

Costs of Maternal Hemorrhage in California

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Nadereh Pourat, PhD¹

Ana E. Martinez, MPH¹

Jeffrey McCullough, MPH¹

Kimberly D. Gregory, MD, MPH²

Lisa Korst, MD, PhD³

Gerald F. Kominski, PhD¹

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**UCLA Center for Health Policy Research
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¹ UCLA Center for Health Policy Research

² Department Obstetrics and Gynecology, Cedars-Sinai Medical Center; David Geffen UCLA School of Medicine; and Department of Community Health Sciences, UCLA Fielding School of Public Health

³ Department of Obstetrics and Gynecology at the Keck School of Medicine, University of Southern California

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Glossary and Definitions

Acronym/Term	Definition
Average Base Case Costs	Weighted average of costs of vaginal and cesarean deliveries
Base Case Costs	Costs of care associated with an uncomplicated delivery
Incremental Costs	Costs of care associated with maternal hemorrhage in addition to base case costs
CMAC	California Medical Assistance Commission
CPT	Current Procedural Terminology
CT scans	Computerized Tomography
DHCS	California Department of Health Care Services
DPH	Designated Public Hospitals
DRG	Diagnosis Related Group
DSH	Disproportionate Share Hospital
E/M	Evaluation and Management (CPT Code)
FFS	Fee-for-service
HCPCS	Healthcare Common Procedure Coding System
ICD-9-CM	International Classification of Diseases, 9th Edition (Clinical Modification) diagnosis codes
LOS	Length of stay
Medi-Cal	California's Medicaid Program
MRI	Magnetic resonance imaging
NICU	Neonatal intensive care unit
OP	Outpatient
OSHPD	Office of Statewide Health Planning and Development
PPH	Postpartum hemorrhage
SAH	Subarachnoid hemorrhage
SPCP	Medi-Cal Selective Provider Contracting Program
VBAC	Vaginal birth after cesarean

Executive Summary

Maternal hemorrhage is a major public health concern nationally and in California. Early diagnosis and treatment can reduce the significant societal and cost burdens of this condition, as well as prevent some maternal mortality due to maternal hemorrhage. Approximately half a million births occur in California annually, nearly half of which are paid by Medi-Cal. Assessing the magnitude of preventable expenditures due to maternal hemorrhage may aid in the widespread implementation of evidence-based guidelines and a reduction of avoidable expenditures.

We identified the probabilities of various forms of maternal hemorrhage using available literature and expert knowledge. We used these probabilities to develop the likelihood of various maternal and neonatal outcomes given the type of hemorrhage and method of delivery. We also developed cost scenarios associated with these outcomes for the mother and the baby. We developed costs using publicly available data from the Medi-Cal fee-for-service fee schedule and reimbursement rates to public hospitals in California. We then estimated the average cost per uncomplicated delivery and the average cost for a delivery complicated by maternal hemorrhage. We also calculated the overall costs of maternal hemorrhage for the Medi-Cal program. The findings presented in this report are based on conservative estimates of costs and use of resources, and are likely to be the lower-bound estimates of probabilities and costs of maternal hemorrhage.

Findings

- Approximately 4.6% (22,730) of births in California in 2011 were complicated by maternal hemorrhage. Of these, 47.3% (10,750) were estimated to be paid for by Medi-Cal.
- The average cost of an uncomplicated delivery in 2011, inclusive of maternal and neonatal costs associated with vaginal and cesarean deliveries, is estimated at \$5,000. The cost of an uncomplicated delivery with a healthy neonate was estimated at \$4,500 for a vaginal birth and \$6,500 for a cesarean birth.
- The total estimated incremental cost of maternal hemorrhage deliveries to the Medi-Cal program in 2011 is estimated at \$105,956,000.
- The estimated incremental cost per case of deliveries complicated by both antepartum and postpartum hemorrhage and a scheduled cesarean delivery was as high as \$89,300. These costs include hospitalization of the mother during the antepartum phase and hospitalization for preterm neonates.
- The costs of maternal hemorrhage to commercial insurers statewide are likely to be higher than those estimated for Medi-Cal due to higher payment rates under commercial insurance.
- The lifetime costs of maternal hemorrhage are frequently due to high rates of preterm births with antepartum hemorrhage and costs of subsequent developmental disabilities that are more common for infants born preterm. Lifetime medical costs associated with two developmental disabilities, cerebral palsy and mental retardation, are estimated at \$38,250 per child annually.

Introduction and Significance

A. Prevalence of Maternal Hemorrhage

Maternal hemorrhage is a leading cause of pregnancy-related mortality in the United States (U.S.) and is the primary cause of maternal mortality and morbidity worldwide.¹⁻³ The increasing rates of cesarean deliveries have also increased the likelihood of complications such as placental abruption and previa, and uterine rupture (and hemorrhage) in subsequent pregnancies.^{4,5} Maternal hemorrhage can occur prior (antepartum), during (intrapartum), and after (postpartum) delivery.⁶ Delayed or secondary postpartum hemorrhage is another form of hemorrhage and is defined as excessive and abnormal bleeding that occurs between 24 hours and six to 12 weeks after giving birth.^{7,8}

About 2% of low-risk pregnancies and 2.4% of high-risk pregnancies (women with major maternal, fetal or placental conditions such as antepartum hemorrhage, abruption placentae, and placenta previa) involve some form of maternal postpartum hemorrhage.⁹ Reliable estimates of incidence of intrapartum hemorrhage are rare, mostly because administrative data often do not distinguish such hemorrhage from postpartum hemorrhage. A study of women in North Carolina estimated that 1.4% of white women had intrapartum hemorrhage.¹⁰ The rate of delayed postpartum hemorrhage is estimated at 0.7% overall, separated into 1.6% for vaginal deliveries and 0.5% for cesarean deliveries.⁷

B. Causes and Risk Factors

Maternal age, preeclampsia, hypertension, smoking, substance abuse, multiple gestations, duration of labor, prior occurrence of hemorrhage, and prior cesarean delivery are identified risk factors for maternal hemorrhage.¹¹⁻¹³ Prior cesarean delivery is a risk factor because of the increased risks of uterine rupture, atony, and placenta previa and accreta. Placenta accreta is the abnormal integration of the placenta into the uterine muscle, which leads to hemorrhage at the time of attempted placental separation during delivery.^{14,15} The risk of placenta previa and accreta increases after a cesarean delivery. Second pregnancies following a previous cesarean delivery are 2.2 times more likely to be complicated by placenta previa.¹⁶ The risk of placenta accreta increases with prior cesarean deliveries, ranging from 3% for first to 67% for fifth or more repeat cesarean deliveries.⁴ For these reasons, the increase in rates of cesarean delivery in California from 22% in 1998 to 33% in 2010 is a major concern.¹⁷

Approximately 17% of women who have previously delivered by cesarean attempt a vaginal birth after cesarean (VBAC) or trial of labor during subsequent pregnancies, and 70% are successful.¹⁸ However, 0.7% of women with a prior cesarean delivery will experience a uterine rupture.¹⁹ Hence, among these women, the risk of hemorrhage is higher than those who undergo a repeat cesarean delivery because of the increased risk of uterine rupture in a trial of labor by women with a history of a prior cesarean birth.²⁰

The causes of antepartum and intrapartum hemorrhage are different. Although the specific etiologies of antepartum hemorrhage are often unknown, the most commonly identified direct causes are placenta previa, placenta accreta, and placental abruption or separation. Other causes of antepartum hemorrhage include membrane rupture, cervicitis, and genital trauma.²¹ Antepartum hemorrhage leads to an increased risk of preterm birth (increased odds of 3.2) and stillbirth (increased odds of 2.1).²² About 14% of antepartum hemorrhage cases lead to preterm delivery, and about 1.6% of these hemorrhages lead to stillbirth.²²

Intrapartum hemorrhage is frequently caused by placenta previa, placenta accreta, placental abruption, and uterine rupture.¹⁰ Postpartum hemorrhage is primarily due to uterine atony but could also be caused by retained placenta and blood disorders.^{11,23}

The major cause of delayed postpartum hemorrhage, occurring more than 24 hours after delivery, is atony, or sub-involution of the uterus (failure of the uterus to contract down to its normal size), which may be due to infection or retained placenta.²⁴

C. Treatment

Treatment of maternal hemorrhage varies by severity, gestational age, stage of delivery, and whether it occurs antepartum, intrapartum, or postpartum. If antepartum hemorrhage is not life-threatening, the condition can be treated with inpatient management, which may include bed rest, tocolytic medications to decrease uterine contractions, antenatal corticosteroids to accelerate fetal lung development prior to delivery, and transfusion of blood products. However, if the antepartum hemorrhage is severe, it may require emergency cesarean delivery and other procedures such as uterotonic medications to manage atony, arterial ligation or radiologic embolization, uterine rupture or laceration repair, uterine compression measures, or hysterectomy.²⁵ Treatment of delayed postpartum hemorrhage may include transfusion, medications to treat infection and inflammation, and/or surgical procedures.²⁶

D. Short-term and Lifetime Medical Outcomes

Both mother and baby may experience short-term complications of maternal hemorrhage. Maternal consequences of hemorrhage depend on the severity of blood loss, availability of treatments where delivery occurs, and health status of the mother prior to hemorrhage. For example, women with hemorrhagic anemia may have an increased risk of cardiovascular arrest and death.²⁷ The short-term morbidity associated with maternal hemorrhage is anemia. The prevalence of moderate anemia (hemoglobin level between 70-90g/l) is estimated at 1%, but severe postpartum anemia (hemoglobin level below 70 g/l following delivery) is estimated at < 0.001% in the U.S.²⁷ Anemia rates are higher among low income and minority women.²⁸ Low baseline hemoglobin levels can lead to more severe outcomes if hemorrhage occurs. For example, severe anemia may lead to Sheehan's syndrome, which is the necrosis of the pituitary gland following hemorrhagic shock. Hysterectomy is both a treatment and

outcome of maternal hemorrhage and hysterectomy-associated infertility is a lifetime medical outcome of maternal hemorrhage.

