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Hypertension, Preeclampsia, and Eclampsia

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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 gestational hypertensive disorders 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
GHD	Gestational hypertensive disorders
HCPCS	Healthcare Common Procedure Coding System
HELLP	Hemolysis, Elevated Liver Enzymes, Low Platelet Count
ICD-9-CM	International Classification of Diseases, 9th Edition (Clinical Modification) diagnosis codes
ISC	Ischemic stroke
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
SAH	Subarachnoid hemorrhage
SPCP	Medi-Cal Selective Provider Contracting Program

Executive Summary

Gestational hypertensive disorders are a major public health concern nationally and in California, and significant effort is directed towards preventing morbidity and mortality from these conditions. The rising rates of risk factors, including obesity, maternal age, and diabetes, may lead to an increase in the rate of gestational hypertensive disorders. Appropriate management can reduce the significant societal and cost burden of these conditions. With approximately half a million births annually in California, nearly half of which are paid by Medi-Cal, the costs of gestational hypertensive disorders are of particular concern to the Medi-Cal program. Assessing the magnitude of the preventable expenditures due to gestational hypertensive disorders may aid in the widespread implementation of evidence-based guidelines and reduction of these avoidable expenditures.

We identified the probabilities of various forms of gestational hypertensive disorders from available literature. We used these probabilities to develop the likelihood of various maternal and neonatal outcomes given the severity of gestational hypertensive disorders, gestational age, and type of delivery. We also developed cost scenarios associated with these outcomes for the mother and the baby. We used publicly available data from the Medi-Cal fee-for-service (FFS) fee schedule and reimbursement rates to private hospitals in California to develop costs. We then estimated the average cost per uncomplicated delivery and the incremental cost per delivery complicated by gestational hypertensive disorders. We also calculated the overall incremental medical costs of these disorders 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 gestational hypertensive disorders.

Findings

- Approximately 5.6% (27,580) of births in California in 2011 were estimated to be complicated by gestational hypertensive disorders. Of these, 47.3% (13,040) 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, was 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 incremental cost of deliveries complicated by gestational hypertensive disorders in 2011 was estimated to $106,923,000 for the Medi-Cal program.
- The estimated incremental cost per case was highest for cases of severe preeclampsia/Hemolysis, Elevated Liver Function, Low Platelets (HELLP syndrome) at 24-33 weeks of gestation among pregnancies not complicated by chronic hypertension. This cost included deliveries for women with severe preeclampsia/HELLP syndrome who delivered by cesarean before 24 weeks, received expectant management and had maternal complications

and extremely immature infants with complications (estimated incremental cost of $70,100 per delivery for mother and infant).

- The costs of gestational hypertensive disorders statewide and to commercial insurers are likely to be higher than those estimated for Medi-Cal due to higher payment rates under commercial insurance.
- The lifetime costs are frequently due to high rates of preterm births with gestational hypertensive disorders and higher costs of subsequent developmental disabilities that are more common for children born preterm. Lifetime medical costs associated with two developmental disabilities, cerebral palsy and mental retardation is estimated at $38,250 per child annually.
- Maternal stroke is also a severe maternal complication of gestational hypertensive disorders, with an estimated incidence rate of 0.034% per delivery and an estimated lifetime medical cost of $659,156 for a 25 year-old woman.

Introduction and Significance

A. Prevalence of Maternal Hypertension, Preeclampsia, and Eclampsia

Gestational hypertensive disorders are common medical disorders occurring during pregnancy. The overall incidence estimates range from 5-10% in the United States (U.S.) and vary with mother's age at time of birth.[1] Hypertensive disorders include chronic hypertension (precedes pregnancy), gestational hypertension, preeclampsia (mild/severe), preeclampsia superimposed on chronic hypertension, eclampsia, and HELLP syndrome. Generally, the clinical presentation is classified into grades of severity measured by blood pressure elevation (>140 systolic/90 diastolic mmHg) and presence of proteinuria, with or without additional indicators such as abnormal lab values, or evidence of fetal or placental compromise (e.g., placental abruption).[2] Hypertensive disorders associated with pregnancy progress differently and result in various outcomes (including risk of maternal death from eclampsia, which is estimated at as much as 1.8% in developed countries).[3] Infants also experience a range of outcomes that are highly dependent on the timing, severity, and management decisions surrounding maternal hypertensive disorders.

Women with chronic hypertension who develop more severe hypertension accompanied by proteinuria during pregnancy are classified as having superimposed preeclampsia during pregnancy. Gestational hypertension is defined as increased blood pressure during pregnancy without other abnormal signs or symptoms. Preeclampsia is gestational hypertension with proteinuria. Severe preeclampsia is defined as blood pressure elevation 160 systolic and/or 110 diastolic or higher on at least two occasions or in the presence of significant proteinuria (greater than 5 grams in 24 hours), cerebral or visual disturbances or evidence of vital organ dysfunction such as lung, liver or kidney, or fetal growth restriction. HELLP syndrome, which many consider a variant of preeclampsia, is characterized by hemolysis, elevated liver enzymes, and low platelet counts. It may or may not be associated with hypertension or proteinuria.

Finally, eclampsia is diagnosed with the occurrence of new onset seizures in a patient with any of the above symptoms. Usually, gestational hypertensive disorders present at or near term (late onset), however, early-onset preeclampsia is associated with worse perinatal outcomes including low birth-weight. Women with early onset of less severe hypertension can develop more severe disease at a later stage of pregnancy. These disorders can also occur in the postpartum period, including 33% or more of eclampsia cases.[4]

B. Causes and Risk Factors

The mechanism behind the hypertensive disorders of pregnancy are as yet unknown, though they are thought to occur as a result of placental invasion of the trophoblast.[5] Preeclampsia is most common in first pregnancies. Other risk factors include: (1) hypertensive disorder in a previous pregnancy, or chronic hypertension; (2) diabetes mellitus; (3) multifetal pregnancy; (4) vascular and connective tissue disorders; (5) renal disease; (6) obesity; 7) age (35+ years of age), and; (8) being African American.[2] The rate of hypertension complicating pregnancy in California increased by 13% from 1999 to 2005.[6]

C. Treatment

Current guidelines for management of these disorders include monitoring and clinical management of hypertension.[7] There is general consensus that the only definitive cure for these disorders is delivery, though this has been challenged recently. Several studies have shown some efficacy in delaying delivery by expectant management of patients with regard to neonatal benefits, depending on the severity and gestational maturity of the pregnancy. Expectant management includes monitoring the mother and fetus for symptoms in order to prolong the pregnancy and improve the likelihood of survival of the fetus. Interventions include administering medications such as steroids to the mother to mature the lungs of the fetus, and magnesium sulfate to prevent maternal seizures (eclampsia). However, the maternal risks and neonatal benefits have to be weighed carefully when considering expectant management with severe or early-onset disease.

D. Short-term and Lifetime Medical Outcomes

Both mother and baby may experience short-term complications from hypertensive disorders. Maternal complications may be extensions, or effects of the disease, including renal failure, liver failure and neurological sequelae. Other serious morbidities with lifetime consequences include stroke, cerebrovascular disease, hysterectomy with loss of fertility, or other permanent disability. Generally, the risk of stroke is greater in pregnancy, with 34.2 strokes (ischemic and hemorrhagic events) per 100,000 deliveries compared to 10.7 per 100,000 sexually active, non-pregnant reproductive aged women.[8] Compared to pregnant women without hypertension, the risk of stroke for pregnant women with hypertensive disorders is increased six to nine times.[8] Risk of stroke or cardiovascular disease later in life

for women who had hypertensive disorders during pregnancy has also been observed, though evidence is sparse and the prevalence is not well-known.[9]

Neonatal complications from gestational hypertensive disorders are primarily due to preterm birth and may include respiratory distress syndrome and other disorders associated with prematurity and/or fetal growth restriction, and may require admission to the intensive care unit. Lifetime consequences are also possible and may include developmental disabilities. A 2003 national longitudinal study of survivors of preterm birth identified higher prevalence of cerebral palsy compared to individuals born at term (9.1% when born at 23-27 weeks of gestation vs. 0.1% for those born at term). Mental retardation occurred in 4.4% of preterm birth survivors, compared to 0.4% of those born at term.[10]

Maternal and neonatal deaths are also possible outcomes. Their probabilities vary by the timing of onset and severity of the disorder. In California, preeclampsia is the second leading cause of maternal death, with a rate of 1.6 deaths for every 100,000 live births.[11]

E. Costs of Maternal and Neonatal Care

The published data on costs of maternal and neonatal care are sparse and often outdated. 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.[12] 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 woman in California was estimated at $6,683. The cost for a cesarean following a failed trial of labor was higher ($11,360) than an elective repeat cesarean delivery ($9,781).[13]

Few studies of the costs of hypertensive disorders among women of childbearing age are available. One observational study assessed the hospital charges for women with gestational hypertensive disorders at $12,625.[14] The geographic location for the data was not identified.

