CA-PMSS

California Pregnancy Mortality Surveillance System

California Pregnancy-Related Deaths, 2008-2016

SEPTEMBER 2021

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Contents

Acknowledgments

This Surveillance Report was prepared by staff from the California Department of Public Health's (CDPH) Maternal, Child and Adolescent Health Division (MCAH), in collaboration with partners at the Public Health Institute and the California Maternal Quality Care Collaborative.

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The California Pregnancy Mortality Surveillance System (CA-PMSS) would not be possible without a volunteer review committee of experts. The CA-PMSS team is deeply grateful to the physicians, nurses, and other health professionals who volunteered generous time and expertise on the CA-PMSS Committee to review statewide deaths from complications of pregnancy or childbirth.

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Each death in this report represents a woman* whose life ended too soon. We sadly acknowledge the women who died during or after their pregnancies, the families who love and miss them, and the health professionals who cared for them. We honor their memories through work to improve the health and well-being of pregnant and postpartum women everywhere.

**Throughout this report, the terms "woman" or "she" or "her" are used in reference to a person who was pregnant, gave birth or had a pregnancy loss. We recognize not all people who become pregnant identify as women. We believe all persons deserve patient-centered care that helps them live authentic, healthy lives.*

Suggested citation: *CA-PMSS Surveillance Report: Pregnancy-Related Deaths in California, 2008-2016.* Sacramento: California Department of Public Health, Maternal, Child and Adolescent Health Division. 2021.

Executive Summary

Maternal mortality is a key indicator of population health. Deaths in pregnancy and postpartum should be rare events, and thus, routine surveillance of maternal mortality is an essential public health and vital statistics responsibility. The California Department of Public Health (CDPH) conducts surveillance of maternal mortality through vital statistics, as reported here through the California Pregnancy Mortality Surveillance System (CA-PMSS), and also conducts in-depth case reviews when warranted through the California Pregnancy-Associated Mortality Review (CA-PAMR) to gain increased insight into possible contributing factors and opportunities for prevention.

This surveillance report focuses on pregnancy-related mortality among California residents during the years 2008 through 2016. Data on pregnancy-related deaths were compiled through CA-PMSS, a statewide case review of deaths among California women who were pregnant within the prior year. The 2018 launch of CA-PMSS introduced an enhanced surveillance methodology for providing more timely and more accurate accounting of pregnancy-related deaths (i.e., those related to or aggravated by the pregnancy or its management) than can be achieved with death certificate data alone or linked vital records. In CA-PMSS, cases are identified by complex data linkage of vital records (i.e., death, birth and fetal death files) as well as administrative data (i.e., patient discharge, emergency department and ambulatory surgery center data). These data are then supplemented with coroner and autopsy reports and medical records to confirm pregnancy status, verify timing to death and augment case information. An expert review committee performs a limited case review and determines for each death the cause and relationship to pregnancy. CA-PMSS's rigorous methodology produces highly accurate information on pregnancy-related deaths, which is critical for public health surveillance.

This is the first in a series of surveillance reports from CA-PMSS that will provide timely updates on pregnancy-related mortality trends in California. From 2018 to 2020, CA-PMSS succeeded in reviewing nine years of maternal mortality data (for years 2008 through 2016) and is rapidly catching up to current data. CA-PMSS continues its surveillance efforts and plans to release additional data through 2020 by 2022 so that delay will soon be reduced to just two years.

Key Findings

Pregnancy-related deaths in California:

- In 2008-2016, 1,934 women died while pregnant or within one year of the end of a pregnancy; 31% (608) of these deaths were related to pregnancy or its management.
- California's annual pregnancy-related mortality ratios remained low and largely stable in 2008-2016, fluctuating between 9.5 and 14.9 deaths per 100,000 live births. One exception was a spike in pregnancy-related deaths caused by influenza A (H1N1) during the 2009 pandemic, which resulted in an elevated pregnancy-related mortality ratio of 17.1 in 2009.

By cause and timing to death:

- The top five leading causes of pregnancy-related deaths were cardiovascular disease (28%), sepsis or infection (17%), hemorrhage (15%), hypertensive disorders (13%) and thrombotic pulmonary embolism (7%).

- Eighteen percent (18%) of pregnancy-related deaths occurred while pregnant, and of the remaining 82% that occurred after pregnancy ended, nearly half (44%) of the deaths were within six days of childbirth (or end of pregnancy), 24% occurred 7-42 days after pregnancy ended and 14% were 43-365 days after pregnancy. Timing to death varied greatly depending on the cause of death.

By sociodemographic and place-based characteristics:

- Pregnancy-related mortality ratios were elevated for women with the following characteristics: older age (35 years or older), pre-pregnancy obesity (body mass index 30 or greater), public insurance (e.g., Medi-Cal) and no high school diploma.
- The pregnancy-related mortality ratio was highest for women living in the least advantaged communities (16.4 deaths per 100,000 live births), more than twice the mortality ratio for women living in the most advantaged communities (6.8).
- Pregnancy-related mortality ratios varied by geographic region, from 10.8 to 17.8 deaths per 100,000 live births; the Southern Central Valley region (includes Fresno, Kern, Kings, Madera, Mariposa, Merced, Stanislaus, Tulare and Tuolumne counties) had the highest pregnancy-related mortality ratio of 17.8.

By race/ethnicity:

- Racial/ethnic disparities in pregnancy-related mortality ratios widened between 2008 and 2016. From 2014-2016, the pregnancy-related mortality ratio for Black women was 56.2 deaths per 100,000 live births, four to six times greater than the mortality ratios for women of other racial/ethnic groups including White (9.4), Hispanic (11.0) and Asian/Pacific Islander (13.3).
- Black women were overrepresented among pregnancy-related deaths from all causes, especially deaths that occurred in pregnancy prior to birth or after delivery hospitalization (7-42 days and 43-365 days after pregnancy ended). Hispanic/Latina women were the least likely to die during pregnancy or the late post-pregnancy periods.

Pregnancy-associated deaths of interest:

- California suicide ratios remained relatively stable during 2008-2016, regardless of pregnancy status. Women who were pregnant in the year prior to death were significantly less likely to die by suicide than reproductive-age (15-49 years) women who were not pregnant within the prior year (2.6 per 100,000 live births vs. 5.1 per 100,000 population in 2008-2016).
- California homicide ratios remained relatively stable during 2008-2016, regardless of pregnancy status. Women who were pregnant in the year prior to death were significantly more likely to die by homicide than women aged 15-49 years who were not pregnant within the prior year (3.3 per 100,000 live births vs. 2.1 per 100,000 population in 2008-2016).

Limitations

- Deaths from suicide, homicide or accidents were not reviewed to determine relationship to pregnancy. Establishing relationship to pregnancy for deaths from violence or injury is complex and requires comprehensive record review by a specialized review committee, which is beyond the current scope of CA-PMSS's reviews.
- Quality improvement opportunities and preventability were not assessed, but have been assessed previously through a more in-depth case review process known as CA-PAMR.[1] However, CA-PMSS case reviews inform directions for targeted comprehensive case reviews, which assess preventability and quality improvement opportunities by identifying concerning trends in pregnancy-related mortality.

Strengths

- Improved case ascertainment methodology resulted in more complete identification of maternal deaths that occurred within one year of pregnancy and produced a more accurate account of California's pregnancy-related mortality than would have been seen with vital statistics linkages alone, including the discovery of wider racial/ethnic disparities.
- Many more deaths resulting from complications in early pregnancy (i.e., in the first 20 weeks of pregnancy) were identified through inclusion of administrative data than would have been identified using vital statistics data alone. Early pregnancy deaths are often overlooked in maternal mortality reviews when source data are limited to vital records.
- Pregnancy-related mortality was examined within the context of social determinants of health by incorporating the California Healthy Places Index[2], a validated measure of community well-being. California is among the first in the nation to include a validated measure of community conditions in the analysis of pregnancy-related mortality.

Conclusions

California's rate of pregnancy-related deaths has remained low compared with the U.S. rate and has been largely stable from 2008 to 2016, except for a spike in deaths during a novel influenza A (H1N1) pandemic in 2009. However, racial/ethnic disparities in pregnancy-related mortality ratios appear to be worsening, particularly among Black women when compared to women of other racial/ethnic groups. Black women were overrepresented among pregnancy-related deaths from all causes, especially deaths that occurred in pregnancy prior to birth or after delivery hospitalization. While California has made progress to reduce maternal mortality through investment in maternal health programs, strong leadership and

[1] *The California Pregnancy-Associated Mortality Review Report: Pregnancy-Associated Suicide, 2002-2012.* Sacramento: California Department of Public Health, Maternal, Child and Adolescent Health Division. 2019. cdph.ca.gov/PAMR

[2] California Healthy Places Index: www.healthyplacesindex.org

engagement of the maternity care community and targeted hospital quality improvement, more needs to be done to narrow racial/ethnic disparities.

Other characteristics that trended with higher pregnancy-related mortality ratios for all racial/ethnic groups, collectively, were older age, obesity, reliance on public insurance and living in less advantaged communities. Geographic variations in pregnancy-related mortality ratios were also noted. Altogether, these surveillance findings reveal a need for the thorough examination of how systems and community-level characteristics interplay with patient, provider and facility-level factors in contributing to pregnancy-related mortality and related disparities. Social determinants of health[3] are known to shape health, functioning and quality-of-life outcomes, and are likely contributing to disparities in maternal mortality. Holistic examination of factors underlying pregnancy-related mortality and related disparities at all levels, from individual to community, is needed to begin paving the way toward health equity.

[3] Healthy People 2020, Social Determinants of Health: https://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-of-health

Overview

California Pregnancy Mortality Surveillance System

CA-PMSS is a statewide case review of deaths among California women who were pregnant within the prior year. CDPH's Maternal, Child and Adolescent Health Division (MCAH) initiated CA-PMSS in 2018 to provide a timelier and more accurate accounting of deaths related to or aggravated by the pregnancy or its management than can be achieved with death certificate data alone or linked vital records. Data quality issues inherent in death certificate data stem from inaccuracies in the information reported about the decedent. The responsibility for providing complete and accurate information lies solely with the informant and certifier. Errors in pregnancy status, inaccurate timing to death and miscoded causes of death result in many misclassified maternal deaths, and consequently, under- or over-estimations of the true burden of pregnancy-related mortality. The goal of CA-PMSS is to monitor deaths related to pregnancy using the most accurate information available.

To identify all possible deaths that occurred while pregnant or within one year after pregnancy ended among California residents, CA-PMSS developed a hybrid enhanced surveillance methodology, based in part on the Centers for Disease Control and Prevention's Pregnancy Mortality Surveillance System (CDC-PMSS)[4] and in part on a Maternal Mortality Review Committee (MMRC) model for comprehensive case reviews, such as CA-PAMR[5] in California. Compared to CDC-PMSS, CA-PMSS has a more thorough process for identifying deaths (using additional source data) and reviewing them to determine the underlying cause and relationship to pregnancy (using a committee of experts). To optimize case ascertainment, CA-PMSS conducts complex data linkage of vital records (i.e., death, birth and fetal death files) and administrative data (i.e., patient discharge, emergency department and ambulatory surgery center data) to identify all probable deaths within a year of pregnancy, including deaths among women who were less than 20 weeks pregnant identified primarily using administrative data. (Early pregnancy deaths are often overlooked in maternal mortality reviews that rely on vital statistics data alone to identify maternal deaths.) Linked administrative data are then supplemented with coroner and autopsy reports and medical records to confirm pregnancy status, verify timing to death and augment case information. An expert committee reviews the case information and determines the cause of death and whether the death was related to pregnancy. (See Appendix for a more detailed description of this process.)

CA-PMSS is led by CDPH, funded by Title V and relies on a collaboration with three key partners: The Public Health Institute, Stanford University's California Maternal Quality Care Collaborative, and a volunteer review committee of experts.

[4] CDC-PMSS: https://www.cdc.gov/reproductivehealth/maternal-mortality/pregnancy-mortality-surveillance-system.htm

[5] CA-PAMR: www.cdph.ca.gov/PAMR

CA-PMSS aims to:

- identify the cause of and timing to death;
- determine if the death was related to pregnancy;
- serve as an efficient method for enhanced maternal mortality surveillance, particularly for states with large numbers of births and deaths; and
- inform directions for targeted in-depth case reviews of cause-specific deaths through the CA-PAMR process.

Key Terms

The following terms are used throughout this report:

"Pregnancy-associated death" is a death from any cause while pregnant or within one year of the end of a pregnancy regardless of the outcome, duration or site of the pregnancy.

"Pregnancy-related death" is a death while pregnant or within one year of the end of pregnancy – regardless of the outcome, duration or site of the pregnancy – from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.

Background

It is critical to understand how maternal mortality has been studied historically, how the CDC and the CDPH have improved upon these historical efforts, and how current measures are defined.

Historical Measures of Maternal Mortality

Maternal mortality has historically been used as a key indicator of the health of a population. In the United States, the National Vital Statistics System (NVSS) at the CDC's National Center for Health Statistics (NCHS)[6] maintains mortality statistics, including maternal mortality ratios, that are used within the United States and internationally. NVSS identifies maternal deaths using information reported on the women's death certificates and assigns cause-of-death codes based on the International Classification of Disease Coding Manual, 10th revision (ICD-10).

The World Health Organization[7] defines maternal deaths as "the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes." Deaths resulting from accidents, homicide or suicide are excluded. This definition of a maternal death also excludes deaths from complications of pregnancy or childbirth that occurred 43 days to one year following the end of pregnancy (also known as "late maternal deaths"). This definition of a maternal death is used in the construction of the maternal mortality ratio (i.e., maternal deaths per 100,000 live births), which is the most widely recognized measure of maternal mortality. The maternal

[6] National Center of Health Statistics: www.cdc.gov/nchs/maternal-mortality
[7] World Health Organization: https://www.who.int/healthinfo/statistics/indmaternalmortality/en/

mortality ratio is useful for crude comparisons, but this measure does not accurately capture maternal deaths.[8]

Federal Maternal Mortality Surveillance

Decades ago, the CDC recognized that more clinical information is critical to bridge gaps in the death certificate data concerning the pregnancy status, timing to death and the causes of death. In 1986, the CDC's Division of Reproductive Health (DRH) established CDC-PMSS to capture deaths from causes related to pregnancy more accurately at the national level through (1) record linkage of maternal death data with birth/fetal death records and (2) a review of the deaths by medically trained epidemiologists to determine the cause of death and whether the death was pregnancy-related. The CDC-PMSS definition of maternal deaths also expanded the time frame to include late deaths – i.e., those from 43 days to one year following the end of pregnancy.

