Trends in Maternal Morbidity in California
1999-2005

Soraya Boumediene, MPH
Jessica Chow, MPH
Moshe Fridman, PhD
Kimberly D. Gregory, MD, MPH
Lisa M. Korst, MD, PhD
Michael C Lu, MD, MPH
Sonal Shah, MPH
(Alphabetical)

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Executive Summary

More than half a million women give birth each year in California. Until recently, the only national outcome indicator of maternal health was maternal mortality. There is growing concern that maternal mortality may be on the rise in California. According to the California Department of Public Health, maternal mortality ratios (number of maternal deaths per 100,000 live births) in the state of California have nearly tripled in a decade, from 5.6 in 1996 to 16.9 in 2006.

Maternal mortality may be only tip of the iceberg. If priorities are to be established and effective interventions designed to improve maternal health, the burden of morbidity among women giving birth must be identified and monitored. Thus, *Healthy People 2010* objectives included a new maternal health indicator: maternal morbidity during labor and delivery.

The Maternal Quality Indicators Working Group has been commissioned by the California Department of Public Health Maternal, Child and Adolescent Health Branch to conduct a study of trends in maternal morbidity in California. For the purpose of this study, maternal morbidity during labor and delivery was defined as a condition that adversely affects a woman's physical health during childbirth beyond what would be expected in a normal delivery. Maternal morbidity was divided into preexisting medical conditions, obstetrical complications, and cesarean delivery. A preexisting medical condition is an underlying condition that may be aggravated by the pregnancy. An obstetrical complication is a condition caused by the pregnancy itself or by its management. Cesarean delivery, considered a major operative procedure during hospitalized labor and delivery, was also included as a type of maternal morbidity.

We used data from the California Office of State Health Planning and Development (OSHPD) for 1999, 2002, and 2005. The database, which links birth certificates to maternal and infant hospital discharge records, includes 98% of all California deliveries. OSHPD includes data on patient characteristics, medical diagnoses, and procedures; the latter are coded according to the International Classification of Diseases, Ninth Revision, Clinical Modifications (ICD-9-CM). We examined trends in maternal morbidity among 1,551,017 hospital deliveries in California in 310 hospitals in 1999, 2002, and 2005. Because trends in maternal morbidity may be the result of demographic shifts in California, we adjusted for maternal, hospital, and county-level

characteristics using hierarchical logistic regression models. We also explored racial-ethnic disparities in maternal morbidity in California.

Preexisting medical conditions

Our study found significant increases in the prevalence of several preexisting medical conditions in California between 1999 and 2005. Key findings include:

- 47% increase in the prevalence of pre-gestational hypertension (from 0.63% of all deliveries in 1999 to 0.93% in 2005, $p<0.0001$);

- 28% increase in the prevalence of pre-gestational diabetes (from 0.65% of all deliveries in 1999 to 0.83% in 2005, $p<0.0001$);

- 75% increase in the prevalence of maternal asthma (from 1.02% of all deliveries in 1999 to 1.78% in 2005; $p<0.0001$);

- 62% increase in the prevalence of maternal thyroid disorders (from 0.81% of all deliveries in 1999 to 1.31% in 2005, $p<0.0001$).

These trends were independent of demographic shifts in maternal age, race-ethnicity, education, and other maternal, hospital, and/or county characteristics in California during the same time period. In unadjusted analyses, we also found significant increases in the prevalence of obesity, mental illness, tobacco, alcohol and substance use during pregnancy, though hospital discharge reporting for these conditions and behaviors are less reliable.

Obstetrical complications

Our study found significant increases in the rates of several major obstetrical complications in California between 1999 and 2005. Key findings include

- 13% increase in the rate of hypertension complicating pregnancy, childbirth and the puerperium (from 4.36% of all deliveries in 1999 to 4.91% in 2005, $p=0.007$);

- 44% increase in the rate of gestational diabetes (from 3.96% of all deliveries in 1999 to 5.71% in 2005, $p<0.0001$);

- 21% increase in the rate of preterm delivery (from 5.48% of all deliveries in 1999 to 6.61% in 2005, p<0.0001).

These trends were independent of demographic shifts in maternal age, race-ethnicity, education, and other maternal, hospital, and/or county characteristics in California during the same time period. We also found a non-significant 10% increase in the rate of chorioamnionitis.

Given growing public health concerns over "elective" or "iatrogenic" preterm delivery, we attempted to estimate the proportion of preterm deliveries in California that were "elective" (defined in our study as preterm delivery following elective primary or repeat cesarean, surgical or medical induction, failed induction or induction noted in birth certificate where none of the standard indications for "indicated" preterm delivery, such as hypertension or intrauterine growth restriction, were noted). Using this definition, one in five (20.7%) of preterm deliveries in California in 2005 would have been considered "elective," as compared to 15.3% in 1999. While there are likely substantial misclassification errors and further studies are needed to validate our findings, the possibility of more than one in five preterm deliveries in California as "elective" is cause for great clinical and public health concern and warrants closer surveillance.

Cesarean Delivery

Perhaps one of the most important trends observed in our study of maternal morbidity was the 35% increase in cesarean delivery, from 22.9% in 1999 to 30.8% in 2005 (p<0.0001). These trends in cesarean delivery in California were independent of maternal age and other demographic shifts in maternal, hospital, and/or county characteristics during the same time period.

Furthermore, we conducted subgroup analyses of the various types of cesarean delivery. Key findings include:

- 33% increase in primary cesarean without labor ("elective" primary) (from 4.51% of all deliveries in 1999 to 5.99% in 2005, p<0.0001);
- 22% increase in primary cesarean with labor (from 9.21% of all deliveries in 1999 to 11.24% in 2005, p<0.0001);
- 69% increase in repeat cesarean without labor ("elective" repeat) (from 7.38% of all deliveries in 1999 to 12.45% in 2005, p<0.0001);

- 42% decrease in repeat cesarean with labor ("failed vaginal birth after cesarean, or VBAC") (from 1.71% of all deliveries in 1999 to 0.99% in 2005, $p<0.0001$).

The reasons for these observed trends are not well understood. The increasing rates of primary cesarean without labor are likely due to both increases in indicated elective primary cesarean (e.g. for severe hypertension, multiple gestations, and macrosomia), as well as cesarean delivery on maternal request (CDMR). The increasing rates of primary cesarean with labor, in light of decreasing trends in prolonged rupture of membranes and instrumental delivery, suggest that practitioners may be quicker in abandoning labor and proceeding with cesarean delivery when labor dystocia is encountered.

The increasing rates of repeat cesarean without labor ('elective" repeat) was probably driven by both an increase in the number of women with prior cesarean, as well as a decrease in the proportion of women with prior cesarean who attempted a VBAC. Indeed, we found that overall VBAC attempts (including both successful and failed VBACs) decreased by more than half (56%) during the study period, from 5.46% of all deliveries in 1999 to 2.48% in 2005. This trend was driven, in large part, to more restrictive ACOG guidelines on VBAC which created a medicolegal environment that may have discouraged VBAC attempts. The decrease in failed VBAC probably had more to do with the overall decline in VBAC attempts rather than improved success with VBAC. To the contrary, *among women who attempted VBAC*, there has been a 32% *increase* in failed VBAC, suggesting that practitioners in California were not only less likely to attempt VBAC, they may also have been quicker in abandoning VBAC attempts.

<u>Racial-ethnic disparities</u>

We found substantial disparities in maternal morbidity across racial-ethnic groups in California. Non-Hispanic black women were disproportionately affected by hypertension, preterm birth, asthma and cesarean delivery. Native Americans had the highest rates of alcohol and tobacco use and mental illness, though these estimates were rendered imprecise by small numbers and substantial under-reporting. Asian and Pacific Islander (API) women had the highest rates of diabetes. In 2005, nearly one in ten (9.55%) API women who gave birth had diabetes, a rate that has nearly doubled since 1999. Overall, maternal morbidity has been increasing across all racial-ethnic groups in California.

To our knowledge, our study is the first to examine the rising trends of maternal morbidity in California. We observed significant increases in several major preexisting medical conditions and obstetrical complications, as well as cesarean delivery, between 1999 and 2005. While racial-ethnic disparities exist, maternal morbidity appears to be increasing across all racial-ethnic groups in California. Increased surveillance of these trends is needed, while public health practice and policy must promote improved access and quality of health care before, during and between pregnancies.

I. INTRODUCTION

There is growing evidence that maternal mortality is increasing in California. According to California Department of Public Health, maternal mortality ratios (number of maternal deaths per 100,000 live births) in the state have nearly tripled in a decade, from 5.6 in 1996 to 16.9 in 2006 (California Department of Public Health, 2009). While changes in surveillance[1] (Hoyert 2007) may have resulted in better identification of maternal deaths, it is likely that the increase in maternal mortality in California is real. Also concerning is a similar rise in maternal mortality in the U.S. (CDC 2003, Berg *et al* 2010).

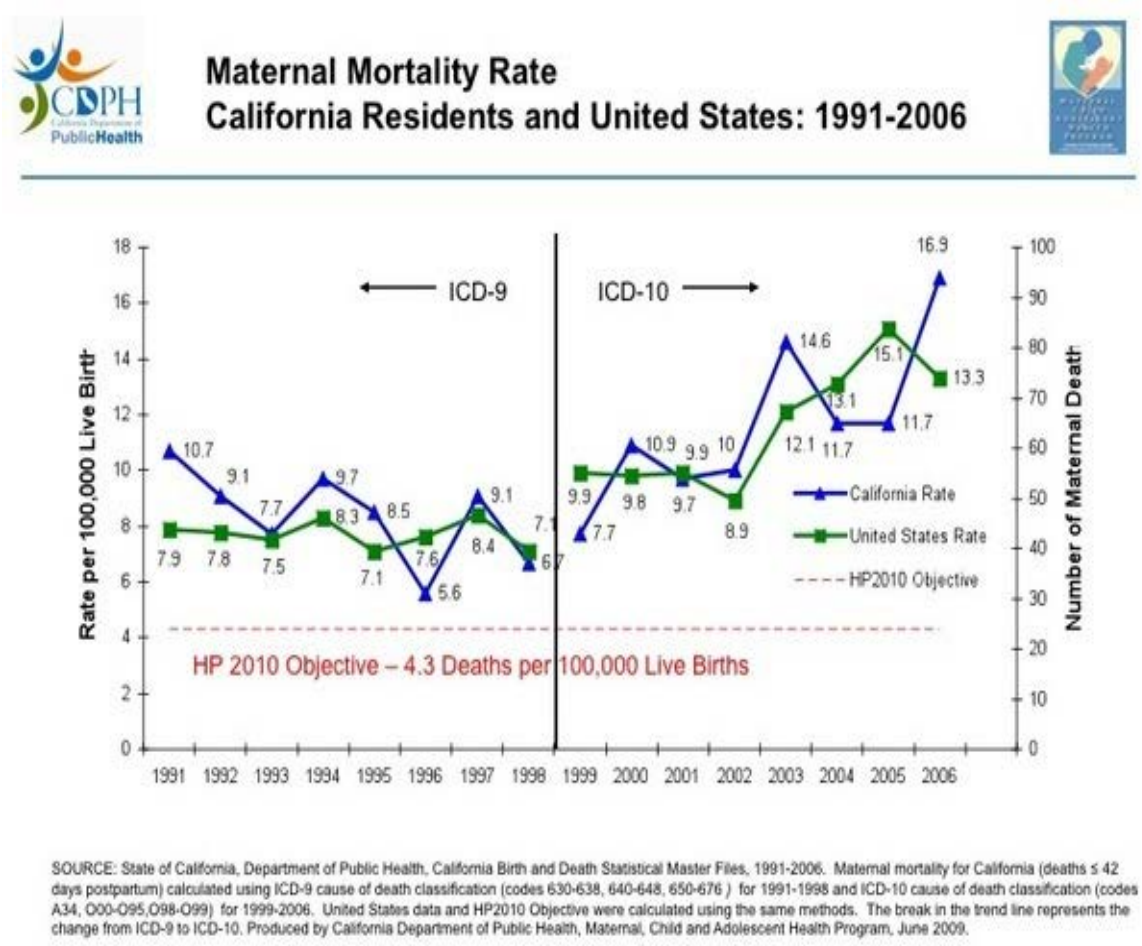


Figure 1: Maternal mortality ratio in California and United States: 1991-2006

[1] The implementation of the *International Classification of Diseases, Tenth Revision* (ICD–10) in 1999 resulted in about a 13 percent increase in the number of deaths identified as maternal deaths in the U.S. between 1998 and 1999. The rate increased again between 2002 and 2003 after a separate pregnancy question became a standard item on the U.S. Standard Certificate of Death.

However, maternal death may be only tip of the iceberg. Severe maternal morbidity is 50 times more common than maternal death (Callaghan 2008). Using the National Hospital Discharge Survey for 1991-2003, Callaghan *et al* (2008) estimated that severe maternal morbidity rate in the U.S. was 5.1 per 1000 deliveries. There is also growing evidence that maternal morbidity may be increasing in the U.S.. Using data from the 1998– 2005 Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project, Kuklina *et al* (2009) reported that the prevalence of delivery hospitalizations complicated by at least one severe obstetric complication increased from 6.4 per 1,000 deliveries (n=48,645) in 1998– 1999 to 8.1 per 1,000 deliveries (n=68,433) in 2004–2005. Rates of complications that increased significantly during the study period included renal failure by 21% (from 0.23 to 0.28), pulmonary embolism by 52% (0.12 to 0.18), adult respiratory distress syndrome by 26% (0.36 to 0.45), shock by 24% (0.15 to 0.19), blood transfusion by 92% (2.38 to 4.58), and ventilation by 21 % (0.47 to 0.57) (Figure 2).

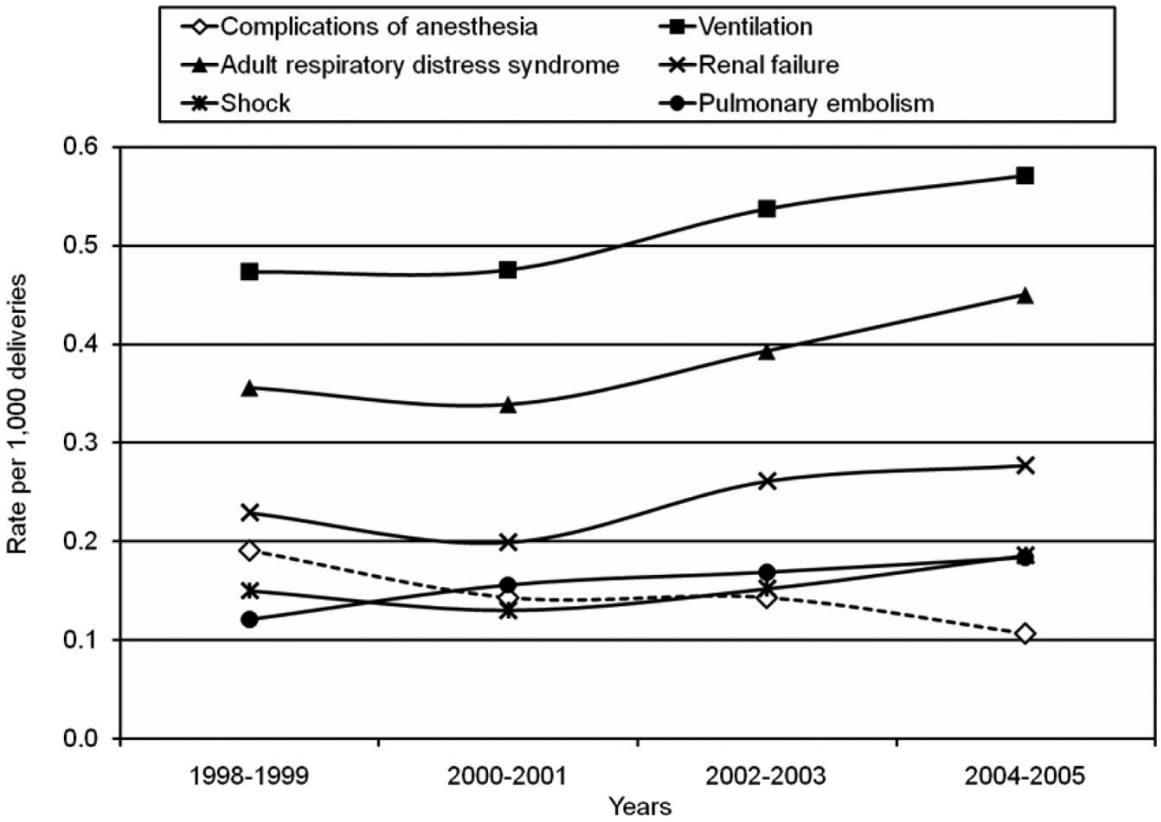


Figure 2: Severe maternal morbidity in the U.S., 1998-2005

The reasons for the increasing trends in maternal mortality and morbidity are unknown. Increasing prevalence of maternal chronic conditions, such as hypertension, diabetes, or obesity, could have contributed to the rise in obstetrical complications and possibly maternal deaths. Increasing rates of cesarean delivery may have also played a role. In logistic regression models, Kuklina *et al* (2009) found changes in cesarean delivery rate appeared to explain the observed change over time for renal failure, respiratory distress syndrome, and ventilation. Furthermore, increasing rates of cesarean delivery, although only partially, also contributed to the increases in shock, pulmonary embolism, and blood transfusions. The total cesarean delivery rate increased by 50%, from the 1996 low of 20.7% to 31.1% in 2006, the highest level ever reported in the U.S. (Martin 2009).

The Maternal Quality Indicators Working Group has been commissioned by the California Department of Public Health, Maternal, Child and Adolescent Health Branch to conduct a study of trends in maternal morbidity in California. Our overall aim was to determine whether maternal morbidity has been increasing in California. Because trends in maternal morbidity may be the result of demographic shifts in California, we adjusted for both maternal and hospital characteristics using hierarchical logistic regression models. Data from over 1.5 million births in California in 1999, 2002, and 2005 were used for this analysis.