The neonatal costs associated with mild or no morbidity has been estimated to be approximately $352 in one California study[13] and $762 in another study.[15] It is recognized that most neonatal morbidity associated with gestational hypertensive disorders is due to complications of prematurity. Several studies have assessed the costs associated with infants based on gestational age or ICD-9-CM diagnostic codes. The hospital costs of 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).[15]

Neonatal costs with neonatal death ($54,566), moderate morbidity ($70,468), and severe morbidity ($109,490) were much higher.[13] Another study also estimated higher costs for newborns from birth to discharge at earlier gestational ages including less than 24 weeks of gestational age ($10,433), 24-26 weeks gestational age ($145,042), 27-29 weeks gestational age ($93,685), 30-32 weeks gestational age ($53,284), and over 32 weeks of gestational age ($29,286).[16]

F. Prevention of Morbidity and Mortality

Research on various preventive treatments, including calcium supplements, low-dose aspirin, and antioxidants, have not found conclusive and significant benefits in preventing gestational hypertension, although studies are ongoing. [2] Currently, the preventive practices recommended for gestational hypertension or preeclampsia may vary, although low-dose aspirin may be beneficial for high-risk pregnancies.[17] Once present however, preeclampsia and deaths due to preeclampsia may be avoided with proper monitoring and appropriate management.[18,19] The diagnosis of illness (based on signs, symptoms, and gestational age) determines the course of treatment, including expectant management or delivery, and the course of treatment has a significant impact on maternal and fetal outcomes. Accurate diagnosis and timely treatment of hypertension to lower blood pressure are the primary tools for prevention of severe morbidity. Diagnosis requires accurate blood pressure readings, testing for the presence of proteinuria, and access to continuous prenatal care during pregnancy.[20,21] Once a patient has an established diagnosis of preeclampsia, antihypertension medication for treatment and control of severe blood pressure (>=160/110) and magnesium sulfate prophylaxis is the standard treatment for the prevention and management of eclamptic seizures.[22] Based on findings from the statewide review of maternal deaths from preeclampsia, tools are in development to improve health care provider and facility response and recognition to preeclampsia and eclampsia.[7]

Methods

A. Probabilities

We conducted a comprehensive review of the literature concerning maternal and neonatal outcomes of maternal hypertensive disorders using PubMed, Google Scholar and the Cochrane library database. The search terms were classified by category and included:

1. Pregnancy-induced or gestational hypertension;
2. Preeclampsia;
3. Eclampsia;
4. HELLP (hemolysis, elevated liver enzymes, low platelet count) syndrome; and
5. Non-specific terms including neonatal/perinatal outcomes/complications and maternal complications/morbidity/mortality.

We included studies focused on maternal and neonatal morbidity or death, English language studies, and human-based research. More recent published studies were given priority primarily because of advances in neonatal intensive care such as the advent of surfactant replacement therapy, and consequently increasing rates of viable premature newborns. These advances contribute to the changing (generally increasing) costs of newborn care over the past few decades, particularly for those newborns with complications and/or needing intensive care services. Only studies published after 1998 were ultimately included in analyses.

Research focused on U.S. data was weighted more heavily than research conducted in other countries. Studies performed within the setting of developing countries, or those with extremely different antenatal/delivery/postpartum technologies or facilities, were excluded entirely, except if they were included in Cochrane or other systematic reviews on the topic. We used snowballing techniques to identify relevant studies not identified through using the search terms. Overall, 94 studies and reviews were identified, and 36 articles were ultimately used to direct the probabilities and costs for the maternal hypertension 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 California Department of Public Health and indicate 509,979 live births, 494,058 (96.9%) of which were singletons.[23]

B. Costs

We developed the costs of hospitalization and physician services for gestational hypertensive disorders based on Medi-Cal (California's Medicaid program) fee-for-service 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.[24,25] Medi-Cal payments to managed care plans are estimated to be approximately $10 billion in 2011,[26] 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.[27] 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.[26]

In fiscal year 2010-11, private contracted hospitals incurred 86% of all-cause inpatient days and 75% of total hospitalization costs.[26] 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).[26] A flat per-diem rate is determined annually and varies by a variety of factors.[26] 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.[26]

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 all California patient discharges. These aggregate data at the state level were not available by specific condition.[28] 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.[29]

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 vaginal birth after cesarean (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 gestational hypertensive disorders.[28] 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.

2. Private/All Payer Costs

Private/all payer costs are not estimated in this report for two reasons. First, there is significant variation in reimbursements by commercial payers. Second, published information on maternity and neonatal costs associated with hypertensive disorders is sparse and frequently outdated, and varies greatly in methodology, geographic area, and generalizability. An accurate and valid assessment of the costs associated with hypertensive disorders would require analysis of claims data from large commercial insurers, which is beyond the scope of this study. However, the available published costs reported in Section E provide a general idea of the available data on costs for maternity and neonatal care in general, and gestational hypertensive disorders specifically.

3. Lifetime Medical Costs

As indicated in Section D, the primary significant maternal complication of gestational hypertensive disorders is stroke. Pregnancy related strokes can be hemorrhagic or ischemic.[7,30] A national study of claims data and other national surveys estimated the lifetime medical costs of these strokes for women age 25 at $700,460 for subarachnoid hemorrhage (SAH) and $617,851 for ischemic stroke (ISC).[31] Nearly half (45%) of these costs were incurred in the first two years, with 35% for long-term ambulatory costs and 17.5% for nursing home costs.[31]

Lifetime medical and societal costs of preterm birth are estimated at $59,431 ($51,589 in 2005) per preterm infant annually.[32] These costs can be broken down into medical care ($38,250), early intervention ($1,386), and special education ($2,476) Appendix Exhibit 2. [32] 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%).[32] Special education services include costs for the four major developmental disabilities including cerebral palsy and mental retardation. [10,32]

C. Cost of Illness Model

We used TreeAge Software to construct a decision tree to estimate the cost of gestational hypertensive disorders.[33] The software allows 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) risk of disease progression to more severe/complex stages, and (2) changing gestational age periods. The model begins with all pregnant women, who are then divided into categories representing those who develop gestational hypertensive disorders, those with chronic hypertension who develop superimposed hypertensive disorders, and those without either condition

during their pregnancy. This last group is further divided into those who develop hypertension in the postpartum phase and those who have an uncomplicated pregnancy.

Changing gestation periods were modeled to represent the increased risk of maternal adverse events as a result of prolongation of pregnancy or during natural progress of pregnancy. Longer gestational age was assumed to increase the chances of fetal survival. Cut-off points for gestational age periods (<24 weeks, 24-33 weeks, 34-36 weeks, and 37 weeks to term delivery) were determined based on the systematic review of existing lay and peer-reviewed literature and expert knowledge. During each gestation period, women with mild hypertension and preeclampsia were considered to be at varying risks for advancement to severe preeclampsia, HELLP, or eclampsia with complications.

It was assumed that developing severe preeclampsia or eclampsia seizures at less than 24 weeks' gestation would lead to termination of pregnancy, as this is the only option to resolve the illness. Corresponding literature on early-term severe preeclampsia and eclampsia indicated low effectiveness of expectant management at this state of pregnancy, with higher maternal morbidity and very minimal benefit to the newborn.[34,35] Inpatient expectant management is an option in early gestation ages, even with severe disease. However, for milder forms of illness (chronic hypertension without proteinuria or mild preeclampsia), outpatient management with close surveillance may aid women to reach advanced gestation. Complications around the time of delivery are also modeled to assess maternal and fetal/perinatal outcomes. Maternal mortality, survival with complication or morbidity, and survival without complication or morbidity were modeled with the probability of fetal/perinatal death or survival with and without morbidity and subsequent treatment for both mother and child.

The pregnancy periods were modeled similarly, with the following exceptions:

(1) The probability of a healthy baby being born before 24 weeks is very low and we assumed all newborns younger than 24 weeks of gestation age to be premature or extremely immature.
(2) A proportion of women at gestational age 24-33 weeks with mild forms of illness were assumed to be eligible for inpatient expectant management to prolong pregnancy.
(3) Women at 34-36 weeks of gestation may also be considered for hypertension management. However, if the illness is severe enough, immediate delivery may be the best treatment option for the mother. The fetus may still be considered premature, but has a stronger chance of being healthy after delivery.
(4) All gestation periods included a probability of being preterm and were automatically assumed to include some probability of complications with neonatal intensive care unit (NICU) treatment except for term deliveries. Deliveries at 37 weeks and older were also modeled with the possibility of complications for term babies such as low birth weight when the mother has chronic hypertension and superimposed preeclampsia or preeclampsia.

The majority of probabilities were obtained from the literature. However, in cases in which no direct probabilities were available, approximations were developed based on the literature. In a few cases, global rates were used in the absence of probabilities for specific gestation period or severity of illness. When a range of probabilities was available, we used the most conservative lower-end estimates, other

than zero. We did not use zero estimates because they were frequently from small or narrowly defined samples. If the lower-end estimates were zero, we used the mid-range or the most representative estimate based on national, U.S.-based, or studies with larger samples.

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 gestational hypertensive disorders was at times from outdated studies, 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. The data on gestational age were frequently complicated by different gestational maturity cut-offs leading to different maternal and neonatal estimates for management, and outcomes. These limitations are not unique to this study but may impact the accuracy of the results. In addition, the rates of gestational hypertensive disorders 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 estimate of the prevalence of gestational hypertensive disorders.

2. Singleton Births

The estimated number of singleton births may be overestimated or underestimated depending on the changes in the birthrate in California since 2010. The examination of the singleton birthrate in California showed an increase from 531,397 in 2005 to 548,650 in 2007 and a decline to 494,058 in 2010.[23]

3. Costs

We calculated the costs of gestational hypertensive disorders using available published cost data using the published 2011 Medi-Cal Fee-Schedule and 2011 Medi-Cal per-diem payment rates to its 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

We calculated the costs of gestational hypertensive disorders using available published cost data rather than estimate costs from claims data or similar sources because the latter methodology was outside the scope of this project. The published data on national or California costs of gestational hypertensive disorders were sparse and frequently outdated. In the absence of such data, we opted to calculate the costs of various scenarios by gestational age and severity of illness using the published 2011 Medi-Cal Fee-Schedule and 2011 Medi-Cal per-diem payment rates to its 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. In addition, given that Medi-Cal costs are considered the lowest level of payment for services used in the care of gestational hypertensive disorders, 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 the LOS were not unique to patients with gestational hypertensive disorders and these data were reported for a limited number of DRGs (Diagnostic Related Groups) for maternal and neonatal hospitalizations, without distinguishing the types of complications. We addressed these limitations by examining the few available studies on length of stay by gestational age and severity 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 higher level of severity.