CDC-PMSS relies on vital statistics records as the primary source of information and is routinely confronted with inconsistencies in data quality, specifically missing or inaccurate information about the pregnancy status, timing to death and the cause of death.[9,10] Under California law, the responsibility for providing complete and accurate information lies with the informant and certifier. The data quality on the death certificate may be affected by inherent limitations in the process of collecting death information from the informant and certifier. For example, a decedent's pregnancy status will be reported if and only if the certifier is aware or learns that the decedent was pregnant at the time of death or within the prior year. However, the certifier is not always informed that the decedent was pregnant, and so the pregnancy status may be reported incorrectly.

The pregnancy status question on the California death certificate does not currently align with the national standard, and this inconsistency has contributed to undercounts of maternal deaths. CDPH is set to release an updated version of the Electronic Death Registration System (EDRS) in 2021, which will bring the pregnancy status question on the California death certificate into alignment with the national standard and will include technical enhancements, such as smart data entry options and drop down menus, to improve accuracy during data entry. Because of the challenges nationwide with tracking pregnancy-related deaths using vital statistics data alone, the CDC began working with state and local MMRCs to strengthen and standardize case identification and review. An MMRC, such as CA-PMSS and CA-PAMR in California, has access to multiple sources of data (e.g., hospital discharge data, coroner/autopsy reports, medical records) to verify pregnancy status and timing to death, and provide more detailed information about each death

[8] Rossen LM, Womack LS, Hoyert DL, Anderson RN, Uddin SFG. The impact of the pregnancy checkbox and misclassification on maternal mortality trends in the United States, 1999–2017. National Center for Health Statistics. Vital Health Stat 3(44). 2020.

[9] Petersen EE, Davis NL, Goodman D, Cox S, Mayes N, Johnston E, Syverson C, Seed K, Shapiro-Mendoza CK, Callaghan WM, Barfield W. Vital Signs: Pregnancy-Related Deaths, United States, 2011–2015, and Strategies for Prevention, 13 States, 2013–2017. *MMWR Morb Mortal Wkly Rep* 2019; 68:423–429.

[10] MacDorman MF, Declercq E. The failure of United States maternal mortality reporting and its impact on women's lives. *Birth*. 2018;45(2):105-108. doi:10.1111/birt.12333

(e.g., sequence of events, circumstances) with an aim to develop actionable recommendations for preventing future maternal deaths.

State Maternal Mortality Surveillance

At the state level, CDPH mirrors the federal systems (i.e., CDC's NCHS and DRH) for collecting information on the number of maternal deaths and characteristics of women who died from complications of pregnancy or its management. Like CDC's DRH, CDPH's MCAH Division conducts surveillance and epidemiologic analyses of all deaths to women while pregnant or within a year of pregnancy via CA-PMSS[11] and CA-PAMR[12] to produce an accurate accounting of maternal deaths and to gain increased insight into possible contributing factors and opportunities for prevention.

As described earlier, CA-PMSS is a statewide surveillance of pregnancy-related mortality that uses a committee to determine relationship to pregnancy and cause of death. CA-PAMR conducts comprehensive case reviews, using more detailed source data than CA-PMSS, and seeks to identify quality improvement opportunities, determine preventability and generate actionable recommendations for preventing maternal deaths. Both CA-PMSS and CA-PAMR utilize multiple data sources for case identification and rely on expert review committees to establish causes of death and relationship to pregnancy. However, compared with CA-PAMR, CA-PMSS's review committee is smaller, with a narrower scope of expertise and a charge to examine just enough information to determine the cause of death and relationship to pregnancy. The trade-off when doing rapid but limited case reviews is yielding timely, highly accurate maternal mortality surveillance data, but lacking the wealth of quality-improvement-related data obtained via CA-PAMR.

[11] CA-PMSS: www.cdph.ca.gov/PMSS
[12] CA-PAMR: www.cdph.ca.gov/PAMR

Measures of Maternal Mortality

The table below defines and contrasts the most widely used measures of maternal mortality within public health surveillance systems.

Measure:	Maternal Mortality Ratio (MMR) *Deaths per 100,000 live births*	Pregnancy-Related Mortality Ratio (PRMR) *Deaths per 100,000 live births*
Time frame:	Pregnancy up to 42 days after the end of pregnancy	Pregnancy up to 365 days (1 year) after the end of pregnancy
Defined by:	ICD-10 codes for obstetric deaths: A34, O00-O95, O98-O99 "O" code exclusions: O96, O97	Any deaths deemed to be pregnancy-related by expert review committee after review of selected cases
Data source:	Death certificate data	Vital statistics files (birth, death, fetal death certificate data), patient discharge data, emergency department data, ambulatory surgery center data, medical records, coroner/autopsy reports, obituaries, LexisNexis queries
Limitations:	Limited verification of maternal deaths (no pregnancy testing, no medical record review), reliance on death certifier to accurately report pregnancy status and timing Less accurate data as only deaths in pregnancy up to 42 days after pregnancy ended are captured Single source of data, unreliable data quality (miscoded or missed maternal deaths) can result in undercounts or overcounts of deaths	Can be time consuming, may not be available for all jurisdictions Methods may differ across jurisdictions given varying capacity and/or experience with multidisciplinary review committees
Strengths:	Readily available, standard death certificate, feasible in all jurisdictions making comparison of data easier	Includes late maternal deaths (43-365 days after pregnancy ended), captures information from a wide range of data sources resulting in more accurate surveillance of maternal deaths

Case Review Flow Diagram

This flow diagram summarizes the case selection details and final committee determinations for the present review of cases from 2008-2016. (See Appendix for more details.)

Pregnancy-associated deaths, 2008-2016 (N = 1,934)

Data sources: Vital statistics files (birth, death, fetal death); administrative data files (patient discharge, emergency department, ambulatory surgery center). Pregnancy status and timing verified with coroner/autopsy reports and medical records as needed.

Deaths excluded from CA-PMSS committee review (n = 1,182)

In consultation with CDC-PMSS leadership and based on prior in-depth case reviews via CA-PAMR, CA-PMSS applies case selection criteria to review deaths that are most likely to be related to the pregnancy or its management. Like CDC-PMSS, CA-PMSS excludes deaths from unintentional injury (including drug overdose), suicide and homicide. The following are not reviewed:

Unintentional injury deaths (e.g., poisoning, motor vehicle crash, drowning, fall)

EXCEPTIONS: (1) Deaths resulting from surgical error in obstetric care are reviewed as they are related to pregnancy management. (2) Deaths from drug overdose with cardiovascular disease present are reviewed due to physiologic effects of pregnancy on cardiovascular health.

Suicides (intentional injury deaths including drug overdose)

Homicides

Cancer deaths

Prior reviews via CA-PAMR showed that very few cancer deaths within one year of pregnancy were related to the pregnancy, unless cancer origin or progression was clearly attributed to hormonal or other physiologic changes of pregnancy.

EXCEPTION: Deaths from gestational trophoblastic disease (e.g., choriocarcinoma) are reviewed due to their relationship to pregnancy.

Non-obstetric medical deaths more than 90 days of the pregnancy ending

A vast majority of pregnancy-related deaths occurs within 90 days of the pregnancy ending, with some exceptions as noted. This cut-point was set in consultation with CDC-PMSS leadership and based on findings from CA-PAMR.

EXCEPTIONS: (1) Deaths from medical causes with any mention of pregnancy are reviewed regardless of timing. (2) Cardiovascular deaths are reviewed regardless of timing due to lasting physiologic effects of pregnancy on cardiovascular health.

Pregnancy-associated deaths for CA-PMSS committee review (n = 752)

Not pregnancy-related (n = 135)	Pregnancy-related (n = 608)	Unable to determine (n = 9)

Findings

This section describes pregnancy-related mortality among California residents during the years 2008 through 2016. Additionally, the trends in pregnancy-associated suicide and homicide are included at the end of this section. The data are presented graphically with the key findings noted below each figure. The figures found in this section are organized as follows:

Maternal mortality measures by source data (Death certificate vs. CA-PMSS)

- Figure 1: Maternal Mortality Ratio in the U.S. and California, 1999-2016
- Figure 2: Pregnancy-Related Mortality Ratio in California, 2008-2016

CA-PMSS: Causes and timing to death

- Figure 3: Pregnancy-Associated Deaths
- Figure 4: Pregnancy-Related Deaths by Cause
- Figure 5: Pregnancy-Related Mortality Ratio by Cause
- Figure 6a: Pregnancy-Related Deaths by Timing to Death
- Figure 6b: Pregnancy-Related Deaths by Cause and Timing to Death

CA-PMSS: Pregnancy-related mortality by maternal, sociodemographic and place-based characteristics

- Figure 7: Pregnancy-Related Mortality Ratio by Age
- Figure 8: Pregnancy-Related Mortality Ratio by Body Mass Index
- Figure 9: Pregnancy-Related Mortality Ratio by Education
- Figure 10: Pregnancy-Related Mortality Ratio by Payer Source
- Figure 11: Pregnancy-Related Mortality Ratio by Community Conditions
- Figure 12: Pregnancy-Related Mortality Ratio by Geographic Region

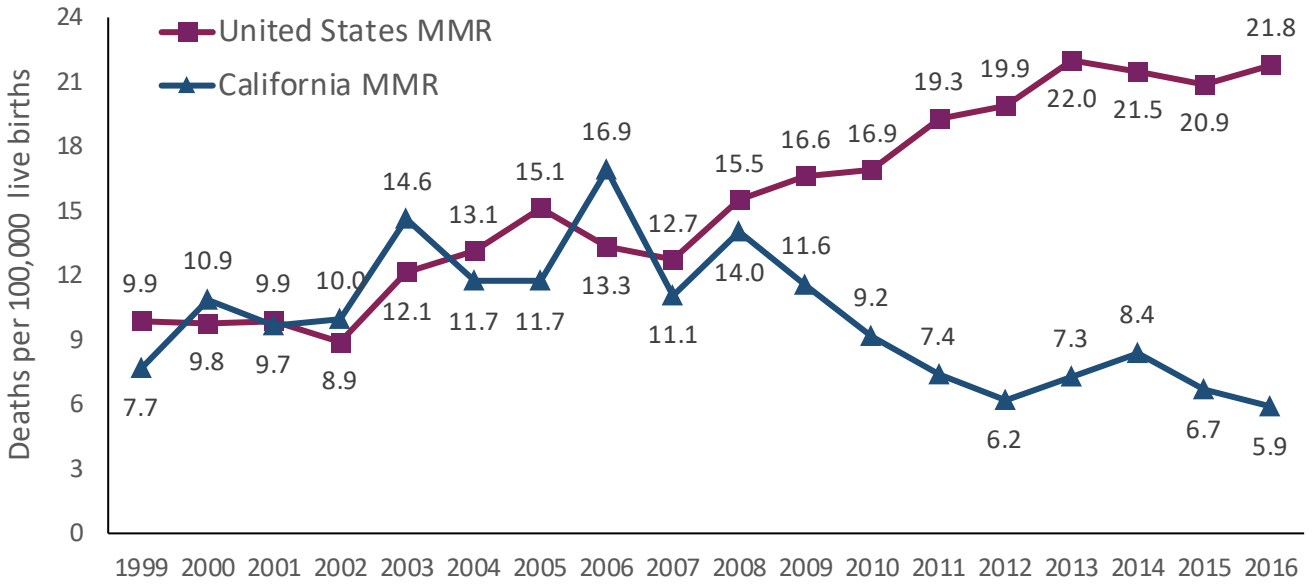
CA-PMSS: Racial/ethnic disparity in pregnancy-related mortality

- Figure 13a: Pregnancy-Related Mortality Ratio by Race/Ethnicity
- Figure 13b: Black-White Disparity in Pregnancy-Related Mortality Ratios
- Figure 14: Pregnancy-Related Deaths by Timing to Death and Race/Ethnicity

Pregnancy-associated deaths: Suicide and homicide

- Figure 15: Pregnancy-Associated Suicide
- Figure 16: Pregnancy-Associated Homicide

Figure 1: Maternal Mortality Ratio in U.S. and California, 1999-2016

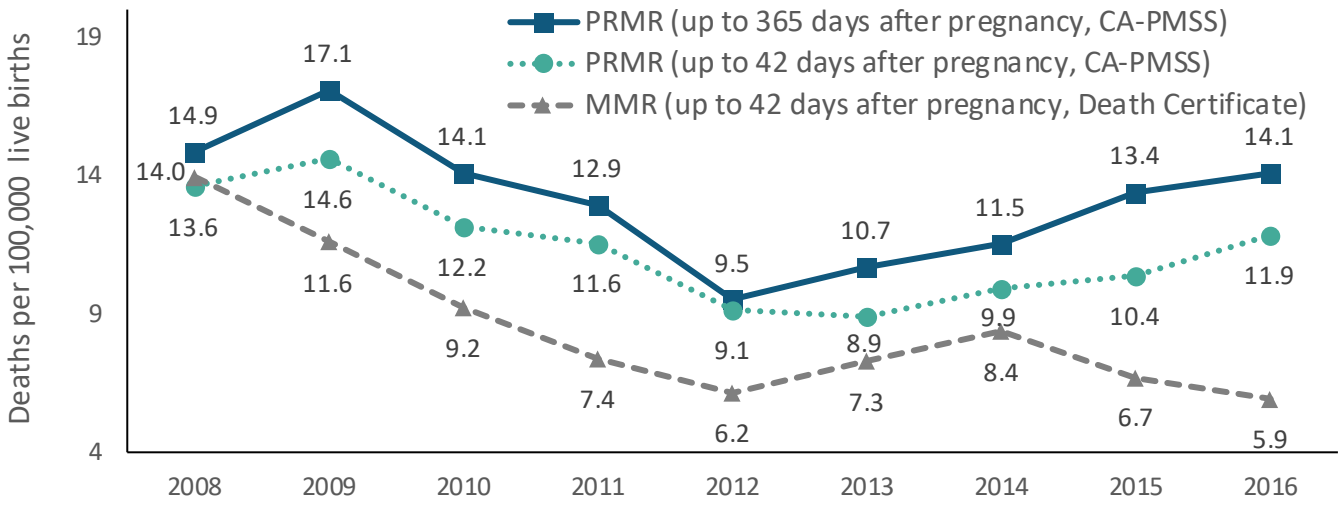


Key Findings

California's maternal mortality ratio (MMR) has steadily declined after peaking in 2006 while the national MMR has continued to rise. MMR, which is based on death certificate data alone, is a widely used indicator of maternal deaths and can be easily compared with other U.S. states or the national MMR. However, data quality issues inherent in death certificate data, such as missing or inaccurate information about the pregnancy status, timing to death or the cause of death, can result in underestimations or overestimations of the true burden of pregnancy-related mortality. California's MMR in 2012-2016 under-estimated the actual burden of maternal mortality by 15% to as much as 50% (see Figure 2).

