medical SMM. Disparities among other racial and ethnic categories were comparatively lower. Compared with non-Hispanic White individuals, SMM rates were highest for sepsis and other obstetric SMM among U.S.-born Hispanic individuals; sepsis and hemorrhage SMM for non-U.S.-born Hispanic individuals; and sepsis, respiratory, and renal SMM for Asian/Pacific Islander individuals. Disparities increased over time for respiratory SMM among Black, U.S.-born Hispanic, and non-U.S.-born Hispanic individuals and for sepsis SMM among Asian or Pacific Islander individuals compared with White individuals. Disparities decreased over time for sepsis SMM among Black individuals yet remained substantial.

Increasing SMM is of significant concern due to the high immediate and persisting physical, psychological, and economic costs these conditions place on individuals, families, and health systems. Furthermore, 25% of individuals who develop SMM also give birth preterm, which can significantly compound family stress.[36] Broader financial costs of SMM born by families, insurance, health facilities, and taxpayers include a 3-fold higher cost of childbirth-related care when compared with less complicated births,[37–40] far outweighing the cost of preventing such complications.

The increasing trends observed for hemorrhage, renal, respiratory, and sepsis SMM suggest key drivers of overall and nontransfusion SMM trends and priority focal points for research and intervention, both for California[9,18] and nationally.[4,41,42] Studies focused on major obstetric complications have identified differing time trends[19,43] and variation in SMM disparity by complication type,[8] suggesting the need to understand SMM overall and its underlying conditions to identify changing clinical contributors. For example, National Inpatient Sample 2012 to 2019data demonstrated statistically significant increases in acute renal failure, sepsis, shock, adult respiratory distress syndrome, hysterectomy, embolism, and multiple cardiac complications during childbirth.[4] However, disparities were not assessed. Our data are comparable with prevalent national nontransfusion SMM indicators and generally consistent with_national pregnancy-related mortality etiologies, with some exceptions.[4,44] We observed no increase in cardiac SMM despite the increasing contribution

of cardiovascular conditions to pregnancy-related deaths, now responsible for more than one-third of U.S. cases. This is consistent with time discrepancies between most SMM measurement (including ours) and cardiac deaths, which frequently occur more than 2 months' postpartum.[45,46]

Consistent with other literature assessing SMM disparities, we observed elevated SMM among all racially and ethnically minoritized groups when compared with non-Hispanic White individuals, with the highest rates among non-Hispanic Black individuals. This study extends the evidence on SMM trends and disparities, including research by Leonard et al that confirmed significantly increasing SMM prevalence for all racial and ethnic categories from 1997 to 2014 in California,[9] by demonstrating differential SMM indicator categories by racial and ethnic group. Comparative literature is sparse; however, nationally representative (2012–2015) and multistate (2008–2010) analyses identified substantially elevated SMM across most indicators for non-Hispanic Black versus non-Hispanic White individuals, with some heterogeneity in rate differences.[8,10]

Identifying salient intervention points for reversing increasing SMM prevalence and persistent disparities is critically important for maternal health and well-being, and our findings contribute to the literature supporting the imperative of looking beyond individual characteristics of individuals as explanatory factors for increasing SMM trends and disparities, including close attention to health care accessibility and quality of obstetric services,[20,21,47] and structural influences on maternal health.[41,48]

The evidence base on risk factors for disaggregated SMM indicators is largely limited to individual biological factors, which suggest important clinical interventions for optimizing obstetric care quality of, but which may be inadequate for disparity resolution as evidenced by persisting disparities after risk adjustment using expanded obstetric comorbidity scores.[49] For example, some increased SMM among non-Hispanic Black versus White individuals may be attributable to antenatal anemia, which has been linked to multiple SMM indicators.[50–53] Similarly, increasing disparities noted for respiratory SMM over time among Black, U.S.-born Hispanic, and non-U.S.-born Hispanic individuals may be partially due to preexisting chronic hypertension increasing risk of severe preeclampsia and pulmonary edema.[54–56] This combination of findings and their precursors supports the important and complex role of other factors such as structural racism and economic inequalities in structuring risk of SMM through multiple and intersecting pathways.[41]