4. Analytic Methods

Our analytic decision tree and cost estimates did not include pregnancies with multiple gestation or chronic conditions other than chronic hypertension. We assumed that many chronic conditions may be randomly distributed across both uncomplicated pregnancies and those complicated by gestational hypertensive disorders. In addition, the presence of comorbidities may have increased the maternal and neonatal costs and therefore, the findings in this report are more likely to underreport costs of pregnancies complicated by various comorbid conditions and are more conservative.

Eclampsia may occur after development of severe preeclampsia, but the time lapse between these two diagnoses may be too short to distinguish illness progression in the model. Therefore, we modeled eclampsia as a separate diagnosis from severe preeclampsia/HELLP. Lifetime medical and societal costs such as loss of productivity, including costs associated with maternal mortality were not modeled. We addressed this caveat by providing published data in the literature on potential lifetime medical costs associated with gestational hypertensive disorders. However, the societal costs 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 gestational hypertensive disorders can be replicated in various settings or different states to obtain similar estimates of such costs.
- Our findings make an important contribution toward estimating the public costs associated with gestational hypertensive disorders. 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 gestational hypertensive disorders.

Findings

A. Probability of Gestational Hypertensive Disorders

The probabilities of gestational hypertensive disorders are provided in Exhibit 1.

Exhibit 1. Probabilities of Outcomes of Gestational Hypertensive Disorders

		Rates	Source	Study Location
Global Rates (not differentiated by gestational age or severity)				
	Eclampsia - general risk of perinatal mortality	5.60%	Liu 2011[36]; Sibai 2005[3]	Canada; U.S.
<24 weeks gestation				
<24 weeks Severe Preeclampsia/HELLP				
	Proportion of superimposed GHD that are severe Preeclampsia	20%	Sibai 2006[37]; Sibai 2003[38]; Livingston 2003[39]	U.S.
	Stillborn/abortion	52%	Budden 2006[40]	New Zealand
	Maternal complication/morbidity rate	43%	Gaugler 2006[41]; Belghiti 2011[41]	Netherlands; France
	Maternal mortality	0.45%	Sibai 2007[34]	
	Perinatal death	80%	Magee 2009[42]	Canada
<24 weeks eclampsia				
	Proportion of superimposed GHD that are eclampsia	0.00002%	Ventura 2008[43]; Sibai 2005[3]	U.S.
24-33 weeks gestation				
24-33 weeks Severe Preeclampsia, Inpatient management or immediate delivery (rather than inpatient management)				
	Maternal mortality (with inpatient management)	1.50%	Curiel 2011[44]	Spain
	Neonatal/perinatal death (with inpatient management)	10.87%	Haddad 2004[45]; Witlin 2000[46]	France; U.S.
	Neonatal morbidity (with inpatient management)	66.50%	Haddad 2004[45]	France
	Probability of delivery vs. inpatient management	12.50%	Barton 2001[47]	U.S.
	Rate of vaginal delivery	51.50%	Alanis 2008[48]	U.S.
	Maternal morbidity (with delivery)	26.90%	Curiel 2011[48]	Spain
	Maternal mortality (with delivery)	3.30%	Curiel 2011[48]	Spain
	Neonatal mortality (with delivery)	2.50%	Alanis 2008[48]	U.S.
24-33 weeks Severe Preeclampsia, cesarean delivery				
	Neonatal morbidity/complications	76.10%	Alanis 2008[48]	U.S.
	Neonatal mortality	8.60%	Alanis 2008[48]	U.S.
	Vaginal delivery	55.00%	Berkley 2007[49]	U.S.
24-33 weeks Eclampsia				
	Maternal morbidity	6.30%	Curiel 2011[48]	Spain
34-36 weeks gestation				
34-36 weeks Severe Preeclampsia/HELLP				
	Rate of severe preeclampsia/HELLP (progression from prior state)	25.10%	Knuist 1998[50]; Gyamfi-Bannerman 2011[51]	U.S.
	Vaginal delivery	69%	Berkley 2007[49]	U.S.

		Rates	Source	Study Location
	Neonatal mortality	1%	Abramovici 1999[52]; Sibai 2006[37]	U.S.
	Neonatal morbidity/complications	2%	Sibai 2006[37]	U.S.
	Maternal morbidity/complications-vaginal delivery	3.20%	Berkley 2007[49]	U.S.
	Maternal morbidity/complications-cesareans	7.10%	Berkley 2007[49]	U.S.
	Cesarean-postpartum stay (days)	4 days	Berkley 2007[49]	U.S.
	Fetal/neonatal complications - vaginal	4.85%	Berkley 2007[49]	U.S.
	Fetal/neonatal complications - cesareans	3.55%	Berkley 2007[49]	U.S.
	Maternal morbidity	3.20%	Berkley 2007[49]	U.S.
	Severe preeclampsia - risk of maternal mortality	0.02%	Ghulmiyyah 2012[53]	U.S.; International
	Fetal/neonatal morbidity	30%	Lubow 2009[54]	U.S.
34-36 weeks Eclampsia				
	Rate of progression to eclampsia (progression from prior state)	0.05%	Ventura 2008[43]; Sibai 2005[3]	U.S.
	Cesarean delivery rate for hypertension disorders	29.50%	Hauth 2000[55]	U.S.
37 weeks to term, Gestational Hypertension/Mild Preeclampsia				
	Composite adverse maternal outcomes	37%	Koopmans 2009[56]	Netherlands
	Vaginal delivery	72.5%	Berkley 2007[49]	U.S.
	Composite adverse neonatal outcomes	7%	Koopmans 2009[56]	Netherlands
	Fetal complications	7%	Bastek 2008[57]	U.S.
Chronic Hypertension and No Hypertension				
	Rate of chronic hypertension	1%	Sibai 2011[58]; Tuuli 2011[59]; Kuklina 2009 [60]; Walker 2000[61]	U.S; U.S.; U.S.; U.K.
	Rate of superimposed hypertensive disorders among those with chronic hypertension	30%	Tuuli 2011[59]; Matthys 2004; Garovic 2012[62]; Walker 2000[61]	U.S.; U.S.; U.S.; U.K.
	Postpartum hypertension	0.3%	Sibai 2011[63]	U.S.

B. Costs

Exhibit 2 provides the Medi-Cal 2011 reimbursement rates for resources used per delivery for both maternal and neonatal care. Exhibit 3 and Exhibit 4 display the maternal costs and neonatal costs, respectively. Exhibit 3 includes weighted average costs of vaginal and cesarean deliveries used in some of the analyses, using the proportion of vaginal (72%) and cesarean (28%) births in California in 2011.

Exhibit 2. 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	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
59409	Vaginal delivery only (with or w/o episiotomy)	$186.23
01960	Anesthesia for vaginal delivery	$77.11
01961	Anesthesia for cesarean delivery	$107.82
59514	Cesarean delivery only (assisting physician)	$186.50
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
59812	Treatment of miscarriage	$168.65
01966	Anesthesia including AB procedure	$61.59
Z1032	Initial antepartum office visit	$126.31
Z1034	Antepartum follow-up	$60.48
Neonatal Physician Reimbursement		
99477	Initial day hospital neonate care	$265.48
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
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

Source: Medi-Cal Physician Fee-Schedule for 2011.[29] Hospital cost is based on California Medical Assistance Commission (CMAC) per-diem rate.[26,27]

Exhibit 3. Maternal Costs for Uncomplicated Deliveries and Deliveries Complicated by Gestational Hypertensive Disorders, California Medi-Cal, 2011

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
BASE CASE			
Vaginal Delivery, no maternal complications - Vaginal Base Case (Part 1 of Average Base Case below)			
Hospital bed - mother	LOS=2	775	$2,956.00
Global physician fee		59400	$1,088.56
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$ 78.42
Anesthesia for vaginal delivery	2 units	01960	$154.22
TOTAL COSTS			**$ 4,371.52**
Cesarean, no maternal complications - Cesarean Base Case (Part 2 of Average Base Case below)			
Hospital bed - mother	LOS=3.2	766	$4,729.60
Global physician fee		59400	$1,088.56
Cesarean delivery - Assist		59514	$186.50
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$78.42
Anesthesia for cesarean delivery	2 units	01961	$ 215.64
TOTAL COSTS			**$6,393.04**
AVERAGE BASE CASE - Vaginal delivery and Cesarean (weighted by frequency of birth, per OSHPD)			**$4,939.97**

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
< 24 Weeks gestation			
< 24 Weeks Severe Preeclampsia Cesarean, With Maternal Complications			
Hospital bed - mother	LOS=6.5 (includes 2 days of expectant management)	765	$9,607.00
Global physician fee		59510	$1,088.62
Cesarean delivery - assist		59514	$186.50
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$78.42
Anesthesia for cesarean delivery	2 units	01961	$ 215.64
Critical Care (first hour)		99291	$121.60
Critical Care (additional 30 min)		99292	$58.90
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

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
< 24 Weeks gestation			
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$37.60
TOTAL COSTS			**$ 11,731.90**
< 24 Weeks Severe Preeclampsia Vaginal, With Maternal Complications			
Hospital bed - mother	LOS=2.6 and 1 day added for after delivery monitoring of severe preeclampsia +2 days of expectant management	774	$8,276.80
Global physician fee		59510	$1,088.62
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$ 94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$78.42
Anesthesia for vaginal delivery	2 units	01960	$ 154.22
Critical care (first hour)		99291	$ 121.60
Critical care (additional 30 min)		99292	$ 58.90
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)	1.6 average visits	99232	$ 60.48
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$37.60
TOTAL COSTS			**$10,044.16**
AVERAGE <24 weeks Severe Preeclampsia - Vaginal delivery and Cesarean:			**$11,807.24**
< 24 Weeks Eclampsia Cesarean, With Maternal Complications			
Hospital bed - mother	4.5	765	$6,651.00
Global physician fee		59510	$ 1,088.62
Cesarean delivery - assist		59409	$ 186.50
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$ 94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$78.42
Anesthesia for cesarean delivery	2 units	01961	$ 215.64
Critical Care (first hour)		99291	$121.60
Critical Care (additional 30 min)		99292	$58.90
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			**$8,700.30**
< 24 Weeks Eclampsia Vaginal Delivery, With Maternal Complications			
Hospital bed - mother	LOS=2.6	774	$ 5,320.80
Global physician fee		59510	$ 1,088.56
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks		76805	$ 94.32