Neonatal complications of maternal hemorrhage are primarily due to antenatal hemorrhage leading to preterm birth. Consequences may include respiratory distress syndrome and other disorders associated with prematurity and/or fetal growth restriction, and may require admittance to the intensive care unit. Intrapartum bleeding may also cause neonatal complications leading to neonatal intensive care unit admissions.

Lifetime consequences of maternal hemorrhage leading to preterm birth include developmental disabilities. A national longitudinal study of survivors of preterm birth in 2003 identified the prevalence of cerebral palsy to be 9.1% when born at 23-27 weeks of gestation, compared to 0.1% for those born at term. Mental retardation occurred in 4.4% and 0.4% of preterm and term births, respectively.²⁹

Maternal and neonatal deaths are other potential outcomes. Their probabilities vary by severity of bleeding in the mother, gestational age of the fetus, and when hemorrhage occurs relative to labor. The maternal mortality rate due to hemorrhage is estimated at 0.1% in the U.S.¹¹ and 1.0 deaths from hemorrhage for every 100,000 live births in California, where it is the third leading cause of maternal mortality.³⁰ The rate of infant mortality due to antepartum hemorrhage is estimated at 0.1% for scheduled cesareans and 0.38% for vaginal birth following a prior cesarean.³¹ About 1.6% of these antepartum hemorrhages lead to stillbirth.²²

E. Costs of Maternal and Neonatal Care

The published data on costs of maternal and neonatal care are sparse and not always current. We updated all the costs found in the literature to 2011 dollars using the Bureau of Labor Statistics calculator to be consistent with the cost estimates presented in this study.³² The original costs reported in the literature are presented in Appendix Exhibit 1 and Appendix Exhibit 2. The total cost of an average uncomplicated vaginal birth for a hypothetical 30 year-old patient in California was estimated at \$6,683.¹⁹ The cost for a cesarean following a failed trial of labor was higher (\$11,360) than an elective repeat cesarean delivery (\$9,781).¹⁹

Few studies of the costs of maternal hemorrhage are available. The incremental costs of maternal hemorrhage were \$443 in a successful trial-of-labor delivery and \$361 in a failed trial-of-labor or scheduled cesarean delivery. A maternal hemorrhage requiring hysterectomy was estimated to have an incremental cost of \$6,403 in a successful trial-of-labor delivery, and \$1,735 in a failed trial-of-labor or scheduled cesarean delivery.¹⁹

The neonatal costs associated with no or mild morbidity have been estimated to be approximately \$352 in one California study¹⁹ and \$762 in a national study.³³ Neonatal costs with neonatal death (\$54,566), moderate morbidity (\$70,468), and severe morbidity (\$109,490) were much higher.¹⁹ It is recognized

that most neonatal morbidity associated with maternal hemorrhage is due to complications of prematurity. Several studies have assessed the costs associated with premature infants based on ICD-9-CM diagnoses. The hospital costs for extremely immature infants (less than 28 weeks of gestation and/or birth weight below 1,000 grams) in the U.S. were estimated to be \$83,320 and \$15,369 for other preterm infants (28-36 weeks of gestation and/or birth weight of 1,000-2,499 grams).³³

F. Prevention of Morbidity and Mortality

A statewide, multidisciplinary expert panel review of maternal mortality cases in 2002 and 2003 found that 70% of California’s obstetrical hemorrhage deaths were potentially preventable.³⁴

Prevention of significant morbidity from postpartum hemorrhage is focused on early recognition of and rapid response to hemorrhage during and after birth. Active management of the third stage of labor, including administration of oxytocin, cord clamping and cutting, and controlled cord traction and uterine massage after delivery of placenta are the principal approaches to the prevention of postpartum hemorrhage.³⁵ Interventions such as administration of Methergine to contract the blood vessels in the uterus may also be considered.⁸ Standardizing the thresholds for diagnosis of hemorrhage, quantifying the amount of blood loss, and monitoring maternal vital signs are recommended for early diagnosis of hemorrhage. Based on findings from the statewide review of maternal deaths from obstetric hemorrhage, tools were developed to improve health care provider and facility response and recognition to obstetric hemorrhage.³⁶ Prevention strategies for women with inherited coagulation disorders or those who refuse transfusions may include complete patient history and screening tests and planning for alternative means of treating hemorrhage.^{37,38} Early diagnosis of placenta previa and accreta with ultrasound may also be used to prepare in advance for delivery and determine timing and location of delivery.³⁹

Methods

A. Probabilities

We conducted a comprehensive review of the literature concerning maternal and neonatal outcomes of maternal hemorrhage using PubMed, Google Scholar, and the Cochrane library database. The search terms were classified by category and are displayed in Exhibit 1.

Exhibit 1. Search Terms for Estimates of Maternal Hemorrhage

Category	Search Terms
Timing of hemorrhage	<ol style="list-style-type: none"> 1. Antepartum hemorrhage 2. Intrapartum hemorrhage 3. Postpartum hemorrhage

Category	Search Terms
	4. Secondary postpartum hemorrhage
Specific diagnosis	5. Placenta previa 6. Placenta accreta 7. Placental abruption 8. Uterine atony
Non-specific, high-risk disease etiology	9. Placental abnormalities 10. Placental separation
Other non-specific terms	11. Neonatal/perinatal outcomes/complications 12. Maternal complications/morbidity/mortality 13. Maternal/pregnancy/obstetric bleeding

We included English-language, human-based research studies focused on maternal and neonatal morbidity or death. More recently published studies were given priority primarily because of continuing developments in imaging technology, diagnostic precision, and treatment options. The diagnostic developments have refined the definition of maternal hemorrhage and its diagnosis, and have led to the proliferation of standardized clinical protocols. Recent advances in the treatment of maternal hemorrhage, like interventional radiology and uterine artery embolization, have reduced severe maternal morbidity and mortality rates and may help reduce the cost of treating this condition.⁴⁰ Therefore, more recent data were used when appropriate. Similarly, studies conducted in western countries with comparable rates of medical profusion and systems of care were included, and those from non-comparable countries were excluded. We used snowballing techniques to identify relevant studies not identified through using the search terms. These searches returned 71 studies and reviews and 13 articles were ultimately used to direct the probabilities and costs for the maternal obstetric hemorrhage decision tree.

Singleton Births in California

The latest available data on number of singleton births at the time of this analysis was published in 2010 by the California Department of Public Health and indicate that 509,979 live births, 494,058 (96.9%) of which were singletons.⁴¹

B. Costs

We developed the costs of hospitalization and physician services for maternal hemorrhage based on Medi-Cal (California’s Medicaid program) 2011 payment rates.

1. Medi-Cal Costs

Medi-Cal reimburses hospitals under the fee-for-service (FFS) payment model or delegates that responsibility to managed care plans. About 62% of Medi-Cal beneficiaries were enrolled in managed care plans in 2011.^{42,43} Medi-Cal payments to managed care plans are estimated to be approximately \$10 billion in 2011,⁴⁴ but managed care payment rates for hospitals are not publicly available. Under the FFS payment mechanism, payment rates to private hospitals are different from those to Designated Public Hospitals (DPH). The latter are reimbursed annually on a certified public expenditures basis (referred to as interim rates), which range from approximately \$1,260 to \$2,240 per delivery.⁴⁵ The final payments to these hospitals are later reconciled based on their overall expenditures. DPHs also qualify for Medi-Cal supplemental funding for reasons such as medical education or teaching. The overall payments in the 2010-2011 fiscal year included \$1.1 billion in DPH interim payments, \$0.9 billion in non-contract hospital payments and \$2.1 billion in disproportionate share hospital payments.⁴⁴

In fiscal year 2010-11, private contracted hospitals incurred 86% of all-cause inpatient days and 75% of total hospitalization costs.⁴⁴ The California Medical Assistance Commission (CMAC) runs the Medi-Cal Selective Provider Contracting Program (SPCP), which negotiates rates for acute inpatient care with private hospitals on behalf of the California Department of Health Care Services (DHCS).⁴⁴ A flat per-diem rate is determined annually and varies by a variety of factors.⁴⁴ As of 1989, contracted hospitals with a disproportionate share of Medi-Cal patients may qualify for and receive supplemental funding. CMAC reported \$2.8 billion in per diem and \$0.3 billion in supplemental funding in the 2010-2011 fiscal year.⁴⁴

We used the publicly available average statewide CMAC Medi-Cal FFS per-diem reimbursement rate in this study due to a lack of specific data on hospital reimbursement under managed care plans and DPH. We believe that the CMAC rates are a fair proxy for the majority of Medi-Cal payments for maternity and neonatal hospital care given that the average private hospital rates paid by CMAC fall within the range of DPH interim rates. Private hospitals provide a larger share of Medi-Cal FFS services than DPHs.