II. METHODS

Study Population

California Office of Statewide Health Planning and Development (OSHPD) linked birth cohort data for 1999, 2002, and 2005 were used for this analysis, which included a total N=1,551,295 deliveries in 325 hospitals. The database, which links birth certificates to maternal and infant hospital discharge records, includes 98% of all California deliveries. OSHPD includes data on patient characteristics, medical diagnoses and procedures; the latter are coded according to the International Classification of Diseases, Ninth Revision, Clinical Modifications (ICD-9-CM).

Twenty of the 26 hospitals excluded had an average of less than 3 deliveries per year and the others had averages between 4-27 annual deliveries. These are likely to be emergency room deliveries in hospitals not set up for labor and delivery (L&D), and therefore not representative of patients or outcomes in L&D units. In addition, adjustment for hospital characteristics requires a reasonably large sample of patients per hospital in hierarchical models that use hospitals as the second level unit in the model specification. Therefore we excluded hospitals with fewer than 50 annual deliveries (on average, during the study period). After these exclusions, there remained N=1,551,017 deliveries in 310 hospitals in California in 1999, 2002, and 2005.

Diagnostic Codes and Maternal Morbidity

Only birth discharge records with Major Diagnostic Category (MDC) related to pregnancy, childbirth, and puerperium (MDC='14') and Diagnostic Related Groups (DRGs) related to childbirth hospitalizations (DRG= '370','371','372','373','374', or '375', cesarean and vaginal deliveries, with or without complications, and with or without associated procedures) were included in the analyses. We used DRG and ICD-9-CM diagnosis and procedure codes to extract records from OSHPD datasets. We assumed that if codes for a condition or a procedure were lacking, then the condition or procedure was not present. This analysis does not distinguish between primary and secondary codes. Rather it loops through all codes to determine the presence or absence of a specific code.

Maternal morbidity during labor and delivery was defined as a condition that adversely affects a woman's physical health during childbirth beyond what would be expected in a normal delivery. Maternal morbidity was divided into obstetrical complications, preexisting medical conditions,

and cesarean delivery. An obstetric complication is a condition caused by the pregnancy itself or by its management. For the purpose of this study, we examined hypertension complicating pregnancy, gestational diabetes, chorioamnionitis, prolonged rupture of membranes (PROM), preterm delivery, cesarean delivery, instrumental delivery, and hysterectomy. These 8 diagnoses and procedures were selected because they have been previously validated to have moderate to high accuracy. The code type, code, weighted sensitivity and positive predictive value for each diagnosis or procedure are presented in Table 1.

Preterm deliveries were further classified into 3 subgroups: indicated, non-indicated or "elective", and spontaneous. Detailed description of each subgroup is provided under the Results section. Maternal and neonatal hospital charges by preterm delivery subgroup are reported. These charges were obtained from neonatal OSHPD records at the birth hospital only. In this analysis we did not account for newborn transfer charges; because 1.4% of all newborns and 5.9% of preterm newborns were transferred acutely elsewhere their neonatal charges are likely to be under-estimated.

A preexisting medical condition is an underlying condition that may be aggravated by the pregnancy. For the purpose of this study, we examined hypertension (excluding hypertension complicating pregnancy), diabetes (excluding gestational diabetes), thyroid disorders, asthma, heart disease, obesity, and mental illness. We also examined 3 risk behaviors: tobacco, alcohol and substance use. We recognize that there is substantial under-reporting of these diagnoses in hospital discharge data, and that the sensitivity and predictive value of these diagnoses have not been clearly established.

In addition, we included cesarean delivery in our study of maternal morbidity because it is a major operative procedure that could adversely affects a woman's physical health during childbirth beyond what would be expected in a normal delivery. Labor is identified using DRG codes 372, 373, 374, 375 or DRG codes 370, 371 and ICD-9-CM codes 653, 660, 661, 662, 6521, 6591, 6563, 6630, 6597. Prior cesarean delivery is identified using ICD-9-CM code 6542. Thus mode of delivery is determined as follow. Vaginal deliveries are categorized as vaginal with no prior cesarean (labor + no prior cesarean) and vaginal birth after cesarean (VBAC) (labor + prior cesarean + no cesarean). Cesarean deliveries are categorized as primary cesarean with labor (cesarean + no prior cesarean + labor), primary cesarean without labor

(cesarean + no prior cesarean + no labor), repeat cesarean without labor (cesarean + prior cesarean + no labor) and repeat cesarean with labor (cesarean + prior cesarean + labor).

Table 1: Indicators of Maternal Morbidity and Diagnostic Codes, Code Type, Sensitivity and Positive Predictive Value

Diagnosis or Procedure	Code Type	Codes	Sensitivity	Positive Predictive Value
Hypertension	ICD-9 Diagnosis	401, 402, 403, 404, 405, 642	88%	91%
Diabetes	ICD-9 Diagnosis	648.0, 648.8, 250	64%	96%
Chorioamnionitis	ICD-9 Diagnosis	658.4	79%	87%
Prolonged rupture of Membranes	ICD-9 Diagnosis	658.2	65%	66%
Preterm delivery	ICD-9 Diagnosis	644.2	77%	96%
Cesarean delivery	DRG	370,371	100%	100%
Instrumental Delivery	ICD-9 Procedure	720, 721, 722, 723, 724, 727, 728, 729	89%	99%
Hysterectomy	ICD-9 Procedure	683, 684, 685, 686, 687, 689	N/A	N/A
Thyroid	ICD-9 Diagnosis	648.1, 240-246	N/A	N/A
Asthma	ICD-9 Diagnosis	493	N/A	N/A
Heart	ICD-9 Diagnosis	648.5, 648.6, 745-747, 390-398, 410-429	N/A	N/A
Obesity	ICD-9 Diagnosis	278	N/A	N/A
Substance abuse	ICD-9 Diagnosis	648.3, 655.5, 304, 305.2-305.9	N/A	N/A
Mental disease	ICD-9 Diagnosis	648.4, V11, 290-302, 317-319	N/A	N/A
Alcohol abuse	ICD-9 Diagnosis	303, 305	N/A	N/A
Tobacco use	ICD-9 Diagnosis	305.1, V1582	N/A	N/A

Analyses

We conducted unadjusted and adjusted analyses. Covariate Trends and Unadjusted Rates are provided in Appendices A and B, respectively. Variables used for adjusted analyses include maternal age, maternal race-ethnicity, maternal education, insurance status, parity and prenatal care adequacy. Race-ethnicity was categorized as Asian/Pacific Islander, Native American, Hispanic, Non-Hispanic Black (African-American), and Non-Hispanic White (Caucasian). Maternal education was categorized to elementary, secondary, college and graduate. Insurance status was categorized as Private, MediCal and other. Route of delivery was categorized into 6 categories: vaginal with no prior cesarean, VBAC, primary cesarean with labor, primary cesarean without labor, repeat cesarean without labor, and failed VBAC. Hospital annual delivery volume was categorized to small (50-749), medium (750-2499) and large (≥2500), based on rounded empirical cutoff points for the lower quartile (50-749), middle 50% of hospitals (750-2499) and upper quartile (>=2500) of annual delivery volume. Hospital ownership was categorized into Corporate (For Profit), Not for Profit, County/District, State and Church. Two additional dichotomous hospital characteristics used for adjustments were teaching status and NICU availability.

Hierarchical logistic regression models were used for adjusted analyses of trends in maternal morbidity. Models were implemented using generalized mixed models (SAS Glimmix procedure) with random intercepts for hospitals or counties. Models for cesareans, instrumental delivery, chorioamnionitis, PROM and preterm delivery used hospitals as a higher level cluster. Models for hysterectomy, diabetes and hypertension used counties as a higher level cluster. For hysterectomy we used county instead of hospital as a cluster due to its very low frequency. For diabetes and hypertension we used county as a cluster since these conditions are more likely to be associated with an area rather than a specific hospital. All models were adjusted for maternal age, maternal race, maternal education, parity and prenatal care adequacy. In addition, models were adjusted for preterm delivery (except for preterm outcomes), for C-section delivery route and prior C-section (except for C-section which is not adjusted for C-section and for primary C-section that is not adjusted for both C-section and prior C-section). Models for cesarean delivery, primary cesarean delivery, instrumental delivery, chorioamnionitis, PROM and preterm birth also are adjusted for hospital delivery volume, hospital OB teaching status and NICU availability in addition to the hospital random intercepts. Models for the rest of the conditions (hysterectomy, hypertension and diabetes) used patients

within county and had no further adjustments other than the county random intercepts. All models, with the exception of chorioamnionitis and PROM, had hospital ownership omitted as a covariate due to non-convergence.

Trends over the 3 time points 1999, 2002, and 2005 were tested using two methods:

1. Linear Trend: A linear trend using a continuous time variable with equidistant values (1, 2, and 3). The estimated odds ratios (OR) and 95% confidence intervals (CI) were reported and represented change in the risk of each maternal morbidity per 3 year periods.

2. Relative Change: Individual 3-year period changes for 2002 vs. 1999, 2005 vs. 2002, and overall 6 years for 2005 relative to 1999 using indicator variables for 2002 and 2005. Odds ratios and 95% confidence intervals were reported and represented change in the risk of each maternal morbidity over the two 3 year periods and over the entire 6 year period.

Results using both methods are reported in Appendix C. For all maternal morbidity, rates are reported using the denominator of all deliveries, with the exception of instrumental deliveries, which is reported with a denominator of all vaginal deliveries. In addition, preterm delivery subgroups are analyzed separately.

III. RESULTS

In this section we show trends for maternal morbidity in California from 1999 to 2005.

1. Hypertension

For the purpose of this analysis, we included essential hypertension (ICD-9-CM code 401), hypertensive heart disease (402), hypertensive renal disease (403), hypertensive heart and renal disease (404), secondary hypertension (405), as well as hypertension (642). Adjusted estimates indicated a significant increase in hypertension associated with deliveries in California from 5.52% of all deliveries in 1999 to 5.80% in 2002 to 6.30% in 2005. This represents a significant 14% increase in maternal hypertension over the study period ($p<0.0001$) (Figure 3).

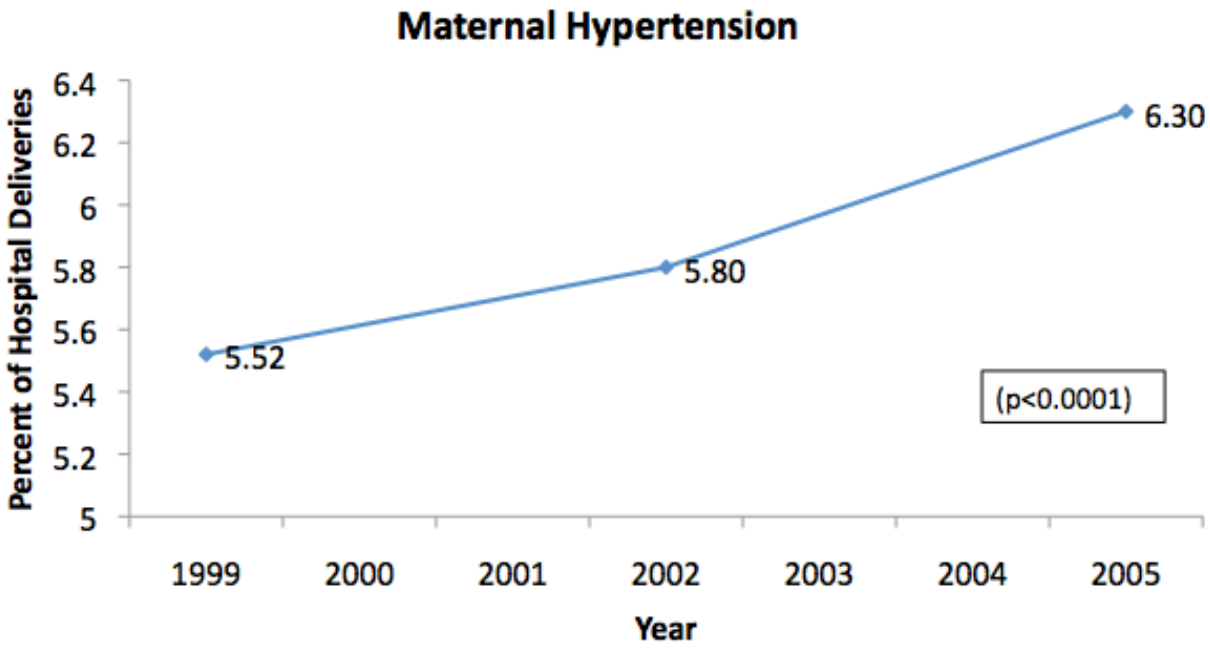


Figure 3. Adjusted Trends in Maternal Hypertension in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

1a. Pre-Gestational Hypertension

Adjusted estimates indicated a significant increase in pre-gestational hypertension (including all ICD-9-CM codes 401-405 and 642.0,1,2) from 0.63% in 1999 to 0.72% in 2002 to 0.93% in 2005. This represents a significant 47% increase in pre-gestational hypertension over the study period ($p<0.0001$) (Figure 3a).

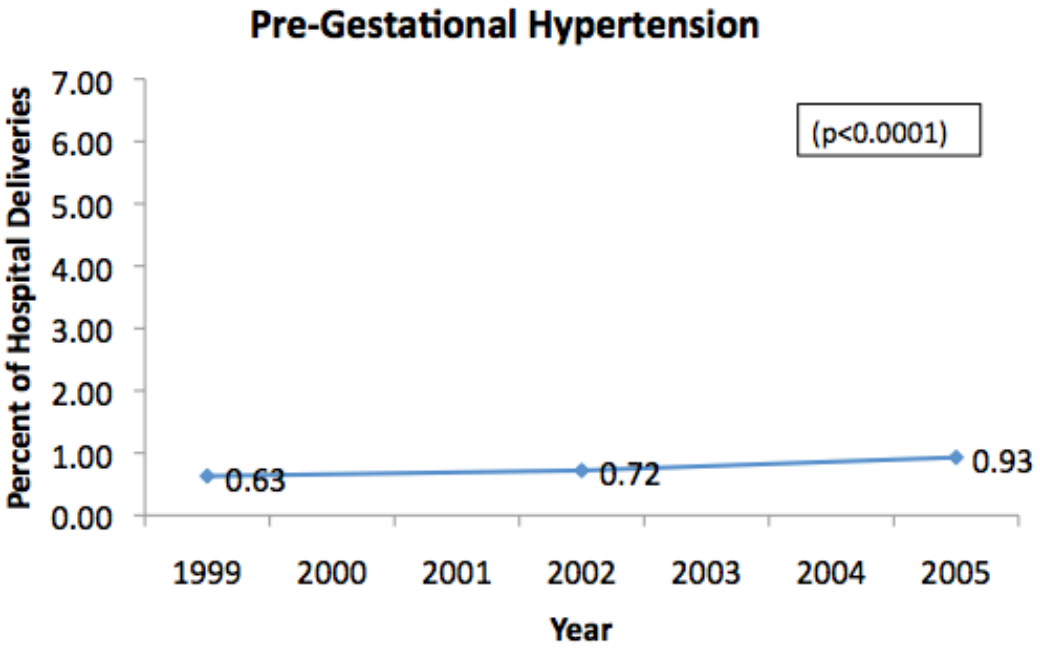


Figure 3a. Adjusted Trends in Pre-Gestational Hypertension in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

1b. Gestational Hypertension

Adjusted estimates for gestational hypertension (ICD-9-CM 642.3,4,5,6,7) also indicated a significant increase from 4.36% of all deliveries in 1999 to 4.70% in 2002 to 4.91% in 2005. This represents a significant 13% increase in gestational hypertension over the study period (p=0.007) (Figure 3b).

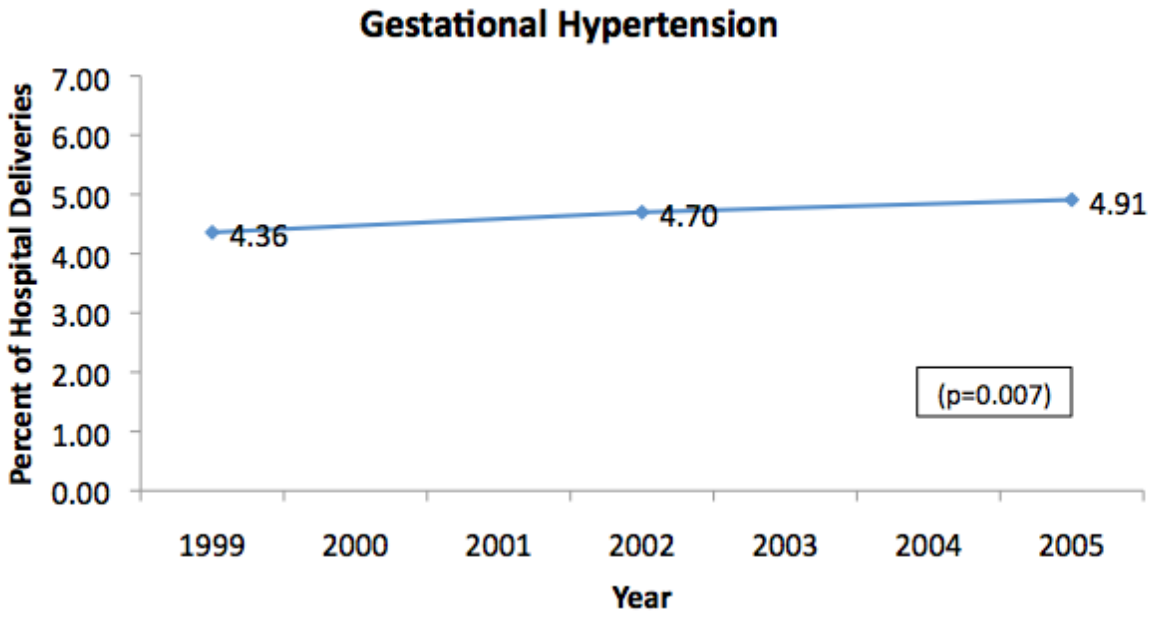


Figure 3b. Adjusted Trends in Gestational Hypertension in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

2. Diabetes

For diabetes, we included both pregestational diabetes (250) and diabetes mellitus (6480) or glucose intolerance (6488) complicating pregnancy, childbirth, or the puerperium. Adjusted estimates indicated a significant increase in diabetes associated with deliveries in California from 4.55% of all deliveries in 1999 to 5.80% in 2002 to 6.50% in 2005. This represents a significant 43% increase in maternal diabetes over the study period (p<0.0001) (Figure 4).