Substantial prior research delineates the lower maternal health care quality received by racially and ethnically minorized individuals,[57–59] and targeted quality improvement initiatives have decreased racial and ethnic disparities in SMM.[60,61] Advocacy groups have called for comprehensive and sustained efforts to improve obstetrical care quality and patient centeredness, reorienting care models to address both clinical and social needs and respecting patient autonomy and informed decision-making.[35,62] They call for coordinated and comprehensive approaches incorporating multilevel strategies across policy, institution, and community, with broad foci including ensuring equitable and stable access to health insurance and evidence-based community-centered respectful and culturally appropriate

care, and strong social safety nets for pregnant individuals and families.[48] Efforts at all levels must employ antiracist and health equity-oriented approaches.[63,64]

Evaluating SMM using intermediate etiologic or affected organ system grouping revealed important nuance while mitigating sample size limitations. Our findings demonstrating changes in disparity over time by SMM indicator categories, particularly where reductions are observed, are an important point from which further elucidation of pathways and intervention points may be possible. For example, analyses could explore potential causal pathways incorporating physiological and clinical care factors and social/structural determinants of health to identify precision intervention targets for prevention of specific SMM indicator categories. Future research also must focus on understanding the potential for multilevel approaches across the social to clinical continuum to reduce disparities in obstetric outcomes through the implementation and evaluation of policy change, social interventions, and quality improvement initiatives.[48]

Our large administrative dataset incorporated most California births from 1997 to 2017, allowing for generalizable results and robust exploration of prevalence and disparities of a rare event over time. Data limitations include potential misclassification due to reliance on billing codes for diagnosis and procedures defining SMM that may have caused under-reporting and potential changes in the quality of SMM documentation over time, which may have contributed to observed rates. Administrative data in general limits precise evaluation of behavioral risk factors, care processes, and structural factors such as housing, insurance, and care access. The current analysis sought to describe but not explain SMM prevalence, prevalence trends, racial and ethnic disparities, and racial and ethnic disparity trend; thus, we excluded other covariates. This allowed us to characterize the experience of SMM by type among the racial and ethnic groups included; however, identifying the causes of these findings must be done subsequently. Second, our classification of maternal race and ethnicity as proxy for exposure to racism is limited by the broad federal standards operationalized in linked birth certificate data, which combine heterogenous population groups (e.g., broad race groups and prioritization of Hispanic ethnicity) and small sample sizes for certain groups, which necessitated collapsing (e.g., Asian and Pacific Islander) or exclusion (i.e., American Indian and Alaska Native, other, and unknown) yet is self-reported and validated.[65] This is a limited operationalization of the multilevel social exposures that race and ethnicity represent, which obscures between-group variation and intersection of multiple minoritized identities, preventing further critical exploration of the varied mechanisms through which racism impacts maternal health.

We employed a validated SMM index developed by the CDC for population-level SMM assessment.[30] Our study dates span the ICD-9 to ICD-10 transition, which has not influenced overall SMM incidence in national or California data, but which did influence certain SMM indicators nationally.[4] Our study limited our assessment of SMM during the childbirth hospitalization; this time period is when most but not all SMM occurs, and a similar analysis of SMM occurring in the postpartum period would provide a more comprehensive picture. Finally, while 1 in 8 births nationally occur in California, these findings may not be generalizable to other states.

Our research further supports the critical need to better understand underlying causes of SMM, changes in SMM over time, and SMM disparities as a significant public health priority in the United States and suggests that grouping SMM by affected organ system may improve the utility of population-level SMM surveillance.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key Points

- By SMM subgroup, trends and racial and ethnic disparities varied yet Black individuals consistently had highest rates.
- Hemorrhage, renal, respiratory, and sepsis SMM significantly increased over time.
- Disparities increased for respiratory SMM among Black, U.S.-born Hispanic and non-U.S.-born Hispanic individuals and for sepsis SMM among Asian or Pacific Islander individuals.