Length of stay (LOS) was obtained from the aggregate data published by the Office of Statewide Health Planning and Development (OSHPD) for 2010, representing almost all California patient discharges. These aggregate data at the state level were not available by specific condition.⁴⁶ We modified the LOS estimates for the specific pathways based on expert judgment and published literature. Accurate LOS estimates are best developed with claims and other relevant data, which is beyond the scope of this study.

Under Medi-Cal FFS, physician costs are estimated using the global fees for maternity care. Medi-Cal global fees are not adjusted for complications or type of delivery. Medi-Cal FFS reimburses maternity care with a global fee to the physician, which includes prenatal care, delivery, and immediate postpartum care. Medi-Cal allows for two ultrasounds to be billed by the primary OB/GYN physician in addition to the global fee. Any services provided by other physicians, such as hospitalists, intensivists,

anesthesiologists, perinatologists, pediatricians, or neonatologists are billed separately under the reimbursement rates listed on the Medi-Cal FFS fee schedule. The reimbursement rates are slightly higher for services provided to children, and we applied those rates to neonatal costs. Covered procedures were defined by HCPCS (Healthcare Common Procedure Coding System) and CPT-4 (Current Procedural Terminology) coding systems as of 05/15/2012.⁴⁷

We developed costs for each method of delivery and level of complication based on various outcomes in the model. Methods of delivery included vaginal delivery (including successful VBAC), cesarean delivery following labor (including failed VBAC), and elective cesarean delivery (including elective repeat cesarean). We then estimated costs of uncomplicated maternal delivery for vaginal and cesarean deliveries (base case), calculated a weighted average base case cost using the frequency of each type of birth from OSHPD data, and calculated the additional costs due to hemorrhage.⁴⁶ We also estimated neonatal costs for healthy neonates and neonates with complications, as described below.

We identified the likely resources used for each outcome (uncomplicated versus complicated delivery, healthy neonate versus neonate with complications), including the number of days of hospitalization for each method of delivery and the number of physician visits and services likely to be used during the stay. We identified the costs associated with each service and summed the overall maternal and neonatal costs for each outcome in the model. The costs of maternal and neonatal outcomes were estimated separately. Some degree of error in estimating resources used per each type of outcome is likely, due to significant variations in physician practice patterns, hospital practices, geographic location, and type of hospital. A more accurate method of estimating costs would be based on analysis of claims data from public and private payers, which is beyond the scope of this study.

We added laparotomy for women who delivered vaginally and had hemorrhage, to account for numerous procedures employed to stop the hemorrhage such as sutures, ligation, or obstetrical embolization procedures. We chose this approach because the Medi-Cal FFS fee schedule did not have specific amounts for the variety of procedures that may be employed in these cases.

To determine neonatal costs attributable to hemorrhage, we first estimated the average cost of a full-term neonate, a preterm neonate, an extremely immature neonate, and neonatal death. We made the simplifying assumption that babies born after antepartum hemorrhage have complications. We also assumed that antepartum hemorrhage increased the risk of preterm birth and neonatal death.^{22,31} To account for the increased risk of preterm birth and infant death due to antepartum hemorrhage, we inflated the OSHPD rate for the general proportion of California babies born preterm or who died to match the increased risk.⁴⁶ We then calculated a weighted average of the cost of babies born preterm and the cost of those who died, and added the weighted average to the cost of antepartum hemorrhage births.

2. Private/All Payer Costs

Private/all payer costs are not estimated in this report for a number of reasons. There is significant variation in reimbursements by commercial payers and published information on maternity costs. Also, information on neonatal costs associated with maternal hemorrhage is sparse, frequently outdated, and varies greatly in terms of methodology, geographic area, and generalizability. Again, an accurate and valid assessment of the costs associated with maternal hemorrhage requires analysis of claims data from large commercial insurers. However, the available published costs reported in Section E of this report provide a general idea of the available data on costs for maternity and neonatal care, as well as costs of maternal hemorrhage specifically.

3. Lifetime Medical Costs

As previously indicated in Section D, a key maternal complication of maternal hemorrhage is hemorrhagic anemia, which can frequently be resolved with treatment. The costs of severe anemia, including Sheehan's syndrome, are not estimated due to the extremely low prevalence of this condition in the U.S.²⁷

Lifetime medical and societal costs of preterm birth are estimated at \$59,431 (\$51,589 in 2005) per preterm infant annually.⁴⁸ These costs can be broken down into medical care (\$38,250), early intervention (\$1,386), and special education (\$2,476), as shown in Appendix Exhibit 2.⁴⁸ These costs consist of maternal delivery (7%), neonatal medical costs (65%), early intervention services (2%), special education services (4%), and lost household and labor market productivity (22%).⁴⁸ Special education services include costs associated with the four major developmental disabilities, including cerebral palsy and mental retardation.^{29,48}

C. Cost of Illness Model

We used TreeAge Software to construct a decision tree to estimate the cost of maternal hemorrhage.⁴⁹ The software allows for modeling of the treatment decisions by health care providers and progression of illness based on probabilities of maternal and neonatal outcomes. We constructed the model accounting for 1) prior cesarean and 2) the occurrence of antepartum, intrapartum, postpartum, or delayed postpartum hemorrhage. The model begins with all pregnant women, who are subsequently divided into those with prior cesareans and those without a prior cesarean. Antepartum hemorrhage is assumed to change the likelihood of vaginal and cesarean deliveries, as well as the likelihood of scheduled versus emergency cesarean deliveries. The model does not account for the gestational age at which antepartum hemorrhage occurs. The impact of earlier gestational age on outcomes is determined by assuming an increased proportion of neonatal outcomes ending in preterm birth and neonatal mortality.

D. Limitations and Strengths

A number of limitations apply to the findings of this study.

1. Probabilities

The available research on incidence or prevalence of maternal hemorrhage was at times outdated, based on small sample sizes from a single medical center, based on international studies, or varied greatly in the estimated probabilities of disease and/or outcomes. These limitations are not unique to this study but may impact the accuracy of the results. Additionally, the rates of maternal hemorrhage may differ under the Medi-Cal FFS program compared to births paid for by Medi-Cal managed care or by commercial insurance. To address these limitations, we selected the most appropriate studies and frequently selected the lower estimates. As a result, our findings can be considered conservative and lower-bound estimates of the prevalence of maternal hemorrhage.

2. Singleton Births

The estimated number of singleton births in California may be overestimated or underestimated depending on changes in the state's birth rate since 2010. The examination of the singleton birth rate in California showed an increase from 531,397 in 2005 to 548,650 in 2007, and a decline to 494,058 in 2010.⁴¹

3. Costs

We calculated the costs of maternal hemorrhage using available published cost data from the 2011 Medi-Cal Fee Schedule and 2011 Medi-Cal per-diem payment rates to private contracted hospitals. Significant variations in physician practice patterns, hospital practices, geographic location, managed care practices, and type of hospital were likely to exist, leading to variations in length of stay and resources used in the care of patients. We addressed these limitations by including a conservative list of resources used in each cost scenario. Given that Medi-Cal costs are considered the lowest level of payment for services used in the care of maternal hemorrhage, our estimates of costs can be considered the lower-bound estimates of the costs of these conditions across all payers for the state of California.

The OSHPD data on LOS were not unique to patients with maternal hemorrhage and these data were reported for a limited number of DRGs (Diagnosis Related Groups) for maternal and neonatal hospitalizations, without distinguishing the types of complications. We addressed these limitations by examining the few available studies and calculating weighted averages of DRGs that may apply to a given cost scenario. We believe that the length of stay estimates may also be lower-bound and conservative estimates, particularly for patients with more severe hemorrhage.

For simplicity, we have limited the neonatal morbidity associated with maternal hemorrhage to the complications of prematurity, although antepartum placental abruption and previa can also lead to profound anemia and associated secondary sequelae in the neonate.

4. Analytic Methods

Our analytic decision tree and cost estimates did not account for pregnancies with multiple gestation or comorbidities. We assumed that many comorbidities may be randomly distributed across both uncomplicated pregnancies and those complicated by maternal hemorrhage. Additionally, the presence of comorbidities may have increased maternal and neonatal costs, thus the findings in this report are more likely to underreport costs of pregnancies complicated by various comorbid conditions and are more conservative.

Lifetime medical and societal costs such as loss of productivity, including costs associated with maternal mortality, were not modeled. We partially addressed this caveat by providing published data in the literature on potential lifetime neonatal medical costs associated with maternal hemorrhage. Societal costs from maternal deaths, however, were beyond of scope of this study.

Despite the limitations described above, our findings have at least two significant strengths.

- Our conservative, thorough, and systematic approach to calculating the costs of maternal hemorrhage can be replicated in various settings or different states to obtain similar estimates.
- Our findings make an important contribution toward estimating the public costs associated with maternal hemorrhage. Such data help provide an evidence basis for the value of improving the management, both its quality and timeliness, of these costly conditions and bolster public health efforts to prevent the morbidity and mortality associated with obstetric hemorrhage.

Findings

A. Probability of Obstetric Hemorrhage

The probabilities related to maternal hemorrhage used in the analysis in this report are provided in Exhibit 2.