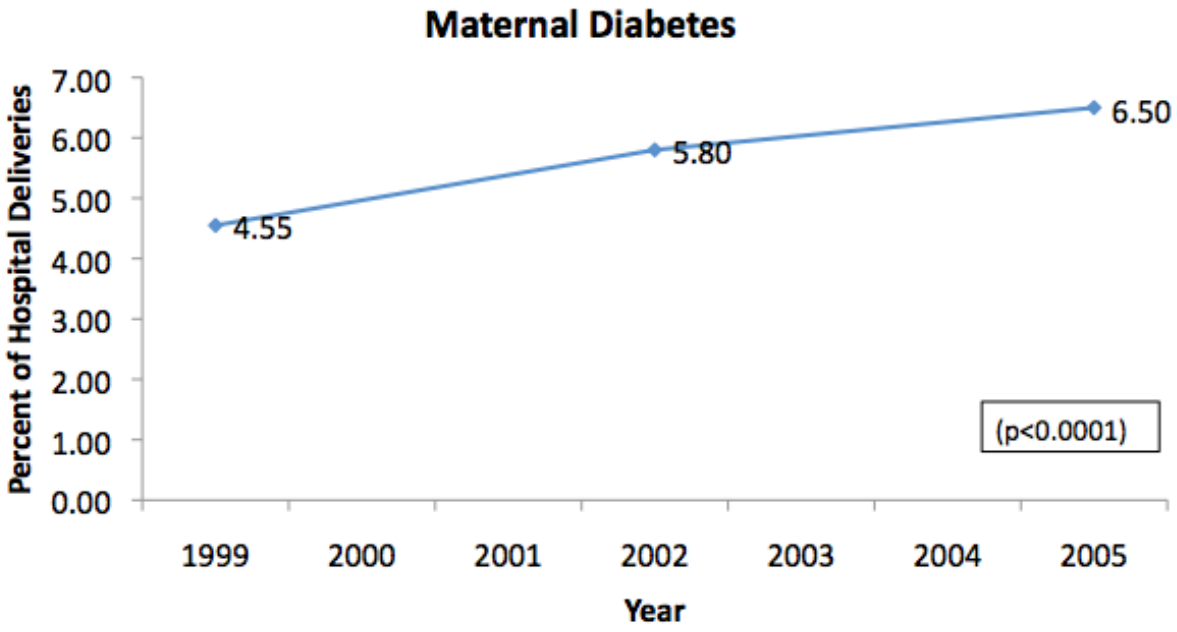


Figure 4. Adjusted Trends of Maternal Diabetes in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

2a. Pre-Gestational Diabetes

For pre-gestational diabetes (ICD-9-CM 250), adjusted estimates indicated a significant increase from 0.65% of all deliveries in 1999 to 0.81% in 2002 to 0.83% in 2005. This represents a significant 28% increase in pre-gestational diabetes over the study period (p<0.0001) (Figure 4a).

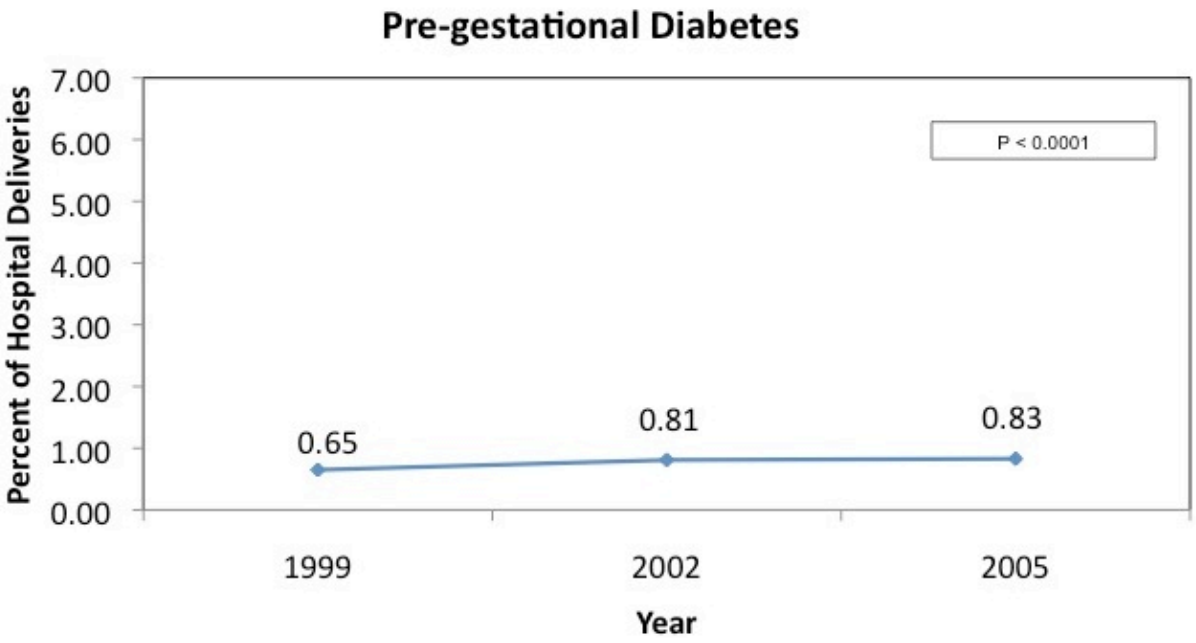


Figure 4a. Adjusted Trends of Pre-Gestational Diabetes in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

2b. Gestational Diabetes

For gestational diabetes (ICD-9-CM 6480 and 6488), adjusted estimates also show a significant increase in gestational diabetes associated with deliveries in California from 3.96% of all deliveries in 1999 to 5.01% in 2002 to 5.71% in 2005. This represents a significant 44% increase in gestational diabetes over the study period ($p<0.0001$) (Figure 4b).

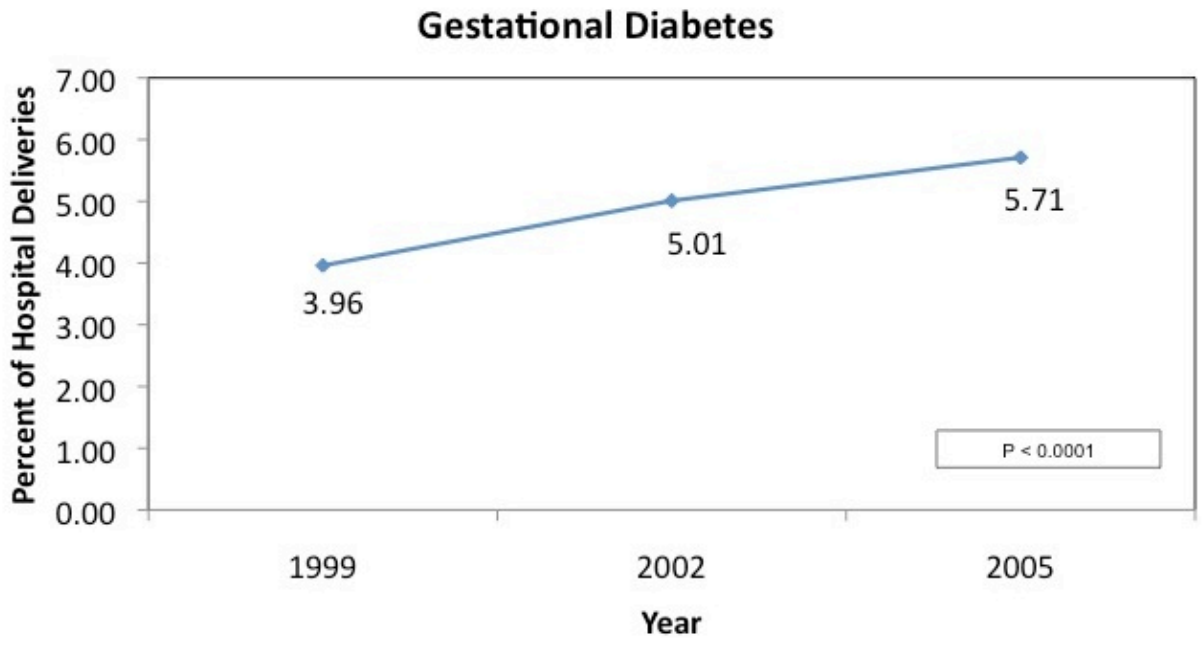


Figure 4b. Adjusted Trends of Gestational Diabetes in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

3. Chorioamnionitis

For chorioamnionitis, we used ICD-9-CM code 658.4 (infection of the amniotic cavity and inflammation of the amnion). Adjusted estimates indicated an initial increase in chorioamnionitis in California by about 5.8% (OR = 1.01) over Years 99 to 02 followed by an increase of 4.0% (OR = 1.04) over Years 02 to 05. The adjusted estimates were 1.89%, 2.00%, and 2.08% for Years 99, 02 and 05 respectively. Overall, this represents a non-significant 10% increase in chorioamnionitis over the study period (p=0.0511) (Figure 5).

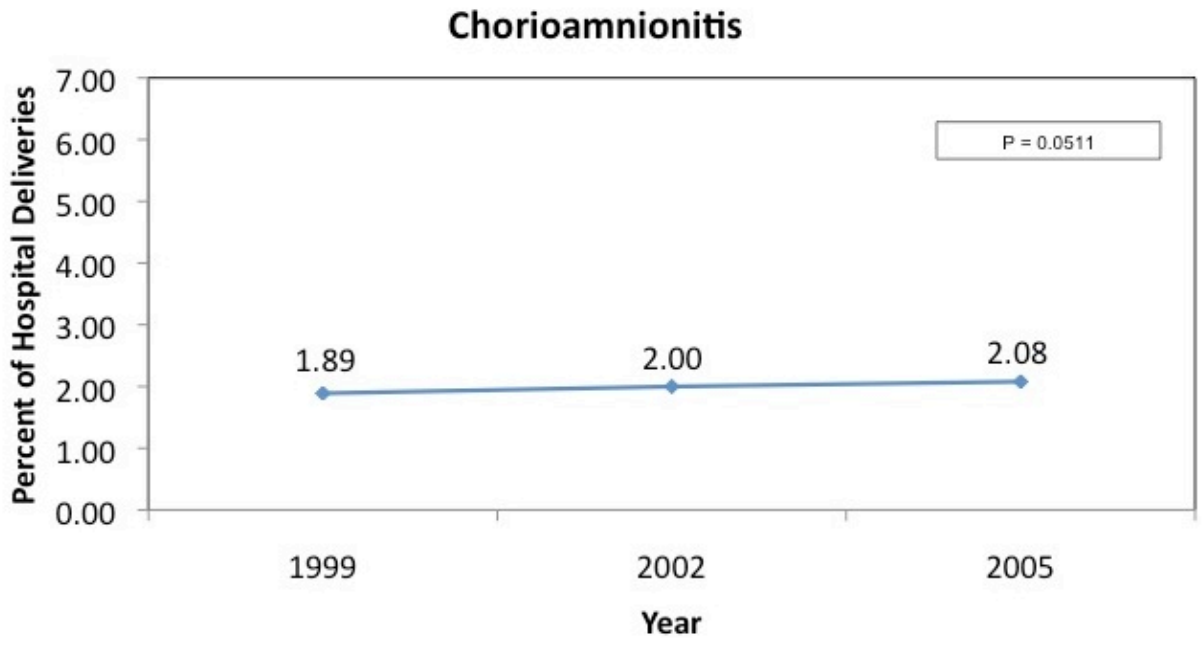


Figure 5. Adjusted Trends of Chorioamnionitis in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

4. Prolonged Rupture of Membranes (PROM)

For PROM, we used ICD-9-CM code 658.2 (delayed delivery after spontaneous or unspecified rupture of membranes). Adjusted estimates indicated a significant decrease in PROM in California from 1.44% of all deliveries in 1999 to 1.41% in 2002 to 1.00% in 2005. This represents a significant 31% decrease in prolonged rupture of membranes over the study period ($p<0.0001$) (Figure 6).

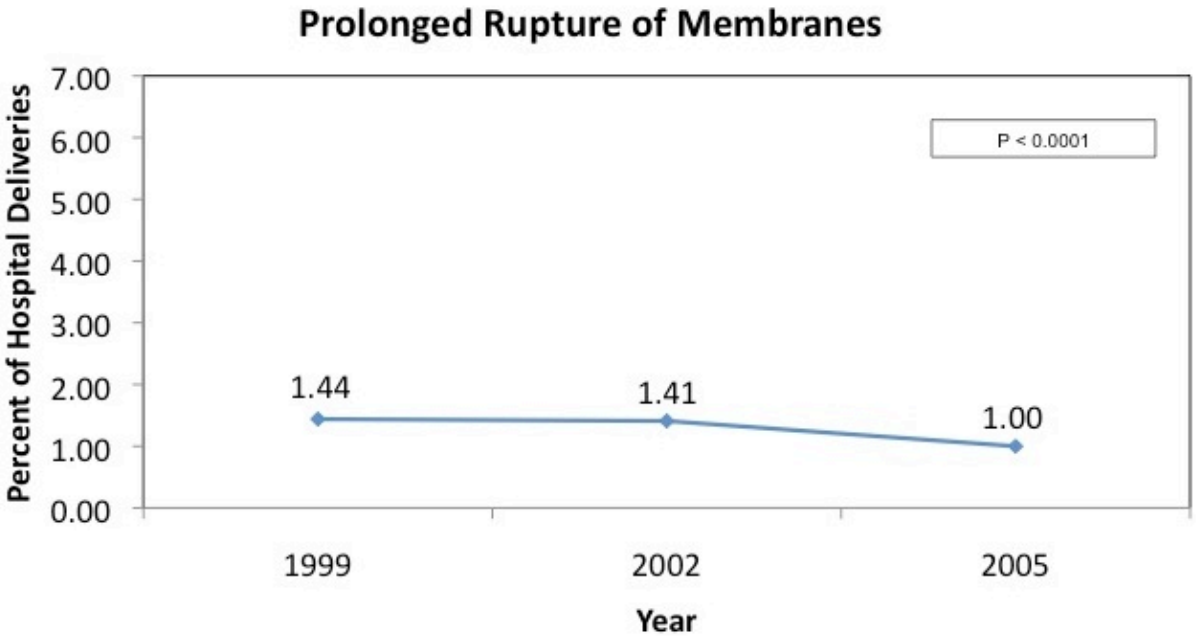


Figure 6. Adjusted Trends of Prolonged Rupture of Membranes in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

5. Preterm Delivery

For preterm delivery, we used ICD-9-CM codes 644.2 (Early onset of delivery). Adjusted estimates indicated a significant increase in preterm birth in California from 5.48% of all deliveries in 1999 to 6.09% in 2002 to 6.61% in 2005. This represents a 21% increase in preterm delivery over the study period (p<0.0001) (Figure 7).

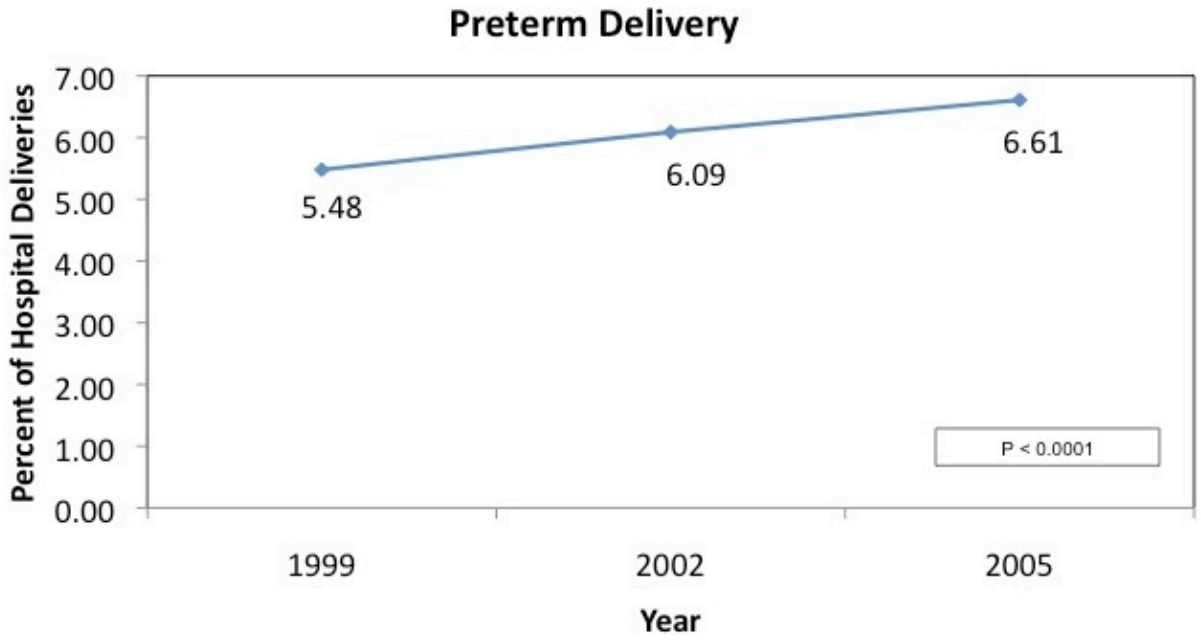


Figure 7. Adjusted Trends of Preterm Delivery in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

5a. Non-Indicated Preterm Delivery

Furthermore, we conducted trend analyses of preterm delivery subgroups. We categorized preterm delivery into 3 groups, using methodology adapted from Ananth and Vintzileos (2006). The denominator was all preterm births which we defined using birth certificate gestational age, sub-setting all deliveries with gestation >139 and <260 days. Multiple gestation and intrauterine fetal demise (IUFD) deliveries are excluded from this analysis.

