Postpartum Hospital Stay and the Outcomes of Mothers and their Newborns

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Abstract

During the 1980s and 1990s, the lengths of postpartum hospital stays declined for both vaginal and cesarean births. Health professionals and policy makers expressed concern that shorter hospital stays might jeopardize the health of both mothers and infants. The federal government and states responded by passing laws requiring insurance carriers provide coverage for longer postpartum stays. One such law was the California Newborn's and Mother's Health Act of 1997, which went into effect on August 26, 1997, and mandated that insurance carriers provide coverage for at least 48-hour hospital stays for normal deliveries and at least 96-hour hospital stays for cesarean deliveries. If the physician, in consultation with the mother, discharges the patient before these time limits, the law requires that insurers provide coverage for a home or office follow-up visit for these women. A similar federal law called the Newborns' and Mothers' Health Protection Act of 1996 went into effect on January1, 1998. In this paper, we use a restricted-use data set of all births in California over a six-year period to examine the effect of these early discharge laws. Using an interrupted time series design, we demonstrate that early discharge laws reduced considerably the fraction of newborns and mothers who were discharged early. In two-stage least square models using the state and Federal law as instruments for the length of hospital stay, we find that an additional day in the hospital reduces the probability of readmission by about one percentage point for vaginal deliveries with complications and c-sections of all types. The former result is statistically significant at conventional levels but the latter result is only significant at a p-value of around 0.10. We find there was no statistically significant change in 28-day newborn readmission rates for babies whose mothers had uncomplicated vaginal deliveries. Finally, although the statutes did not cover Medicaid patients and patients with no insurance, we find that their postpartum length of stay was affected by the law changes as well.

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I. Introduction

Between 1970 and 1992, the average postpartum length of stay for mothers who delivered vaginally declined by 46 percent, from 3.9 to 2.1 days. Over the same period, the length of stay for those delivering by cesarean section fell from 7.8 to 4.0 days, a drop of 49 percent (Thilo *et al.* 1998; Hyman 1999). As a result of these trends, health professionals and policy makers expressed concern that shorter hospital stays might jeopardize the health of both mothers and newborns. A number of tragic stories about mothers and newborns discharged early who later developed life-threatening but preventable conditions fueled the desire of legislatures to address this issue. Between 1995 and 1998, 42 states passed laws requiring insurance carriers to provide minimum postpartum length of stays and a similar federal law called the Newborns' and Mothers' Health Protection Act of 1996 went into effect on January 1, 1998.

A number of authors have demonstrated that these laws increased average postpartum hospital length of stay, decreased the fraction of mothers and newborns discharged 'early', and increased hospitalization costs. There is however limited evidence about the impact of these laws on the health of the mothers and their newborns, and estimates from these studies provide conflicting results.

In this paper, we use a restricted-use data set of California births over the 1995-2000 periods to examine the impact of both the California and federal early discharge laws. The California Newborns' and Mothers' Health Act of 1997 (NMHA), which went into effect on August 26, 1997, mandated that insurance carriers provide coverage for at least 48 hour hospital stays for normal vaginal deliveries and at least 96 hour hospital stays for cesarean deliveries. If the mother, in consultation with the physician, agreed to be discharged before the state minimum time limits, the law also required that insurers provide coverage for an early home or office follow-up visit for the new mother and her newborn. The federal law is similar to the California statute but it does not require that insurance carriers provide coverage for follow-up visits. Both the California and Federal laws explicitly excluded Medicaid births from coverage.

Using an interrupted time series model, we find that the California and federal law generated substantial and abrupt drops in the early discharge rate for vaginal and cesarean deliveries for births insured by private carriers. Although the law did not cover Medicaid patients, their lengths of stay were

affected by the laws as well. We find that the law had no statistically significant impact on the 28-day readmission rates for newborns from uncomplicated vaginal deliveries, but there were statistically precise drops in readmission rates for newborns with complicated vaginal deliveries and c-sections without complications. There was no statistically significant change in 28-day mortality rates for newborns in any subsample.