Exhibit 2. Maternal Hemorrhage Probability Estimates and Sources

	Rates	Source	Study Location
Global Rates			
Percent of women in California with prior cesarean	13.70%	Gregory 2008 ³¹	CA (U.S.)
Antepartum hemorrhage	2.00%	Magann 2005 ²² and Roberts 1970 ⁵⁰	Literature review (multiple countries)
Percent of antepartum hemorrhage due to placenta	50.00%	Dolea (WHO), 2003 ²⁷	Multiple countries

	Rates	Source	Study Location
previa or abruption			
Intrapartum hemorrhage	0.00%	Assumed to be reported under postpartum hemorrhage	Expert assumption
Maternal mortality	0.10% ⁵	Bateman 2010 ¹¹	U.S.
Prior Cesarean			
VBAC (trial of labor)	17.0%	Gregory 2010 ¹⁸	U.S.
PPH with prior cesarean and in repeat cesarean	0.68%	Lu 2005 ⁹	U.S.
PPH with prior cesarean and VBAC	2.36%	Lu 2005 ⁹	U.S.
Delayed PPH (any cause)	0.69%	Hoveyda 2001 ⁷	U.K.
Delayed PPH and cesarean	0.52%	Hoveyda 2001 ⁷	U.K.
Delayed PPH and VBAC	1.58%	Hoveyda 2001 ⁷	U.K.
Hysterectomy after scheduled cesarean	0.05%	Taylor 2005 ⁵¹	Australia
Hysterectomy after VBAC	0.07%	Taylor 2005 ⁵¹	Australia
No Prior Cesarean			
Scheduled cesarean without prior cesarean	17.23%	Martin 2011 ⁵²	U.S.
PPH without prior cesarean	2.05%	Lu 2005 ⁹	U.S.
Hysterectomy	0.02%	Taylor 2005 ⁵¹	Australia

Our original analysis plan included obtaining conditional probability estimates from the peer-reviewed literature for a full range of maternal hemorrhage and outcomes. We found several reliable studies of the risks of hemorrhage for women with prior cesareans, but the same estimates were not always available for women without a prior cesarean delivery. Therefore, we used the global estimate for a given condition or outcome in the absence of conditional probabilities. We relied on expert opinion in the absence of specific data or when the findings in the literature were conflicting or inconsistent. For example, we relied on expert judgment to resolve the problem posed by lack of data on the overlap between antepartum, intrapartum, and postpartum hemorrhage. We also did not find reliable and representative data on rates of intrapartum hemorrhage. In response to the unavailability of such data, and in consultation with our experts, we assumed that all intrapartum hemorrhage cases were accounted for in estimated rates of postpartum hemorrhage.

B. Costs

Exhibit 3 provides the 2011 Medi-Cal reimbursement rates for resources used per delivery for both maternal and neonatal care. Exhibit 4 and Exhibit 5 display the maternal costs and neonatal costs, respectively.

Exhibit 3. Medi-Cal Reimbursement Rates for Selected Procedures, California 2011

CPT Code	Code Description	Medi-Cal Reimbursement Rate
Hospital Reimbursement		
N/A	Hospital bed, per diem, maternal or neonatal	\$1,478.00
Physician Global Reimbursement		
59400	Obstetrical care, vaginal delivery - Global Fee	\$1,088.56
59510	Obstetrical care, cesarean delivery - Global Fee	\$1,088.62
Maternal Physician Reimbursement to Additional Providers		
76801	OB U.S. < 14 weeks gestation, single fetus	\$78.42
76805	OB U.S. ≥ 14 weeks gestation, single fetus	\$94.32
01960	Anesthesia for vaginal delivery	\$77.11
49000	Exploration of abdomen	\$421.82
49000	Exploration of abdomen - assist	\$84.51
58150	Total abdominal hysterectomy	\$810.72
58150	Total abdominal hysterectomy - assist	\$162.14
01961	Anesthesia for cesarean delivery	\$107.82
59525	Remove uterus after cesarean	\$239.09
59525	Remove uterus after cesarean - assist	\$36.97
59514	Cesarean delivery - assist	\$186.50
01963	Anesthesia for hysterectomy (including after cesarean)	\$101.17
99291	Critical care, first hour	\$121.60
99292	Critical care, additional 30 minutes	\$58.90
99222	Hospital care, initial, level 2	\$73.20
99232	Hospital care, subsequent, level 2	\$37.80
99238	Hospital discharge day management; ≤ 30 minutes	\$37.60
99239	Hospital discharge day management; > 30 minutes	\$53.40
Neonatal Physician Reimbursement		
99221	Hospital care, initial, level 1	\$33.38
99223	Hospital care, initial, level 3	\$77.90
99231	Hospital care, subsequent, level 1	\$26.73
99233	Hospital care, subsequent, level 3	\$49.97
99238	Hospital discharge day management; ≤ 30 minutes	\$41.02
99239	Hospital discharge day management; > 30 minutes	\$58.26
99291	Critical care, first hour	\$132.67
99292	Critical care, additional 30 minutes	\$64.26
99460	Newborn E/M per day in hospital, initial	\$51.50
99462	Newborn E/M per day in hospital, subsequent	\$27.49
99477	Initial day hospital neonate care	\$265.48

Source: Medi-Cal Physician Fee Schedule for 2011.⁴⁷ Hospital cost is based on the California Medical Assistance Commission (CMAC) per-diem rate.^{44,45}

Exhibit 4. Maternal Costs for Uncomplicated Deliveries and Deliveries Complicated by Maternal Hemorrhage, California Medi-Cal, 2011

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
Vaginal Delivery			
Vaginal Delivery, no maternal complications - Vaginal Delivery Base Case (Part 1 of 2, Average Base Case)			
Hospital bed - mother	LOS=2	775	\$2,956.00
Global physician fee		59400	\$1,088.56
Ultrasounds (outpatient only, normal prenatal care at ≥ 14 weeks gestation)		76805	\$94.32
Ultrasounds (outpatient only, normal prenatal care at < 14 weeks gestation)		76801	\$78.42
Anesthesiology (epidural)	2 units	01960	\$154.22
TOTAL COSTS			\$4,371.52
Vaginal delivery, with maternal complications and laparotomy			
Hospital bed - mother	LOS=4.5 based on cesarean with complications	765	\$6,651.00
Global physician fee		59510	\$1,088.62
Ultrasounds (outpatient only, normal prenatal care at ≥ 14 weeks gestation)		76805	\$94.32
Ultrasounds (outpatient only, normal prenatal care at < 14 weeks gestation)		76801	\$78.42
Anesthesia for vaginal delivery and Anesthesia for laparotomy (using cesarean as proxy)	2 units	01960	\$369.86
Exploration of abdomen		49000	\$421.82
Exploration of abdomen - assist		49000	\$84.51
Critical care (first hour)		99291	\$121.60
Critical care (additional 30 minutes)	2.5 average visits	99292	\$147.25
Other specialist: Physician services, hospital care (initial, level 2)	Day one/during labor	99222	\$73.20
Other specialist: Physician services, hospital care (subsequent care, level 2)	2.5 average visits	99232	\$94.50
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	\$37.60
TOTAL COSTS			\$9,262.70
Vaginal delivery, with maternal complications and hysterectomy			
Hospital bed - mother	LOS=4.5 based on Cesarean with complications and 2 days for hysterectomy	765	\$9,607.00
Global physician fee		59510	\$1,088.62
Ultrasounds (outpatient only, normal prenatal care at ≥ 14 weeks gestation)		76805	\$94.32

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
Ultrasounds (outpatient only, normal prenatal care at < 14 weeks gestation)		76801	\$78.42
Anesthesia for hysterectomy (including after cesarean)	3 units	01963	\$303.51
Total abdominal hysterectomy		58150	\$810.72
Total abdominal hysterectomy - assist		58150	\$162.14
Critical care (first hour)		99291	\$121.60
Critical care (additional 30 minutes)	4.5 average visits	99292	\$265.05
Other specialist: Physician services, hospital care (initial, level 2)	Day one/during labor	99222	\$73.20
Other specialist: Physician services, hospital care (subsequent care, level 2)	4.5 average visits	99232	\$170.10
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99239	\$53.40
TOTAL COSTS			\$12,828.08
Cesarean delivery			
Cesarean delivery, no maternal complications - Cesarean Base Case (Part 2 of 2, Average Base Case)			
Hospital bed - mother	LOS= 3.2	766	\$4,729.60
Global physician fee		59510	\$1,088.62
Ultrasounds (outpatient only, normal prenatal care at ≥ 14 weeks gestation)		76805	\$94.32
Ultrasounds (outpatient only, normal prenatal care at < 14 weeks gestation)		76801	\$78.42
Cesarean delivery - assist		59514	\$186.50
Anesthesia for cesarean delivery	2 units	01961	\$215.64
TOTAL COSTS			\$6,393.10
AVERAGE BASE CASE - Vaginal delivery and Cesarean (weighted by OSHPD frequency per type of delivery)			\$4,939.99
Cesarean delivery, with maternal complications			
Hospital bed - mother	LOS=4.5	765	\$6,651.00
Global physician fee		59510	\$1,088.62
Ultrasounds (outpatient only, normal prenatal care at ≥ 14 weeks gestation)		76805	\$94.32
Ultrasounds (outpatient only, normal prenatal care at < 14 weeks gestation)		76801	\$78.42
Cesarean delivery - assist		59514	\$186.50
Anesthesia for cesarean delivery	2 units	01961	\$215.64
Critical care (first hour)		99291	\$121.60
Other specialist: Physician services, hospital care (initial, level 2)	Day one/during labor	99222	\$73.20
Other specialist: Physician services, hospital care (subsequent care, level 2)	2.5 average visits	99232	\$94.50
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	\$37.60
TOTAL COSTS			\$8,641.40