For numerator, preterm deliveries were classified into one of three groups –

Group 1: Preterm deliveries with medical/obstetrical complications as specified, with any one of these conditions

- Hypertension (642, 401, 402, 403, 404, 405)
- Bleeding/previa (641)
- IUGR/SGA (656.5)
- Fetal distress (656.3)
- Isoimmunization (656.1,2)
- Maternal Cardiac (648.5,6)
- Maternal Renal (646.2)

Group 2: Preterm delivery without medical/obstetrical complications specified ("Elective" or "Non-Indicated") but with any one of the following coded interventions:

- Elective primary or repeat C-section
- Induction noted in birth certificate (labor problem code 11)
- Surgical or Medical induction (procedure codes 73.1, 73.01, 73.4)
- Failed induction (659.0,1)

Women with premature or prolonged rupture of membranes (658.1, 658.2) were excluded from this Group.

Group 3: Spontaneous preterm delivery, including all uncomplicated preterm deliveries not included in Groups 1 and 2 above (remaining preterm births).

Limitations regarding interpretation of these three Groups are as follow:

Group 1: Preterm births associated with serious complications that might justify early delivery. This group may be slightly over-counted because fetal distress may occur before labor, and may serve as an indication for delivery (appropriate classification), or it may occur after spontaneous labor has already begun (misclassification). Also, this group may be under-counted because of lack of documentation of serious complications.

Group 2: Preterm births without serious complications that could justify early delivery, associated with an elective delivery as coded in the birth certificate or discharge record. This group is likely to be under-counted because of poor documentation regarding induction, but may be over-counted because of poor documentation regarding ruptured membranes, which is associated with spontaneous preterm birth.

Group 3: All preterm births without serious complications or indication of an elective delivery. This group is likely to be over-counted because of failure to document elective delivery (cesarean or induction) to place in Group 2.

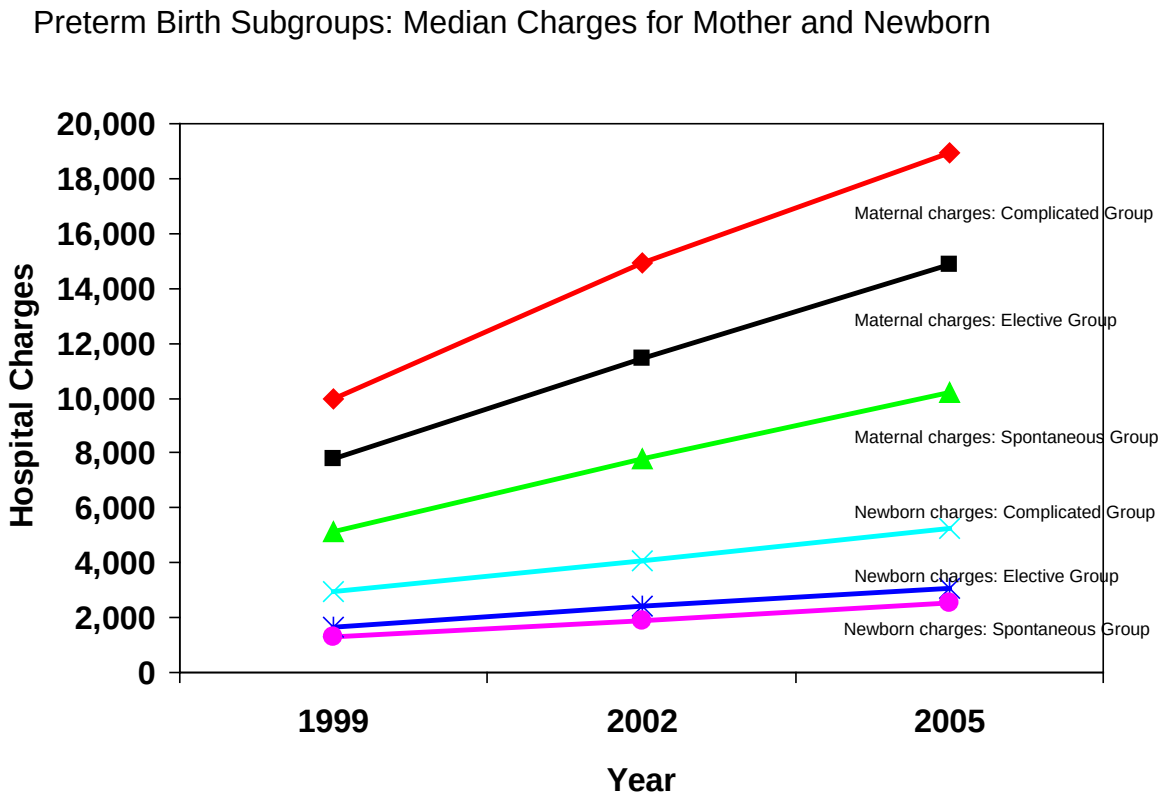
These limitations notwithstanding, Table 2 shows an increase in preterm deliveries without medical/obstetrical complications, suggesting an increased trend in ”elective“ preterm deliveries from 15.5% in 1999 to 20.8% in 2005 ($p<0.0001$).

Table 2: Adjusted Trends in Preterm Delivery (PTD) in All Hospital Deliveries in California in 1999, 2002 and 2005, by types of PTD. OSHPD data, N= 147,223

Group	1999	2002	2005
Group 1: PTD with complications	**20.8%**	**21.8%**	**22.5%**
Group 2: PTD w/o complications	**15.3%**	**17.4%**	**20.7%**
Group 3: Spontaneous PTD	**63.9%**	**60.8%**	**56.8%**

Figure 8 illustrates the median maternal and neonatal hospital charges for preterm delivery stratified by Group. For all Groups, maternal median charges were higher than newborn charges, and the "elective" or "uncomplicated" preterm delivery Group (Group 2) had higher charges than the spontaneous labor Group (Group 3).

Figure 8. Median charges for mother and newborn by preterm birth subgroups in California in 1999, 2002 and 2005, OSHPD data, N (total deliveries) = 147,223.



6. Cesarean Delivery

We used DRG codes 370 and 371 to identify cesarean deliveries. Adjusted estimates indicated a significant increase in cesarean deliveries in California, from 22.89% of all deliveries in 1999 to 26.93% in 2002 to 30.82% in 2005. This represents a 35% increase in cesarean deliveries over the study period ($p<0.0001$) (Figure 9).

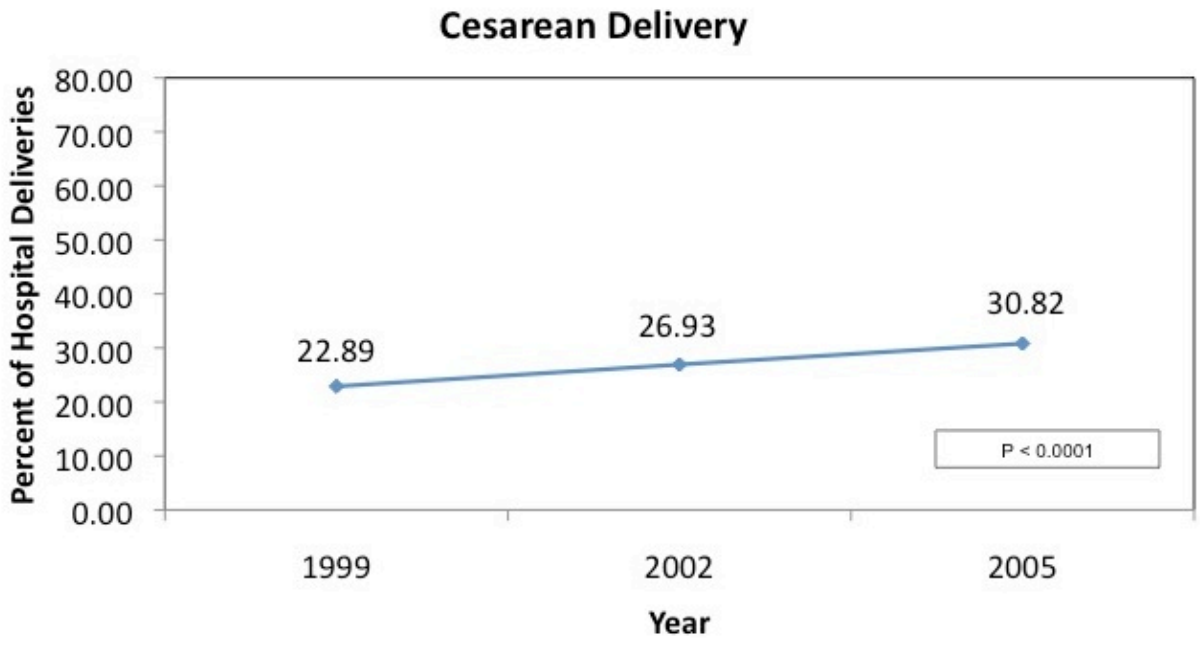


Figure 9. Adjusted Trends of Cesarean Delivery in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

We conducted trends analyses on the 4 cesarean subgroups.

6a. Primary cesarean with labor

Primary cesarean with labor accounted for 9.2% of all deliveries in 1999, 10.3% of deliveries in 2002 and 11.2% of deliveries in 2005, which is a significant 22% increase in primary cesarean with labor over the study period ($p<0.0001$) (Figure 10).

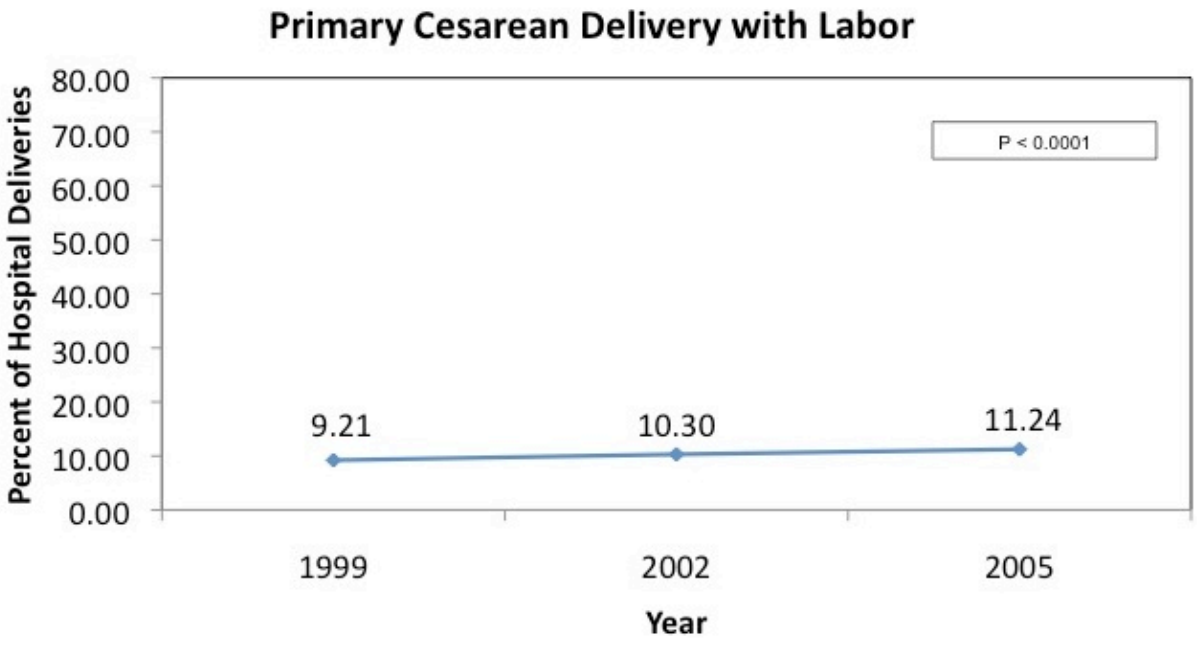


Figure 10. Adjusted Trends of **Primary** Cesarean Delivery **with** Labor Rate in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data,
N= 1,551,017.

6b. Primary cesarean without labor

Primary cesarean without labor, often referred to as "elective primary cesarean," accounted for 4.5% of all deliveries in 1999, 5.0% of deliveries in 2002 and 6.0% of deliveries in 2005, which is a significant 33% increase in primary cesarean delivery without labor over the study period ($p<0.0001$) (Figure 11).

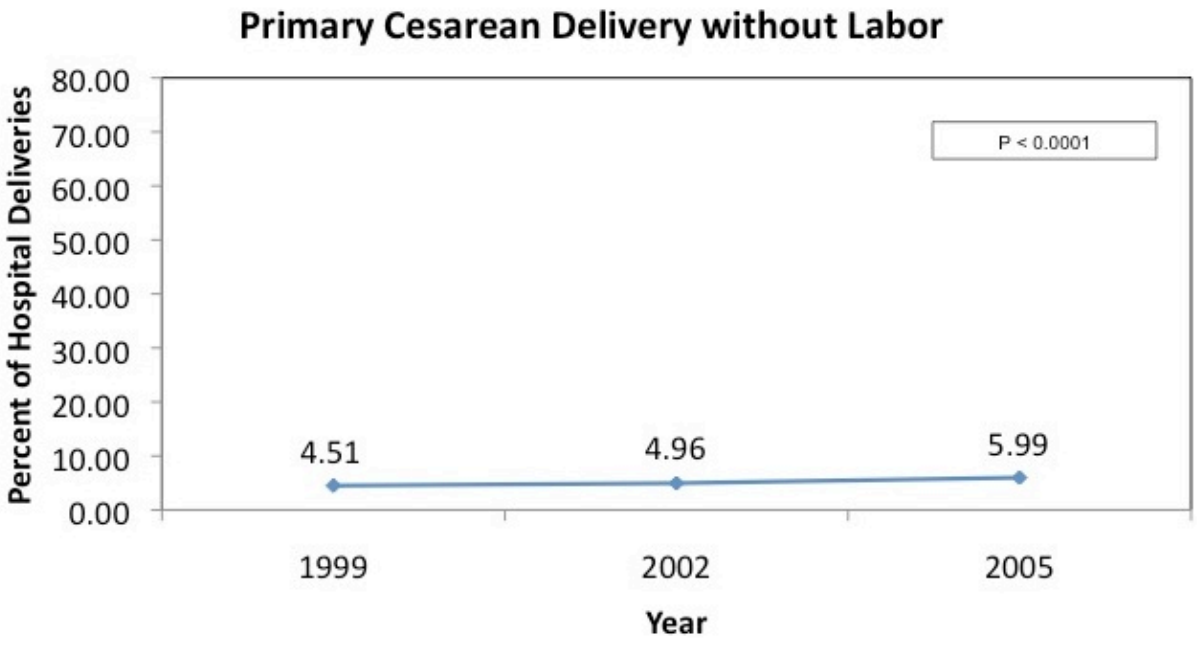


Figure 11. Unadjusted Trends of **Primary** Cesarean Deliveries **without** Labor in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data,
N= 1,551,017.

6c. Repeat cesarean with labor

Repeat cesarean with labor, often referred to as "failed VBAC," accounted for 1.7% of all deliveries in 1999, 1.3% of deliveries in 2002 and less than 1% of deliveries in 2005, which is a significant 42% decrease in repeat cesarean delivery with labor over the study period (Figure 12). When considering the proportion of failed VBAC out of attempted VBAC, the trend in failed VBAC increased from 31.27% in 1999, 35.16% in 2002, to 41.23% in 2005. This represents a significant 32% increase in the proportion of failed VBAC out of attempted VBAC ($p<0.0001$).

Figure 12. Unadjusted Trends of **Repeat** Cesarean **with** Labor (**Failed** Vaginal Birth After Cesarean (**VBAC**) in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

6d. Repeat cesarean without labor

Repeat cesarean without labor, commonly referred to as "elective repeat cesarean," accounted for 7.4% of all deliveries in 1999, 10.3% of deliveries in 2002 and 12.5% of deliveries in 2005, which is a significant 69% increase in repeat cesarean delivery without labor (Figure 13):

Figure 13. Unadjusted Trends of **Repeat** Cesarean Deliveries **without** Labor in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data,
N= 1,551,017.

We also conducted trends analyses on the 2 vaginal delivery subgroups: vaginal birth without prior cesarean and vaginal birth after cesarean (VBAC).

6e. Vaginal birth without prior cesarean

As seen in Figure 14, the proportion of women who had a vaginal birth without prior cesarean decreased slightly by a factor of 7%, from 73.4% in 1999 to 67.9% in 2005 (p<0.0001).