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
< 24 Weeks gestation			
gestation)			
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$78.42
Anesthesia for vaginal delivery	2 units	01960	$154.22
Critical care (first hour)		99291	$121.60
Critical care (additional 30 min)		99292	$ 58.90
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)	1.6 average visits	99232	$ 60.48
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$ 37.60
TOTAL COSTS			**$ 7,088.10**
AVERAGE <24 weeks Eclampsia			**$ 8,496.55**

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
24-33 Weeks gestation			
24-33 Weeks Severe Preeclampsia Cesarean, With Maternal Complications Inpatient Management Scenario			
Hospital bed - mother	LOS=4.5 and 5 additional days of inpatient management	765	$ 14,041.00
Global physician fee		59510	$1,088.62
Cesarean delivery - assist		59514	$ 186.50
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$ 94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$78.42
Anesthesia for cesarean delivery	2 units	01961	$ 215.64
Critical care (first hour)		99291	$ 121.60
Critical care (additional 30 min)		99292	$58.90
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)	7.5 average visits	99232	$ 283.50
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$ 75.20
TOTAL COSTS			**$ 16,316.90**
24-33 Weeks Severe Preeclampsia Vaginal Delivery, With Maternal Complications Inpatient Management Scenario			
Hospital bed - mother	LOS=2.6 and 1 day of added monitoring after delivery and 5 additional days of inpatient management	774	$ 12,710.80
Global physician fee		59510	$1,088.56
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks		76805	$94.32

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
24-33 Weeks gestation			
gestation)			
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$ 78.42
Anesthesia for vaginal delivery	2 units	01960	$ 154.22
Critical care (first hour)		99291	$ 121.60
Critical care (additional 30 min)		99292	$ 58.90
Other specialist: Physician services, hospital care (initial, level 2)	Day one/during labor	99222	$ 37.80
Other specialist: Physician services, hospital care (subsequent care, level 2)	6.49 average visits	99232	$245.32
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$ 37.60
TOTAL COSTS			**$ 14,627.54**
AVERAGE 24-33 Weeks Severe Preeclampsia- Vaginal Delivery And Cesarean with Inpatient Management:			**$ 16,895.42**
24-33 Weeks Severe Preeclampsia/Eclampsia, Vaginal Delivery, With Maternal Complications Delivery Without Inpatient Management			
Hospital bed - mother	LOS=2.6 and 1 additional day of after delivery monitoring.	774	$ 5,320.80
Global physician fee		59510	$1,088.56
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$ 94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$ 78.42
Anesthesia for vaginal delivery	2 units	01960	$154.22
Critical care (first hour)		99291	$ 121.60
Critical care (additional 30 min)		99292	$ 58.90
Other specialist: Physician services, hospital care (initial, level 2)	Day one/during labor	99222	$ 37.80
Other specialist: Physician services, hospital care (subsequent care, level 2)	1.49 average visits	99232	$56.32
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$37.60
TOTAL COSTS			**$7,048.54**
24-33 Weeks Severe Preeclampsia/Eclampsia, Cesarean Delivery, With Maternal Complications Delivery Without Inpatient Management			
Hospital bed - mother	LOS=4.5	767, 768	$ 6,651.00
Global physician fee		59510	$ 1,088.56
Cesarean delivery - assist		59514	$ 186.50
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$ 94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$ 78.42
Anesthesia for cesarean delivery	2 units	01961	$ 215.64
Critical care (first hour)		99291	$ 121.60

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
24-33 Weeks gestation			
Critical care (additional 30 min)		99292	$ 58.90
Other specialist: Physician services, hospital care (initial, level 2)	Day one/during labor	99222	$ 37.80
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			**$ 8,664.84**

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
34-36 Weeks gestation			
34-36 Weeks Severe Preeclampsia Vaginal Delivery, With Maternal Complications, Inpatient Management Scenario			
Hospital bed - mother	LOS=2.6 and 1 additional day after delivery monitoring + 2 days of expectant management	774	$ 8,276.80
Global physician fee		59510	$ 1,088.56
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$ 94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$ 78.42
Anesthesia for vaginal delivery	2 units	01960	$ 154.22
Critical care (first hour)		99291	$121.60
Critical care (additional 30 min)		99292	$ 58.90
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)	6.6 average visits	99232	$ 249.48
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$ 37.60
TOTAL COSTS			**$ 10,233.10**
34-36 Weeks Severe Preeclampsia Cesarean, With Maternal Complications, Inpatient Management Scenario			
Hospital bed - mother	LOS=4.5	765	$ 14,041.00
Global physician fee		59510	$ 1,088.62
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$94.32
Ultrasounds (OP 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
Medicine and critical care consult during labor and per length of stay		99222	$232.60
Critical care (first hour)		99291	$121.60
Critical care (additional 30 min)		99292	$ 58.90
Other specialist: Physician services, hospital care (initial, level	Day one/during labor	99222	$ 73.20

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
34-36 Weeks gestation			
2)			
Other specialist: Physician services, hospital care (subsequent care, level 2)	7.5 average visits	99232	$ 283.50
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$ 37.60
TOTAL COSTS			**$ 16,511.90**
AVERAGE 34-36 weeks Severe Complications- Inpatient Expectant Management			**$ 15,183.64**
34-36 Weeks Severe Preeclampsia/Eclampsia, Vaginal Delivery, With Maternal Complications Without Inpatient Management			
Hospital bed - mother	LOS=2.6 and 1 additional day after delivery monitoring	774	$ 5,320.80
Global physician fee		59510	$1,088.56
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$ 94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$ 78.42
Anesthesia for vaginal delivery	2 units	01960	$ 154.22
Medicine and critical care consult during labor and per length of stay		99222	$ 232.60
Critical care (first hour)		99291	$ 121.60
Critical care (additional 30 min)		99292	$ 58.90
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)	1.6 average visits	99232	$ 60.48
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$ 37.60
TOTAL COSTS			**$ 7,320.70**
34-36 Weeks Severe Preeclampsia/Eclampsia, Cesarean delivery, With Maternal Complications Without Inpatient Management			
Hospital bed - mother	LOS=4.5	765	$ 6,651.00
Global physician fee		59510	$1,088.62
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$ 94.32
Ultrasounds (OP 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
Critical care (additional 30 min)		99292	$ 58.90
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

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
34-36 Weeks gestation			
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$ 37.60
TOTAL COSTS			**$ 8,700.30**
Services Included per Type of Delivery	**Assumptions**	**DRG/CPT Code**	**Cost**
Term pregnancy with complications and postpartum hypertension disorder			
Term Vaginal Delivery, With Maternal Complications -Mild Hypertension and/or Mild Preeclampsia			
Hospital bed - mother	LOS=2.6	774	$ 3,842.80
Global physician fee		59510	$1,088.56
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$ 94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$ 78.42
Anesthesia for vaginal delivery	2 units	01960	$ 154.22
Other specialist: Physician services, hospital care (initial, level 2)	Day one/during labor	99222	$ 34.40
Other specialist: Physician services, hospital care (subsequent care, level 2)	0.6 average visits	99232	$22.68
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$37.60
TOTAL COSTS			**$ 5,353.00**
Term Cesarean Delivery, With Maternal Complications -Mild Hypertension and Mild Preeclampsia			
Hospital bed - mother	LOS=4.5	768	$6,651.00
Global physician fee		59510	$ 1,088.56
Cesarean delivery - assist		59514	$ 186.50
Ultrasounds (OP only, normal prenatal care at ≥ 14 weeks gestation)		76805	$ 94.32
Ultrasounds (OP only, normal prenatal care at < 14 weeks gestation)		76801	$ 78.42
Anesthesia for cesarean delivery	2 units	01961	$ 215.64
Critical care (first hour)		99291	$ 121.60
Critical care (additional 30 min)		99292	$ 58.90
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	$37.60
TOTAL COSTS			**$ 8,700.24**
Postpartum Hypertension Disorder			
Hospital bed - mother	LOS=4	n/a	$ 5,912.00
Critical care (first hour)		99291	$ 121.60
Critical care (additional 30 min)		99292	$58.90
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 average visits	99232	$75.60

Services Included per Type of Delivery	Assumptions	DRG/CPT Code	Cost
34-36 Weeks gestation			
Other specialist: Physician services (discharge day management; ≤ 30 minutes)	Discharge visit	99238	$ 53.40
TOTAL COSTS			**$ 6,294.70**

Source: Medi-Cal Physician Fee-Schedule for 2011.[29] Hospital cost is based on California Medical Assistance Commission (CMAC) per-diem rate.[26,27] LOS (days) is obtained from OSHPD aggregate hospitalization data for 2010.[28]

Exhibit 4. Neonatal Costs for Healthy Neonates and Pre-term Neonates, California Medi-Cal, 2011