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
Cesarean delivery, with maternal complications and hysterectomy			
Hospital bed - mother	LOS=4.5 and 2 days for hysterectomy	765	\$9,607.00
Global physician fee		59510	\$1,088.62
Ultrasounds (outpatient only, normal prenatal care at ≥ 14 weeks gestation)		76805	\$94.32
Ultrasounds (outpatient only, normal prenatal care at < 14 weeks gestation)		76801	\$78.42
Cesarean delivery - assist		59514	\$186.50
Remove uterus after cesarean		59525	\$239.09
Remove uterus after cesarean - assist		59525	\$36.97
Anesthesia for cesarean delivery and for hysterectomy	2 units	01961	\$239.09
Critical care (first hour)		99291	\$121.60
Critical care (additional 30 minutes)	4.5 average visits	99292	\$265.05
Other specialist: Physician services, hospital care (initial, level 2)	Day one/during labor	99222	\$73.20
Other specialist: Physician services, hospital care (subsequent care, level 2)	4.5 average visits	99232	\$170.10
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99239	\$53.40
TOTAL COSTS			\$12,253.36
Incremental cost of inpatient management for antepartum hemorrhage			
Hospital bed - mother	6 weeks plus 4 days for management	N/A	\$67,988.00
Other specialist: Physician services, hospital care (subsequent care, level 2)	Perinatologist supervision	99232	\$1,738.80
TOTAL COSTS			\$69,726.80

Source: Medi-Cal Physician Fee-Schedule for 2011.⁴⁷ Hospital cost is based on California Medical Assistance Commission (CMAC) per-diem rate.^{44,45} LOS (days) is obtained from OSHPD aggregate hospitalization data for 2010.⁴⁶

Exhibit 5. Neonatal Costs for Healthy Neonates and Pre-term Neonates, California Medi-Cal, 2011

Service per Delivery at Term	Assumptions	DRG/CPT Code	Cost
Healthy term baby (BASE CASE)			
Hospital LOS - not billable to Medi-Cal	LOS=2	795	\$-
Hospital: First visit	Pediatrician	99460	\$51.50
Hospital: Subsequent visits/day	Pediatrician	99462	\$27.49
TOTAL COSTS			\$78.99
Term baby with short-term complications			
Hospital bed - baby	LOS=3.27, weighted average of 2.5 & 6.4	793, 794	\$4,831.65
Initial day hospital neonate care	Neonatologist	99477	\$265.48
Hospital care, subsequent, level 3	Neonatologist	99233	\$63.41
Hospital discharge day management; > 30 minutes	Neonatologist	99239	\$58.26
TOTAL COSTS			\$5,218.80
Term baby w/ severe morbidity			
Hospital bed - baby	LOS=6.4	795	\$9,459.20
Initial day hospital neonate care	Neonatologist	99477	\$265.48
Hospital care, subsequent, level 3	Neonatologist	99233	\$219.87
Hospital discharge day management; > 30 minutes	Neonatologist	99239	\$58.26
TOTAL COSTS			\$10,002.81
Premature baby (healthy)			
Hospital bed - baby	LOS=6	792	\$8,868.00
Hospital: First visit	Pediatrician	99460	\$51.50
Hospital: Subsequent visits/day	Pediatrician	99462	\$137.45
TOTAL COSTS			\$9,056.95
Premature baby w/ morbidity			
Hospital bed - baby	LOS= 19	791	\$28,082.00
Initial day hospital neonate care	Neonatologist	99477	\$265.48
Hospital care, subsequent, level 3	Neonatologist	99233	\$849.49
Hospital discharge day management; > 30 minutes	Neonatologist	99239	\$58.26
TOTAL COSTS			\$29,255.23
Extremely immature baby			
Hospital bed - baby	LOS=38	790	\$56,164.00
Initial day hospital neonate care	Neonatologist	99477	\$265.48
Hospital care, subsequent, level 3	Neonatologist	99233	\$1,798.92
Hospital discharge day management; > 30 minutes	Neonatologist	99239	\$58.26
TOTAL COSTS			\$58,286.66
Neonatal death			
Hospital bed - baby	LOS=5.2	789	\$7,685.60
Initial day hospital neonate care	Neonatologist	99477	\$265.48
Hospital care, subsequent, level 3	Neonatologist	99233	\$159.90
Hospital discharge day management; > 30 minutes	Neonatologist	99239	\$58.26
TOTAL COSTS			\$8,169.24
AVERAGE COSTS OF PRETERM BIRTHS AND NEONATAL DEATH			\$16,640.50

Source: Medi-Cal Physician Fee Schedule for 2011.⁴⁷ Hospital cost is based on the California Medical Assistance Commission (CMAC) per-diem rate.^{44,45} LOS is obtained from OSHPD aggregate hospitalization data for 2010.⁴⁶

C. Cost Analysis Trees

Exhibit 6 and Exhibit 7 display two different views of the model decision tree that incorporate both the probability and cost of each outcome for maternal hemorrhage. Exhibit 6 displays the main branches of the decision tree. The overall percentage of the population with any type of maternal hemorrhage is calculated at 4.6%. This rate is calculation based on a combination of the probabilities displayed in Exhibit 2 above. An accurate estimate of incidence of hemorrhage is not available due to lack of standardized definitions of hemorrhage and underreporting.⁸ Exhibit 7 displays the expanded view of the branch indicating VBAC. The nodes displayed in this branch are repeated in other branches of the tree as appropriate.