Figure 1 notes: Maternal mortality ratio (MMR) = Number of maternal deaths per 100,000 live births, up to 42 days after the end of pregnancy. Maternal deaths in California were identified using ICD-10 cause of death classification for obstetric deaths (codes A34, O00-O95, O98-O99) from the California death certificate data (1999-2013) and the California pregnancy status errata file (2014-2016). Data on U.S. maternal deaths are published by the National Center for Health Statistics and found in the CDC WONDER Database for years 2008 or later (accessed at http://wonder.cdc.gov on February 25, 2020).

Figure 2: Pregnancy-Related Mortality Ratio in California, 2008-2016



Key Findings

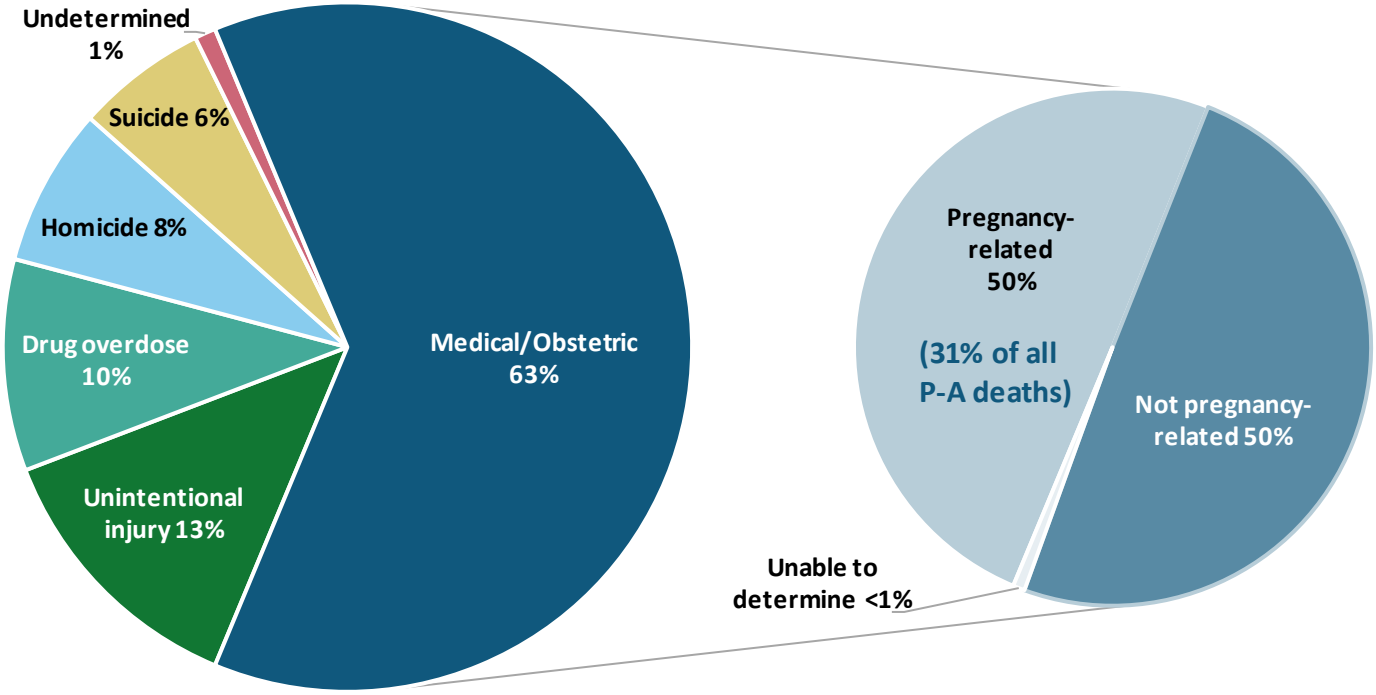
California's annual pregnancy-related mortality ratios (PRMRs) remained low and largely stable in 2008-2016, fluctuating between 9.5 and 14.9 deaths per 100,000 live births. One exception was a spike in pregnancy-related deaths caused by influenza A (H1N1) during the 2009 pandemic, which resulted in an elevated PRMR of 17.1 in 2009. The latest PRMR was 14.1 in 2016. For comparison, the MMR (dashed gray line) and PRMR up to 42 days after pregnancy ended (dotted teal line) are also shown in Figure 2. The latter measures exclude "late" maternal deaths (43 days and one year after pregnancy ended). The resulting lower mortality ratios indicate the scale of undercounted pregnancy-related mortality. In 2016, the MMR was 5.9 deaths per 100,000 live births and the PRMR up to 42 days after pregnancy was 11.9. By comparison, the PRMR up to a year after pregnancy was 14.1, more than double the MMR of 5.9. Maternal deaths are measured in several ways that differ in terms of (1) the time frame in which the deaths occurred (i.e., pregnancy up to one year vs. up to 42 days after pregnancy ended) and (2) the source data used to identify those deaths. While PRMR is a more accurate measure of maternal deaths (i.e., captures "late" deaths, expert committee determines cause and pregnancy-relatedness), methods for obtaining this measure vary across states, making direct comparisons with other states (and the U.S. as a whole) challenging.

Figure 2 notes: Pregnancy-related mortality ratio (PRMR) = Number of pregnancy-related deaths per 100,000 live births, up to one year after the end of pregnancy. Pregnancy-relatedness determinations were made through a structured expert committee case review process.

Maternal mortality ratio (MMR) = Number of obstetric deaths (up to 42 days after the end of pregnancy) per 100,000 live births, identified using ICD-10 cause of death classification for obstetric deaths (codes A34, O00-O95, O98-O99) from the California death certificate data (2008-2013) and California pregnancy status errata file (2014-2016).

† *The 2009 and 2012 PRMRs were significantly different (p<0.05); no statistically significant differences were detected for any other years.*

Figure 3: Pregnancy-Associated Deaths in California, 2008-2016 (N=1,934)

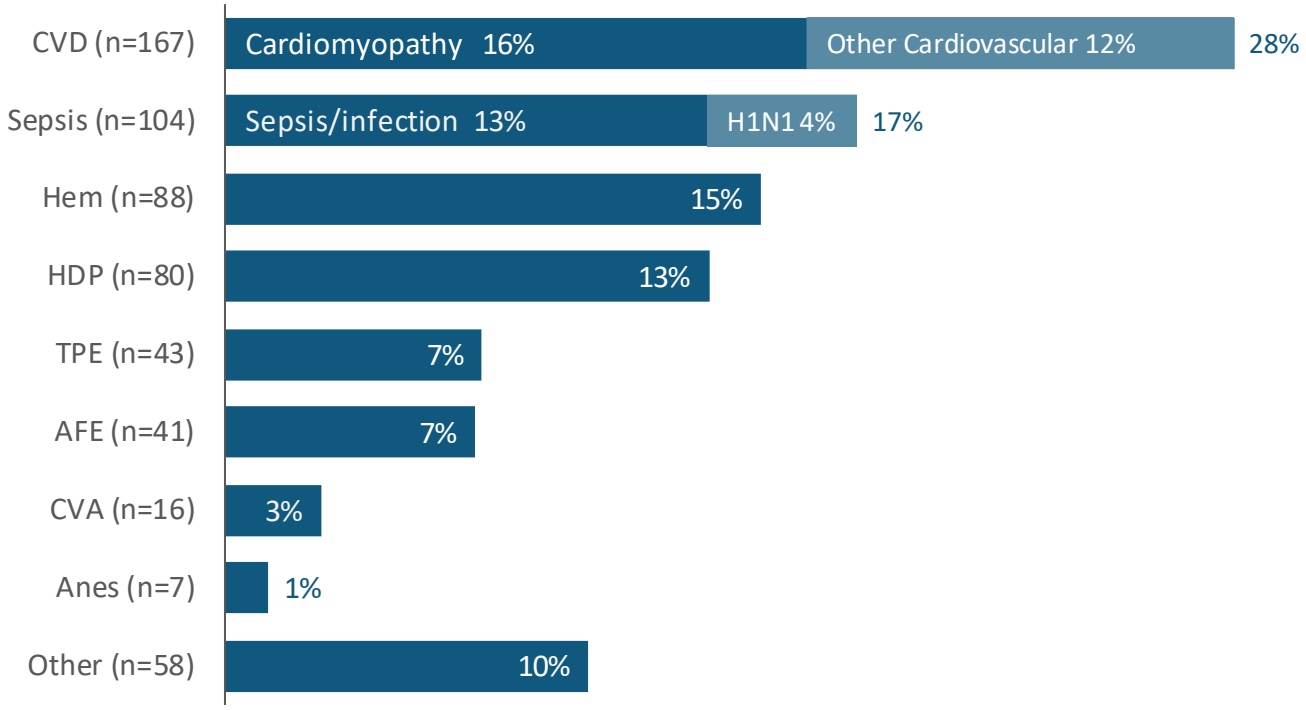


Key Findings

In 2008-2016, 1,934 deaths occurred during pregnancy or within one year after pregnancy ended among California women (i.e., pregnancy-associated deaths). Deaths from obstetric and other medical causes made up the largest proportion (63%) of pregnancy-associated deaths. After review, half (50%) of the deaths from medical/obstetric causes were deemed related to or aggravated by the pregnancy or its management and comprised nearly one-third (31%) of all pregnancy-associated deaths. However, not all pregnancy-related deaths were identified. Deaths from injury (i.e., suicide, homicide, drug overdose, other unintentional injury) were not reviewed in CA-PMSS because establishing a causal relationship to pregnancy is difficult and requires in-depth review. The rates of deaths from injury remained largely stable in 2008-2016 (data not shown). Trends in pregnancy-associated suicide and homicide are shown in Figures 15 and 16.

Figure 3 notes: Pregnancy-associated (P-A) deaths include deaths from any cause while pregnant or within one year of the end of pregnancy. P-A deaths were identified by linking the California vital records, patient discharge data, emergency department data, and ambulatory surgery center data (2008-2016). These linked data were supplemented with information from coroner and autopsy reports and medical records to verify the decedent's pregnancy status and grouped cause-of-death classifications from ICD-10 codes in the California death certificate data. Pregnancy-relatedness determinations were made through a structured expert committee case review process.

Figure 4: Pregnancy-Related Deaths by Cause, California 2008-2016 (N=608)

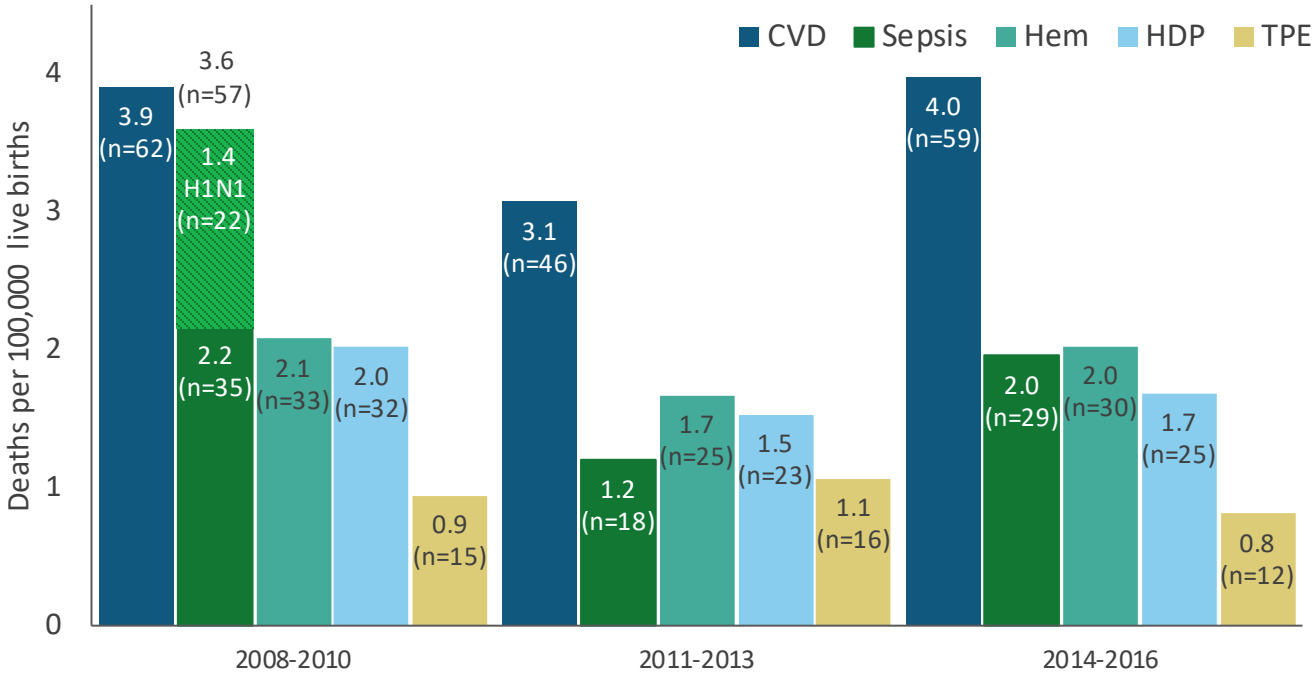


Key Findings

Cardiovascular disease (CVD) was the leading cause of pregnancy-related mortality among California women, accounting for 28% of deaths. Cardiomyopathy accounted for 16% of deaths, and 12% were due to other cardiovascular disease. Additional leading causes of pregnancy-related mortality were sepsis or infection (17%), hemorrhage (15%) and hypertensive disorders (13%). "Other" causes of death comprised a spectrum of underlying medical conditions including epilepsy, diabetes, liver diseases, respiratory conditions, lupus and other autoimmune conditions, among others.

Figure 4 notes: Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.
Abbreviations: CVD = Cardiovascular disease; Sepsis = Sepsis or infection; Hem = Hemorrhage; HDP = Hypertensive disorders of pregnancy; AFE = Amniotic fluid embolism; TPE = Thrombotic pulmonary embolism; CVA = Cerebrovascular accident; Anes = Anesthesia complications; Other = Other medical condition(s).
Note: Deaths with undetermined cause were excluded from analysis (n=4).