Services per Delivery for Neonate	Assumptions	DRG/CPT Code	Cost
Healthy term baby (base case)			
Hospital LOS - not billable to Medi-Cal	LOS=2	795	$ -
New born screening		S3620	$ 102.75
Hospital: First visit	Pediatrician	99460	$ 51.50
Hospital: Subsequent visits/day	Pediatrician	99462	$ 27.49
TOTAL COSTS			**$ 181.74**
Term baby with short term complications			
Hospital bed - baby	LOS=3.27, weighted average of 2.5 & 6.4 days of stay per DRG	793, 794	$ 4,831.65
New born screening		S3620	$ 102.75
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			**$ 5,321.55**
Premature baby (healthy)			
Hospital bed - baby	LOS=6	792	$ 8,868.00
New born screening		S3620	$ 102.75
Hospital: First visit	Pediatrician	99460	$ 51.50
Hospital: Subsequent visits/day	Pediatrician	99462	$ 137.45
TOTAL COSTS			**$ 9,159.70**
Premature baby (complications) Average			
Hospital bed - baby	LOS=28.57, weighted average of 19 & 38 days of stay per DRG	790, 791	$ 42,225.93
New born screening		S3620	$ 102.75
Initial day hospital neonate care	Neonatologist	99477	$ 265.48
Hospital care, subsequent, level 3	Neonatologist	99233	$ 1,327.68
Hospital discharge day management; > 30 minutes	Neonatologist	99239	$ 58.26
TOTAL COSTS			**$ 43,980.10**

Services per Delivery for Neonate	Assumptions	DRG/CPT Code	Cost
Extremely immature baby (complications) <24 weeks			
Hospital bed - baby	LOS=38	790, 791	$ 56,164.00
New born screening		S3620	$ 102.75
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			**$ 58,389.41**
Premature baby (complications) 24-33 weeks			
Hospital bed - baby	LOS=28.57, weighted average of 19 & 38 days of stay per DRG	790, 791	$ 42,225.93
New born screening		S3620	$ 102.75
Initial day hospital neonate care	Neonatologist	99477	$ 265.48
Hospital care, subsequent, level 3	Neonatologist	99233	$ 1,327.68
Hospital discharge day management; > 30 minutes	Neonatologist	99239	$ 58.26
TOTAL COSTS			**$ 43,980.10**
Premature baby (complications) 34-36 weeks			
Hospital bed- baby	LOS= 19	791	$ 28,082.00
New born screening		S3620	$ 102.75
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			**$ 29,357.98**
Newborn death			
Hospital bed - baby	LOS=5.2	789	$ 7,685.60
New born screening		S3620	$ 102.75
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			**$ 8,271.99**

Source: Medi-Cal Physician Fee-Schedule for 2011 [29]. Hospital cost is based on California Medical Assistance Commission (CMAC) per-diem rate.[26,27] LOS (days) is obtained from OSHPD aggregate hospitalization data for 2010.[28]

C. Cost Analysis Trees

Exhibit 5, Exhibit 6 and Exhibit 7 display three different views of the model decision tree, which incorporates both the probability and costs of each outcome for gestational hypertensive disorders. Exhibit 5 displays the main branches of the decision tree. The overall percentage of the population with gestational hypertensive disorders is estimated at 5.8%. This rate is slightly higher than the 4.3% for this disorder estimated in California in 2005, allowing for an increase from 2005 as well as a small additional percentage of women with superimposed gestational hypertensive disorder.[6] Exhibit 6 displays the expanded view of the final stages of a pregnancy with mild preeclampsia. Exhibit 7 displays the expanded view of the final stages of a pregnancy with preeclampsia/HELLP. The eclampsia stages are similar to those of preeclampsia/HELLP but without expectant management and are not shown.

Exhibit 5. Outcomes of Gestational Hypertensive Disorders, Main Branches of Decision Tree

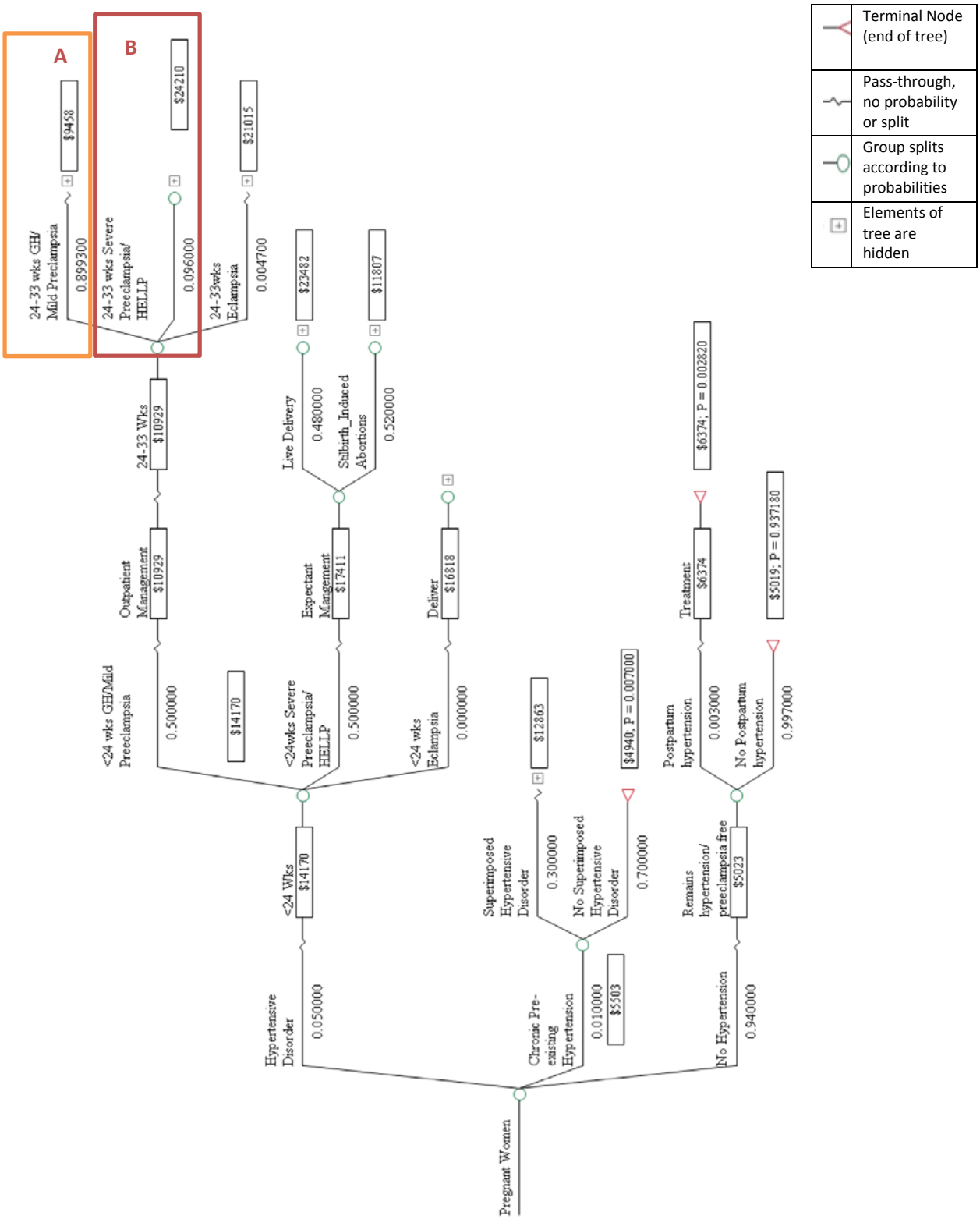
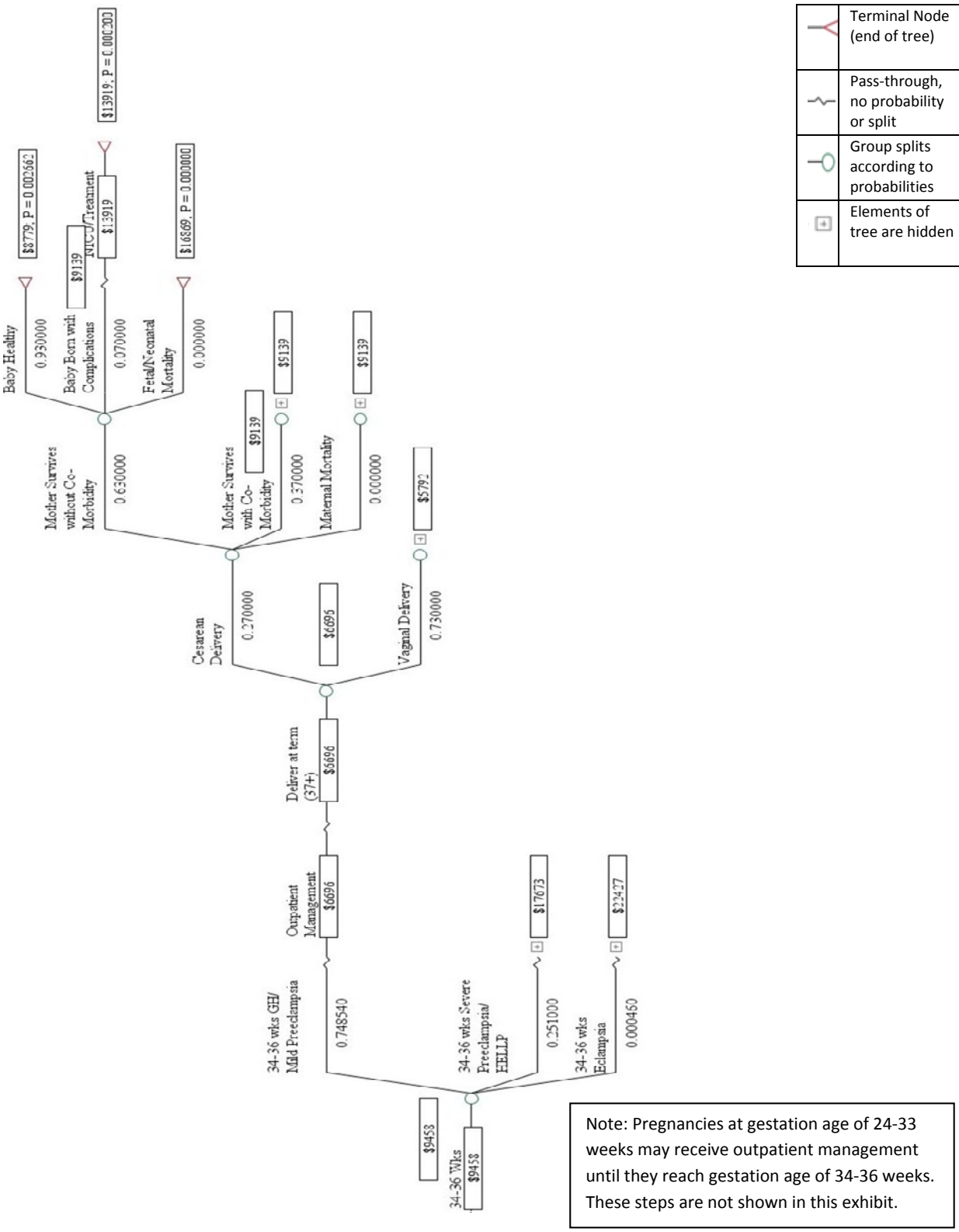
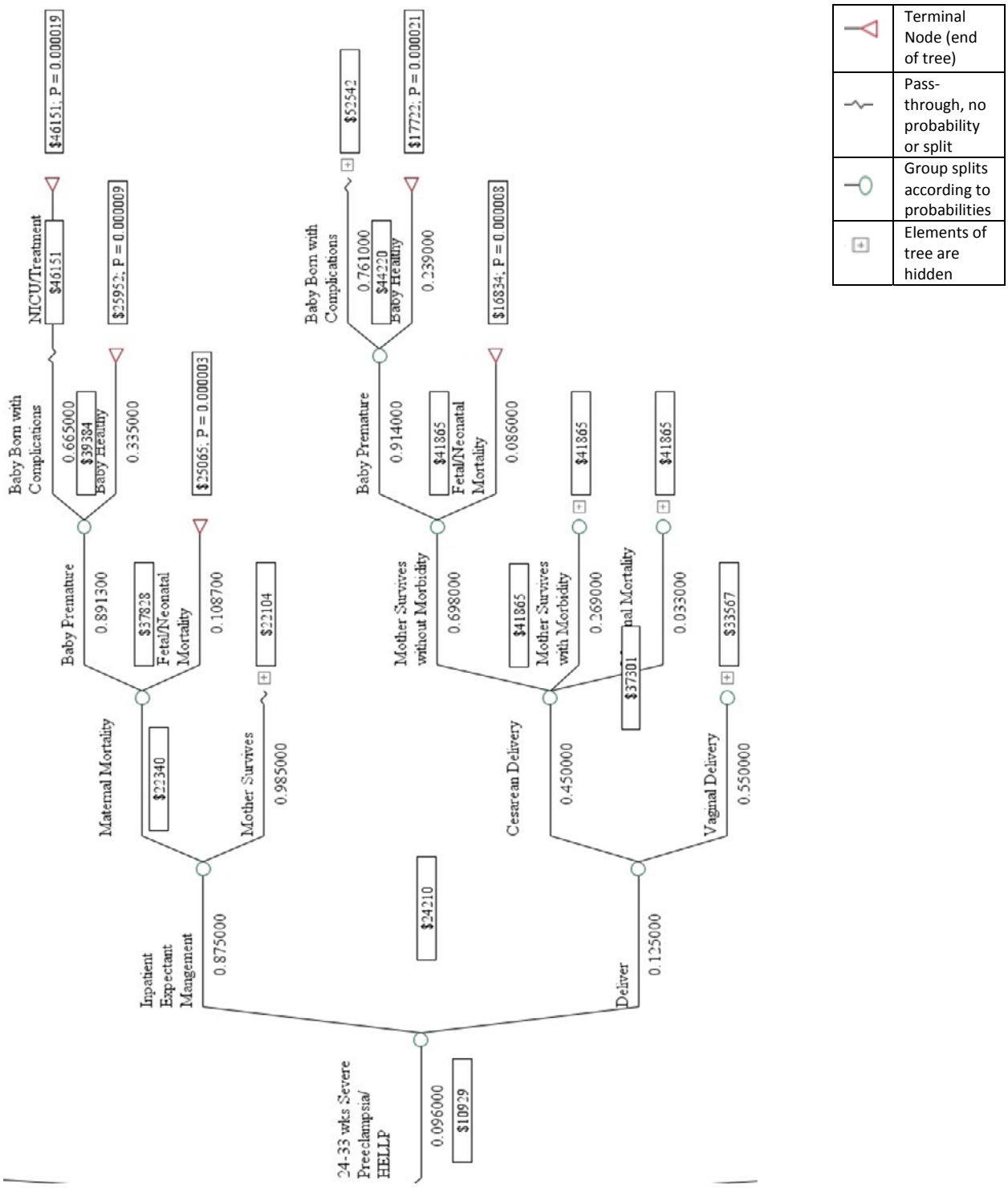