Exhibit 6. Outcomes of Maternal Hemorrhage, Main Branches of Decision Tree

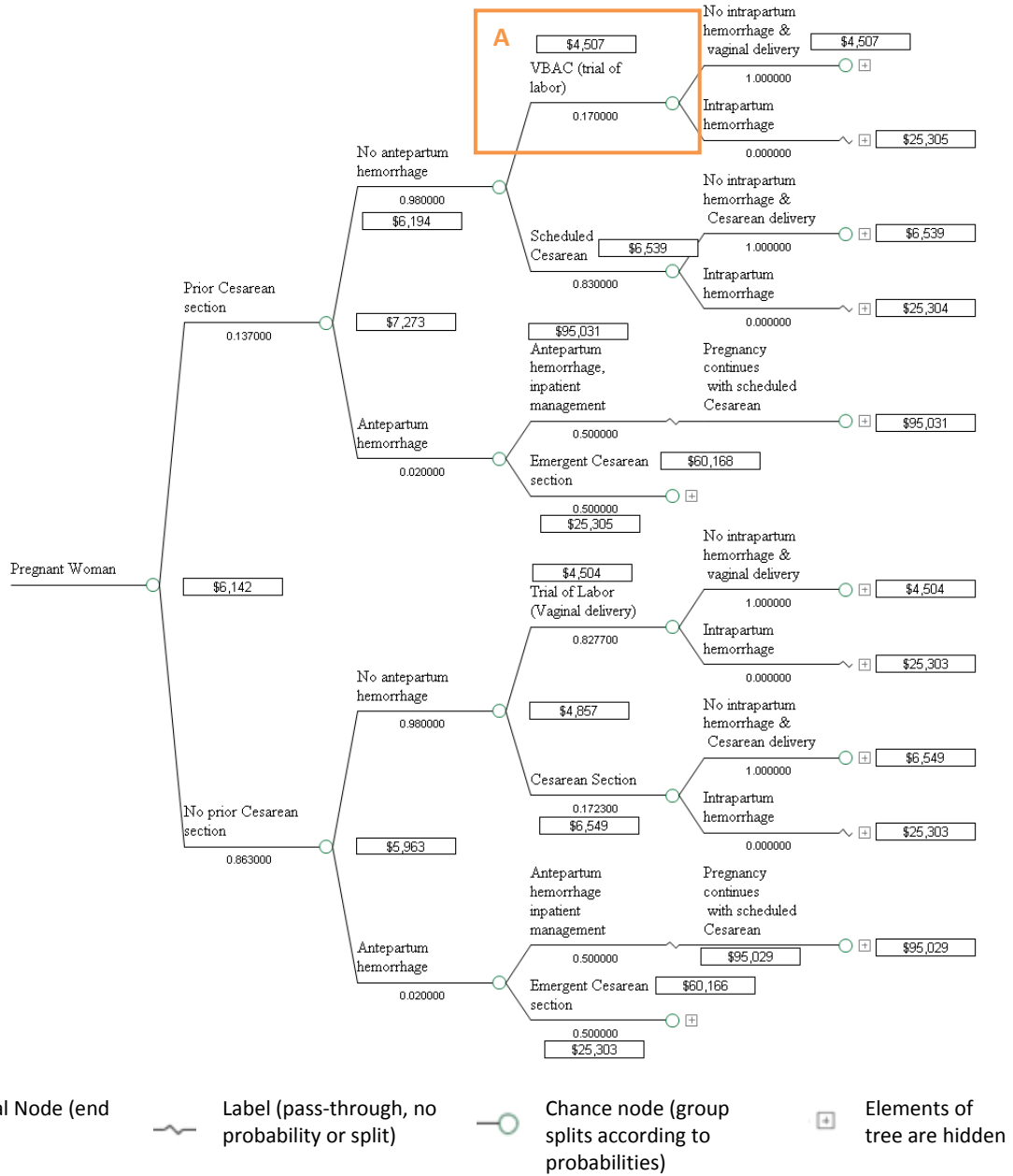
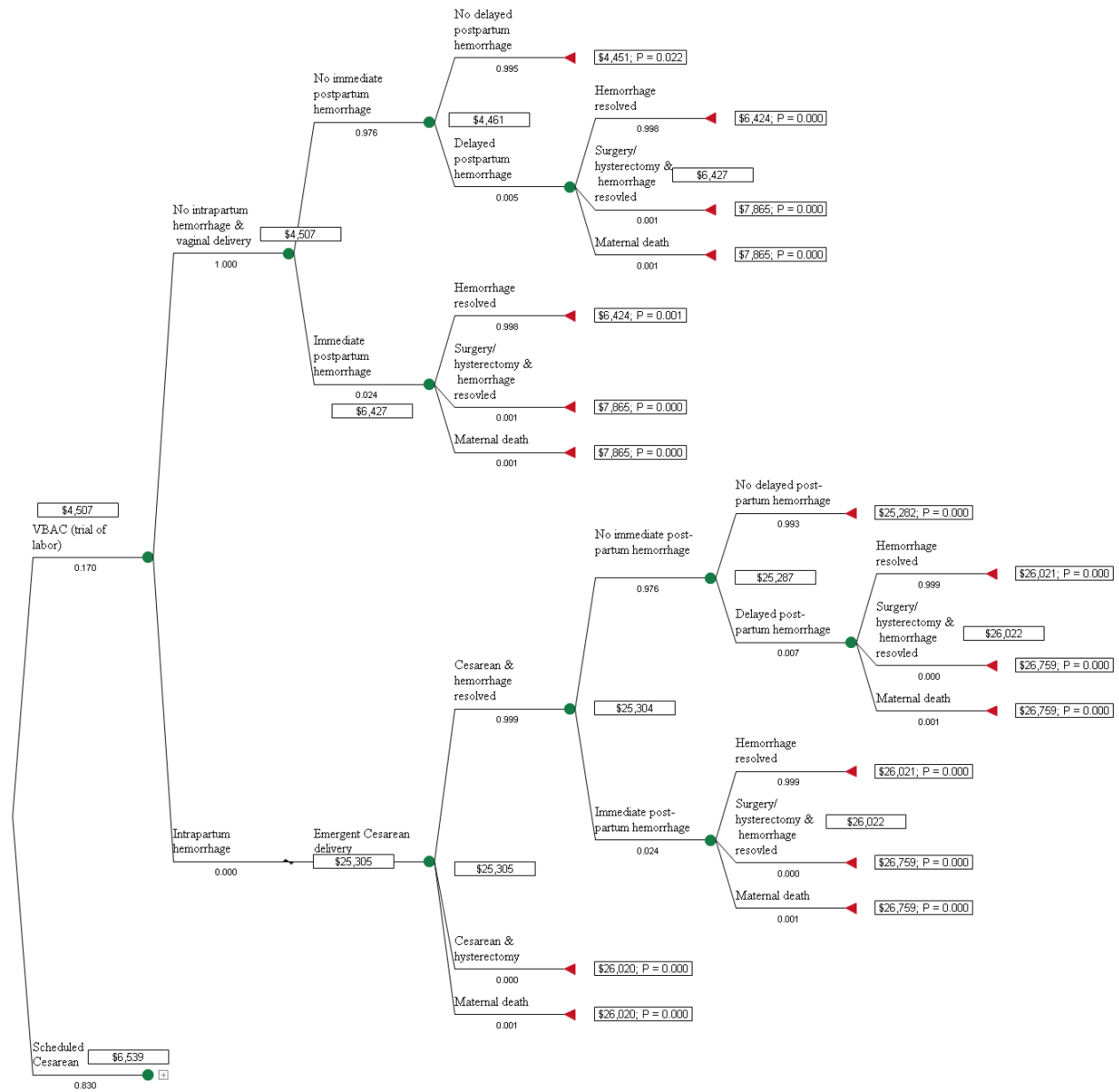


Exhibit 7. Outcomes of Maternal Hemorrhage, VBAC Detailed Tree (expansion of Box A in Exhibit 6)



- Terminal Node (end of tree)
- Label (pass-through, no probability or split)
- Chance node (group splits according to probabilities)
- Elements of tree are hidden

D. Analysis of Medi-Cal Costs

1. Costs of Uncomplicated Deliveries

The cost of uncomplicated singleton deliveries to the Medi-Cal FFS program is presented in Exhibit 8. These costs include uncomplicated maternal and neonatal costs for healthy term babies. The weighted average of maternal vaginal and cesarean deliveries is calculated using the proportion of vaginal (72%) and cesarean (28%) births in California in 2011.

Exhibit 8. Average Estimated Cost per Uncomplicated Singleton Delivery, Medi-Cal Fee-for-Service Program, 2011

Cost of Uncomplicated Vaginal Delivery with Healthy Term Neonate	Cost of Uncomplicated Cesarean Delivery with Healthy Term Neonate	Weighted Average Cost of Vaginal and Cesarean Uncomplicated Deliveries with Healthy Term Neonate
\$4,500	\$6,500	\$5,000

Notes: All estimates are rounded and estimated costs in table may not add up due to rounding. Cost estimates include maternal and neonatal costs.

2. Costs of Deliveries Complicated with Maternal Hemorrhage

Of the 494,058 singleton births in California in 2010, 4.6% (22,730) are estimated to be complicated by maternal hemorrhage. Of these, 47.3% (10,750) are estimated to be births paid for by Medi-Cal (assuming Medi-Cal and other payers covers similar proportions of births that result in maternal hemorrhage).⁵³ Exhibit 9 displays the cost per case, the incremental cost over uncomplicated deliveries, the number of deliveries paid for by Medi-Cal, and the additional costs of maternal hemorrhage to the Medi-Cal program by type of maternal hemorrhage. The overall incremental costs of maternal hemorrhage to the Medi-Cal program in 2011 are estimated at \$105,956,000.

The incremental costs of maternal hemorrhage to Medi-Cal are higher when antepartum hemorrhage is a complicating condition. For example, the incremental cost of a scheduled cesarean with antepartum and postpartum hemorrhage is estimated at \$89,300, compared to \$3,000 without antepartum hemorrhage. This is primarily because of the potential for a lengthy hospitalization for observation and treatment during the pregnancy.

If the costs paid by the Medi-Cal program were extrapolated to all in-state births with maternal hemorrhage, it is estimated that the overall costs of maternal hemorrhage in California were \$224,009,000 in 2011.

Exhibit 9. Average Estimated Costs of Singleton Deliveries with Maternal Hemorrhage, Medi-Cal Fee-for-Service Program and California, 2011¹

	Average Cost per Delivery	Incremental Cost per Case (Compared to Uncomplicated Delivery)	Number of Deliveries Covered by Medi-Cal Complicated with Maternal Hemorrhage	Total Incremental Cost of Maternal Hemorrhage to Medi-Cal	Number of California Deliveries Complicated with Maternal Hemorrhage	Total Incremental Costs of Maternal Hemorrhage in California
Antepartum hemorrhage						
Immediate and delayed postpartum hemorrhage with scheduled cesarean	\$95,700	\$89,300	60	\$5,758,000	140	\$12,174,000
Immediate and delayed postpartum hemorrhage with emergency cesarean	\$26,000	\$19,500	60	\$1,256,000	140	\$2,656,000
Cesarean and hysterectomy, death	\$26,000	\$19,500	<10	\$59,000	10	\$126,000
No postpartum hemorrhage	\$25,300	\$18,800	4,540	\$85,413,000	9,600	\$180,576,000
No antepartum hemorrhage						
Immediate and delayed postpartum hemorrhage with scheduled cesarean	\$9,500	\$3,000	1,460	\$4,354,000	3,080	\$9,206,000
Immediate and delayed postpartum hemorrhage with VBAC	\$6,400	\$1,900	160	\$307,000	330	\$648,000
Immediate and delayed postpartum hemorrhage with vaginal delivery	\$6,400	\$1,900	4,460	\$8,809,000	9,430	\$18,623,000
Total	--	--	10,750	\$105,956,000	22,730	\$224,009,000

Note: All estimates are rounded and estimated costs in table may not add up due to rounding. For example, dividing 60 Medi-Cal deliveries complicated by maternal hemorrhage by 140 total births complicated by maternal hemorrhage does not equal 47.3% due to rounding the number of each type of birth. Note that cost estimates include maternal and neonatal costs. Also, complicated deliveries are compared with uncomplicated vaginal or cesarean delivery as appropriate.

Conclusions and Implications

The estimated \$105,956,000 in incremental costs of maternal hemorrhage to the Medi-Cal program and \$224,009,000 to California are based on the 2011 Medi-Cal FFS fee schedule and the negotiated per-diem rates for contracted private hospitals, which are used as proxies for the costs of these births. The actual expenditures to the Medi-Cal program for maternal hemorrhage depend on multiple factors

including Medi-Cal payments to public hospitals, negotiated rates with Medi-Cal Managed Care organizations, and physician and hospital practice variations, as well as actual length of stay and claims. For example, the expenditures would be lower or higher depending on the proportion of designated public hospitals that are reimbursed at \$1,260- \$2,240 compared to \$1,480 per-diem rates for contracted private hospitals used in this study.⁴⁵ Also, expenditure levels may be lower in rural hospitals facing shortages of specialists or lacking the infrastructure to care for severe complications and emergencies. Expenditure could vary by a shrinking proportion of enrollees that will remain in the FFS Medi-Cal due to Medi-Cal policies overtime. Increasing enrollment of Medi-Cal FFS beneficiary in managed care plans may add to the difficulty in assessing future expenditure estimates due to lack of public data on service use and costs.