Figure 5: Pregnancy-Related Mortality Ratio by Cause, California 2008-2016



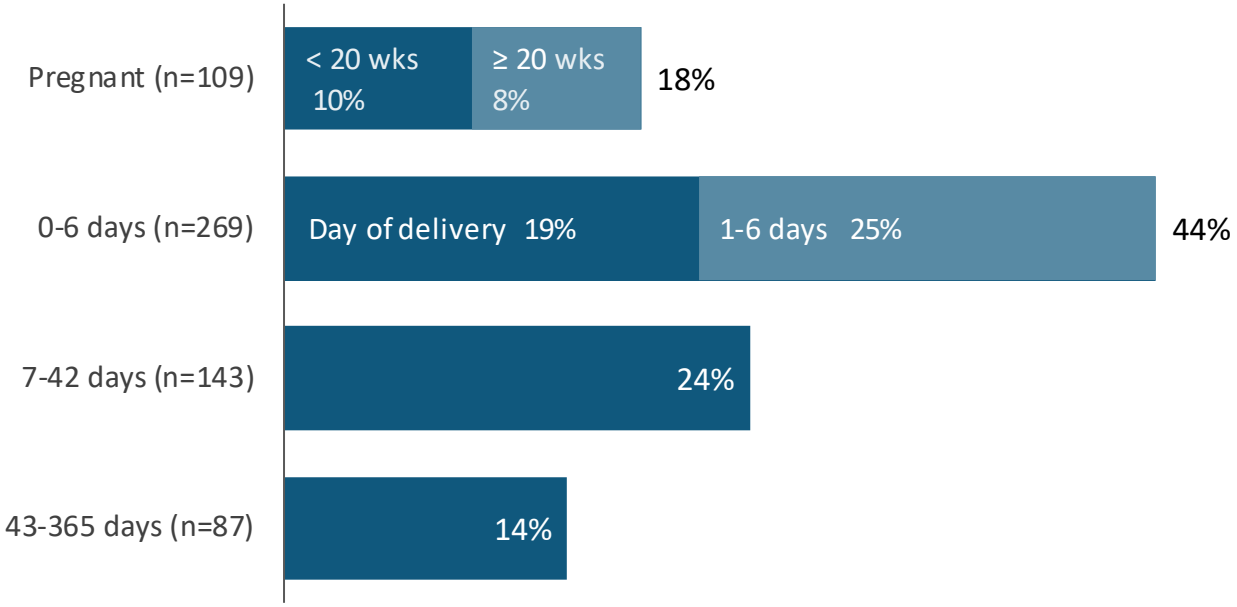
Key Findings

The pregnancy-related mortality ratios for the top five leading causes of pregnancy-related death – cardiovascular disease, sepsis/infection, hemorrhage, hypertensive disorders and thrombotic pulmonary embolism – remained largely stable in 2008-2016. The greatest change in mortality ratios occurred for deaths from sepsis or infection. Deaths from influenza A (H1N1) infection peaked during the 2009 pandemic, more than tripling the pregnancy-related mortality ratio from sepsis or infection in 2008-2010 compared with the mortality ratio of 1.0 in 2005-2007.[13]

Figure 5 notes: Pregnancy-related mortality ratio (PRMR) = Number of pregnancy-related deaths per 100,000 live births. Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.
Abbreviations: CVD = Cardiovascular disease; Sepsis = Sepsis or infection; Hem = Hemorrhage; HDP = Hypertensive disorders of pregnancy; TPE = Thrombotic pulmonary embolism. H1N1 = Novel influenza A virus subtype that emerged in 2009.
Note: Deaths not shown in figure were from amniotic fluid embolism (41), cerebrovascular accidents (16), anesthesia (7), other medical causes (58) and undetermined (4).

[13] The pregnancy-related mortality ratio for sepsis or infection was 1.0 per 100,000 live births in 2005-2007.
Source: *The California Pregnancy-Associated Mortality Review. Report from 2002-2007.*

Figure 6a: Pregnancy-Related Deaths by Timing to Death, California 2008-2016 (N=608)

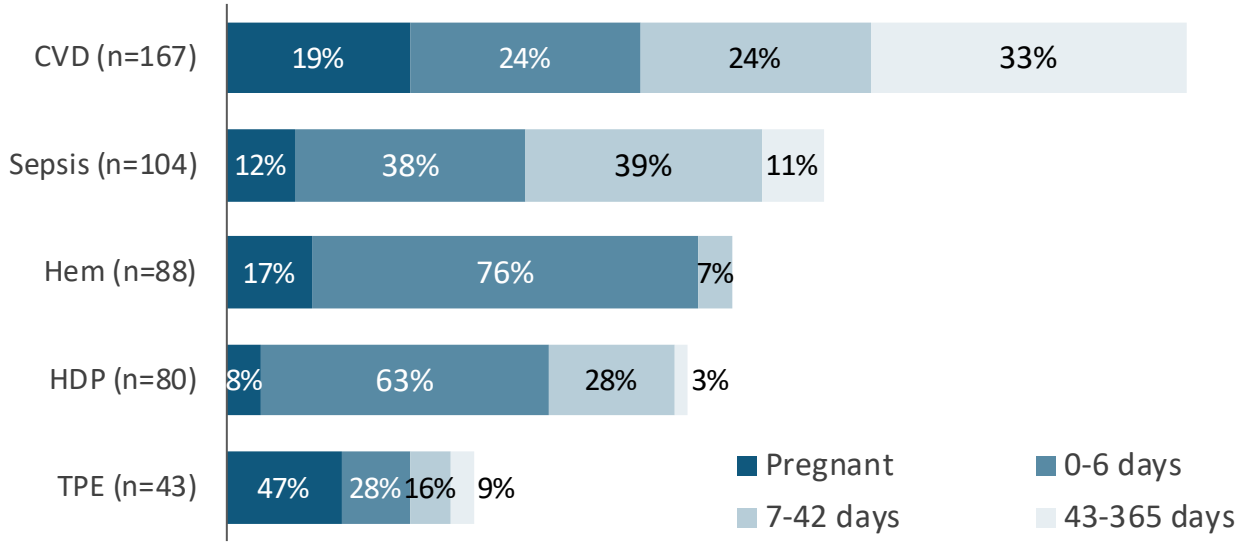


Key Findings

Eighteen percent (18%) of pregnancy-related deaths occurred while pregnant, and of the remaining 82% that occurred after pregnancy ended, nearly half (44%) of the deaths were within 6 days of childbirth (or end of pregnancy), 24% occurred 7-42 days after pregnancy ended, and 14% were 43-365 days after pregnancy ended. The causes of death were similar for deaths that occurred on the day of delivery (19% of all pregnancy-related deaths) and those that occurred 1-6 days after childbirth or end of pregnancy (25%); both time intervals captured delivery hospitalizations.

Figure 6A notes: Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.

Figure 6b: Pregnancy-Related Deaths by Cause and Timing to Death, California 2008-2016 (N=608)

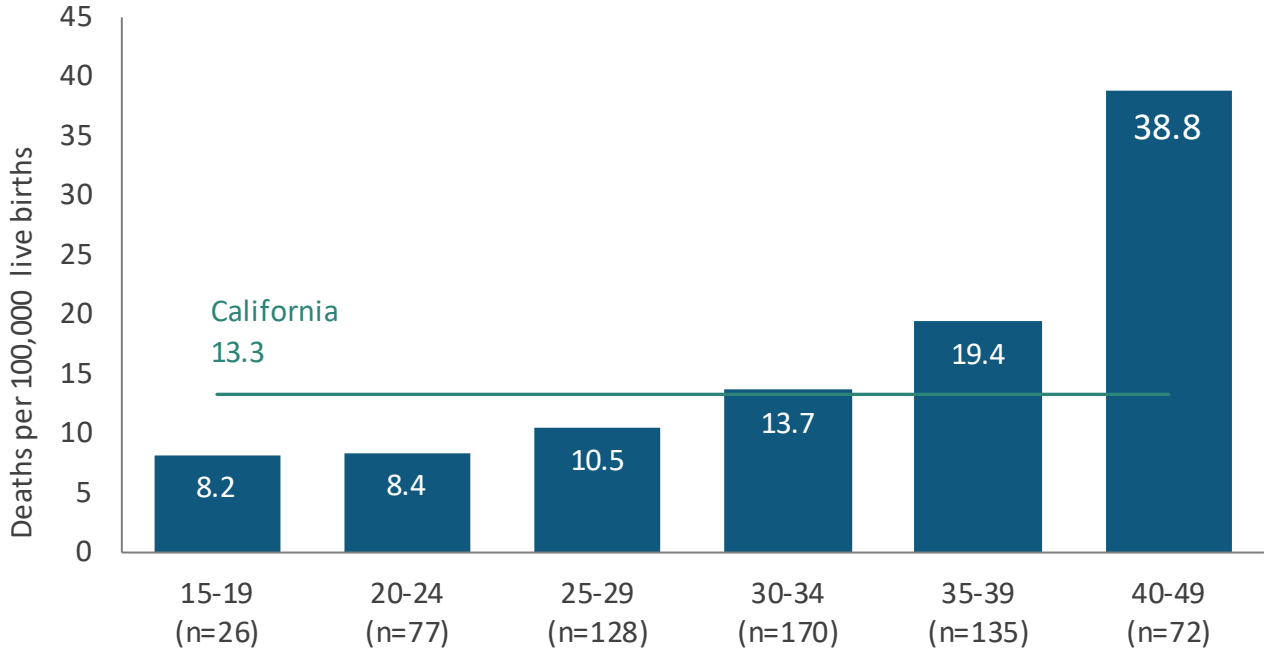


Key Findings

A vast majority of the leading causes of pregnancy-related deaths (from 67% to 100%, depending on the cause) occurred while pregnant or within 42 days following the end of pregnancy. Most deaths from hemorrhage (76%) and hypertensive disorders (HDP; 63%) occurred on the day of delivery or within one week after childbirth. Close to half (47%) of deaths from thrombotic pulmonary embolism (TPE) occurred while pregnant. Most deaths from TPE occurred in early pregnancy and among Black women (data not shown). Two-fifths (39%) of deaths from sepsis occurred 7-42 days after childbirth and another two-fifths (38%) within one week after pregnancy ended. Meanwhile, one-third (33%) of deaths from cardiovascular disease (CVD) occurred between 43 days and one year following the end of pregnancy. Late deaths from CVD were disproportionately higher among Black women, as were early postpartum deaths (0-42 days after pregnancy ended) from sepsis and HDP (data not shown).

Figure 6B notes: Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.
Abbreviations: CVD = Cardiovascular disease; Sepsis = Sepsis or infection; Hem = Hemorrhage; HDP = Hypertensive disorders of pregnancy; TPE = Thrombotic pulmonary embolism.
Note: Deaths not shown in the above figure were from amniotic fluid embolism (41), cerebrovascular accidents (16), anesthesia (7), other medical causes (58) and undetermined (4).

Figure 7: Pregnancy-Related Mortality Ratio by Age, California 2008-2016

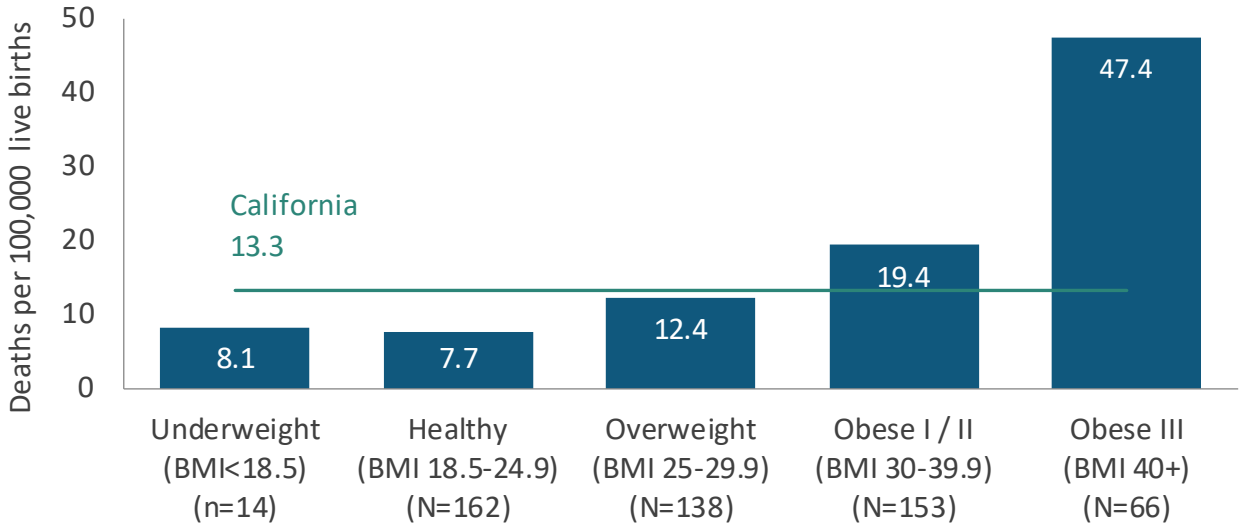


Key Findings

Pregnancy-related mortality ratios (PRMR) increased with age, from 8.2 deaths per 100,000 live births among women 15-19 years old to 38.8 among women 40-49 years old in 2008-2016. The PRMR for women aged 40-49 years (38.8) was significantly higher than the mortality ratios for all other age groups: 2.8 times the mortality ratio for women 30-34 years old (13.7) and 4.7 times the mortality ratio for women 15-19 years old (8.2). (The PRMRs for age groups 40-44 and 45-49 were similar. Ten women who died were 45-49 years old.) In 2008-2016, women 35 years or older comprised one-fifth (20%) of the California birthing population (data not shown) but accounted for one-third (34%) of pregnancy-related deaths. Overall, the maternal age distribution has been shifting toward older ages. Between 2011-2013 and 2014-2016, the proportion of women 35 years or older giving birth increased by 10%, while the proportion of women 25 years or younger declined by 15% (data not shown). Pregnancy at older age is associated with more comorbidities and a higher risk of pregnancy and labor complications including multiple gestation. Twin births were not noted in this pregnancy-related death cohort.

Figure 7 notes: Pregnancy-related mortality ratio (PRMR) = Number of pregnancy-related deaths per 100,000 live births. Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.