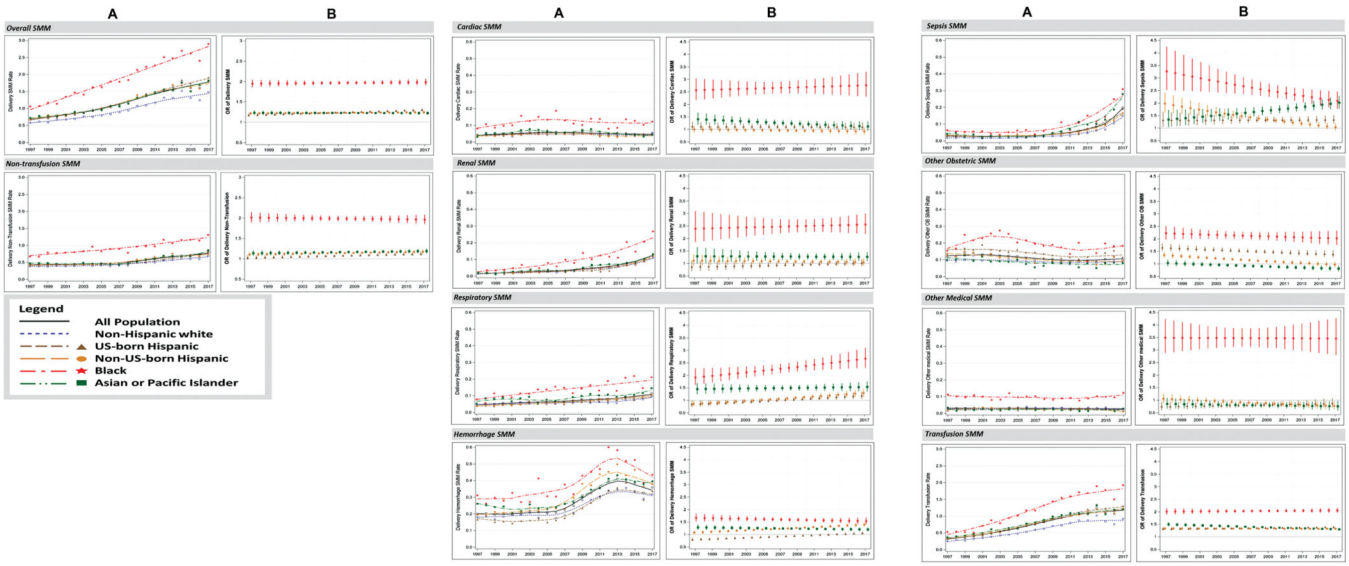

Fig. 1.

(A) Trend in severe maternal morbidity (SMM) prevalence: smooth curve from Loess regression overlaid on a scatter plot. Trend in prevalence was statistically significant for all racial and ethnic categories for overall SMM, non-transfusion SMM, renal SMM, respiratory SMM, hemorrhage SMM, sepsis SMM and other obstetric SMM. Trend in prevalence was statistically significant for all population and foreign-born Hispanic individuals for other medical SMM. (B) Racial and ethnic disparities: Odds ratio of SMM among racial and ethnic group of interest compared to non-Hispanic white. These results are from models that included main effects for race and ethnicity category and year, and their interaction. Vertical lines represent 95% confidence intervals. Trend in SMM prevalence was statistically significantly different from the non-Hispanic white trend for the following categories: overall SMM (US-born Hispanic), non-transfusion SMM (US-born Hispanic), respiratory SMM (US-born Hispanic, non-US-born Hispanic, Black), hemorrhage SMM (US-born Hispanic, non-US-born Hispanic), sepsis SMM (non-US-born Hispanic, Black, Asian or Pacific Islander), other obstetric SMM (US-born Hispanic, non-US-born Hispanic, Asian or Pacific Islander), and transfusion SMM (Asian or Pacific Islander). SMM indicator category composition is presented in ►Table 1.