Exhibit 6. Outcomes of Gestational Hypertensive Disorders, Final Stages of a Pregnancy with Mild Preeclampsia (expansion of Box A in Exhibit 5)



Note: Pregnancies at gestation age of 24-33 weeks may receive outpatient management until they reach gestation age of 34-36 weeks. These steps are not shown in this exhibit.

Exhibit 7. Outcomes of Gestational Hypertensive Disorders, Final Stages of a Pregnancy with Preeclampsia/HELLP (expansion of Box B in Exhibit 5)



D. Analysis of Medi-Cal Costs

1. Costs of Uncomplicated Deliveries

The costs of uncomplicated singleton deliveries to the Medi-Cal FFS program are presented in Exhibit 8. These costs include uncomplicated maternal costs 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	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 Gestational Hypertensive Disorders

Of the 494,058 singleton births in California in 2010, 5.6% (27,580) were estimated to be complicated by gestational hypertensive disorders. Of these 47.3% (13,040) are estimated to be births paid for by Medi-Cal, assuming a similar proportion of births with gestational hypertensive disorders are paid by Medi-Cal and other payers.[64] Exhibit 9 displays the estimated cost per case, the incremental cost over uncomplicated deliveries, and the additional costs of this complication to the Medi-Cal program by type of gestational hypertensive disorder. The overall incremental costs of gestational hypertensive disorders in California are estimated at $226,053,000 and the costs to the Medi-Cal program is estimated at $106,923,000 in 2011. The incremental costs of gestational hypertensive disorders not complicated by chronic hypertension are higher than costs of gestational hypertensive disorders complicated by chronic hypertension because of the higher prevalence of the latter group.

If the costs paid by the Medi-Cal program were extrapolated to all in-state births with gestational hypertensive disorders, it is estimated that the overall costs of gestational hypertensive disorders in California were $226,053,000 in 2011.

Exhibit 9. Estimated Cost of Gestational Hypertensive Disorders by Type of Disorder, Medi-Cal Program and California, 2011

	Average Cost per Delivery	Incremental Cost per Case: Difference with Uncomplicated Delivery	Number of Deliveries Covered by Medi-Cal Complicated with Gestational Hypertensive Disorders	Total Incremental Cost of Gestational Hypertensive Disorders to Medi-Cal	Number of California Deliveries Complicated with Gestational Hypertensive Disorders	Total Incremental Costs of Gestational Hypertensive Disorders in California
Postpartum Hypertension only	$6,400	$1,400	660	$893,000	1,390	$1,887,000
Gestational Hypertensive Disorders superimposed on chronic hypertension	$12,900	$7,800	700	$5,499,000	1,480	$11,626,000
Gestational Hypertensive Disorders without chronic hypertension	$14,200	$9,200	11,680	$106,923,000	24,700	$226,053,000

Note: All estimates are rounded and estimated costs in table may not add up due to rounding. For example, dividing 660 Medi-Cal deliveries complicated by gestational hypertensive disorders by 1,390 total births complicated by gestational hypertensive disorders 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 or the average of the two types of delivery as appropriate.

Exhibit 10 provides more detail on incremental costs of gestational hypertensive disorders not complicated by chronic hypertension displayed in Exhibit 9. Exhibit 10 displays variations by severity and gestational age. The estimated incremental costs are highest for severe preeclampsia/HELLP at 24-33 weeks of gestation because of the increased likelihood of additional length of inpatient stay for the mother and higher rates of premature neonates with complications that require lengthy neonatal intensive care stays. This cost included deliveries for women with severe preeclampsia/HELLP who deliver by cesarean before 24 weeks, receive expectant management and have maternal complications and extremely immature infants with complications (estimated at incremental cost of $63,600; data not shown).