Because early discharge laws exogenously increased the postpartum length of stay, we use their passage as instrumental variables for length of stay in a two-stage least squares (2SLS) model to obtain consistent estimates of the impact of length of stay on medical outcomes. In the sample of vaginal deliveries with complications and in both c-section deliveries subsamples, we find that an additional postpartum day in the hospital reduces 28-day readmission rates by 1 percentage point. The former result is statistically significant at conventional levels but the latter result is only significant at a p-value of around 0.10. In most cases, 2SLS results are larger in absolute value than their ordinary least-squares counterparts, suggesting OLS estimates are biased due to positive selection: those most likely to be readmitted are also those most likely to have longer stays.

II. Declining Postpartum Length of Stay and Passage of Early Discharge Laws

The trend towards shorter postpartum hospital stays outlined above was brought about by a number of factors including a shortage of hospital beds, cost containment efforts by managed care organizations, and an effort to 'de-medicalize childbirth' (Braverman *et al.* 1995, Eaton, 2000). As an increasing number of new mothers were discharged prior to the medically recommended length of stay, the press took notice and increasingly used terms such as "drive through deliveries" or "drive by deliveries" to describe early discharges.[1]

In the middle of the 1990s, the medical profession and a number of state and federal legislators began recognizing the potential problems of shorter postpartum hospital length of stay. Tragic stories of

[1] According to Declercq (1999), "…a June 1991 article in the Philadelphia Inquirer was the first reference to early postpartum discharge and the phrase "drive through deliveries" first appeared in the headline in a February 14, 1994, editorial in the *New York Times*."

mothers and newborns discharged early[2] who later developed life-threatening but preventable conditions fueled the desire of legislatures to address this issue. For legislatures, mandating a minimum postpartum hospital length of stay seemed to be a reasonable and direct solution at that time. Declercq (1999) notes "early discharge laws involved incremental changes to an existing policy, a simple solution to a problem whose health consequences are unclear…." The first bill regulating early discharge was passed by the Maryland legislature in 1995. By 1998, early discharge laws had been adopted by 42 states.

The Newborns' and Mothers' Health Protection Act of 1996 (NMHPA) was signed by President Clinton on September 26, 1996 and became effective on January 1, 1998. The federal law mandated insurance carriers provide coverage for at least a 48-hour hospital stays for vaginal deliveries and at least a 96-hour hospital stays for cesarean deliveries. A decision to discharge a patient before these time limits could be made by a physician only after consulting with the mother.

The California Newborns' and Mothers' Health Act of 1997 (NMHA), which was passed and went into effect on the same day, August 26, 1997, adopted similar mandatory minimum stays as the NMHPA. The California law did however require that if the physician, in consultation with the mother, discharged the patient before these time limits, insurers must provide coverage for an early home or office follow-up visit for both the newborn and mother. Both the federal and California statutes specifically exempted Medicaid patients from coverage.[3]

III. Literature Review

a. The Health and Medical Consequences of Short Postpartum Hospital Stays

Research results vary widely regarding the consequences of an early postpartum discharge for the mother and newborn. Most of the research on this topic correlates medical outcomes with the length of stay, controlling for observed characteristics of the patient and hospital. Many of these studies have

[2] The American College of Obstetrics and Gynecology (ACOG) and the American Academy of Pediatrics (AAP) define "early discharge" as a postpartum stay of less than 48 hours for uncomplicated vaginal births and a stay of less than 96 hours for cesarean deliveries (American College of Obstetrics and Gynecology 1992).
[3] Declercq (1999) suggests that by exempting Medicaid, the laws required minimal public funds and assured quick passage of the statutes.

demonstrated that shorter hospital stays for newborns are associated with higher probabilities of hospital re-admissions (Lee *et al.*, 1995; Liu *et al.*, 1997; Malkin *et al.*, 2000a), increased non-urgent visits to health centers and primary care providers (Madden *et al.*, 2002; Mandl *et al.*, 2000; Kotagal *et al.*, 1999), increased the risk of jaundice (Liu *et al.*, 1997; Grupp-Phelan *et al.*, 1999) and increased neonatal mortality (Malkin *et al.*, 2000). The magnitudes of these effects are sometimes quite large. Using Washington State linked birth certificate and hospital discharge abstracts covering 310,578 live births from 1991 to 1994, Liu and Davis (1997) used logistic regressions to assess the impact of an early discharge (a discharge less than 30 hours after birth) on the risk of rehospitalization within one month of birth. They found that newborns discharged early had a 28 percent higher 7-day re-admission rate and a 12 percent higher 28-day rate. Using linked birth and death certificates, plus hospital discharge records for 48,000 births from Washington state in 1989 and 1990, Malkin *et al.*, (2000b) found that neonatal mortality rates (death within 28 days) were 265 percent higher for infants discharged early compared to those with longer hospital stays.