Table 1

Categorization strategy for severe maternal morbidity indicators

SMM indicator category	SMM indicators
Cardiac SMM	Acute heart failure, acute myocardial infarction, aneurysm, cardiac arrest/ventricular fibrillation, cardiac arrest/ventricular fibrillation, conversion of cardiac rhythm, heart failure/arrest during surgery or procedure
Renal SMM	Acute renal failure
Respiratory SMM	Adult respiratory distress syndrome, pulmonary edema, temporary tracheostomy, ventilation
Hemorrhage SMM	Disseminated intravascular coagulation, shock, hysterectomy
Sepsis SMM	Sepsis
Other Obstetric SMM	Air and thrombotic embolism, amniotic fluid embolism, eclampsia, severe anesthesia complications
Other Medical SMM	Puerperal cerebrovascular disorders, sickle cell disease with crisis
Transfusion SMM	Blood products transfusion

Abbreviations: ICD, International Classification of Diseases; SMM, severe maternal morbidity.

Note: Corresponding ICD-9 and ICD-10 CM codes are presented in ►Supplementary Table S1 (available in the online version).

Table 2

Prevalence and disparity in severe maternal morbidity during childbirth hospitalization by race and ethnicity, overall and for severe maternal morbidity indicator categories, California, 1997 to 2017

SMM indicator category[a]	Total[c] *N* = 10,580,096	White *N* = 3,070,249 (29.0%)	Non-U.S.-born Hispanic *N* = 3,011,323 (28.5%)		U.S.-born Hispanic *N* = 2,305,239 (21.8%)		Asian and PI *N* = 1,375,344 (13.0%)		Black *N* = 61 5,438 (5.8%)	
	PR	PR	PR	OR (95% CI)	PR	OR[b] (95% CI)	PR	OR (95% CI)	PR	OR (95% CI)
SMM overall	116.1	93.9	111.8	1.19 (1.17–1.21)	126.2	1.35 (1.33–1.37)	121.3	1.29 (1.27–1.32)	183.6	1.97 (1.93–2.02)
Nontransfusion SMM	53.7	46.4	51.9	1.12 (1.09–1.14)	52.5	1.13 (1.10–1.16)	55.9	1.21 (1.17–1.24)	91.9	1.99 (1.93–2.05)
Hemorrhage SMM	27.2	23.8	28.9	1.21 (1.17–1.24)	24.0	1.01 (0.97–1.04)	30.7	1.29 (1.24–1.34)	38.1	1.60 (1.53–1.68)
Cardiac SMM	5.1	4.5	4.5	0.96 (0.89–1.04)	4.9	1.11 (1.03–1.20)	5.6	1.25 (1.14–1.37)	11.8	2.66 (2.43–2.91)
Renal SMM	4.5	3.7	4.3	1.00 (0.92–1.09)	4.1	1.11 (1.02–1.21)	5.2	1.40 (1.28–1.54)	9.3	2.50 (2.27–2.77)
Respiratory SMM	7.0	5.9	6.1	1.04 (0.98–1.11)	6.4	1.08 (1.01–1.16)	9.0	1.54 (1.43–1.66)	13.5	2.30 (2.12–2.49)
Sepsis SMM	5.2	3.6	4.4	1.23 (1.14–1.34)	5.6	1.55 (1.43–1.67)	7.3	2.02 (1.85–2.20)	8.8	2.44 (2.20–2.71)
Other OB SMM	11.2	9.2	10.9	1.18 (1.13–1.25)	13.7	1.49 (1.42–1.57)	8.3	0.90 (0.84–0.97)	19.6	2.13 (1.99–2.28)
Other Med SMM	3.0	2.8	2.6	0.93 (0.84–1.02)	2.3	0.81 (0.73–0.91)	2.2	0.80 (0.70–0.91)	9.7	3.48 (3.13–3.86)

Abbreviations: CDC, Centers for Disease Control and Prevention; CI, confidence interval; Med, medical; OB, obstetric; OR, odds ratio; PI, Pacific Islander; PR, prevalence per 10,000 births; SMM, severe maternal morbidity.