Figure 8: Pregnancy-Related Mortality Ratio by Body Mass Index, California 2008-2016

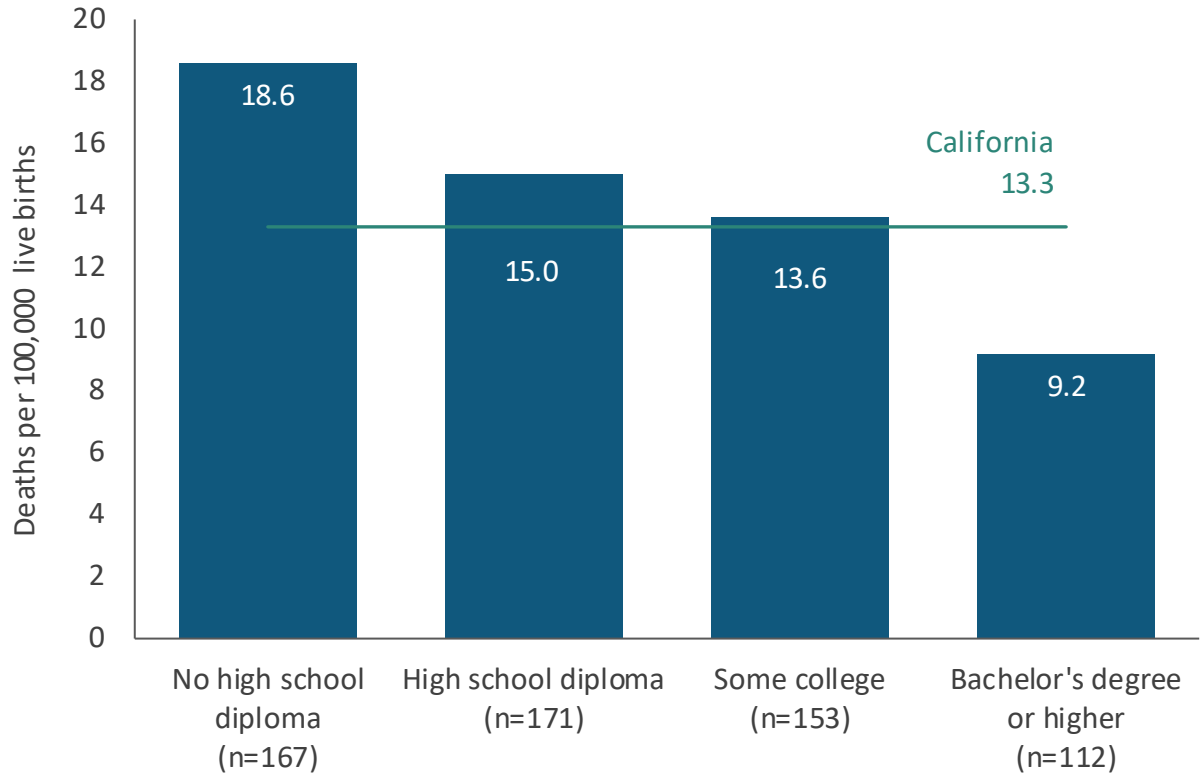


Key Findings

The pregnancy-related mortality ratio (PRMR) increased significantly with greater pre-pregnancy body mass index (BMI), from 7.7 deaths per 100,000 live births among women with a healthy weight (BMI 18.5-24.9) to 47.4 among women with high-risk obesity (BMI ≥40) in 2008-2016. The PRMR for women with high-risk obesity (47.4) was 2.4 times the mortality ratio for women with low-risk obesity (19.4), 3.8 times the mortality ratio for overweight women (12.4), and 6.2 times the mortality ratio for women whose weight was in the healthy range (7.7). In 2008-2016, women with high-risk obesity comprised 3% of California births (data not shown) but accounted for 12% of pregnancy-related deaths. The proportion of women with overweight and obese pre-pregnancy BMI has increased over time within the California birthing population. Between 2011-2013 and 2014-2016, the proportion of women with BMI in the healthy range declined by 3% while the proportions of women with low- and high-risk obesity increased by 7% and 10%, respectively (data not shown). Starting pregnancy at a healthy weight is important for reducing the risk of pregnancy and labor complications.

Figure 8 notes: Pregnancy-related mortality ratio (PRMR) = Number of pregnancy-related deaths per 100,000 live births. Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.
Body Mass Index (BMI) = A person's weight in kilograms divided by the square of height in meters. Obesity was classified into risk-level classes: Class I (BMI 30-34.9) = low-risk obesity, Class II (BMI 35-39.9) = moderate-risk obesity, and Class III (BMI ≥40) = high-risk obesity.
Note: BMI was unknown for 76 of the 608 women who died.

Figure 9: Pregnancy-Related Mortality Ratio by Education, California 2008-2016



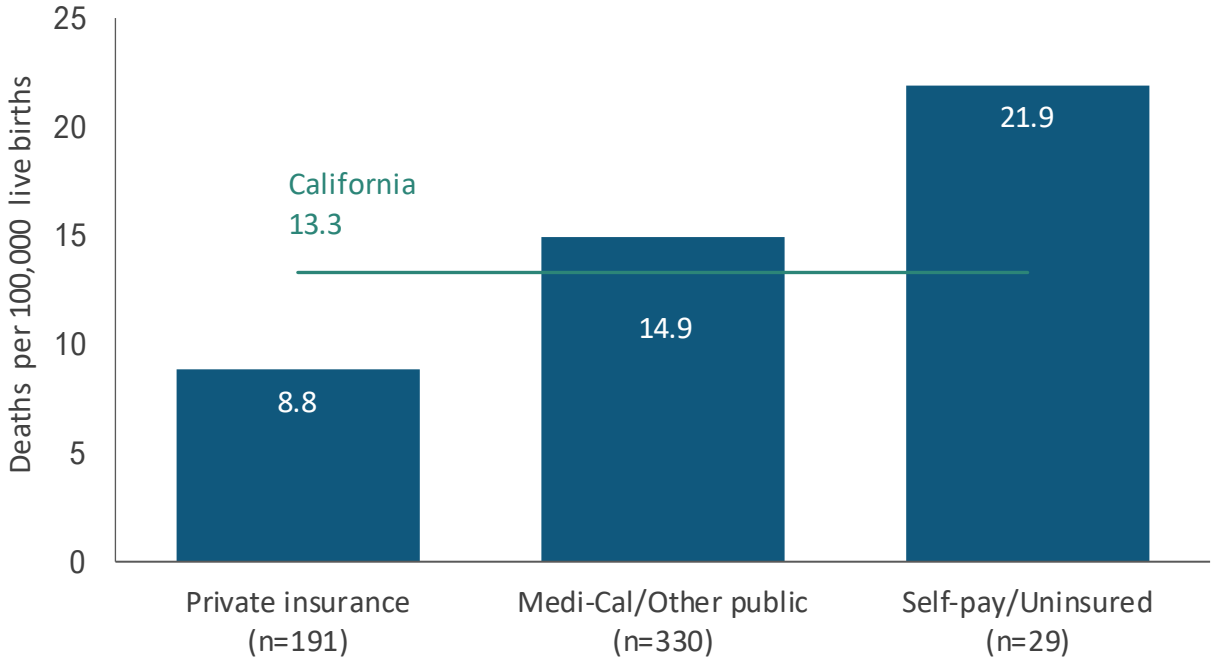
Key Findings

The pregnancy-related mortality ratio (PRMR) was the highest for women without high school diplomas (18.6 deaths per 100,000 live births), more than double the PRMR for women with bachelor's degrees or higher educational attainment (9.2) in 2008-2016. Women without high school diplomas (28%) were overrepresented and those with college degrees underrepresented (19%) among the pregnancy-related deaths compared to the California birthing population (21% and 28%, respectively) whose distribution of educational attainment remained stable in 2008-2016 (data not shown).

Figure 9 notes: Pregnancy-related mortality ratio (PRMR) = Number of pregnancy-related deaths per 100,000 live births. Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.

Note: Education attainment was unknown for 3 of the 608 women who died.

Figure 10: Pregnancy-Related Mortality Ratio by Payer Source, California 2008-2016

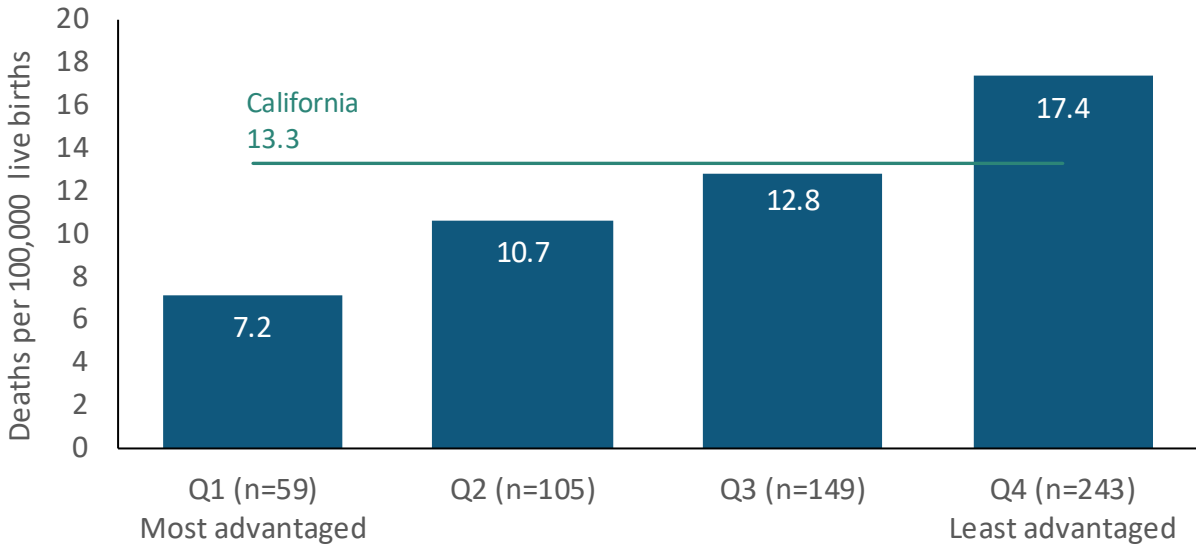


Key Findings

The pregnancy-related mortality ratio was lower for privately insured women (8.8 deaths per 100,000 live births) than for women with Medi-Cal coverage (14.9) and those with no health coverage (21.9) in 2008-2016. Among women who died of pregnancy-related causes, more than half (60%) had Medi-Cal coverage, one-third (35%) were privately insured, and 5% were uninsured. Meanwhile, within the California birthing population, 49% were covered by Medi-Cal, 48% had private insurance and 3% lacked health insurance in 2008-2016 (data not shown). There were no notable temporal changes in the proportion of women with Medi-Cal coverage who gave birth in 2008-2016.

Figure 10 notes: Pregnancy-related mortality ratio (PRMR) = Number of pregnancy-related deaths per 100,000 live births. Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.
Note: Payer source was unknown for 58 of the 608 women who died.

Figure 11: Pregnancy-Related Mortality Ratio by Community Conditions, California 2008-2016



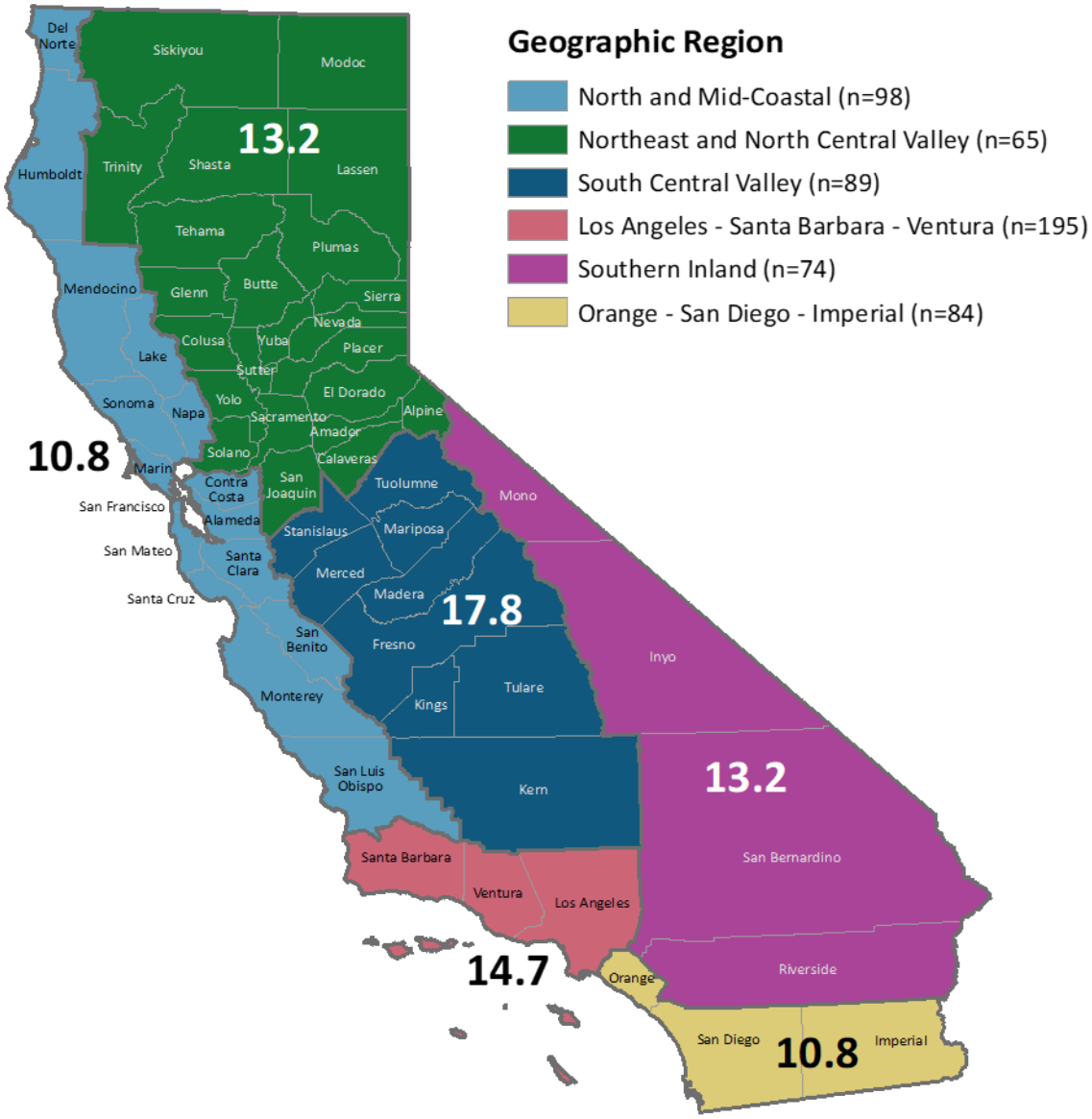
Key Findings

The pregnancy-related mortality ratio was the highest for women living in the least advantaged communities (17.4 deaths per 100,000 live births) and lowest for women living in the most advantaged communities (7.2), as measured by the California Healthy Places Index[14], a validated measure of community well-being derived from place-based factors linked to health. In 2008-2016, 42% of the women who died from pregnancy-related causes lived in the least advantaged communities (Q4 - lowest quartile). Only 10% of the women who died lived in the most advantaged communities (Q1 - highest quartile) in contrast to 19% of California's birthing population. Temporal changes in California births by community conditions were minor and varied based on race/ethnicity (data not shown).