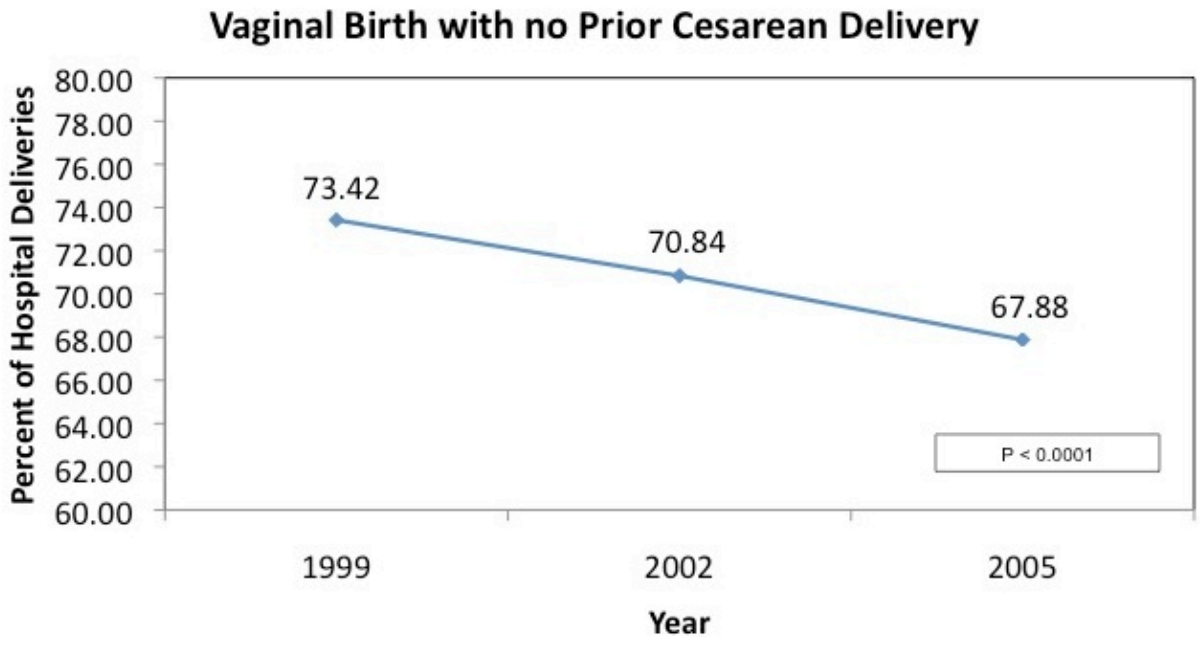


Figure 14. Unadjusted Trends of Vaginal Birth with no Prior Cesarean Delivery in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

6f. Vaginal birth after cesarean (VBAC)

Vaginal birth after cesarean (VBAC) were relatively few and decreased from 3.75% in 1999 to 1.41% in 2005 ($p<0.0001$). This represents a significant 62% decrease in VBAC over the study period (Figure 15).

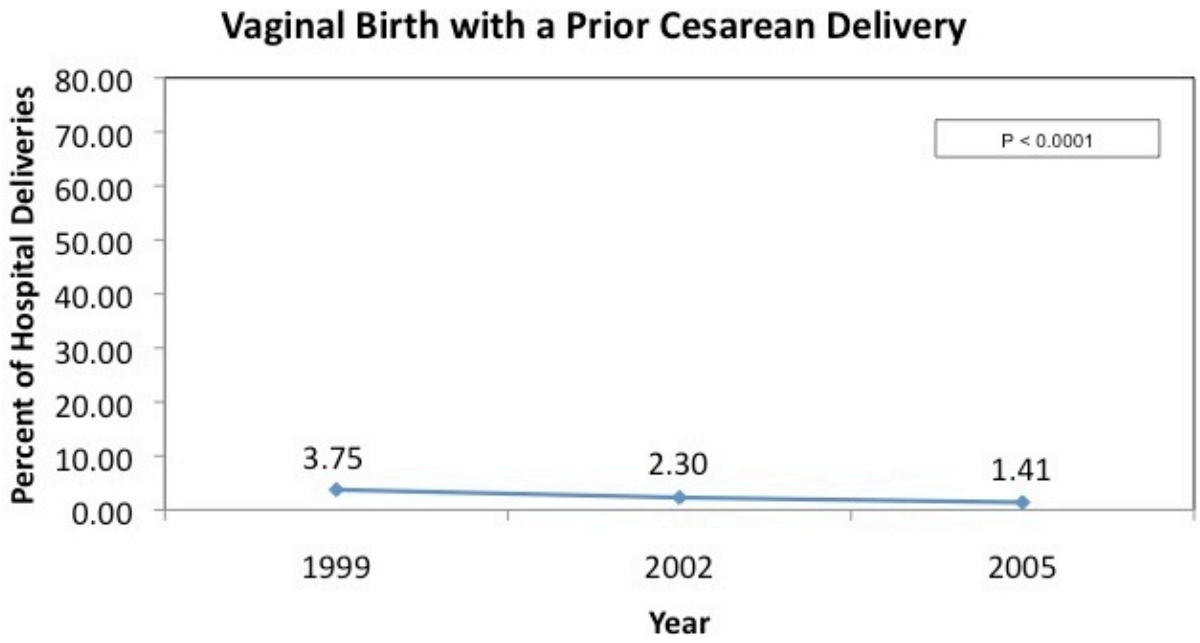


Figure 15. Unadjusted Trends of Vaginal Birth After Cesarean (VBAC) in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

7. Instrumental Vaginal Delivery

Instrumental vaginal delivery includes both vacuum and forcep-assisted vaginal deliveries. Adjusted estimates indicated a significant drop in instrumental vaginal delivery in California, from 12.56% of all vaginal deliveries in 1999 to 11.27% in 2002 to 9.76% in 2005. This represents a significant 22% decrease in instrumental vaginal deliveries over the study period ($p<0.0001$) (Figure 16).

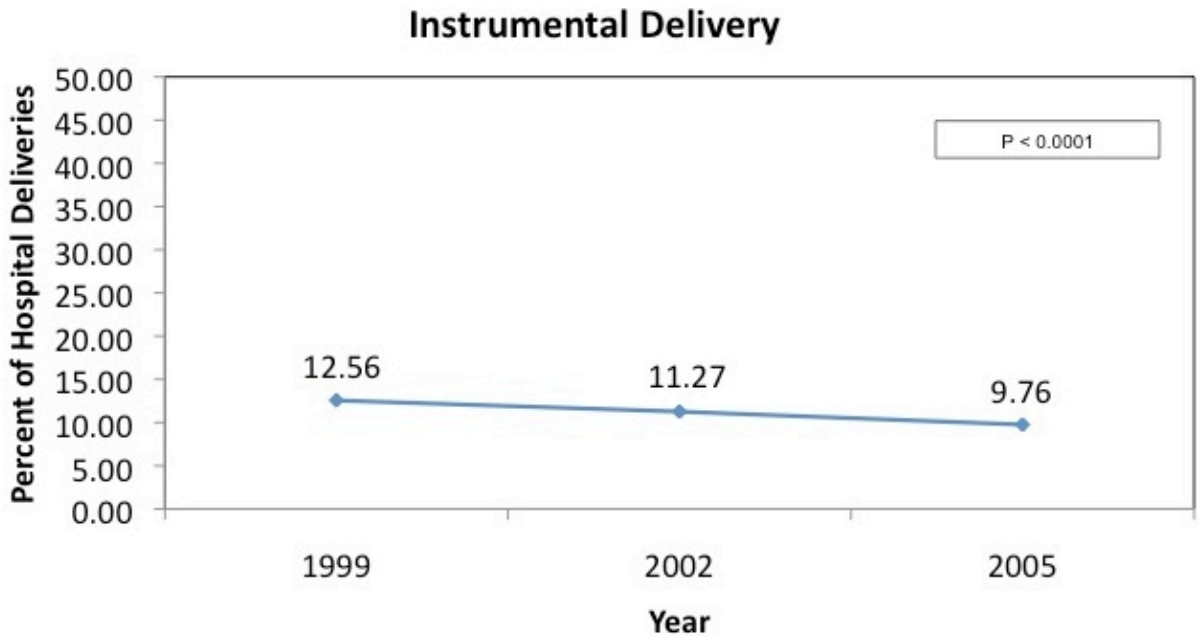


Figure 16. Adjusted Trends of Instrumental Vaginal Delivery Rate in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,134,167.

8. Hysterectomy

Adjusted estimates indicated no significant change in hysterectomy rates (0.07% of all deliveries) in California in 1999, 2002, and 2005 (Figure 17).

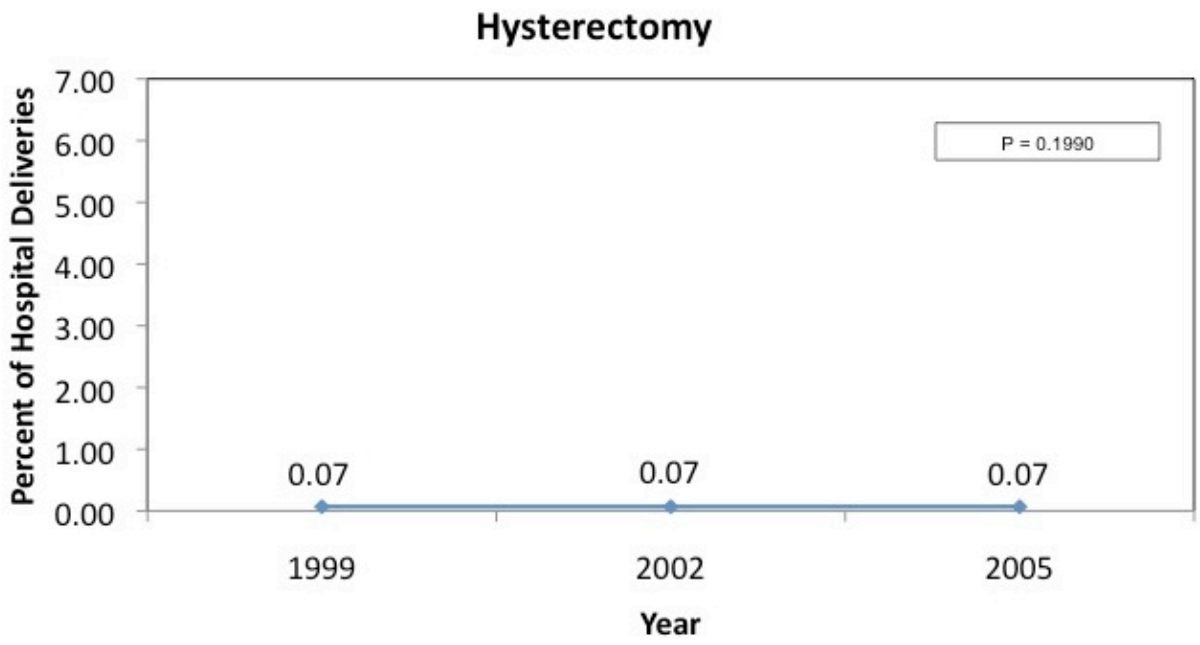


Figure 17. Adjusted Trends of Hysterectomy in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

9. Heart Disease

We conducted trends analyses for heart disease (648.5, 648.6, 745-747, 390-398, and 410-429). Adjusted estimates indicated a trend toward increase in heart disease associated with deliveries in California from 0.67% of all deliveries in 1999 to 0.66% in 2002 to 0.69% in 2005. This represents a 3% increase in maternal heart disease over the study period, though this trend is not statistically significant (p=0.0735) (Figure 18).

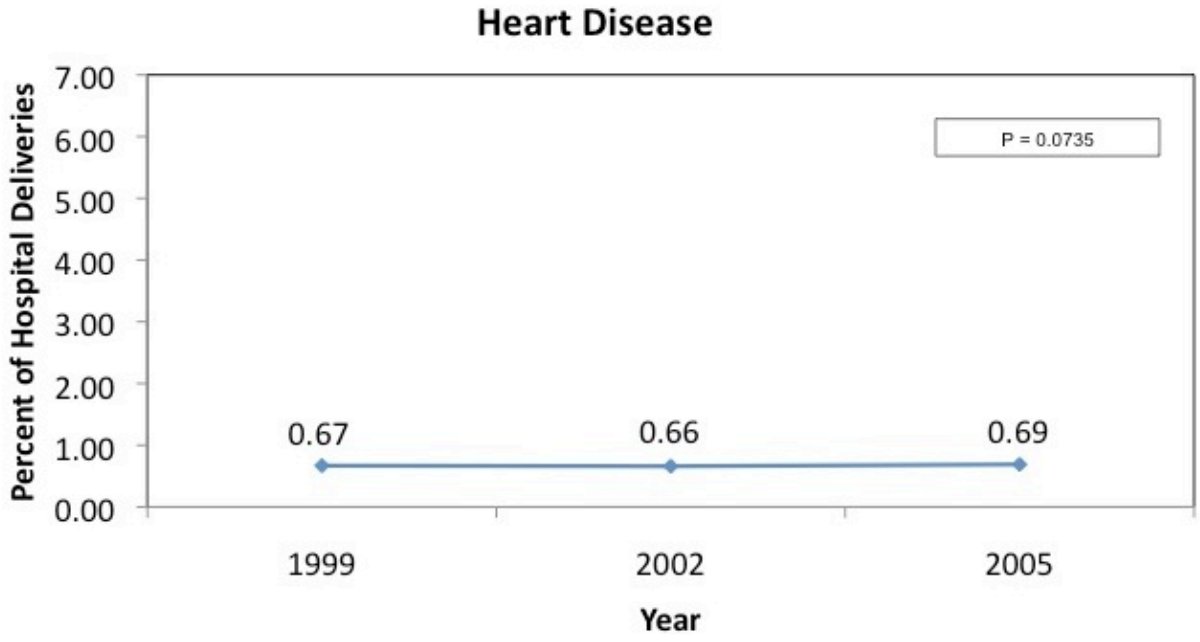


Figure 18. Adjusted Trends of Heart Disease in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

10. Asthma

Trend analyses on asthma (ICD-9 code 493) showed adjusted estimates that indicate a significant increase in asthma associated with deliveries in California from 1.02% of all deliveries in 1999 to 1.12% in 2002 to 1.78% in 2005. This represents a 75% increase in maternal asthma over the study period ($p<0.0001$) (Figure 19).

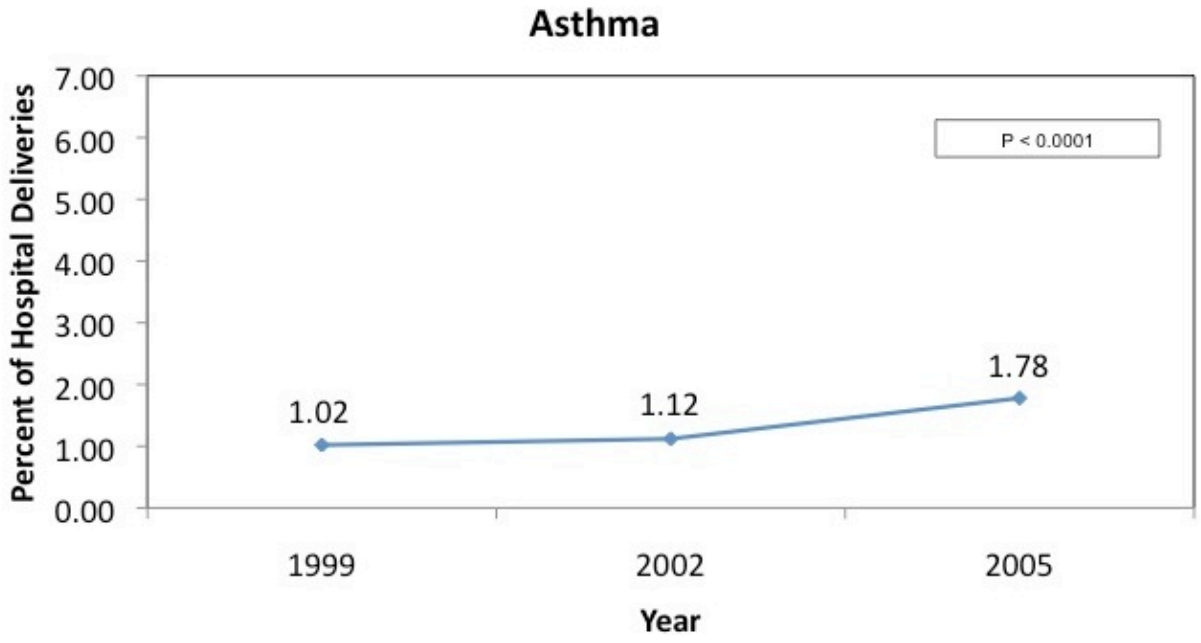


Figure 19. Adjusted Trends of Asthma in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

11. Thyroid Disorders

We conducted trend analyses on thyroid disorders (including 648.1 and 240-246). Adjusted estimates indicated a significant increase in California from 0.81% of all deliveries in 1999 to 1.02% in 2002 to 1.31% in 2005. This represents a 62% increase in maternal thyroid over the study period ($p<0.0001$) (Figure 20).

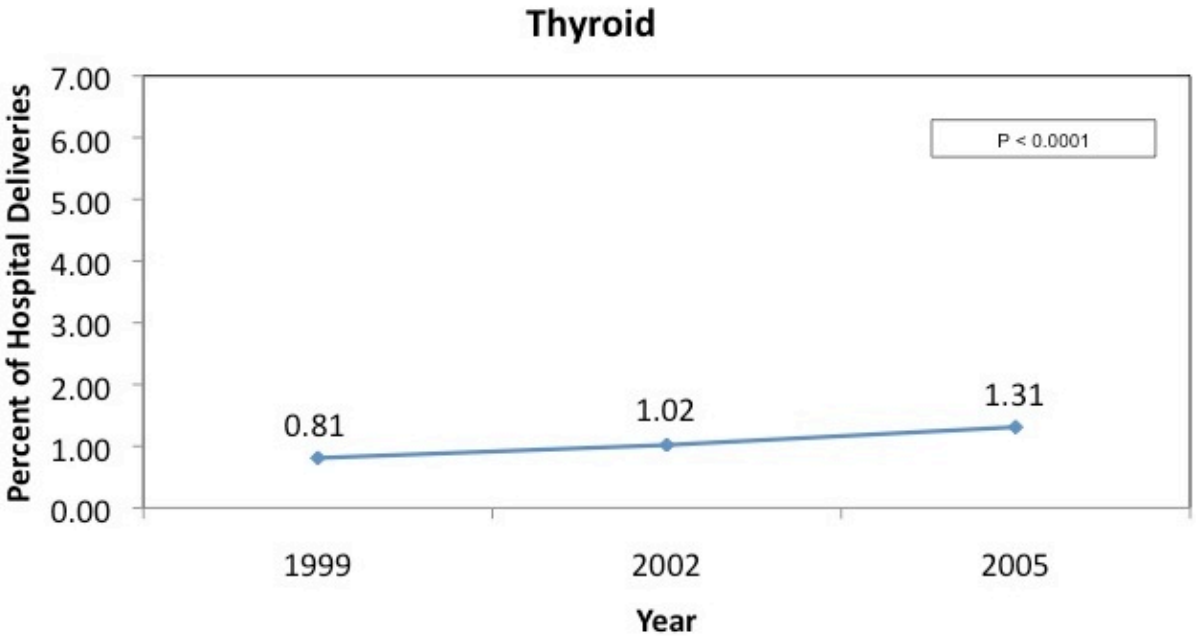


Figure 20. Adjusted Trends of Thyroid in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

12. Obesity

For obesity, we used ICD-9-CM code 278. Adjusted estimates indicated a significant increase in obesity in California from 0.84% of all deliveries in 1999 to 0.96% in 2002 to 1.30% in 2005. This represents a 55% increase in obesity over the study period (p<0.0001) (Figure 21).