Exhibit 10. Estimated Incremental Cost of Gestational Hypertensive Disorders Not Complicated by Chronic Hypertension, by Severity and Gestational Age, Medi-Cal Program and in California, 2011

	Average Cost per Delivery	Incremental Cost per Case: Difference with Uncomplicated Delivery[1]	Number of l Deliveries Covered by Medi-Cal Complicated with Gestational Hypertensive Disorders	Total Incremental Cost of Gestational Hypertensive Disorders to Medi-Cal	Number of California Deliveries Complicated with Gestational Hypertensive Disorders	Total Incremental Costs of Gestational Hypertensive Disorders in California
Mild maternal hypertension and term delivery: averaged over vaginal and Cesarean deliveries, all outcomes	$6,700	$1,700	3,930	$6,594,000	8,310	$13,940,000
Severe preeclampsia/HELLP, before 24 weeks: averaged over vaginal and Cesarean deliveries, all outcomes	$17,400	$12,400	5,840	$72,399,000	12,350	$153,063,000
Severe preeclampsia/HELLP, 24-33 weeks: averaged over vaginal and Cesarean deliveries, all outcomes	$24,200	$19,200	560	$10,764,000	1,190	$22,756,000
Severe preeclampsia/HELLP, 34-36 weeks: averaged over vaginal and Cesarean deliveries, all outcomes	$17,700	$12,700	1,320	$16,687,000	2,790	$35,280,000
Eclampsia, 24-33 weeks: averaged over vaginal and Cesarean deliveries, all outcomes	$21,000	$16,000	30	$437,000	60	$925,000
Eclampsia, 34-36 weeks: averaged over vaginal and Cesarean deliveries, all outcomes	$22,400	$17,400	<10	$41,000	<10	$86,000
Total	--	--	**11,680**	**$106,921,000**	**24,700**	**$226,049,000**

[1] Complicated deliveries are averaged over vaginal and cesarean deliveries and are compared with average costs of uncomplicated vaginal and cesarean deliveries.

Notes: Estimated costs in table may not add up due to rounding. Cost estimates include maternal and neonatal costs.

Conclusions and Implications

The estimated $106,921,000 in incremental costs of gestational hypertensive disorders to the Medi-Cal program and $226,049,000 in California are based on the 2011 Medi-Cal FFS Fee Schedule and the negotiated per diem rates for contracted private hospitals used as proxies for the costs of these births. The actual expenditures to the Medi-Cal program for gestational hypertensive disorders depends on many factors including Medi-Cal payments to public hospitals, negotiated rates with Medi-Cal Managed Care organizations, and physician and hospital practice variations. 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.[27] 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.

The costs of gestational hypertensive disorders statewide are likely to be higher than those to the Medi-Cal program, particularly because Medi-Cal reimbursement levels are lower than those paid by commercial insurers. Assuming an estimated $10,327 for maternal costs and $109,490 for neonatal costs with severe morbidity in the literature,[13,65] the overall costs of deliveries complicated by gestational hypertensive disorders are likely to be much higher than the highest-cost deliveries (women with severe preeclampsia/HELLP syndrome who delivered by cesarean before 24 weeks, received expectant management and had maternal complications and extremely immature infants with complications at $70,100; data not shown) estimated in this study.[66]

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 hypertensive disorders post ACA implementation could differ due to changes in types of coverage and the settings in which maternal care is received.

The estimated expenditures reported above do not incorporate the lifetime medical and societal costs of the disease. Estimating these costs was not the focus of this study. However, as described in Section D, the risks of stroke are greater in pregnant women (34.2 per 100,000) and six to nine times higher in women with gestational hypertensive disorders. This translates to roughly a 0.21%-0.31% risk of stroke among women who deliver with hypertensive disorders. Thus, an estimated 28 to 41 women who deliver under the Medi-Cal program may suffer strokes following gestational hypertensive disorders. Therefore, the overall lifetime medical costs of strokes occurring in a single year (2011) to the Medi-Cal

program may range from $18.1 million to $26.7 million dollars, based on a calculated average of $659,156 per case.

In addition, the annual lifetime medical costs per preterm birth with developmental disabilities are estimated at $38,250, as previously described in SectionB3. Lifetime Medical Costs and Appendix Exhibit 2.[67] The likelihood of preterm birth is the same among deliveries without gestational hypertensive disorders and women with mild gestational hypertensive disorders. However, the percentage of women with severe gestational hypertensive disorders is approximately 36.4% higher than the previous group.[68] The lifetime medical costs associated with gestational hypertensive disorders to Medi-Cal may be estimated at over $9.8 million annually given that about 3.3% of births in California are complicated by severe gestational hypertensive disorders, roughly 36.4% of these births lead to preterm live births, and approximately 9.1% of these preterm neonates develop cerebral palsy (Section D. Short-term and Lifetime Medical Outcomes). [10,32] Similarly, if 4.4% of preterm babies suffer from mental retardation, the estimated lifetime medical costs to Medi-Cal may be $4.7 million annually.

The significant cost of deliveries complicated by gestational hypertensive disorders highlights the importance of efforts to prevent or mitigate the maternal and neonatal morbidity and mortality associated with the disease. The success of available preventive and treatment measures in mitigating the costs of gestational hypertensive disorders depends on the measures' effectiveness and the level of adherence to current standards of medical care. If preventive and treatment measures are effectively implemented and are successful in averting complications of and morbidity due to gestational hypertensive disorders in 10% of Medi-Cal births in California, an estimated minimum of $11.3 million would be saved. If such measures are successful in averting complications or morbidity in up to 50% of births, the savings would be an estimated minimum of $56.7 million. The magnitude of incremental costs of gestational hypertensive disorders and the potential savings resulting from the success of prevention activities highlight the importance of public health activities directed at reducing the mortality and morbidity costs associated with gestational hypertensive disorders.

Appendix: Cost Conversions

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

	Original Costs	2011 Costs
Chung et al, 2001[13]: 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
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
Barton et al, 2006[14]: Incremental costs of births complicated by GHD -- 1999-2003 estimates	$10,327	$12,625
Russell et al, 2007[15]: 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, 1999[16]: Treatment costs by gestational age in a network with 25 hospitals -- 1994 estimates		
Less than 24 weeks of gestational age	$6,874	$10,433
24-26 weeks gestational age	$95,560	$145,042
27-29 weeks gestational age	$61,724	$93,685
30-32 weeks gestational age	$35,106	$53,284
Over 32 weeks of gestational age	$19,295	$29,286

Note: Costs found in the literature were converted to 2011 dollars using the Bureau of Labor Statistics calculator.[12]

Appendix Exhibit 2. Costs of Preterm Birth in the Literature

	Original Costs	2011 Costs
Institute of Medicine, 2007[32]: Annual lifetime medical and societal costs of preterm birth per preterm infant -- 2005 estimates		
Total	$51,589	$59,418
Medical care	$33,210	$38,250
Early intervention	$1,203	$1,386
Special education	$2,150	$2,476
Taylor, 1996[31]: Lifetime medical costs of stroke for a woman at age 25-- 1990 estimates		
Subarachnoid hemorrhage (SAH)	$407,000	$700,460
Ischemic stroke (ISC)	$359,000	$617,851

Note: Costs found in the literature were converted to 2011 dollars using the Bureau of Labor Statistics calculator.[12]

References

1. Chang JJ, Muglia LJ, Macones GA. Association of early-onset pre-eclampsia in first pregnancy with normotensive second pregnancy outcomes: a population-based study. *BJOG: International Journal of Obstetrics and Gynaecology.* Jul 2010;117(8):946-953.
2. American College of Obstetricians and Gynecologists. Diagnosis and Management of Preeclampsia and Eclampsia #33. *American College of Obstetricians and Gynecologists.* 2002 (Reaffirmed 2008);Practice Bulletin Number 33.
3. Sibai BM. Diagnosis, prevention, and management of eclampsia. *Obstetrics and Gynecology.* Feb 2005;105(2):402-410.
4. Munjuluri N, Lipman M, Valentine A, Hardiman P, Maclean AB. Postpartum eclampsia of late onset. *BMJ.* Nov 5 2005;331(7524):1070-1071.
5. National High Blood Pressure Education Program Working Group. Report of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Pregnancy. *Am J Obstet Gynecol.* 2000;183:S1-S22.
6. Chow J, Fridman M, Gregory KD, Korst LM, Lu MC, Shah S. *Trends in Maternal Morbidity in California 1999-2005.* Technical report developed under contract #09-1119 with the California Department of Public Health, Maternal, Child, and Adolescent Health Division and the Regents of the University of California, Los Angeles, Maternal Quality Indicators Project; 2011 Available at: http://www.cdph.ca.gov/programs/mcah/Documents/MO-CAPAMR-TrendsinMaternalMorbidityinCalifornia-1999-2005-TechnicalReport.pdf. Accessed December 10, 2012.
7. Druzin M, Shields L, Peterso N, Melsop K, Cape V. Preeclampsia Toolkit: Improving Health Care Response to Preeclampsia. California Maternal Quality Care Collaborative Toolkit to Transform Maternity Care. Developed under contract #08-85012 with the California Department of Public Health; Maternal, Child and Adolescent Health Division; Published by the California Maternal Quality Care Collaborative. Palo Alto, CA. April 2013. Available at: http://www.cmqcc.org/preeclampsia_task_force. Accessed July 20, 2012.
8. Tate J, Bushnell C. Pregnancy and stroke risk in women. *Women's Health.* May 2011;7(3):363-374.
9. Garovic VD, Bailey KR, Boerwinkle E, et al. Hypertension in pregnancy as a risk factor for cardiovascular disease later in life. *Journal of Hypertension.* Apr 2010;28(4):826-833.
10. 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.
11. 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.
12. U.S. Bureau of Labor Statistics (BLS). CPI Inflation Calculator. http://www.bls.gov/data/inflation_calculator.htm. Accessed July, 2012.
13. 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.
14. Barton JR, Istwan NB, Rhea D, Collins A, Stanziano GJ. Cost-savings analysis of an outpatient management program for women with pregnancy-related hypertensive conditions. *Disease Management.* 2006;9(4):236-241.
15. 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.
16. Rogowski J. Measuring the cost of neonatal and perinatal care. *Pediatrics.* Jan 1999;103(1 Suppl E):329-335.