Figure 11 notes: Pregnancy-related mortality ratio (PRMR) = Number of pregnancy-related deaths per 100,000 live births. Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.
Community conditions were measured using the California Healthy Places Index (HPI). Higher HPI percentiles indicate healthier community conditions relative to other California census tracts. Quartile 1 (Q1) is the highest quarter of percentiles indicating most advantaged community conditions, and Quartile 4 (Q4) is the lowest quarter of percentiles indicating the least advantaged community conditions.
Note: Community conditions were unknown for 52 of the 608 women who died.

[14] The California Healthy Places Index (healthyplacesindex.org) is a validated measure of community well-being, or social determinants of health, constructed from publicly available census-tract data on place-based factors linked to health (i.e., economic, education, transportation, social, neighborhood, housing, clean environment, and health care access).

Figure 12: Pregnancy-Related Mortality Ratio by Geographic Region, California 2008-2016



Key Findings

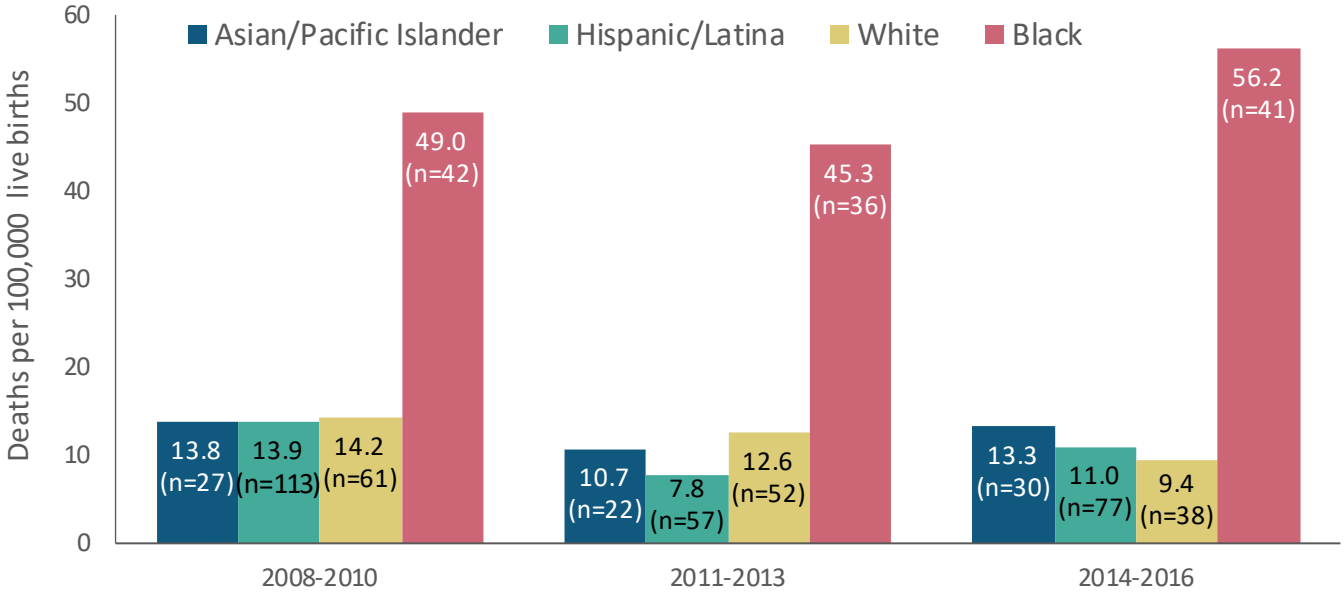
California geographic regions, as defined by the Regional Perinatal Programs of California (RPPC),[15] had varying rates of pregnancy-related deaths, ranging from 10.8 to 17.8 deaths per 100,000 live births in 2008-2016. The highest pregnancy-related mortality ratio was in the Southern Central Valley region (17.8 deaths per 100,000 live

[15] Regional Perinatal Programs of California provide region-specific educational opportunities and resources for health professionals and data-informed quality improvement strategies to positively impact the health of women and their families. www.cdph.ca.gov/RPPC

births), nearly double that of the North and Mid-Coastal and the Orange - San Diego - Imperial regions, both of which had the lowest mortality ratio (10.8). In 2008-2016, 1 in 9 births (11%) occurred in the Southern Central Valley region, a region with the highest rate of pregnancy-related deaths in the state. Each RPPC region consists of contiguous counties with similar provision of maternal and neonatal care, referral patterns of tertiary care, as well as geographic and socioeconomic characteristics and rates of pregnancy-related deaths.

Figure 12 notes: Pregnancy-related mortality ratio (PRMR) = Number of pregnancy-related deaths per 100,000 live births. Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.
Counties in each region:
North and Mid-Coastal Region: Alameda, Contra Costa, Del Norte, Humboldt, Lake, Marin, Mendocino, Monterey, Napa, San Benito, San Francisco, San Luis Obispo, San Mateo, Santa Clara, Santa Cruz, and Sonoma;
Northeastern and Northern Central Valley Region: Alpine, Amador, Butte, Calaveras, Colusa, El Dorado, Glenn, Lassen, Modoc, Nevada, Placer, Plumas, Sacramento, San Joaquin, Shasta, Sierra, Siskiyou, Solano, Sutter, Tehama, Trinity, Yolo, and Yuba;
Southern Central Valley Region: Fresno, Kern, Kings, Madera, Mariposa, Merced, Stanislaus, Tulare, and Tuolumne;
Los Angeles - Santa Barbara - Ventura Region; Los Angeles, Santa Barbara, and Ventura;
Southern Inland Region: Mono, Inyo, San Bernardino, and Riverside; and
Orange - San Diego – Imperial Region: Orange, San Diego, and Imperial.

Figure 13a: Pregnancy-Related Mortality Ratio by Race/Ethnicity, California 2008-2016



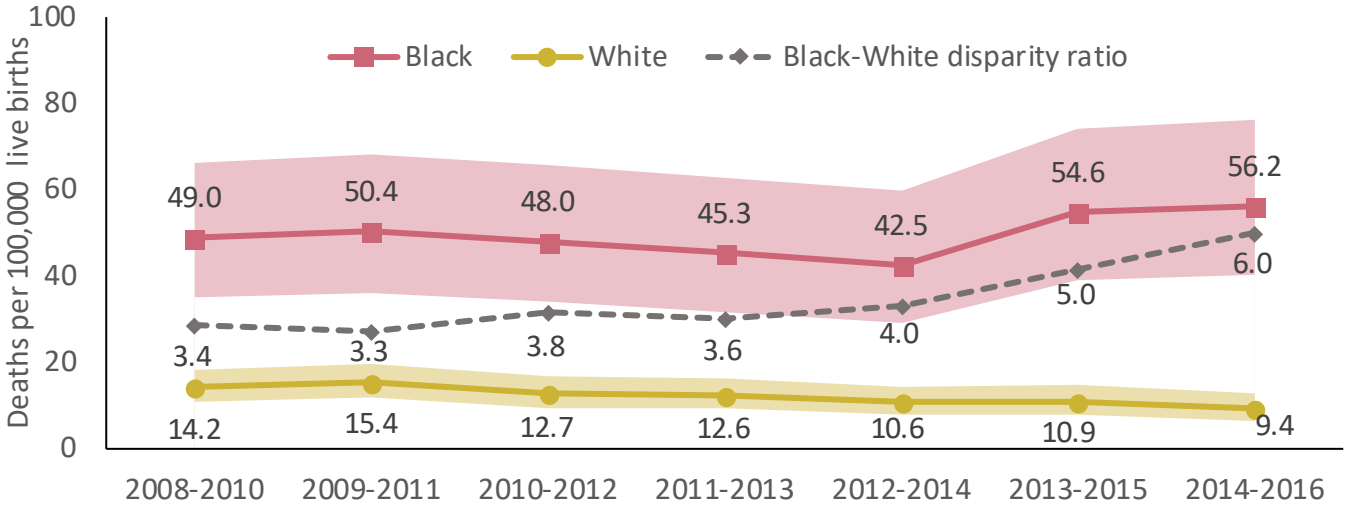
Key Findings

Racial/ethnic disparities in pregnancy-related mortality ratios widened between 2008 and 2016. In 2008-2010, the pregnancy-related mortality ratio (PRMR) for Black women was 49.0 deaths per 100,000 live births, more than three times the PRMR for women of other racial/ethnic groups, including White (14.2), Hispanic/Latina (13.9) and Asian/Pacific Islander (13.8). PRMRs declined for all racial/ethnic groups in 2011-2013, but disparities in PRMRs persisted between Black women (45.3) and those of other racial/ethnic groups: White (12.6), Hispanic/Latina (7.8) and Asian/Pacific Islander (10.7). In 2014-2016, the PRMR for Black women was 56.2 deaths per 100,000 live births, four to six times greater than the mortality ratios for White (9.4), Hispanic (11.0) and Asian/Pacific Islander women (13.3).

Pregnancy-related mortality ratio (PRMR) = Number of pregnancy-related deaths per 100,000 live births Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.

Note: PRMRs for American Indian / Alaska Native (2) or as multiple or other race(s) (9), are not shown due to small numbers. Race/ethnicity was unknown for one woman who died.

Figure 13b: Black-White Disparity in Pregnancy-Related Mortality Ratios, California 2008-2016

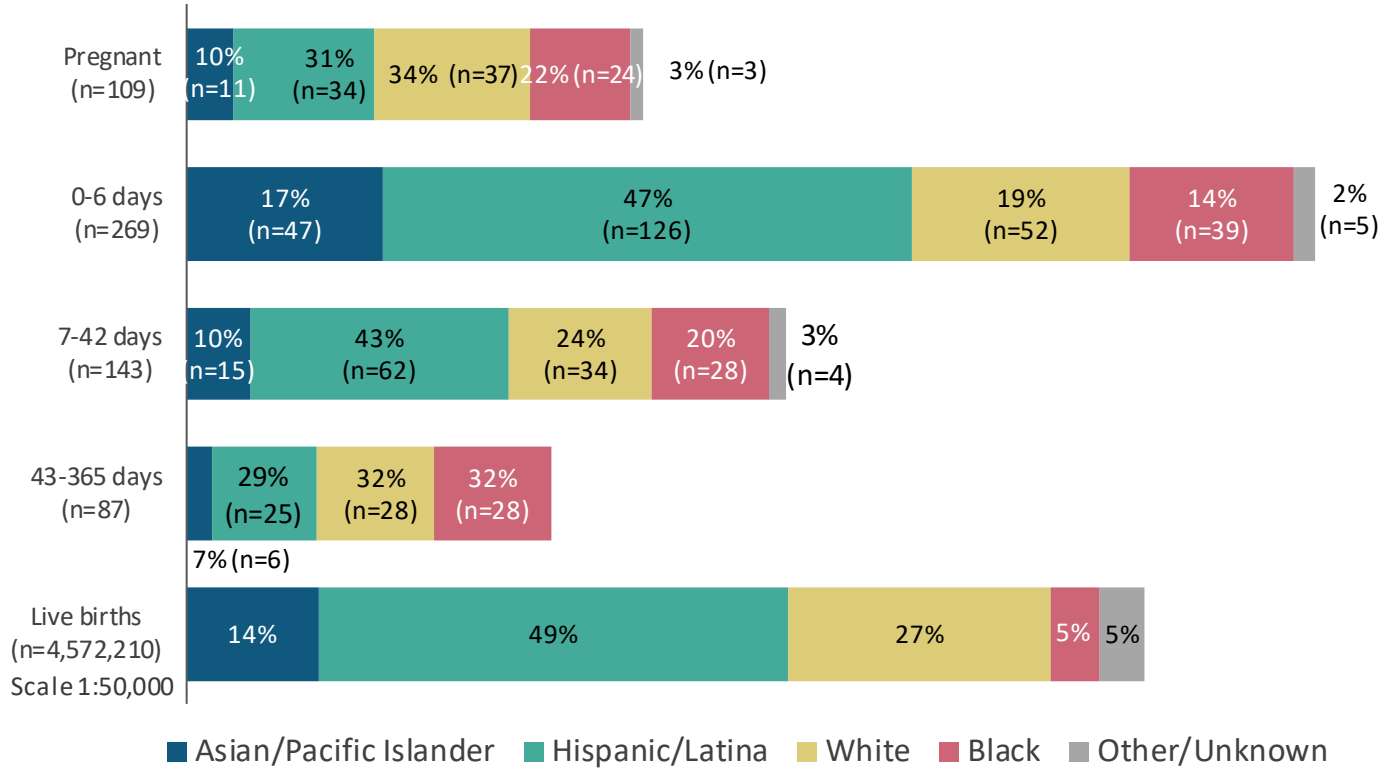


Key Findings

Between 2011-2013 and 2014-2016, the disparity in pregnancy-related mortality ratios (PRMRs) between Black and White women widened from 3.6 to 6.0, highlighting the increasingly disproportionate burden felt by Black women. However, the temporal variations in PRMRs for both Black and White women were within ranges expected by chance alone (i.e., no statistically significant increases or decreases in PRMRs were detected for either Black or White women), and so the widening disparity trend should be interpreted with caution. For early deaths (in pregnancy or within 42 days after pregnancy ended), which comprised most pregnancy-related deaths (86%), the PRMR for Black women remained steady, while the PRMR for White women gradually declined; for late deaths (43-365 days after pregnancy), the PRMR increased for Black women but remained stable for White women (data not shown). These slight shifts in Black and White PRMRs collectively led to a rise in the disparity ratio. It should also be noted that the Black-White disparity in PRMRs widened most prominently for deaths from cardiovascular disease, hypertensive disorders, sepsis and thrombotic pulmonary embolism (data not shown). Notably, California's birthing population characteristics changed over time toward older ages and a higher prevalence of obesity, both associated with higher rates of pregnancy-related mortality. These changes were more pronounced among Black women than White women (data not shown).