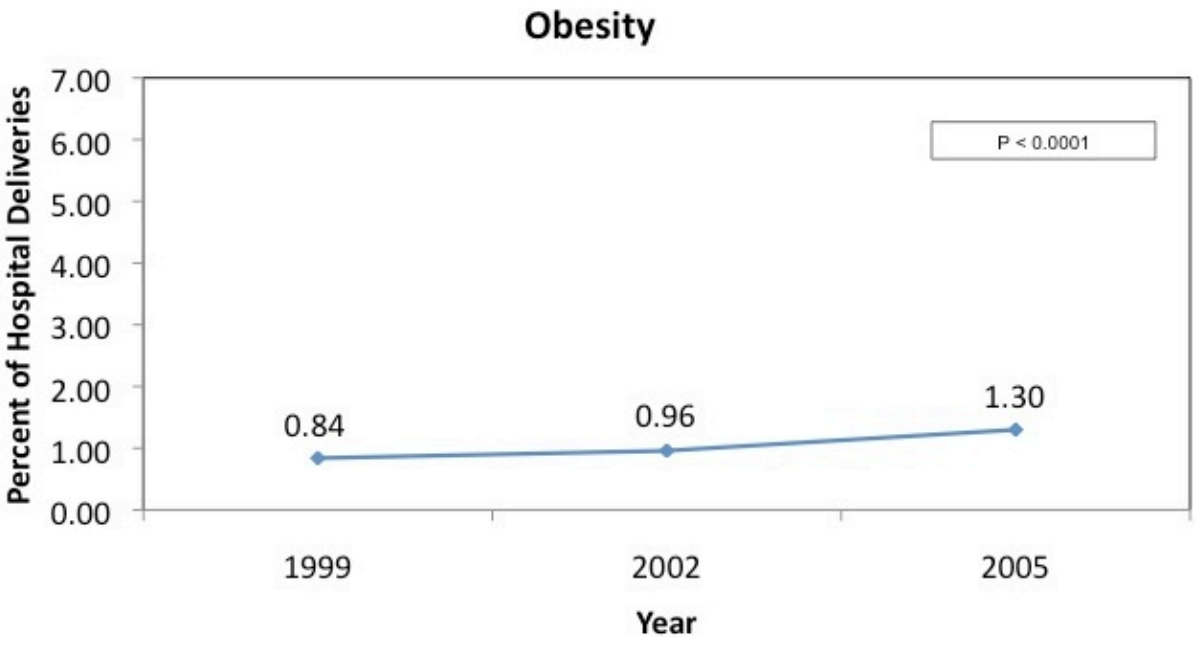


Figure 21. Adjusted Trends of Obesity in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

13. Substance use

We used ICD-9 codes 648.3, 655.5, 304 and 305.2-305.9 to identify substance use. Unadjusted estimates indicated a significant increase in substance abuse in California, from 1.10% of all deliveries in 1999 to 1.04% in 2002 to 1.31% in 2005. This represents a 19% increase in substance use over the study period (p<0.0001) (Figure 22).

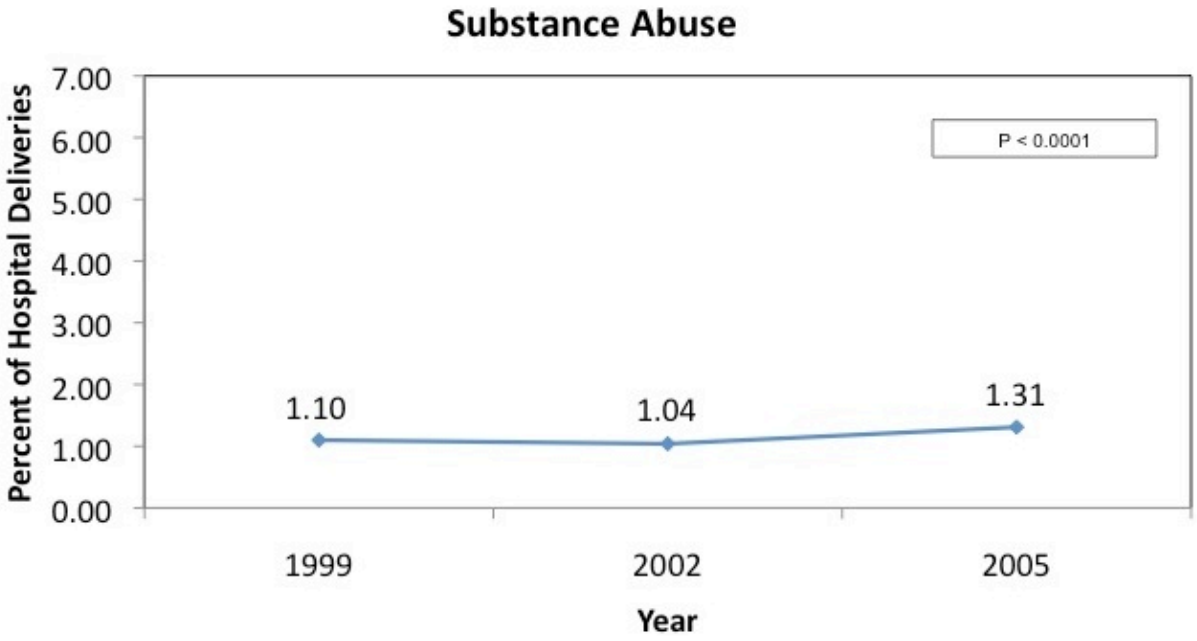


Figure 22. Unadjusted Trends of Substance Use in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

14. Mental Illness

Mental illness includes ICD-9 codes 648.4, V11, 290-302, and 317-319. Unadjusted estimates indicated a significant increase in mental illness in California, from 1.77% of all vaginal deliveries in 1999 to 2.12% in 2002 to 2.92% in 2005. This represents a significant 65% increase in mental illness over the study period (p<0.0001) (Figure 23).

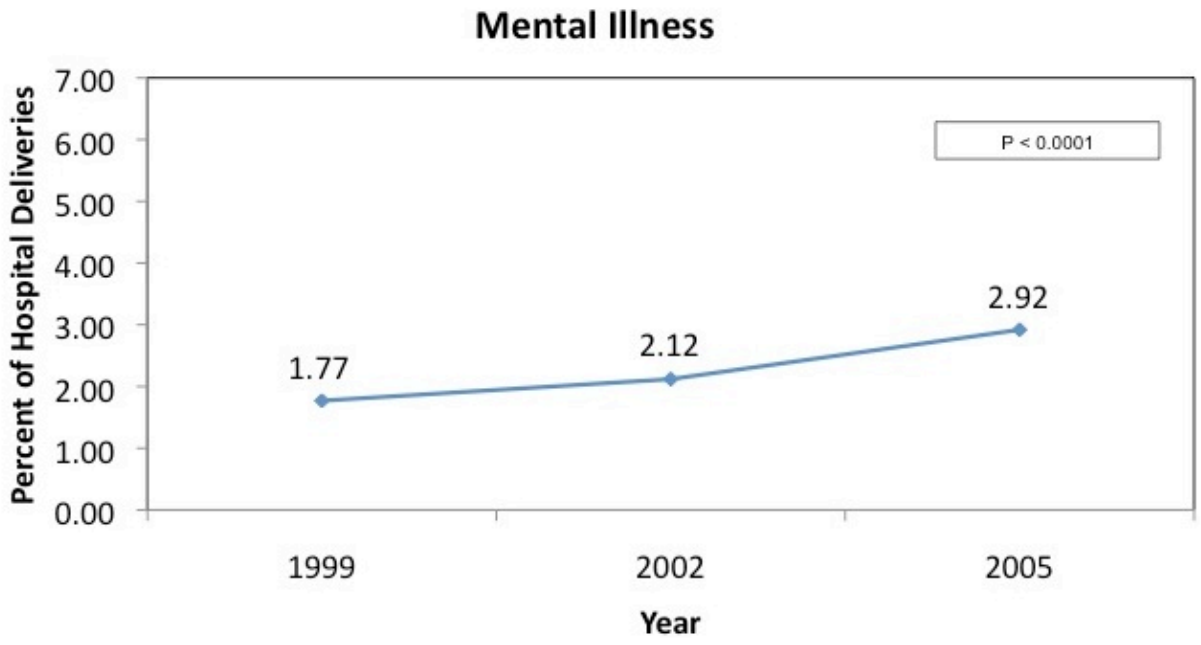


Figure 23. Unadjusted Trends of Mental Illness in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

15. Alcohol Abuse

Unadjusted estimates indicated no significant change in the prevalence of alcohol use during pregnancy (ICD-9 codes 303 and 305.0) in California, from 0.11% of all deliveries in 1999 to 0.11% in 2002 to 0.10% in 2005 (p=0.1489) (Figure 24).

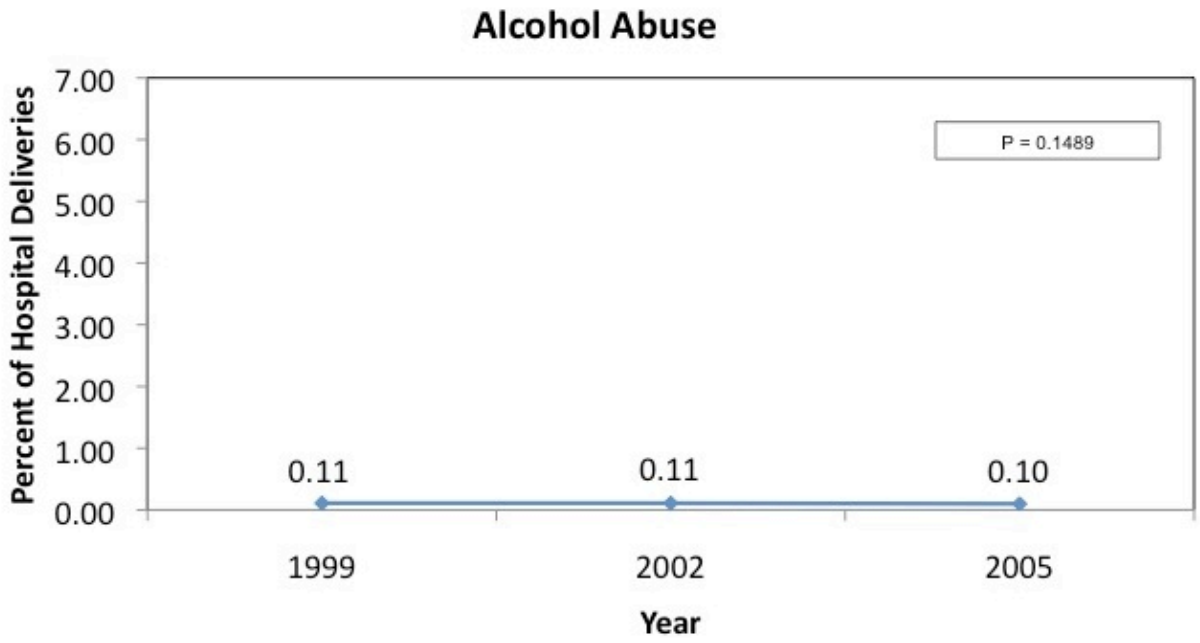


Figure 24. Unadjusted Trends of Alcohol Abuse in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

16. Tobacco Use

Trend analyses on tobacco use (ICD-9-CM codes 305.1 and V1582) showed unadjusted estimates that indicate a significant increase in tobacco use associated with deliveries in California from 1.26% of all deliveries in 1999 to 1.27% in 2002 to 1.62% in 2005. This represents a 29% increase in maternal tobacco use over the study period ($p<0.0001$) (Figure 25).

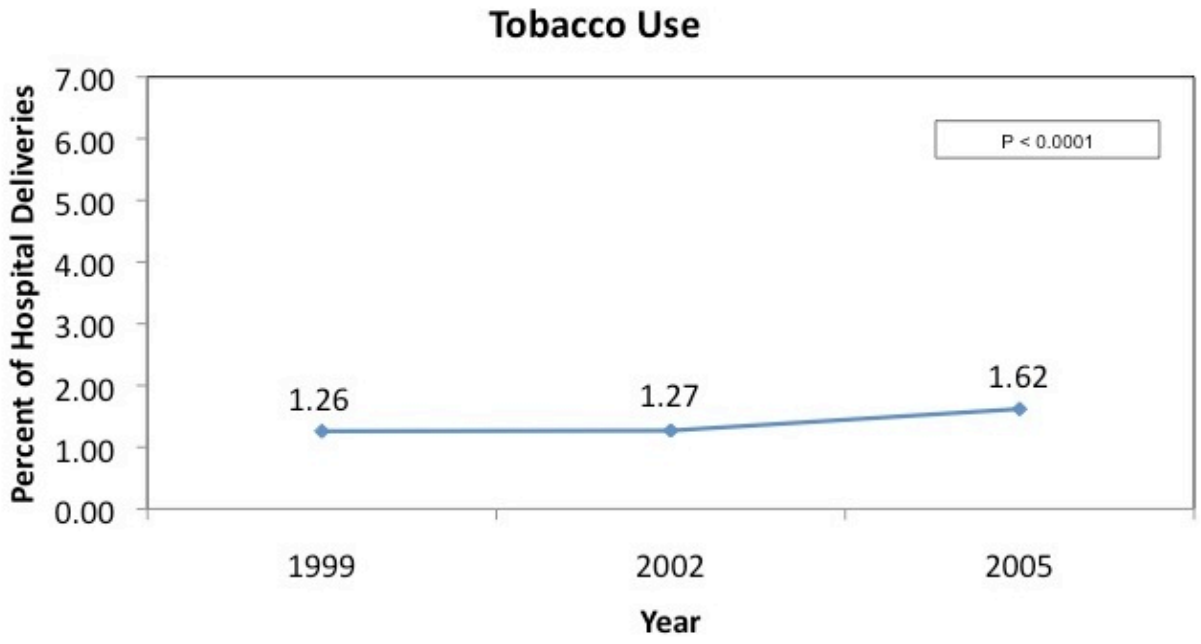


Figure 25. Unadjusted Trends of Tobacco Use in All Hospital Deliveries in California in 1999, 2002 and 2005, OSHPD data, N= 1,551,017.

17. Racial-Ethnic Disparities in Maternal Morbidity

The following table (Table 3) summarizes trends in maternal morbidity by race-ethnicity in all hospital deliveries in California, from 1999 to 2005. Significant racial-ethnic disparities in maternal morbidity were noted. For example, black women were disproportionately affected by hypertension, whereas Asian and Pacific Islander women were disproportionately affected by diabetes. Cesarean delivery rate was highest among non-Hispanic black women and lowest among Asian and Pacific Islander women. There were also significant changes over time, with some of the greatest increases in maternal morbidity found among Native American women in California (e.g. hypertension, diabetes, mental illness, tobacco use, cesarean delivery etc). Overall there are substantial increases in maternal morbidity between 1999 and 2006 across all racial-ethnic groups in California.