Medi-Cal reimbursements for most procedures and hospitalizations are significantly lower than commercial reimbursements, as described in the limitations section of this report.⁵⁴ Thus, the costs of maternal hemorrhage statewide are likely to be higher than those to the Medi-Cal program, including the highest-cost deliveries estimated in this report (\$95,700).

The cost estimates presented in this report are considered to be baseline data prior to implementation of the Patient Protection and Affordable Care Act (ACA). In January 2014 the number of Medi-Cal beneficiaries in California with increase significantly, though the newly enrolled are primarily childless adults who will be enrolled in managed care organizations. The number of privately insured will also increase in 2014 due to ACA through enrollment in *Covered California*. Costs of maternal hemorrhage post ACA implementation could differ due to changes in types of coverage and the settings in which maternal care is received.

The estimated costs reported above do not incorporate the lifetime medical and societal costs of maternal hemorrhage. Estimating these costs was not the focus of this study. The risk of lifetime morbidity due to hemorrhage in the U.S. is estimated at less than 0.001%, as described in Section D (p. 8).³ As such, no lifetime maternal medical costs are estimated. However, the annual lifetime medical costs per preterm birth with developmental disabilities are estimated at \$38,250, as previously described in Section B3. Lifetime Medical Costs and Appendix Exhibit 2. The lifetime medical costs to Medi-Cal associated with cerebral palsy as a consequence of preterm birth due to antepartum hemorrhage may be estimated at over \$8.1 million annually, given that about 2% of births in California are complicated by antepartum hemorrhage, roughly 50% of these births lead to emergency cesareans and preterm live births, and approximately 9.1% of these preterm neonates develop cerebral palsy (Section D. Short-term and Lifetime Medical Outcomes).^{29,48} Similarly, if 4.4% of preterm babies suffer from mental retardation, the estimated lifetime medical costs to Medi-Cal due to mental retardation as a consequence of preterm birth and antepartum hemorrhage may be \$3.9 million annually.

The significant cost of deliveries complicated by maternal hemorrhage highlights the importance of efforts to reduce cesarean deliveries in general as well as prevent or mitigate the maternal and neonatal morbidity and mortality associated with maternal hemorrhage. The success of the available preventive

and treatment measures in mitigating the costs of maternal hemorrhage depends on the effectiveness of these measures and the level of adherence to recommended protocols and current standards of medical care. Reduction in cesarean deliveries is likely to significantly reduce placenta accreta and previa, two major risk factors for maternal hemorrhage. If such measures are effectively implemented and are successful in reducing 10% of Medi-Cal births in California complicated with maternal hemorrhage, an estimated minimum of \$10.6 million may be saved each year. If such measures are successful in reducing up to 50% of births complicated by maternal hemorrhage, the estimated savings may be more than \$53 million annually.

Appendix: Cost Conversions

Appendix Exhibit 1. Maternal and Neonatal Costs of Uncomplicated and Complicated Delivery and Birth in the Literature

	Original Costs	2011 ¹ Costs
Chung et al, 2001¹⁹ : A hypothetical 30 year-old woman in a medical center in California --1999 estimates		
The total cost of an average uncomplicated vaginal birth	\$4,950	\$6,683
The average cost of a cesarean following a failed trial of labor	\$8,414	\$11,360
An elective repeat cesarean	\$7,244	\$9,781
Incremental costs of births complicated by hemorrhage		
Vaginal birth	\$328	\$443
Cesarean following a failed trial of labor	\$267	\$361
Incremental costs of births complicated by hemorrhage and hysterectomy		
Vaginal birth	\$4,742	\$6,403
Cesarean following a failed trial of labor	\$1,285	\$1,735
Neonatal costs		
Mild or no morbidity	\$261	\$352
Moderate morbidity	\$52,192	\$70,468
Severe morbidity	\$81,093	\$109,490
Neonatal death	\$40,414	\$54,566
Russell et al, 2007³³ : Hospital costs for infant hospitalizations in United States -- 2001 estimates		
Uncomplicated newborns	\$600	\$762
Extremely immature infants	\$65,600	\$83,320
Other preterm infants	\$12,100	\$15,369
Rogowski, 1999⁵⁵ : Treatment costs by gestational age in a network with 25 hospitals -- 1994 estimates		
Less than 24 weeks of gestational age	\$6,874	\$10,433

¹The costs found in the literature were converted to 2011 dollars using the Bureau of Labor Statistics calculator.³²

Appendix Exhibit 2. Costs of Preterm Birth in the Literature

	Original Costs	2011 ¹ Costs
Institute of Medicine, ⁴⁸2007 : Annual lifetime medical and societal costs of preterm birth per preterm infant -- 2005 estimates		
Total	\$51,589	\$59,431
Medical care	\$33,210	\$38,250
Early intervention	\$1,203	\$1,386
Special education	\$2,150	\$2,476

¹The costs found in the literature were converted to 2011 dollars using the Bureau of Labor Statistics calculator.³²

References

1. Minino AM, Heron MP, Murphy SL, Kochanek KD. *National Vital Statistics Reports: Deaths 2004*. U.S. Department of Health and Human Services and the Centers for Disease Control and Prevention; 2007. Accessed July, 2012.
2. Berg C, Callaghan WM, Syverson C, Henderson Z. Pregnancy-related mortality in the United States, 1998-2005. *Obstetrics and Gynecology*. 2010;116(6):1302.
3. World Health Organization. *World Health Report 2005: Make Every Mother and Child Count*. World Health Organization; 2005 http://www.who.int/whr/2005/whr2005_en.pdf. Accessed July, 2012.
4. Silver RM, Landon MB, Rouse DJ, et al. Maternal morbidity associated with multiple repeat cesarean deliveries. *Obstetrics and Gynecology*. Jun 2006;107(6):1226-1232.
5. Goffman D, Madden RC, Harrison EA, Merkatz IR, Chazotte C. Predictors of maternal mortality and near-miss maternal morbidity. *Journal of Perinatology : Official Journal of the California Perinatal Association*. Oct 2007;27(10):597-601.
6. Symonds EM, Symonds IM. *Essential Obstetrics and Gynaecology*. Edinburgh; New York: Churchill Livingstone; 2004.
7. Hoveyda F, MacKenzie IZ. Secondary postpartum haemorrhage: incidence, morbidity and current management. *BJOG: An International Journal of Obstetrics and Gynaecology*. 2001;108(9):927-930.
8. Gregory K, Main E, Lyndon A. *Definition, Early Recognition and Rapid Response Using Triggers*. Improving Health Care Response to Obstetric Hemorrhage. Obstetric Hemorrhage Care Guidelines and Compendium of Best Practices. Stanford University, Palo Alto, CA California Maternal Quality Care Collective (CMCQQ). 2009 Available at: www.cmccc.org/resources/617/download. Accessed June 11, 2013.
9. Lu MC, Fridman M, Korst LM. Variations in the incidence of postpartum hemorrhage across hospitals in California. *Maternal and Child Health Journal*. 2005;9(3):297-306.
10. Rathore SS, McMahon MJ. Racial variation in the frequency of intrapartum hemorrhage. *Obstetrics and Gynecology*. 2001;97(2):178.
11. Bateman BT, Berman MF, Riley LE, Leffert LR. The epidemiology of postpartum hemorrhage in a large, nationwide sample of deliveries. *Anesth Analg*. May 1 2010;110(5):1368-1373.
12. Rageth JC, Juzi C, Grossenbacher H. Delivery after previous cesarean: a risk evaluation. Swiss Working Group of Obstetric and Gynecologic Institutions. *Obstetrics and Gynecology*. Mar 1999;93(3):332-337.
13. Knight M, Callaghan WM, Berg C, et al. Trends in postpartum hemorrhage in high resource countries: a review and recommendations from the International Postpartum Hemorrhage Collaborative Group. *BMC Pregnancy and Childbirth*. 2009;9:55.
14. Lu MC, Korst LM, Fridman M, Muthengi E, Gregory KD. Identifying women most likely to benefit from prevention strategies for postpartum hemorrhage. *Journal of Perinatology : Official Journal of the California Perinatal Association*. Jun 2009;29(6):422-427.
15. Lydon-Rochelle M, Holt VL, Easterling TR, Martin DP. First-birth cesarean and placental abruption or previa at second birth. *Obstetrics and Gynecology*. May 2001;97(5 Pt 1):765-769.
16. Gurol-Urganci I, Cromwell D, Edozien L, et al. Risk of placenta previa in second birth after first birth cesarean section: a population-based study and meta-analysis. *BMC Pregnancy and Childbirth*. 2011;11(1):95.