17. Trivedi NA. A meta-analysis of low-dose aspirin for prevention of preeclampsia. *Journal of Postgraduate Medicine.* Apr-Jun 2011;57(2):91-95.
18. Isler CM, Rinehart BK, Terrone DA, Martin RW, Magann EF, Martin JN, Jr. Maternal mortality associated with HELLP (hemolysis, elevated liver enzymes, and low platelets) syndrome. *American Journal of Obstetrics and Gynecology.* Oct 1999;181(4):924-928.
19. Berg CJ, Harper MA, Atkinson SM, et al. Preventability of pregnancy-related deaths: results of a state-wide review. *Obstetrics and Gynecology.* Dec 2005;106(6):1228-1234.
20. Peters RM. High blood pressure in pregnancy. *Nursing for Women's Health.* Oct 2008;12(5):410-421; quiz 422.
21. Champagne H, Kilpatrick S. *Proteinuria.* Preeclampsia Task Force - Preeclampsia Toolkit : Improving Health Care Response to Preeclampsia. California Maternal Quality Care Collaborative. Palo Alto, CA. April 2013. Available at: http://www.cmqcc.org/preeclampsia_task_force. Accessed July 20, 2012.
CA.
22. Berg CJ. *Magnesium Sulfate.* Preeclampsia Task Force - Preeclampsia Toolkit: Improving Health Care Response to Preeclampsia. California Maternal Quality Care Collaborative. Palo Alto, CA. April 2013. Available at: http://www.cmqcc.org/preeclampsia_task_force. Accessed July 20, 2012.
23. 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.
24. 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.
25. 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.
26. 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.
27. 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.
28. 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.
29. California Department of Healthcare Services. Medi-Cal Rates. 2012; http://files.medi-cal.ca.gov/pubsdoco/rates/rateshome.asp.
30. Bushnell C, Chireau M. Preeclampsia and Stroke: Risks during and after Pregnancy. *Stroke Research and Treatment.* 2011;2011:1-9.
31. Taylor TN, Davis PH, Torner JC, Holmes J, Meyer JW, Jacobson MF. Lifetime Cost of Stroke in the United States. *Stroke; Journal of Cerebral Circulation.* September 1, 1996 1996;27(9):1459-1466.

32. 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

33. TreeAge Software. 2012. Pro T. Williamstown, MA: TreeAge Software, Inc.

34. Sibai BM, Barton JR. Expectant management of severe preeclampsia remote from term: patient selection, treatment, and delivery indications. *American Journal of Obstetrics and Gynecology.* Jun 2007;196(6):514 e511-519.

35. Sibai BM. Evaluation and management of severe preeclampsia before 34 weeks' gestation. *American Journal of Obstetrics and Gynecology.* Sep 2011;205(3):191-198.

36. Liu S, Joseph KS, Liston RM, et al. Incidence, Risk Factors, and Associated Complications of Eclampsia. *Obstetrics and Gynecology.* Nov 2011;118(5):987-994.

37. Sibai BM. Preeclampsia as a cause of preterm and late preterm (near-term) births. *Seminars in Perinatology.* Feb 2006;30(1):16-19.

38. Sibai BC, Steve; Hauth, John. *What We Have Learned About Preeclampsia* Seminars in Perinatology. 2003.

39. Livingston J, Livingston L, Ramsey R, Mabie B, Sibai B. Magnesium sulfate in women with mild preeclampsia: A randomized control trial. *Obstetrics & Gynecology.* 2003;101(2):217-220.

40. Budden A, Wilkinson L, Buksh M, McCowan L. Pregnancy outcomes in women presenting with pre-eclampsia at less than 25 weeks gestation. *Australia and New Zealand Journal of Obstetrics and Gynaecology.* 2006;46:407-412.

41. Gaugler-Senden I, Huijssoon A, Visser W, Steegers E, Groot C. Maternal and perinatal outcome of preeclampsia with an onset before 24 weeks' gestation: Audit in a tertiary referral center. *European Journal of Obstetrics & Gynecology and Reproductive Behavior.* 2006;128:216-221.

42. Magee LA, Yong PJ, Espinosa V, Cote AM, Chen I, von Dadelszen P. Expectant management of severe preeclampsia remote from term: a structured systematic review. *Hypertension in pregnancy : official journal of the International Society for the Study of Hypertension in Pregnancy.* 2009;28(3):312-347.

43. Ventura SJ, Abma JC, Mosher WD, Henshaw SK. Estimated pregnancy rates by outcome for the United States, 1990-2004. *National Vital Statistics Reports : from the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System.* Apr 14 2008;56(15):1-25, 28.

44. Curiel E, Prieto-Palomino M, Munoz-Bono J, Elvira MRd, Galeas J, Garcia G. Analysis of maternal morbidity and mortality among patients admitted to obstetric intensive care with severe preeclampsia, eclampsia, or HELLP syndrome. *Medicina Intensiva.* 2011;35(8):478-483.

45. Haddad B, Deis S, Goffinet F, Paniel BJ, Cabrol D, Siba BM. Maternal and perinatal outcomes during expectant management of 239 severe preeclamptic women between 24 and 33 weeks' gestation. *American Journal of Obstetrics and Gynecology.* Jun 2004;190(6):1590-1595; discussion 1595-1597.

46. Witlin AG, Saade GR, Mattar F, Sibai BM. Predictors of neonatal outcome in women with severe preeclampsia or eclampsia between 24 and 33 weeks' gestation. *American Journal of Obstetrics and Gynecology.* Mar 2000;182(3):607-611.

47. Barton JR, O'Brien J M, Bergauer NK, Jacques DL, Sibai BM. Mild gestational hypertension remote from term: progression and outcome. *American Journal of Obstetrics and Gynecology.* Apr 2001;184(5):979-983.

48. Alanis MC, Robinson CJ, Hulsey TC, Ebeling M, Johnson DD. Early-onset severe preeclampsia: induction of labor vs elective cesarean delivery and neonatal outcomes. *American Journal of Obstetrics and Gynecology.* Sep 2008;199(3):262 e261-266.

49. Berkley E, Meng C, Rayburn WF. Success rates with low dose misoprostol before induction of labor for nulliparas with severe preeclampsia at various gestational ages. *The Journal of Maternal-Fetal and Neonatal Medicine.* Nov 2007;20(11):825-831.
50. Knuist M, Bonsel GJ, Zondervan HA, Treffers PE. Intensification of fetal and maternal surveillance in pregnant women with hypertensive disorders. *International Journal of Gynaecology and Obstetrics.* May 1998;61(2):127-133.
51. Gyamfi-Bannerman C, Fuchs KM, Young OM, Hoffman MK. Nonspontaneous late preterm birth: etiology and outcomes. *American Journal of Obstetrics and Gynecology.* Nov 2011;205(5):456 e451-456.
52. Abramovici D, Friedman SA, Mercer BM, Audibert F, Kao L, Sibai BM. Neonatal outcome in severe preeclampsia at 24 to 36 weeks' gestation: Does the HELLP (hemolysis, elevated liver enzymes, and low platelet count) syndrome matter? *American Journal of Obstetrics and Gynecology.* 1999;180(1):221-225.
53. Ghulmiyyah L, Sibai B. Maternal mortality from preeclampsia/eclampsia. *Seminars in Perinatology.* Feb 2012;36(1):56-59.
54. Lubow JM, How HY, Habli M, Maxwell R, Sibai BM. Indications for delivery and short-term neonatal outcomes in late preterm as compared with term births. *American Journal of Obstetrics and Gynecology.* May 2009;200(5):e30-33.
55. Hauth JC, Ewell MG, Levine RJ, et al. Pregnancy outcomes in healthy nulliparas who developed hypertension. Calcium for Preeclampsia Prevention Study Group. *Obstetrics and Gynecology.* Jan 2000;95(1):24-28.
56. Koopmans CM, Bijlenga D, Groen H, et al. Induction of labour versus expectant monitoring for gestational hypertension or mild pre-eclampsia after 36 weeks' gestation (HYPITAT): a multicentre, open-label randomised controlled trial. *Lancet.* Sep 19 2009;374(9694):979-988.
57. Bastek JA, Sammel MD, Pare E, Srinivas SK, Posencheg MA, Elovitz MA. Adverse neonatal outcomes: examining the risks between preterm, late preterm, and term infants. *American Journal of Obstetrics and Gynecology.* Oct 2008;199(4):367 e361-368.
58. Sibai BM, Koch MA, Freire S, et al. The impact of prior preeclampsia on the risk of superimposed preeclampsia and other adverse pregnancy outcomes in patients with chronic hypertension. *American Journal of Obstetrics and Gynecology.* Apr 2011;204(4):345 e341-346.
59. Tuuli MG, Rampersad R, Stamilio D, Macones G, Odibo AO. Perinatal outcomes in women with preeclampsia and superimposed preeclampsia: do they differ? *American Journal of Obstetrics and Gynecology.* Jun 2011;204(6):508 e501-507.
60. Kuklina EV, Ayala C, Callaghan WM. Hypertensive disorders and severe obstetric morbidity in the United States. *Obstetrics and Gynecology.* Jun 2009;113(6):1299-1306.
61. Walker JJ. Pre-eclampsia. *Lancet.* Oct 7 2000;356(9237):1260-1265.
62. Garovic VD. The role of angiogenic factors in the prediction and diagnosis of preeclampsia superimposed on chronic hypertension. *Hypertension.* Mar 2012;59(3):555-557.
63. Sibai B. Etiology and management of postpartum hypertension-preeclampsia. *American Journal of Obstetrics and Gynecology.* 2011:1-6.
64. 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.
65. Barton JR, Stanziano GJ, Jacques DL, Bergauer NK, Sibai BM. Monitored outpatient management of mild gestational hypertension remote from term in teenage pregnancies. *American Journal of Obstetrics and Gynecology.* Dec 1995;173(6):1865-1868.
66. 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#ixzz21CxkYCSO.

67. 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.

68. Buchbinder A, Sibai BM, Caritis S, et al. Adverse perinatal outcomes are significantly higher in severe gestational hypertension than in mild preeclampsia. *American Journal of Obstetrics and Gynecology.* Jan 2002;186(1):66-71.