Table 7. Trends in Maternal Morbidities in California by race-ethnicity (%), 1999-2005

	N	1999	2002	2005	% Change	P-value[1]
Hypertension						
Missing	70505	5.54%	5.88%	6.76%	22.0%	.
Native Americans	6787	5.40%	6.14%	8.04%	48.9%	< 0.001
Asian/PI	152099	4.16%	4.26%	4.64%	11.5%	< 0.0001
Hispanic	718003	5.18%	5.35%	5.81%	12.2%	< 0.0001
White, non-Hispanic	518113	5.94%	6.33%	6.96%	17.2%	< 0.0001
Black, non-Hispanic	85510	8.46%	9.36%	10.40%	22.9%	< 0.0001
All	1551017	5.56%	5.81%	6.35%	14.2%	
Diabetes						
Missing	70505	4.19%	5.32%	6.44%	53.7%	.
Native Americans	6787	5.05%	6.55%	7.43%	47.1%	< 0.001
Asian/PI	152099	6.70%	8.52%	9.55%	42.5%	< 0.0001
Hispanic	718003	4.97%	6.26%	7.02%	41.2%	< 0.0001
White, non-Hispanic	518113	3.66%	4.44%	4.95%	35.2%	< 0.0001
Black, non-Hispanic	85510	3.84%	5.01%	5.25%	36.7%	< 0.0001
All	1551017	4.56%	5.77%	6.50%	42.5%	
Chorioamnionitis						
Missing	70505	2.32%	2.66%	2.53%	9.05%	.
Native Americans	6787	2.22%	2.30%	1.89%	-14.86%	0.44
Asian/PI	152099	2.62%	3.02%	3.12%	19.1%	< 0.0001
Hispanic	718003	1.87%	1.98%	2.02%	8.02%	< 0.001
White, non-Hispanic	518113	1.75%	1.82%	1.82%	4.0%	0.12
Black, non-Hispanic	85510	2.54%	2.56%	2.61%	2.75%	0.64

All	1551017	1.96%	2.09%	2.12%	8.16%	
PROM						
Missing	70505	1.88%	1.69%	1.18%	-37.2%	.
Native Americans	6787	1.92%	1.67%	1.67%	-13.0%	0.53
Asian/PI	152099	1.55%	1.61%	1.08%	-30.3%	< 0.0001
Hispanic	718003	1.29%	1.26%	0.89%	-31.0%	0.00
White, non-Hispanic	518113	1.61%	1.52%	1.11%	-31.1%	0.00
Black, non-Hispanic	85510	1.98%	1.88%	1.43%	-27.8%	< 0.0001
All	1551017	1.50%	1.44%	1.02%	-32.0%	
Preterm Delivery						
Missing	70505	6.19%	6.47%	7.36%	18.9%	.
Native Americans	6787	5.35%	6.14%	6.64%	24.1%	0.07
Asian/PI	152099	5.67%	6.18%	6.44%	13.6%	< 0.0001
Hispanic	718003	5.26%	5.93%	6.49%	23.4%	< 0.0001
White, non-Hispanic	518113	5.73%	6.20%	6.76%	18.0%	< 0.0001
Black, non-Hispanic	85510	8.61%	9.37%	10.70%	24.3%	< 0.0001
All	1551017	5.71%	6.26%	6.83%	19.6%	
Cesarean Delivery						
Missing	70505	22.20%	26.20%	30.10%	35.6%	.
Native Americans	6787	21.20%	25.50%	31.30%	47.6%	< 0.0001
Asian/PI	152099	21.90%	25.80%	29.80%	36.1%	< 0.0001
Hispanic	718003	22.21%	26.30%	30.20%	36.0%	0.00
White, non-Hispanic	518113	23.50%	27.60%	31.10%	32.3%	0.00
Black, non-Hispanic	85510	26.40%	30.30%	35.10%	33.0%	< 0.0001
All	1551017	22.80%	26.90%	30.70%	34.6%	
Instrumental Delivery						
Missing	70505	15.70%	13.50%	11.80%	-24.8%	.
Native Americans	6787	10.40%	10.90%	8.77%	-15.7%	0.12
Asian/PI	152099	17.50%	16.40%	14.60%	-16.6%	0.00
Hispanic	718003	10.90%	9.61%	8.37%	-23.2%	0.00
White, non-Hispanic	518113	13.70%	12.10%	10.60%	-22.6%	0.00
Black, non-Hispanic	85510	9.19%	8.17%	7.65%	-16.8%	< 0.0001
All	1551017	12.60%	11.20%	9.83%	-22.0%	
Hysterectomy						
Missing	70505	0.06%	0.08%	0.09%	50.0%	.
Native Americans	6787	0.17%	0.14%	0.09%	-47.1%	0.42
Asian/PI	152099	0.11%	0.01%	0.11%	0.0%	0.75
Hispanic	718003	0.06%	0.07%	0.07%	16.7%	0.17
White, non-Hispanic	518113	0.06%	0.07%	0.07%	16.7%	0.53
Black, non-	85510	0.11%	0.11%	0.08%	-27.3%	0.27

Hispanic						
All	1551017	0.07%	0.08%	0.08%	14.3%	
Heart Disease						
Missing	70505	0.79%	0.72%	0.68%	-13.5%	.
Native Americans	6787	0.83%	0.59%	0.75%	-9.7%	0.75
Asian/PI	152099	0.54%	0.66%	0.68%	24.8%	<0.01
Hispanic	718003	0.32%	0.36%	0.41%	26.6%	< 0.0001
White, non-Hispanic	518113	1.11%	1.06%	1.09%	-1.8%	0.56
Black, non-Hispanic	85510	0.73%	0.74%	0.98%	33.0%	<0.01
All	1551017	0.67%	0.66%	0.70%	4.4%	
Asthma						
Missing	70505	0.96%	1.06%	1.72%	78.6%	.
Native Americans	6787	1.70%	1.44%	2.46%	44.7%	0.06
Asian/PI	152099	0.68%	0.75%	1.21%	78.5%	< 0.0001
Hispanic	718003	0.59%	0.67%	1.13%	92.2%	< 0.0001
White, non-Hispanic	518113	1.42%	1.60%	2.49%	75.4%	< 0.0001
Black, non-Hispanic	85510	2.43%	2.72%	4.46%	83.5%	< 0.0001
All	1551017	1.02%	1.12%	1.78%	74.5%	
Thyroid						
Missing	70505	0.89%	1.10%	1.53%	72.9%	.
Native Americans	6787	1.04%	1.22%	1.93%	85.6%	0.01
Asian/PI	152099	0.87%	1.19%	1.60%	83.3%	< 0.0001
Hispanic	718003	0.44%	0.57%	0.80%	80.2%	< 0.0001
White, non-Hispanic	518113	1.31%	1.62%	2.03%	55.0%	< 0.0001
Black, non-Hispanic	85510	0.54%	0.64%	0.84%	55.8%	< 0.0001
All	1551017	0.81%	1.02%	1.31%	60.9%	
Obesity						
Missing	70505	0.76%	0.80%	1.00%	31.7%	.
Native Americans	6787	1.18%	1.94%	2.42%	105.1%	<0.01
Asian/PI	152099	0.26%	0.29%	0.44%	68.3%	< 0.0001
Hispanic	718003	0.68%	0.82%	1.22%	79.9%	< 0.0001
White, non-Hispanic	518113	1.06%	1.17%	1.47%	38.7%	< 0.0001
Black, non-Hispanic	85510	1.73%	2.14%	2.90%	67.6%	< 0.0001
All	1551017	0.84%	0.96%	1.30%	54.0%	
Substance Abuse						
Missing	70505	1.06%	1.08%	1.17%	10.4%	.
Native Americans	6787	2.79%	2.48%	3.78%	35.5%	0.05
Asian/PI	152099	0.29%	0.25%	0.30%	1.0%	0.86
Hispanic	718003	0.62%	0.64%	0.86%	37.8%	< 0.0001
White, non-Hispanic	518113	1.37%	1.39%	1.89%	38.0%	< 0.0001
Black, non-	85510	4.19%	3.48%	3.86%	-7.9%	0.03

Hispanic						
All	1551017	1.10%	1.04%	1.31%	19.1%	
Mental Illness						
Missing	70505	1.71%	2.04%	2.67%	56.1%	.
Native Americans	6787	3.09%	4.06%	8.00%	158.9%	< 0.0001
Asian/PI	152099	0.68%	0.83%	1.05%	54.4%	< 0.0001
Hispanic	718003	0.81%	1.08%	1.60%	97.3%	< 0.0001
White, non-Hispanic	518113	2.81%	3.48%	4.90%	74.4%	< 0.0001
Black, non-Hispanic	85510	4.51%	4.85%	6.49%	43.9%	< 0.0001
All	1551017	1.77%	2.12%	2.92%	65.0%	
Alcohol Abuse						
Missing	70505	0.13%	0.11%	0.11%	-15.0%	.
Native Americans	6787	0.31%	0.27%	0.35%	15.4%	0.78
Asian/PI	152099	0.02%	0.06%	0.05%	104.5%	0.10
Hispanic	718003	0.07%	0.06%	0.06%	-18.8%	0.08
White, non-Hispanic	518113	0.14%	0.15%	0.16%	12.3%	0.18
Black, non-Hispanic	85510	0.35%	0.32%	0.25%	-29.0%	0.03
All	1551017	0.11%	0.11%	0.10%	-8.3%	
Tobacco Use						
.	70505	1.25%	1.08%	1.22%	-2.4%	.
Native Americans	6787	1.78%	2.03%	4.62%	159.6%	< 0.0001
Asian/PI	152099	0.50%	0.53%	0.67%	33.3%	< 0.001
Hispanic	718003	0.39%	0.41%	0.58%	51.4%	< 0.0001
White, non-Hispanic	518113	2.41%	2.53%	3.22%	33.6%	< 0.0001
Black, non-Hispanic	85510	2.15%	2.32%	3.39%	57.7%	< 0.0001
All	1551017	1.26%	1.27%	1.62%	28.6%	

[1]Two-sided Cochran-Armitage linear trend test p-values

IV. DISCUSSION

More than four million women give birth in the United States each year; approximately one in eight in California. Until recently, the only national outcome indicator of maternal health was maternal mortality. There is growing concern that maternal mortality may be on the rise in the U.S. and in California. In 2010, the Joint Commission issued a new sentinel event alert on maternal death (The Joint Commission, 2010). According to the National Center for Health Statistics, in 2006, the national maternal mortality ratio was 13.3 deaths per 100,000 live births, double that recorded in the 1980s. While changes in surveillance may have resulted in better ascertainment of maternal deaths, there is growing concern that the increase in U.S. maternal mortality may be real. In California, maternal mortality ratio has nearly tripled in a decade, from 5.6 deaths per 100,000 live births in 1996, to 16.9 in 2006 (California Department of Public Health, 2009).

While maternal mortality may be on the rise, it is only tip of the iceberg. If priorities are to be established and effective interventions designed to improve maternal health, the burden of morbidity among women giving birth must be identified and monitored. Thus, *Healthy People 2010* objectives included a new maternal health indicator: maternal morbidity during labor and delivery (US Department of Health and Human Services, 2000). Specifically, Healthy People 2010 established a national goal to reduce maternal complications during hospitalized labor and delivery to 24 per 100 deliveries. The benchmark for maternal morbidity was 30.7 per 100 deliveries, based on a 2003 analysis of data from the National Hospital Discharge Survey from 1993-1997 (Danel 2003). Since that analysis, only one published study has reported national rates of maternal morbidity. Using the National Hospital Discharge Survey, Berg *et al* (2009) reported a maternal morbidity rate of 31.6% for 2001-2005. Compared to 1993-1997, obstetrical complications rate remained unchanged at 28.6% while the prevalence of preexisting conditions at delivery increased from 4.1% to 4.9%. When cesarean delivery was included, nearly half (48.5%) of U.S. women experienced maternal morbidity during hospitalized labor and delivery.

Our study confirms a significant increase in maternal morbidity in California from 1999 to 2005. In this discussion we will separate out the 3 components of maternal morbidity: preexisting conditions, obstetrical complications, and cesarean delivery. We will also discuss observed racial-ethnic disparities in trends for maternal morbidity in California.

Preexisting Conditions

Our study found significant increases in the prevalence of several preexisting conditions in California between 1999 and 2005. Key findings include:

- 47% increase in the prevalence of pre-gestational hypertension
- 28% increase in the prevalence of pre-gestational diabetes
- 75% increase in the prevalence of maternal asthma
- 62% increase in the prevalence of maternal thyroid disorders

These trends were independent of demographic shifts in maternal age, race-ethnicity, education, and other maternal characteristics in California during the same time period. In addition, we also found significant increases in the prevalence of mental illness, tobacco, alcohol and substance use during pregnancy in unadjusted analyses. Because of the general unreliability of hospital reporting for these latter 4 conditions, we did not conduct adjusted analyses on these 4 conditions and caution against over-interpretation of our findings for them.

Our findings are consistent with previous reports of the increasing prevalence of preexisting maternal conditions in the United States. Using data from the National Hospital Discharge Survey from 1993-1997 to 2001-2005, Berg *et al* (2009) found

- 24% increase in the prevalence of pre-gestational hypertension
- 23% increase in the prevalence of pre-gestational diabetes
- 95% increase in the prevalence of maternal asthma

While there are some differences in reported prevalence and the magnitude of the increase between the two studies, (possibly due to differences in time periods studied and case definitions used), the similarities in the rise in preexisting conditions reported by both studies are striking. In fact, our analyses not only confirm, but also improve upon the previous study by Berg *et al* (2009) by adjusting for a number of maternal demographic characteristics not controlled for in their study. The rise in maternal morbidity has been attributed by some researchers to the

changing demographics of childbearing; indeed, in our study mean maternal age increased from 27.6 in 1999 to 28.0 in 2005 in California ($p<0.001$). Some researchers have attributed this rise in maternal morbidity to the changing demographics of childbearing; indeed, in our study mean maternal age increased from 27.6 in 1999 to 28.0 in 2005 in California ($p<0.001$). However, even after controlling for demographic shifts in maternal age, race-ethnicity, education and other characteristics, we continue to find significant rising trends in maternal morbidity *independent* of these demographic shifts in California. In fact, comparing unadjusted and adjusted analyses, these trends really did not change much with adjustment, suggesting that mothers in California are not only getting older, but are also getting sicker.

One of the most discussed changes in the health status of Americans over the past 30 years has been an increase in the prevalence of overweight and obesity among pregnant women. Our data suggests that maternal obesity increased by 55%, from 0.84% of all deliveries in 1999 to 0.96% in 2002 to 1.30% in 2005. Because obesity is such an important risk factor for several major causes of maternal mortality including obstetrical hemorrhage, infection, preeclampsia, and thromboembolism, increasing prevalence of maternal obesity may be a key driver of the rising maternal mortality in California. However, we believe maternal obesity is grossly under-reported in hospital discharge data; indeed, using survey data from the Pregnancy Risk Assessment Monitoring System in nine states, Kim *et al* (2007) found pre-pregnancy obesity increased 69.3%, from 13.0% in 1993 to 1994 to 22.0% in 2002 to 2003. Under-reporting of obesity in hospital discharge data renders our trend estimates very imprecise, and we caution against over-interpretation of our findings on obesity.

Cardiovascular disease is an increasingly important cause of maternal death in the U.S.. Using data from the Pregnancy Mortality Surveillance System, Berg *et al* (2010) estimated that cardiovascular conditions (excluding cardiomyopathy) accounted for less than 5% of maternal deaths in the U.S. from 1987 to 1990, but 12.4% of maternal deaths from 1998 to 2005. We found a small, non-significant 3% increase in the prevalence maternal cardiovascular diseases, from 0.67% in 2002 to 0.69% in 2005. Simiarly, Berg *et al* (2010) found a 13% increase in prevalence, from 0.9% in 1993-1997 to 1.0% in 2001-2005. Small numbers and under-reporting may render these estimates imprecise, but given the increasingly important contributions of cardiovascular diseases to maternal mortality, continued surveillance of maternal cardiovascular disease is strongly advised.

Obstetrical Complications

Our study found significant increases in the rates of several major obstetrical complications in California between 1999 and 2005. Key findings include

- 13% increase in the rate of hypertension complicating pregnancy, childbirth and the puerperium;
- 44% increase in the rate of gestational diabetes;
- 21% increase in the rate of preterm delivery

These trends were independent of demographic shifts in maternal age, race-ethnicity, education, and other maternal characteristics in California during the same time period. We also found a non-significant 10% increase in the rate of chorioamnionitis.

Our findings are consistent with previous reports of the increasing prevalence of obstetrical complications in the United States. Using data from the National Hospital Discharge Survey (NHDS), Wallis *et al* (2008) reported that age-adjusted rates of preeclampsia and gestational hypertension increased significantly (by 25 and 184%, respectively) between 1987 and 2004; in contrast, the rate of eclampsia decreased by 22% though the trend was statistically non-significant. In 2003-2004, the age-adjusted rate (per 1,000 deliveries) of preeclampsia was 29.4; for gestational hypertension it was 30.6. These numbers are comparable to our findings (approximately 43 per 1,000 deliveries). Baraban *et al* (2008) also observed an increase in pregnancy-related hypertension between 1991 through 2003 in Los Angeles County; the age-adjusted prevalence of pregnancy-related hypertension increased from 40.5 cases per 1000 in 1991 to 54.4 cases per 1000 in 2003. Most recently, Berg *et al* (2009) reported an 11% increase in preeclampsia and eclampsia, from 30 cases per 1000 in 1993-1997, to 34 per 1000 in 2001-2005. Despite differences in data sources and case definitions used in these studies, their comparability with our findings is striking. The cause for these increasing trends is not known; plausible contributors include population-level increases in known risk factors for preeclampsia, including a number of aforementioned preexisting maternal conditions such as pre-pregnancy overweight and obesity, pregestational hypertension, and pregestational diabetes, as well as maternal age and multiple gestations. Preeclampsia has also been linked to asthma, thyroid disorders, and autoimmune diseases, though these links are less well established. These

observed increases in the incidence of preeclampsia and gestational hypertension represent important changes in the burden of maternal morbidity at the population level, raising both clinical and public health concerns.

Between 1999 and 2005, the adjusted rate of maternal diabetes increased by 44% in California, from 4.6% to 6.5%. Our finding is consistent with previous reports of increased prevalence of maternal diabetes. A study of women living in Colorado reported that the prevalence of GDM doubled between 1994 and 2002 (Dabelea 2005). In a cohort of 267,051 pregnancies screened for GDM in Northern California (Ferrara 2004), the prevalence increased from 5.1% in 1991 to 7.4% in 1997 (relative increase of 45%). Using data from 58,922,266 births in the United States between 1989 and 2004 in the National Hospital Discharge Survey, Getahun *et al* (2008) found that prevalence of GDM increased from 1.9% in 1989-1990 to 4.2% in 2003-2004, a relative increase of 122%. Berg *et al* (2009) also found a 43% increase in GDM, from 2.8% in 1993-97 to 3.9% in 2001-05. The reason for the increasing rates of gestational diabetes is not well understood; we speculate that the recent increase in the prevalence of obesity among women of child-bearing ages may have partly contributed to the temporal increase in gestational diabetes. Other factors, such as demographic shifts in maternal age, race-ethnicity and socioeconomic status, could have also contributed to the increase in maternal diabetes. However, these demographic factors were adjusted for in our model, and the substantial rise in gestational diabetes in California appears to be independent of these demographic shifts.