17. Main E, Morton C, Hopkins D, Giuliani G, Melsop K, Gould J. *Cesarean Deliveries, Outcomes, and Opportunities for Change in California: Toward a Public Agenda for Maternity Care Safety and Quality*. Stanford University, Palo Alto, CA California Maternal Quality Care Collective (CMCQQ). 2011 Available at: www.cmqcc.org. Accessed June 11, 2013.
18. Gregory KD, Fridman M, Korst L. Trends and patterns of vaginal birth after cesarean availability in the United States. *Seminars in Perinatology*. Aug 2010;34(4):237-243.
19. Chung A, Macario A, El-Sayed YY, Riley ET, Duncan B, Druzin ML. Cost-effectiveness of a trial of labor after previous cesarean. *Obstetrics and Gynecology*. 2001;97(6):932.
20. Lydon-Rochelle M, Holt VL, Easterling TR, Martin DP. Risk of uterine rupture during labor among women with a prior Cesarean delivery. *New England Journal of Medicine*. 2001;345(1):3-8.
21. Sinha P, Kuruba N. Antepartum haemorrhage: an update. *Journal of Obstetrics and Gynaecology: the Journal of the Institute of Obstetrics and Gynaecology*. May 2008;28(4):377-381.
22. Magann EF, Cummings JE, Niederhauser A, Rodriguez-Thompson D, McCormack R, Chauhan SP. Antepartum bleeding of unknown origin in the second half of pregnancy: a review. *Obstetrical and Gynecological Survey*. Nov 2005;60(11):741-745.
23. Callaghan WM, Kuklina EV, Berg CJ. Trends in postpartum hemorrhage: United States, 1994-2006. *American Journal of Obstetrics and Gynecology*. Apr 2010;202(4):353 e351-356.
24. Groom KM, Jacobson TZ. *A textbook of postpartum hemorrhage A comprehensive guide to evaluation, management and surgical intervention*. Dumfriesshire, UK: Sapiens Publishing; 2006. http://www.sapienspublishing.com/pph_pdf/PPH-Chap-35.pdf
25. Bonnar J. Massive obstetric haemorrhage. *Bailliere's Best Practice and Research Clinical Obstetrics and Gynaecology*. Feb 2000;14(1):1-18.
26. Alexander J, Thomas P, Sanghera J. Treatments for secondary postpartum haemorrhage. *Cochrane Database Syst Rev*. 2002(1):CD002867.
27. Dolea C, AbouZahr C, Stein C. *Global burden of maternal haemorrhage in the year 2000*. Global Burden of Disease. Geneva World Health Organization (WHO); 2003 http://www.who.int/healthinfo/statistics/bod_maternalhaemorrhage.pdf. Accessed July, 2012.
28. Bodnar LM, Scanlon KS, Freedman DS, Siega-Riz AM, Cogswell ME. High prevalence of postpartum anemia among low-income women in the United States. *American Journal of Obstetrics and Gynecology*. 2001;185(2):438-443.
29. Moster D, Lie RT, Markestad T. Long-Term Medical and Social Consequences of Preterm Birth. *New England Journal of Medicine*. 2008;359(3):262-273.
30. Mitchell C, Lawton E, Morton C, McCain C, Holtby S, Main E. California Pregnancy-Associated Mortality Review: Mixed Methods Approach for Improved Case Identification, Cause of Death Analyses and Translation of Findings. *Maternal and Child Health Journal*. 2013/04/13 2013:1-9.
31. Gregory KD, Korst LM, Fridman M, et al. Vaginal birth after cesarean: clinical risk factors associated with adverse outcome. *American Journal of Obstetrics and Gynecology*. Apr 2008;198(4):452 e451-410; discussion 452 e410-452.
32. U.S. Bureau of Labor Statistics (BLS). CPI Inflation Calculator. http://www.bls.gov/data/inflation_calculator.htm. Accessed July, 2012.
33. Russell RB, Green NS, Steiner CA, et al. Cost of hospitalization for preterm and low birth weight infants in the United States. *Pediatrics*. Jul 2007;120(1):e1-9.
34. California Department of Public Health. *The California Pregnancy-Associated Mortality Review. Report from 2002 and 2003 Maternal Death Reviews* Sacramento California Department of Public Health, Maternal, Child, and Adolescent Health Division; 2011. Accessed June 10, 2013.

35. Hull A, Lagrew D. *Active management of third stage labor*. CMQCC Obstetric Hemorrhage Toolkit: Obstetric Hemorrhage Care Guidelines and Compendium of Best Practices. Stanford University, Palo Alto, CA California Maternal Quality Care Collective (CMCQQ). 2009 www.cmqcc.org/resources/875/download. Accessed July, 2012.
36. Lagrew D, (co-chaired) AL. OB Hemorrhage Toolkit. Stanford University, Palo Alto, CA http://www.cmqcc.org/ob_hemorrhage. Accessed June 11, 2013.
37. Lagrew D. *Inherited coagulation disorders in pregnancy*. CMQCC Obstetric Hemorrhage Toolkit: Obstetric Hemorrhage Care Guidelines and Compendium of Best Practices. Stanford University, Palo Alto, CA California Maternal Quality Care Collective (CMCQQ). 2009 www.cmqcc.org/resources/885/download. Accessed June 11, 2013.
38. Main E. *Obstetric care for women who decline transfusions (Jehovah's Witnesses and others)*. CMQCC Obstetric hemorrhage toolkit: Obstetric Hemorrhage Care Guidelines and Compendium of Best Practices. Stanford University, Palo Alto, CA California Maternal Quality Care Collective (CMCQQ). 2009 www.cmqcc.org/resources/886/download. Accessed June 10, 2013.
39. Lee R. *Placenta accreta and percreta: Incidence, risks, diagnosis, counseling and preparation for delivery*. CMQCC Obstetric hemorrhage toolkit: Obstetric Hemorrhage Care Guidelines and Compendium of Best Practices. Stanford University, Palo Alto, CA California Maternal Quality Care Collective (CMCQQ). 2010 www.cmqcc.org/resources/631/download. Accessed June 10, 2013.
40. Vedantham S, Goodwin SC, McLucas B, Mohr G. Uterine artery embolization: an underused method of controlling pelvic hemorrhage. *American Journal of Obstetrics and Gynecology*. Apr 1997;176(4):938-948.
41. California Department of Public Health. TABLE 2-14. Live births by plurality of delivery, sex of child, and by race/ethnic group of mother, California. 2010; Available at: <http://www.cdph.ca.gov/data/statistics/Documents/VSC-2010-0214.pdf>. Accessed September 22, 2012.
42. California Department of Health Care Services. Medi-Cal Member Months: Statewide and County Pivot Tables. 2011; <http://www.dhcs.ca.gov/dataandstats/statistics/Pages/Medi-Cal%20Member%20Months%20-%20Statewide%20and%20County%20Pivot%20Tables.aspx>. Accessed June 10, 2013.
43. California Department of Health Care Services. Medi-Cal Managed Care Enrollment Reports. 2011; <http://www.dhcs.ca.gov/dataandstats/reports/Pages/MMCDMonthlyEnrollment.aspx>. Accessed June 10, 2013.
44. California Medical Assistance Commission. *California Medical Assistance Commission Annual Report to the Legislature*. Sacramento 2012 <http://www.dhcs.ca.gov/services/spcp/Documents/cmacannualreport2012.pdf>. Accessed July, 2012.
45. Swol B. Hospital financing (per diem rates). In: Pourat N, ed. email ed. Sacramento, CA: Chief, Hospital Uninsured Care and Subacute Unit, Department of Health Care Service; 2012.
46. Office of Statewide Health Planning and Development (OSHPD). MS-DRG by Patient County of Residence for 2010 Statewide Totals. 2010; <http://www.oshpd.ca.gov/HID/Products/PatDischargeData/PivotTables/Top25DRGs/default.asp>. Accessed July, 2012.
47. California Department of Healthcare Services. Medi-Cal Rates. 2012; <http://files.medi-cal.ca.gov/pubsdoco/rates/rateshome.asp>.

48. Behrman RE, Butler AS, eds. *Preterm Birth: Causes, Consequences, and Prevention*. Washington (DC): Institute of Medicine (US) Committee on Understanding Premature Birth and Assuring Healthy Outcomes; 2007. <http://www.ncbi.nlm.nih.gov/pubmed/20669423>
49. TreeAge Software. 2012. Pro T. Williamstown, MA: TreeAge Software, Inc.
50. Roberts G. Unclassified antepartum haemorrhage incidence and perinatal mortality in a community. *BJOG: An International Journal of Obstetrics & Gynaecology*. 1970;77(6):492-495.
51. Taylor L, Simpson J, Roberts C, Olive E, Henderson-Smart D. Risk of complications in a second pregnancy following caesarean section in the first pregnancy: a population-based study. *Med J Aust*. 2005;183(10):515-519.
52. Martin J, Hamilton B, Ventura S, et al. Births: final data for 2009. *National vital statistics reports: from the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System*. 2011;60(1).
53. Gregory KD, Jackson S, Korst L, Fridman M. Cesarean versus vaginal delivery: whose risks? Whose benefits? *American Journal of Perinatology*. Jan 2012;29(1):7-18.
54. Hunt S, Maerki S, Tompkins R. *Comparing CPT Code Payments for Medi-Cal and Other California Payers*. Oakland, CA California HealthCare Foundation; 2001
<http://www.chcf.org/publications/2001/06/comparing-cpt-code-payments-for-medical-and-other-california-payers#ixzz21CvkYCSO>.
55. Rogowski J. Measuring the cost of neonatal and perinatal care. *Pediatrics*. Jan 1999;103(1 Suppl E):329-335.