Pregnancy-related mortality ratio (PRMR) = Number of pregnancy-related deaths per 100,000 live births. Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.
PRMRs are presented with 95% confidence intervals denoted by shading around the point estimates.
Black-White disparity ratio = Black PRMR / White PRMR, measures health inequity; a ratio less than or greater than 1.0 indicates inequity.

Figure 14: Pregnancy-Related Deaths by Timing to Death and Race/Ethnicity, California 2008-2016 (N=608)

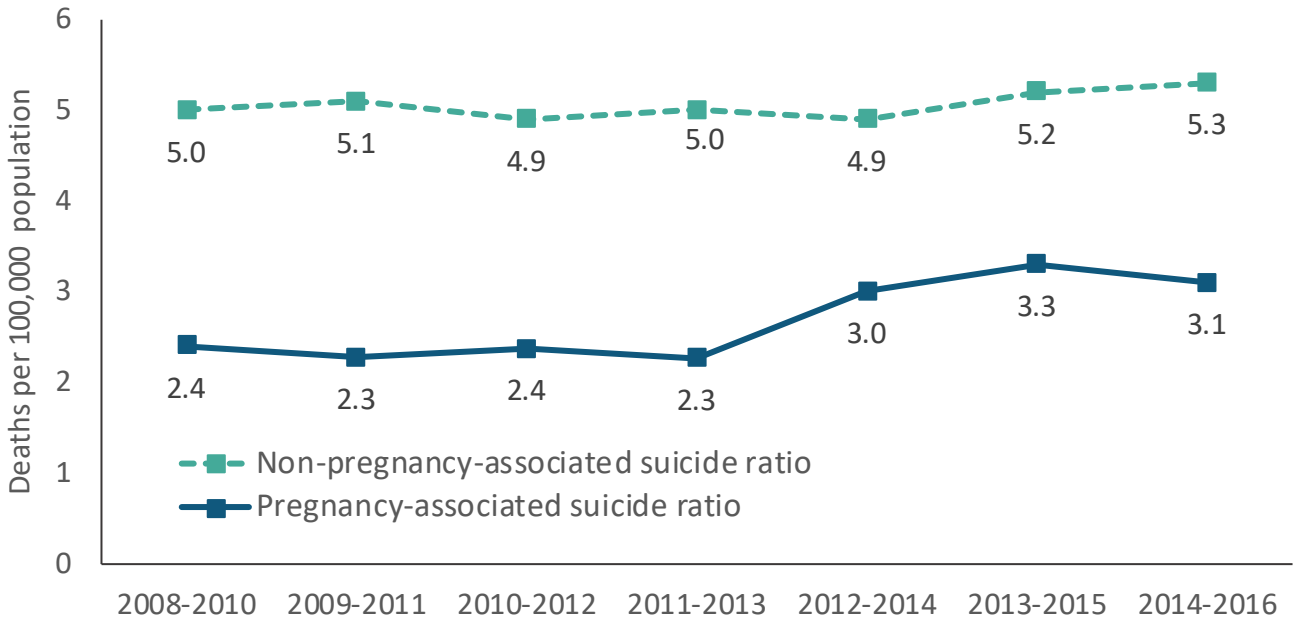


Key Findings

Black women were vastly overrepresented in all timing to death categories, especially among deaths that occurred in pregnancy prior to birth or after delivery hospitalization (7-42 days and 43-365 days after pregnancy ended). In 2008-2016, Black women represented only 5% of all California births but accounted for 22% of pregnancy-related deaths during pregnancy, 20% of deaths 7-42 days after pregnancy, and 32% of deaths 43-365 days after pregnancy. Late deaths (43-365 days) were largely driven by cardiovascular disease and underlying comorbidities for all racial/ethnic groups (see Figure 6B for causes of death by timing). Women of other racial/ethnic groups were not overrepresented in any timing to death categories. Hispanic/Latina women were the least likely to die during pregnancy or the late post-pregnancy periods.

Figure 14 notes: Pregnancy-related deaths include deaths within a year of pregnancy from causes related to or aggravated by the pregnancy or its management, as determined by expert committee review.

Figure 15: Pregnancy-Associated Suicide, California 2008-2016



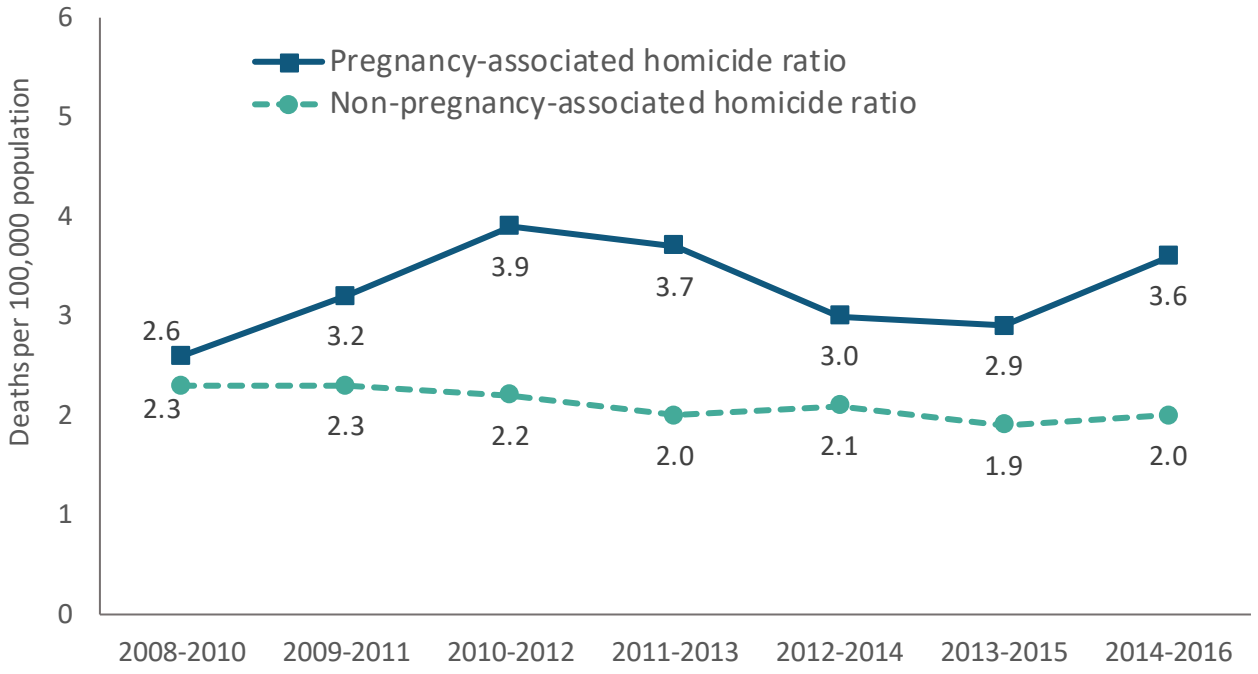
Key Findings

California suicide ratios remained relatively stable in 2008-2016, regardless of pregnancy status. For this time period, the pregnancy-associated suicide ratio was 2.6 per 100,000 live births compared to 5.1 per 100,000 population among the non-pregnant women of reproductive age who also died by suicide. Women who were pregnant in the year prior to death were significantly less likely to die by suicide than women who had not been pregnant, and this held true for all the years shown in Figure 15. Findings from CA-PAMR's in-depth case reviews of pregnancy-associated suicide in 2002-2012 also revealed low and stable mortality ratios, with an average of nine deaths annually, of which more than half (59%) were deemed to be pregnancy-related[16].

Figure 15 notes: Pregnancy-associated suicide ratio = Number of deaths per 100,000 live births, up to 365 days after the end of pregnancy. Pregnancy-associated suicides were identified by ICD-10 codes U03, X60-X84, and Y87.0 from the California death certificate data (2008-2016) and any death coded as suicide in coroner reports (manner of death). Non-pregnancy-associated suicide ratio = Number of deaths per 100,000 population of reproductive-aged women (15-49 years) who were not pregnant within one year of death. Population data on injury and violent deaths are published by CDPH and found on the California EpiCenter Database (accessed at http://epicenter.cdph.ca.gov on August 19, 2020 via Internet Explorer).

[16] *The California Pregnancy-Associated Mortality Review Report: Pregnancy-Associated Suicide, 2002-2012.* Sacramento: California Department of Public Health, Maternal, Child and Adolescent Health Division. 2019

Figure 16: Pregnancy-Associated Homicide, California 2008-2016



Key Findings

California homicide ratios remained relatively stable in 2008-2016, regardless of pregnancy status. Women who were pregnant in the year prior to death were significantly more likely to die by homicide than women who had not been pregnant within the prior year; this held true across most years shown in Figure 16. In 2008-2016, the pregnancy-associated homicide ratio was 3.3 per 100,000 live births compared to 2.1 per 100,000 population among the non-pregnant women of reproductive age. Of note, the highest pregnancy-associated homicide ratio during this period was seen in 2016 (5.5 per 100,000 live births – individual year data not shown) and was significantly higher than pregnancy-associated homicide ratios in 2008, 2009 and 2014.

Figure 15 notes: Pregnancy-associated homicide ratio = Number of deaths per 100,000 live births, up to 365 days after the end of pregnancy. Pregnancy-associated homicides were identified by ICD-10 codes U01, U02, X85-X99, Y00-Y09, Y35, and Y87.1 from the California death certificate data (2008-2016) and any death coded as homicide in coroner reports (manner of death). Non-pregnancy-associated homicide ratio = Number of deaths per 100,000 population of reproductive-aged women (15-49 years) who were not pregnant within one year of death. Population data on injury and violent deaths are published by CDPH and found on the California EpiCenter Database (accessed at http://epicenter.cdph.ca.gov on August 19, 2020 via Internet Explorer).

Conclusions

California's rate of pregnancy-related deaths has remained low and largely stable from 2008 to 2016, except for a spike in deaths during a novel influenza A (H1N1) pandemic in 2009. However, racial/ethnic disparities in pregnancy-related mortality ratios (PRMRs) appear to be worsening, especially among Black women when compared to women of other racial/ethnic groups. Between 2008 and 2016, the PRMRs for Black women remained markedly higher than the PRMRs for White, Hispanic/Latina and Asian/Pacific Islander women. Black women were vastly overrepresented among all causes of pregnancy-related deaths, particularly among deaths that occurred in pregnancy prior to birth or after delivery hospitalization (i.e., 7-365 days after pregnancy ended). Late deaths (43-365 days post-pregnancy) were largely driven by cardiovascular disease and underlying comorbidities for all racial/ethnic groups. These disparities are alarming. While examining the root causes and associated factors are outside the scope of this surveillance report, MCAH continues public health investigations to identify opportunities for intervention and prevention.

Other characteristics that trended with higher PRMRs for all racial/ethnic groups, collectively, were older age, obesity and public insurance coverage. Living in less advantaged communities or in certain geographic regions, such as the Southern Central Valley region, was also correlated with elevated PRMRs. The cause-specific PRMRs for the leading causes of death – cardiovascular disease, sepsis/infection, hemorrhage, hypertensive disorders and thrombotic pulmonary embolism – did not change significantly during 2008-2016. Continued monitoring of these trends will elucidate ways to improve preconception, prenatal and postpartum care and support for all women, especially those in high-risk groups.

These surveillance findings reveal a need for the thorough examination of how systems and community-level characteristics interplay with patient, provider and facility-level factors in contributing to pregnancy-related mortality and related disparities. Social determinants of health[17] – the social and physical conditions in which people live, work, learn and grow up – are known to shape health, functioning and quality-of-life outcomes. Improvements in neighborhood conditions, housing, transportation options, access to healthy food and quality health care services, and social supports are likely to have positive impacts on maternal health outcomes and well-being. Moving from surveillance via CA-PMSS to holistic examination of factors underlying pregnancy-related mortality and related disparities at all levels, from individual to community, can begin to pave the way toward health equity.

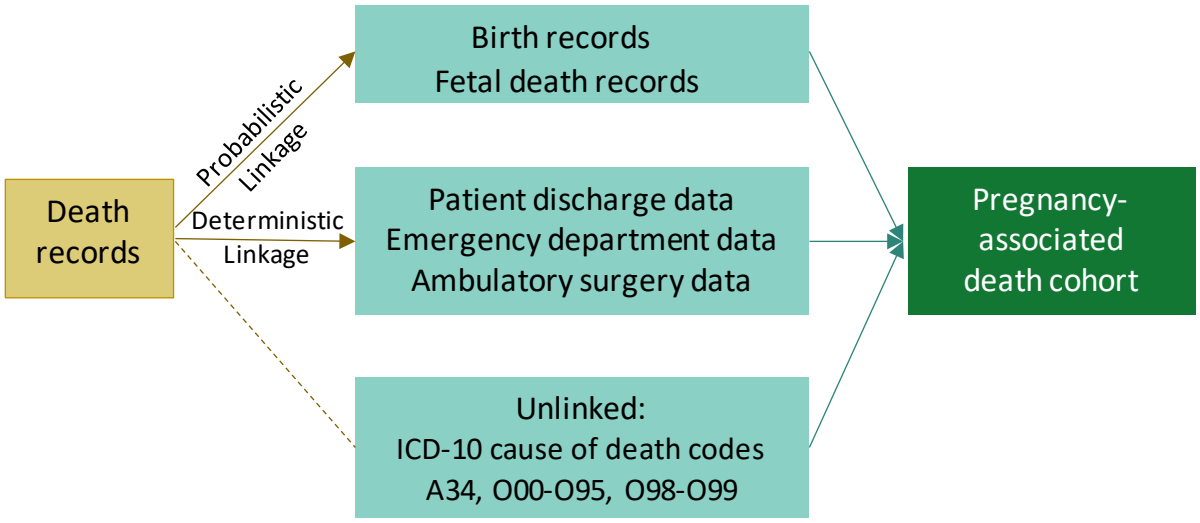
[17] Healthy People 2020, Social Determinants of Health: https://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-of-health

Appendix

Identification of Pregnancy-Associated Deaths

The CA-PMSS case review process begins with the identification of all pregnancy-associated deaths – including deaths among women who were less than 20 weeks pregnant – through a series of complex data linkage steps. Pregnancy-associated death cohorts are defined by the year of birth (or end of pregnancy).