We found a 21% increase in preterm birth rate in California between 1999 and 2005. Our findings are consistent with national data, which showed a 16% increase in preterm birth rate in the U.S. between 1996 and 2006 (March of Dimes 2010; Martin 2009). We caution that the adjusted 2005 preterm birth rate in our study was only 6.6%, well below the national average; this probably reflects the relatively lower sensitivity of hospital discharge data for capturing preterm births.

We attempted to estimate the proportions of “indicated” and “elective” delivery in California, using methodology adapted from Ananth and Vintzileos (2006). We found that the proportion of “indicated” preterm delivery (as a percentage of all preterm deliveries) increased from 20.8% in 1999 to 22.5% in 2005, while that of spontaneous preterm delivery decreased from 63.9% to 56.8% during the same time period. Of great public health concern is the increase in the proportion of “elective” preterm delivery (defined in our study as preterm delivery following elective primary or repeat cesarean, surgical or medical induction, failed induction or induction noted in birth certificate where none of the standard indications for “indicated” preterm delivery,

such as hypertension of intrauterine growth restriction, were noted), from 15.3% in 1999 to 20.7% in 2005. There are likely substantial misclassification errors which could result in over-counting (e.g. due to poor documentation for indications or PPROM) or under-counting (e.g. due to poor documentation of induction of labor) of “elective” preterm delivery. While further studies are needed to validate our findings, the possibility of “elective” delivery accounting for more than one in five preterm deliveries in California is cause for great clinical and public health concern and warrants closer surveillance.

Cesarean Deliveries

We included cesarean deliveries in our study of maternal morbidity because we defined maternal morbidity as a condition that adversely affects a woman's physical health during childbirth beyond what would be expected in a normal delivery. Thus cesarean delivery, as a major operative procedure during hospitalized labor and delivery that could adversely affect a woman's physical health, was included. Perhaps one of the most important trends observed in our study of maternal morbidity is the 35% increase in cesarean delivery, from 22.9% in 1999 to 30.8% in 2005. These trends in cesarean delivery in California are independent of maternal age and other demographic shifts. Our finding is consistent with the national trend; total cesarean delivery rate in the U.S. has increased by 50%, from the 1996 low of 20.7% to 31.1% in 2006 (Martin 2009).

Furthermore, we conducted subgroup analyses of the various types of cesarean delivery. Key findings include:

- 33% increase in primary cesarean without labor ("elective" primary);
- 22% increase in primary cesarean with labor;
- 69% increase in repeat cesarean without labor ("elective" repeat);
- 42% decrease in repeat cesarean with labor ("failed VBAC")

<u>Primary cesarean without labor</u>

We found a 33% increase in primary cesarean without labor, so-called "elective" primary cesarean, from 4.51% of all deliveries in 1999 to 5.99% in 2005. The reason for the increase in primary cesarean without labor is not well understood, but is likely due to both increases in indicated elective primary cesarean as well as cesarean delivery on maternal request (CDMR). Common indications for elective primary cesarean delivery include malpresentation, antepartum bleed, herpes, severe hypertension, multiple gestation, and macrosomia (Gregory 2002); several of these conditions have been on the rise in recent years. CDMR has also been cited as a contributing factor for the rising rate of elective primary cesarean delivery, though data have yet to confirm this. The most recent national statistics estimate that in 2006, approximately 2.5% of all United States births were CDMR. According to the NIH State-of-the-Science Conference Statement on CDMR in 2006, there is presently insufficient evidence to fully evaluate the benefits and risks of cesarean delivery on maternal request as compared to planned vaginal

delivery, and more research is needed. Until quality evidence becomes available, any decision to perform a cesarean delivery on maternal request should be carefully individualized and consistent with ethical principles (National Institutes of Health State-of-the Science Conference on Cesarean Delivery on Maternal Request, 2006).

Primary cesarean with labor

We also found a 22% increase in primary cesarean with labor, from 9.21% of all deliveries in 1999 to 11.24% in 2005. The increasing rates of primary cesarean with labor, in light of decreasing trends in prolonged rupture of membranes and instrumental delivery, suggest that practitioners may be quicker in abandoning labor and proceeding with cesarean delivery when labor dystocia is encountered, We found a 22% decrease in instrumental vaginal delivery in California, from 12.56% of all vaginal deliveries in 1999 to 11.27% in 2002 to 9.76% in 2005. We suspect that the current medico-legal environment, as well as hospital safety efforts aimed at reducing birth trauma from vacuum or forcep use, may be responsible for the decreasing rate of instrumental vaginal delivery. Without the aid of vacuum or forceps, second stage arrests then must be approached with cesarean delivery.

A major cause of primary cesarean with labor is labor dystocia (often referred to as “protracted labor,” “failure to progress,” or “arrest of descent”). While the reason for the increase in primary cesarean with labor is not well understood, several known risk factors associated with labor dystocia, including maternal obesity, fetal macrosomia, and induction of labor, are on the rise. We have previously reported substantial variations across California hospitals in risk-adjusted rates of protracted labor; we suspect that such variability may be partially attributable to differences in the quality of obstetrical care across birth hospitals in California (Lu 2005). Given that labor dystocia is a main driver of primary cesarean with labor, we believe that the rate of primary cesarean with labor could be substantially reduced with quality improvement in obstetrical care (and more specifically, in the management of labor and delivery) in some birth hospitals in California.

Repeat cesarean without labor

We found a dramatic 69% increase in repeat cesarean without labor, so-called “elective” repeat cesarean, from 7.38% of all deliveries in 1999 to 12.45% in 2005. This trend is probably driven by both an increase in the number of women with prior cesarean, as well as a decrease in the proportion of women with prior cesarean who attempted a VBAC. In fact, we found that overall

VBAC attempts (calculated as the sum of successful and failed VBACs) reduced by more than half (56%) during the study period, from 5.46% of all deliveries in 1999 to 2.48% in 2005. This trend was driven, in large part, to more restrictive ACOG guidelines adopted in 1999 and modified in 2004 that VBAC should be attempted in institutions equipped to respond to emergencies with physicians immediately available to provide emergency care. These guidelines were interpreted by many hospitals as requiring 24-hour availability of in-house obstetrician and anesthesiologist, which created a medicolegal environment that discouraged VBAC attempts. A study of California birth certificates from 1996 to 2002 found attempted VBAC deliveries to have decreased significantly, from 24% (of women with prior cesarean) before, to 13.5%, after adoption of the more restrictive VBAC guidelines in 1999 (Zweifler 2006).

Repeat cesarean with labor

Lastly, we found a 42% decrease in repeat cesarean with labor, or so-called failed VBAC, from 1.71% of all deliveries in 1999 to 0.99% in 2005. The decrease in failed VBAC has more to do with the overall decline in VBAC attempts rather than with improved success with VBAC. To the contrary, among women who attempted VBAC, there has been a 32% *increase* in failed VBAC, suggesting that practitioners in California are not only less likely to attempt VBAC, but they may also be quicker in abandoning VBAC attempts.

Racial-Ethnic Disparities in Maternal Morbidity

We found substantial disparities in maternal morbidity across racial-ethnic groups in California. Non-Hispanic black women were disproportionately affected by hypertension, whereas Asian and Pacific Islander (API) women had the highest rates of diabetes. In 2005, nearly one in ten (9.55%) API women who gave birth had diabetes, a rate that has nearly doubled since 1999. Our finding confirmed two recent reports of higher rates of gestational diabetes (GDM) among API women. In a retrospective cohort study of 139,848 women who delivered within a managed care network in California, Caughey *et al* found that Asians had the highest rate ($P < .001$) of GDM (6.8%) as compared with whites (3.4%), African Americans (3.2%), and Hispanics (4.9%). And using Oregon PRAMS of 3,883 women who delivered in Oregon in 2004 and 2005, Hunsberger *et al* found that API women had the highest prevalence of GDM (14.8%); this was true for women with both a normal and a high body mass index (BMI). The high rate of diabetes among API women who gave birth in California, as well as high rate of increase, warrant more research and closer public health surveillance.

Overall non-Hispanic black women had disproportionate share of disease burden for a number of conditions including preterm birth, asthma and obesity (though the latter is substantially under-reported). They were also most likely to have a cesarean delivery, and least likely to undergo instrumental delivery. Native Americans had the highest rates of alcohol and tobacco use and mental illness, though these estimates were rendered imprecise by small numbers and substantial under-reporting.

We also found substantial variations in trends of maternal morbidity by racial-ethnic groups, with some of the greatest increases seen among Native American women. While we caution against over-interpretation of these trends among Native American women in California because of small numbers, these trends do raise public health concerns and warrant closer surveillance. Similarly, the 33% increase in the rate of maternal heart disease among non-Hispanic black women, and the near doubling in the rate of asthma among Hispanic women in 6 years, are quite alarming. There have also been substantial increases in the rates of cesarean delivery across all racial-ethnic groups, with rates increasing by at least one-third for most groups and nearly half (48%) for Native American women. Given the changing demographics of childbearing in California, continued surveillance of trends in maternal morbidity by racial-ethnic group is strongly advised.

V. CONCLUSION

To our knowledge, our study is the first to examine the rising trends of maternal morbidity in California. We observed significant increases in several major preexisting medical conditions and obstetrical complications, as well as cesarean delivery, between 1999 and 2005 in California. While racial-ethnic disparities exist, maternal morbidity appears to be increasing across all racial-ethnic groups in California. Increased surveillance of these trends is warranted, while public health practice and policy must promote improved access to, and quality of, health care before, during, and between pregnancies, and a reduction in the biopsychosocial and behavioral risk factors of maternal morbidity, including overweight and obesity.

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Appendix A: Trends in Covariates

Variable categories:

1. Maternal education was categorized to elementary, secondary, college and graduate.
2. Hospital annual delivery volume was categorized to small (50-749), medium (750-2499) and large (≥2500).
3. Delivery route captures elective (non-laboring) vs emergent (laboring) cesarean and prior cesarean and consists of the following 6 categories: vaginal delivery, primary emergent cesarean, primary elective cesarean, VBAC, failed VBAC, repeat elective cesarean.
4. Maternal race was categorized as Asian/Pacific Islander, Native American, Hispanic, African-American (non-Hispanic) and Caucasian (non-Hispanic).
5. Maternal insurance was categorized as Private, MediCal and other.

Appendix B: Unadjusted trends

Overall Unadjusted Trends for Selected Conditions (%)						
Type	**Condition**	**1999**	**2002**	**2005**	**Total**	***P*-value[a]**
Maternal conditions	**Hypertension ↑**	5.56	5.81	6.35	91,746 (5.92)	**<0.0001**
	Diabetes ↑	4.56	5.77	6.50	87,313 (5.63)	**<0.0001**
	Heart Disease	0.67	0.66	0.69	10,470 (0.68)	**0.0735**
	Asthma ↑	1.02	1.12	1.78	20,369 (1.31)	**<0.0001**
	Thyroid ↑	0.81	1.02	1.31	16,317 (1.05)	**<0.0001**
	Obesity ↑	0.84	0.96	1.30	16,119 (1.04)	**<0.0001**
	Substance abuse ↑	1.10	1.04	1.31	17,847 (1.15)	**<0.0001**
	Mentally ill ↑	1.77	2.12	2.92	35,402 (2.28)	**<0.0001**
	Alcohol abuse	0.11	0.11	0.10	1,633 (0.11)	**0.1489**
	Tobacco use ↑	1.26	1.27	1.62	21,513 (1.39)	**<0.0001**
Maternal complications	**Chorioamnionitis**	1.96	2.09	2.12	31,908 (2.06)	**<0.0001**
	PROM ↓	1.50	1.44	1.02	20,402 (1.32)	**<0.0001**
	Preterm Delivery ↑	5.71	6.26	6.83	97,331 (6.28)	**<0.0001**
	Hysterectomy	0.07	0.08	0.08	1,154 (0.07)	**0.1990**
Mode of Delivery	**Cesarean Section↑**	22.83	26.86	30.71	416,850 (26.88)	**<0.0001**
	Instrumental Delivery[b] ↓	12.61	11.25	9.83	127,596 (11.25)	**<0.0001**
	Failed VBAC[c] ↑	31.27	35.20	41.23	20,284 (34.66)	**<0.0001**
Total Deliveries N(%)		503,141 (32.44)	514,681 (33.18)	533,195 (34.38)	1,551,017 (100.00)	

[a] Two-sided Cochran-Armitage linear trend test

[b] Out of vaginal deliveries; total cases per year for this outcome are 388,266 (34.23%) for 1999, 376,445 (33.19%) for 2002 and 369,456 (32.58%) for 2005

[c] Out of Attempted VBAC; total cases per year for this outcome are 27, 476 (46.95%) for 1999, 18,259 (31.20%) for 2002 and 12,785 (21.85%) for 2005
↓↑ Conditions exhibiting a consistent decreasing/increasing trend over the 3 periods
PROM-Prolonged Rupture of Membranes

Trends for Mode of Delivery N(%)						
Route	**Prior CS and Elective Status**	**1999**	**2002**	**2005**	**Total**	***P*-value[a]**
Vaginal	**No Prior Cesarean ↓**	369,383 (73.42)	364,606 (70.84)	361,942 (67.88)	1,095,931 (70.66)	**<0.0001**
	VBAC ↓	18,883 (3.75)	11,839 (2.30)	7,514 (1.41)	38,236 (2.47)	**<0.0001**
Cesarean	**Primary With labor ↑**	46,428 (9.23)	53,502 (10.40)	60,123 (11.28)	160,053 (10.40)	**<0.0001**
	Primary Without labor ↑	22,716 (4.51)	25,516 (4.96)	31,944 (5.99)	80,175 (5.17)	**<0.0001**
	Repeat Without labor ↑	37,138 (7.38)	52,798 (10.26)	66,401 (12.45)	156,337 (10.08)	**<0.0001**
	Failed VBAC ↓	8,593 (1.71)	6,420 (1.25)	5,271 (0.99)	20,284 (1.31)	**<0.0001**
Total Deliveries		503,141 (32.44)	514,681 (33.18)	533,195 (34.38)	1,551,017 (100.00)	

[a] Cochran-Armitage linear trend test
↓↑ Conditions exhibiting a consistent decreasing/increasing trend over the 3 periods
VBAC-Vaginal Birth After Cesarean;

Appendix C: Crude rates (unadjusted) and adjusted rates (from models)

Indicator	Rate		
	1999	2002	2005
Cesarean -Crude	22.83%	26.86%	30.71%
Cesarean- Linear (3 Yrs)	22.96%	26.80%	30.89%
Cesarean- Relative Change	22.89%	26.93%	30.82%
Primary CS w/Labor - Crude	9.23%	10.40%	11.28%
Primary CS w/Labor - Linear (3 Yrs)	9.26%	10.28%	11.29%
Primary CS w/Labor - Relative Change	9.21%	10.30%	11.24%
Instrumental VD - Crude	12.61%	11.25%	9.83%
Instrumental VD- Linear (3 Yrs)	12.57%	11.26%	9.80%
Instrumental VD- Relative Change	12.56%	11.27%	9.76%
Hysterectomy - Crude	0.07%	0.08%	0.08%
Hysterectomy- Linear (3 Yrs)	0.07%	0.07%	0.07%
Hysterectomy- Relative Change	0.07%	0.07%	0.07%
Hypertension- Crude	5.56%	5.81%	6.35%
Hypertension- Linear (3 Yrs)	5.44%	5.85%	6.27%
Hypertension- Relative Change	5.52%	5.80%	6.30%
Diabetes – Crude	4.56%	5.77%	6.50%
Diabetes- Linear (3 Yrs)	4.64%	5.62%	6.59%
Diabetes- Relative Change	4.55%	5.80%	6.50%
Chorioamnionitis - Crude	1.96%	2.09%	2.12%
Chorioamnionitis- Linear (3 Yrs)	1.89%	2.00%	2.08%
Chorioamnionitis- Relative Change	1.89%	2.00%	2.08%
PROM- Crude	1.50%	1.44%	1.02%
PROM- Linear (3 Yrs)	1.50%	1.28%	1.06%
PROM- Relative Change	1.44%	1.41%	1.00%
Preterm Birth- Crude	5.71%	6.26%	6.83%
Preterm Birth- Linear (3 Yrs)	5.50%	6.04%	6.64%
Preterm Birth- Relative Change	5.48%	6.09%	6.61%

Indicator	Rate	Model	Rate
	1999		1999
Complicated PTD- Crude	20.97%	21.88%	22.63%
Complicated PTD- Linear (3 Yrs)	20.79%	21.76%	22.52%
Complicated PTD- Relative Change	20.78%	21.78%	22.52%
Spontaneous PTD- Crude	63.54%	60.65%	56.59%
Spontaneous PTD- Linear (3 Yrs)	64.07%	60.45%	56.95%
Spontaneous PTD- Relative Change	63.90%	60.79%	56.80%
Uncomp PTD- Crude	15.50%	17.46%	20.78%
Uncomp PTD- Linear (3 Yrs)	15.16%	17.75%	20.54%
Uncomp PTD- Relative Change	15.32%	17.43%	20.68%
Heart Disease - Crude	0.67%	0.66%	0.69%
Heart Disease - Linear (3 Yrs)	0.64%	0.67%	0.67%
Heart Disease - Relative Change	0.66%	0.63%	0.69%
Asthma - Crude	1.02%	1.12%	1.78%
Asthma - Linear (3 Yrs)	0.94%	1.29%	1.72%
Asthma - Relative Change	1.02%	1.13%	1.79%
Thyroid - Crude	0.81%	1.02%	1.31%
Thyroid - Linear (3 Yrs)	0.80%	1.05%	1.29%
Thyroid - Relative Change	0.82%	1.02%	1.30%
Obesity - Crude	0.84%	0.96%	1.30%
Obesity - Linear (3 Yrs)	0.81%	1.05%	1.30%
Obesity - Relative Change	0.85%	0.98%	1.33%