[a] SMM defined by CDC index. Nontransfusion SMM refers to cases who had some indicator other than transfusion.

[b] OR represents the association between individuals of each racial and ethnicity group compared with White individuals.

[c] American Indian and Alaska Native and other race and ethnicity included.

Table 3

Prevalence of severe maternal morbidity during childbirth hospitalization by race and ethnicity, overall and for severe maternal morbidity indicator categories, California, in 1997 and 2017 and percent change from 1997 to 2017

SMM indicator category[a]	Year	SMM per 10,000 births					
		Total[b]	White	Non-U.S.-born Hispanic	U.S.-born Hispanic	Asian and Pacific Islander	Black
SMM overall	1997	67.2	58.0	66.8	67.4	71.8	105.8
	2017	182.0	147.6	177.5	190.6	182.2	289.6
	% Change	170.9	154.7	165.8	182.6	154.0	173.7
Nontransfusion SMM	1997	42.5	38.3	41.3	40.2	47.3	67.4
	2017	80.5	69.2	73.9	79.5	85.7	130.8
	% Change	89.4	80.9	78.9	97.6	81.2	93.9
Transfusion SMM	1997	31.8	25.0	31.4	33.5	36.9	52.9
	2017	120.7	91.6	122.9	129.9	119.5	192.5
	% Change	280.3	266.1	291.0	287.4	224.2	263.9
Hemorrhage SMM	1997	19.9	18.0	19.5	16.5	26.1	31.1
	2017	35.9	31.8	37.8	33.6	39.5	43.5
	% Change	80.5	76.2	94.0	104.3	51.4	39.7
Cardiac SMM	1997	3.9	3.3	3.5	4.6	3.1	8.1
	2017	5.3	5.6	4.0	4.6	4.3	12.2
	% Change	34.2	70.1	16.5	0.00	39.6	49.7
Renal SMM	1997	1.6	1.3	1.6	1.6	2.0	2.3
	2017	13.0	11.0	12.6	12.0	13.1	26.8
	% Change	717.2	747.7	688.4	657.9	553.9	1052.6
Respiratory SMM	1997	4.5	4.9	3.7	3.8	5.3	7.8
	2017	11.4	9.3	10.6	10.4	14.5	21.1
	% Change	152.3	90.8	185.7	174.8	173.6	169.1
Sepsis SMM	1997	3.1	1.8	3.4	3.0	4.2	6.4
	2017	19.8	15.0	16.6	19.1	27.9	30.9
	% Change	543.7	743.7	391.3	528.0	564.2	382.7
Other OB SMM	1997	11.7	9.4	12.6	13.8	9.9	15.4
	2017	10.0	8.5	9.3	11.4	8.0	18.3

SMM indicator category[a]	Year	SMM per 10,000 births					
		Total[b]	White	Non-U.S.-born Hispanic	U.S.-born Hispanic	Asian and Pacific Islander	Black
	% Change	−14.1	−10.1	−26.4	−17.3	−19.0	18.6
Other Med SMM	1997	3.0	2.7	2.2	1.7	3.3	11.3
	2017	2.7	1.8	1.0	2.6	2.8	12.2
	% Change	−9.4	−34.9	−52.1	54.4	−13.5	7.5

Abbreviations: CDC, Centers for Disease Control and Prevention; Med, medical; OB, obstetric; SMM, severe maternal morbidity.

[a] SMM defined by CDC index. Nontransfusion SMM refers to cases who had some indicator other than transfusion.

[b] American Indian and Alaska Native and other race/ethnicity included.