Case Identification Flow Diagram



Data Linkage Methods

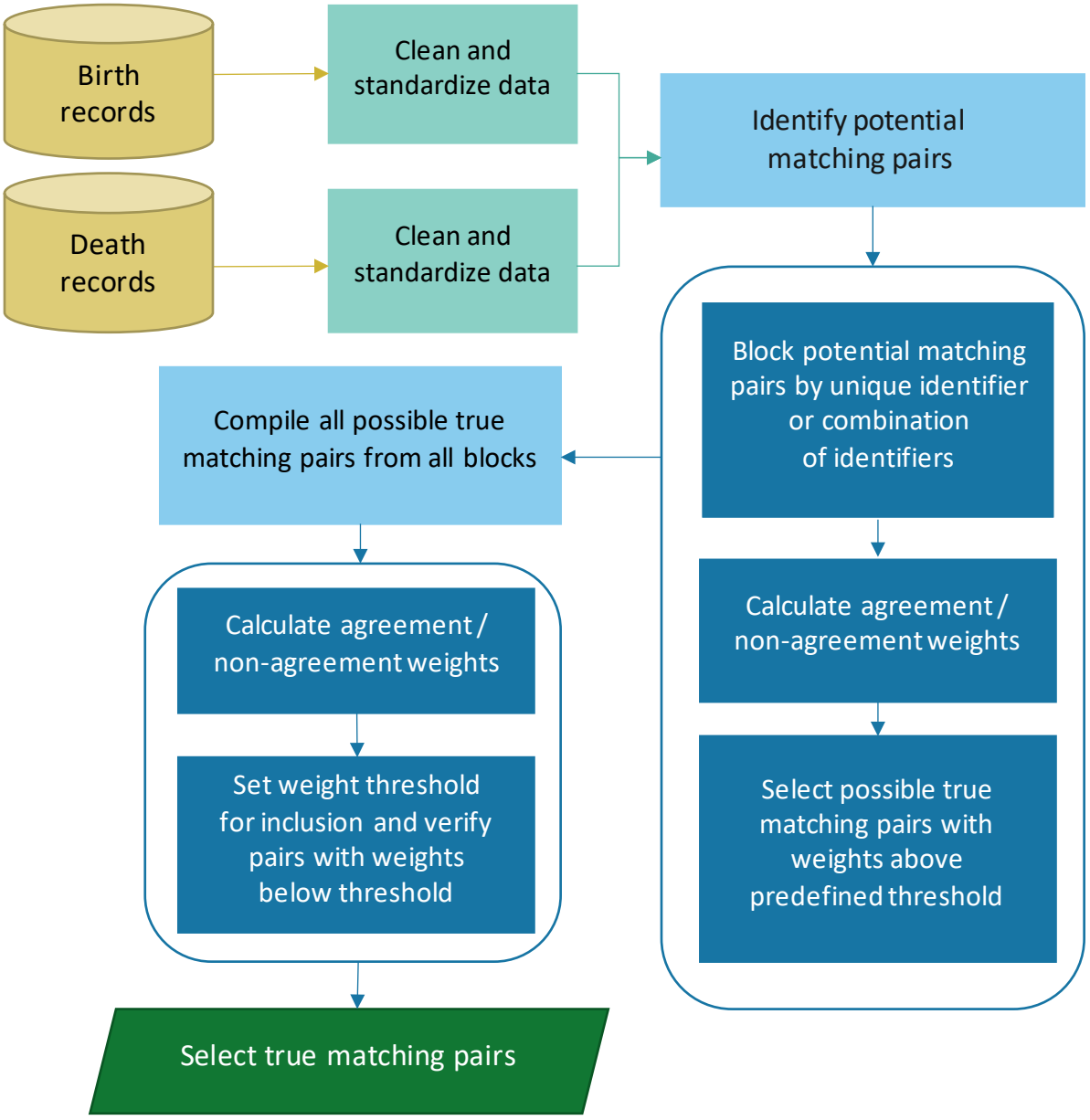
Two data linkage processes are carried out to construct a cohort of all pregnancy-associated deaths, including those that occurred in early pregnancy (less than 20 weeks gestation):

- **Probabilistic record linkage** of vital statistics files (birth, fetal death and death certificate data) to capture women who died within one year of pregnancy.
- **Deterministic record linkage** of the death certificate data, patient discharge, emergency department and ambulatory surgery center data to identify women who had a recent pregnancy, irrespective of pregnancy outcome.

A flow diagram on the next page illustrates the probabilistic data linkage process. Detailed descriptions of these data linkage methods were previously published.[18]

[18] *The California Pregnancy-Associated Mortality Review Report: Pregnancy-Associated Suicide, 2002-2012.* Sacramento: California Department of Public Health, Maternal, Child and Adolescent Health Division. 2019. www.cdph.ca.gov/PAMR

Probabilistic Data Linkage Flow Diagram



Data Sources

This table summarizes the data sources used to identify pregnancy-associated deaths and to augment information about each death.

Data Source	Purpose
Vital statistics and administrative data[19]: ▸ Birth Statistical Master File (BSMF) ▸ Death Statistical Master File (DSMF, 2008-2013), California Comprehensive Master Death File (CCMDF, 2014-2016); collectively referred to as death certificate data ▸ Fetal Death Statistical Master File (FDSMF) ▸ Birth Cohort File (combined BSMF and FDSMF) ▸ Pregnancy Status Errata File (a supplement to CCMDF with corrected maternal death data) ▸ California Office of Statewide Health Planning and Development (OSHPD) Patient Discharge Data (PDD) ▸ OSHPD Emergency Department Data (EDD) ▸ OSHPD Ambulatory Surgery Center Data (AS)	▸ To identify pregnancy-associated deaths; time to death; births; co-morbid conditions before, during, and after pregnancy ▸ To obtain demographic and obstetric information on cases and comparative populations
Coroner/Medical Examiner investigations, autopsy and toxicology reports	▸ To confirm evidence of pregnancy, timing to death and manner of death ▸ To provide details of the decedent's physical and mental health and of circumstances leading up to the death for inclusion in case summary
Hospital discharge summary, medical records *Note: Obtained if the above data sources are limited or not available*	▸ To incorporate clinical events and interactions with the medical community into case summary

[19] Information about vital records and other administrative data can be accessed at CDPH's Center for Health Statistics and Informatics website: www.cdph.ca.gov/Programs/CHSI

Case Selection Process

After all pregnancy-associated deaths have been identified, they are screened further to select and prepare cases for committee review.

Verification of Pregnancy and Timing to Death

1) Request coroner reports for all pregnancy-associated deaths, regardless of age, cause of death, or timing.
2) Conduct ongoing investigations to confirm pregnancy status within the prior year. Exclude California non-residents and any deaths more than 365 days after the end of pregnancy.

Case Selection Criteria for Committee Review

To select cases for committee review, CA-PMSS uses a structured case selection algorithm to identify deaths that may be pregnancy related. Pregnancy-related deaths, as defined by CDC-PMSS, exclude deaths from unintentional injury, suicide, homicide and most types of cancer. According to the CDC[20], "pregnancy-relatedness cannot be determined in PMSS for injury deaths such as drug overdoses, suicides, or homicides, or for cancer-related deaths, because of limited information concerning death circumstances." The case selection criteria in CA-PMSS are as follows:

1) Exclude the following causes of death regardless of timing to death unless noted otherwise:
   - Unintentional injury, except (a) drug overdose deaths with cardiovascular disease and (b) iatrogenic deaths related to obstetric care;
   - Suicide;
   - Homicide; and
   - Cancer, except gestational trophoblastic disease (e.g., choriocarcinoma) due to its relationship to pregnancy.
2) Exclude most deaths from medical causes that occurred more than 90 days after the end of pregnancy. Included up to 365 days after the end of pregnancy are deaths from cardiovascular disease, circulatory system conditions, cardiomyopathy and deaths with histories of prolonged health issues related to the delivery or pregnancy (for example, brain injury due to preeclampsia and prolonged hospitalization).

Preparing Case Review Materials

1) Request hospital discharge summaries for all potential pregnancy-related deaths without a coroner report or those with a very limited coroner report (e.g., no autopsy, poor quality). The labor and delivery medical chart or an entire death chart may also be obtained to fill in key events that led to the death.

2) Summarize cases in a brief paragraph that includes autopsy findings and coroner opinion, toxicology results, relevant pathology labs and other relevant information.

[20] Petersen EE et al. *Vital Signs:* Pregnancy-Related Deaths, United States, 2011-2015, and Strategies for Prevention, 13 States, 2013-2017. *MMWR Morb Mortal Wkly Rep* 2019;68-423.

3) Create a Case Information Sheet for each case. Compile data from vital records, patient discharge, emergency department and ambulatory surgery center data, as well as a summary of information from the coroner report and medical records (described above). Case Information Sheets only contain de-identified case information.

4) Create individualized Committee Review Forms for each case.

5) Email Case Information Sheets and Committee Review Forms in monthly batches of 20 cases to two teams of three review committee members and the committee chair (who serves on both teams as each team's fourth reviewer), for a total of 40 cases per month.

6) Committee members individually review the cases and return completed Committee Review Forms within two weeks.

Committee Review Process

The CA-PMSS committee identifies the cause of death and determines if the death was related to pregnancy. Decisions are made by a "super majority." Committee determinations are then compiled and summarized.

Committee Composition

A volunteer committee of experts – six appointed members and a committee chair – reviews all potential pregnancy-related deaths to identify the cause of death and to determine if the death was related to pregnancy. Collectively, the seven CA-PMSS committee members have expertise in obstetrics (5), maternal fetal medicine (5), obstetric/neonatal nursing (1), nurse-midwifery (1) and cardiology (1). (See Acknowledgments for a complete CA-PMSS Committee roster.)

Summarizing Case Review Determinations

1) Compile and summarize results. If a case has consensus or a "super majority" (i.e., three out of four members agree) on the cause of death and pregnancy-relatedness determinations, then the case is considered final and is entered into a database.

   If a super majority is not reached, cases are prepared for a reconciliation call for committee members to discuss and reach a super majority. Preparation of cases for reconciliation may include requesting more information from hospitals or including more case details on the Case Information Sheet (e.g., from autopsy report).

2) Assign CDC's PMSS-MM[21] codes for grouped cause-of-death categories.

[21] PMSS-MM codes were developed by CDC to systematically track pregnancy-related deaths in CDC-PMSS and in the Maternal Mortality Review Information Application (MMRIA), a data system developed CDC, that is designed to facilitate MMRC functions through a common data language. https://reviewtoaction.org/tools/mmria

CA-PMSS Forms

- CA-PMSS Case Information Sheet
- CA-PMSS Committee Review Form

CA-PMSS Case Information Sheet **PAMRID#**

Age		**Days Between Birth and Death**	
Race/Ethnicity		**Records Received**	

BIRTH CERTIFICATE / CA BIRTH STATISTICAL MASTER FILE			
Number of previous live births		**Number of prior cesareans**	
Gestational Age at delivery		**Method of delivery**	
Body Mass Index (BMI)			
Pregnancy complications			
Labor and delivery complications			

DEATH CERTIFICATE / CA DEATH STATISTICAL MASTER FILE			
Immediate Cause of Death (time interval)			
Underlying Cause of Death (time interval)			
Other Significant Conditions			
Operation Performed			
ICD-10 Code/Code Name/Group			
Pregnancy Box Checked		**Type of place of death**	

PATIENT DISCHARGE DATA					
LOS at delivery admission		**L&D disposition**		**LOS at death admit**	
Diagnoses at L&D admission					
Procedures at L&D admission					
Diagnoses at Death admission					
Procedures at Death admission					

CORONER INFORMATION (includes imaging results, as available)	
MEDICAL RECORD INFORMATION (includes imaging results, as available)	
PSYCHOSOCIAL FACTORS (any data source, include mental health, substance use disorder, housing, transportation, other)	

CA-PMSS Committee Review Form PAMRID#

Pregnancy Related Yes ☐ No ☐ Unable to Determine ☐

The death of a woman while pregnant or within one year of termination of pregnancy, irrespective of the duration and site of the pregnancy from any cause related to or aggravated by her pregnancy or its management, but not from accidental or incidental causes.

Cause of Death (Select ONE cause and specify when indicated)

Cause of death here refers to the initiating or critical underlying process responsible for the chain of events leading to the actual death.

Examples: *Uterine atony leading to DIC, massive transfusions and multi-organ failure.*
Chronic hypertension leading to hypertrophic cardiomyopathy leading to heart failure.

Amniotic Fluid Embolism (AFE) ☐

Anesthesia complications ☐

Cardiomyopathy
- Peripartum ☐
- Hypertrophic ☐
- Other, specify: ☐

Other Cardiovascular Disease ☐
Specify_____

Cerebrovascular Accident (CVA) ☐
(excludes stroke from hypertension, includes AVM or aneurysm)

Hemorrhage
- Atony or other uterine bleeding ☐
- Retained products of conception ☐
- Uterine rupture or laceration ☐
- Abruptio placenta ☐
- Placenta previa ☐
- Placenta accreta, increta, percreta ☐
- Ruptured ectopic ☐
- Other, specify: ☐

Infection/Sepsis
- Chorioamnionitis ☐
- Influenza ☐
- Postpartum genital tract ☐
  (includes uterus, pelvis, necrotizing fasciitis)
- Sepsis, urinary/pyelonephritis ☐
- Sepsis, other, specify: ☐

FOR ALL HYPERTENSIVE DEATHS: Code disorder AND mechanism of death

Hypertensive Disorder (includes stroke if caused by hypertension)
- Preeclampsia ☐
- Eclampsia ☐
- Chronic hypertension w/preeclampsia ☐
- Chronic hypertension w/o preeclampsia ☐

Mechanism of death due to hypertension
- CVA (Stroke) ☐
- Coagulopathy (DIC) ☐
- Liver failure ☐
- Seizure / anoxia ☐
- Other, specify: ☐

Thrombotic Pulmonary Embolism ☐

Other Obstetric Cause of Death, specify below: ☐

Other Medical Cause of Death, specify below: ☐

Unable to determine, specify: ☐

Reviewer Notes

Reviewer Initials	**Date Reviewed**