In contrast to these findings, Dalby *et al.* (1996), Kotagul and Tsang (1996), Brumfield *et al.* (1996), Cooper *et al.*, (1996), Gagnon *et al.* (1997), Bragg *et al.* (1997), Mandl *et al.* (1997), Kotagal *et al.* (1999), Danielsen *et al.*, (2000), Johnson *et al.* (2002), and Madden *et al.* (2002), all show little or no relationship between postpartum hospital stays and hospital re-admission rates. Beebe *et al.* (1996) found no relationship between postpartum length of stay and neonatal mortality. Finally, Mandl *et al.* (2000) and Madden *et al.* (2002) found no impact of early discharges on emergency room or urgent care visits while Bossert *et al.* (2001) and Madden *et al.* (2004) found no link between early discharge and treatment for jaundice. Although many of these studies have smaller samples than the Liu and Davis (1997) paper cited above, not all of the results are simply Type II errors. Using Ohio Medicaid Claims data linked to vital statistics files for 102,678 full-term births from July 1, 1991 to June 15, 1995, Kotagal *et al.* (1999) found that the fraction of newborns discharged early increased 185 percent over the period (from 21 to almost 60 percent). However, there was no corresponding increase in the re-hospitalization rates in the same period. In a sample of 1.2 million vaginally-delivered newborns in California over the 1992-1995

period, Danielson *et al.* (2000) found no statistically significant difference in 28-day hospital readmission rates for babies released after a one-night stay compared to those with two or more nights stay.

It may be no surprise that the results of the single-equation models vary considerably from study to study. Infants assigned longer postpartum hospital stays are not a random selection of newborns but rather, tend to be children with more complications. Therefore, if we expect longer stays to reduce readmissions and there is positive selection on unobserved variables as well, then the expected negative relationship between length of stay and hospital readmission rates should be biased towards zero. Positive selection bias on observed characteristics is easy to establish in our data set. As we outline below, the data for this project includes all hospital discharges for childbirth in California over the 1995-2000 period. Using data from the pre-California law period (1995 and 1996), in a simple OLS model, we regress postpartum length of stay (LOS) on observed characteristics. Likewise, we estimate a logistic model with the same covariates but use as the dependent variable a dummy indicating whether the newborn was readmitted within 28 days. We estimate these models for all vaginal and c-section births covered by private insurance and Medicaid and results for these models are reported in Table 1. We report coefficients from the length of stay regression and marginal effects from the 28-day readmission logit.

The results from these models indicate that for both vaginal and c-section deliveries, there is positive selection, that is, children we expect to have longer hospital stays tend to have observed characteristics that predict higher readmission rates. Focusing on the results for vaginal deliveries, those with private insurance, those admitted to non-profit and for profit hospitals (compared to government-owned hospitals), children whose mothers had fewer complications during pregnancy and delivery, those with one or two previous births and girls, all have lower length of stays and lower odds of being readmitted to the hospital. There is less of a consistent story about the selection bias for some of the demographic variables such as the marriage, race/ethnicity, age, and education. Children with married mothers have shorter stays but the coefficient on marriage in the readmission logit is statistically

insignificant. Likewise, the coefficients on white and black children are of opposite signs in the two models.

b. Analyses of Early Discharge Laws

Udom and Betley (1998), Dato *et al.* (1996), and Liu *et al.* (2004) examined the impact of early discharge laws on the postpartum length of stay and costs. All three studies show the laws increased the postpartum length of stay and increased costs, while the final two studies demonstrate the laws increased length of stays for those not impacted by the law such as Medicaid recipients and the self-insured.

Madden *et al.* (2004) examined the effects of two policies affecting length of stay of mothers and newborns in Massachusetts: An HMO protocol adopted in 1994 requiring a one-night hospital stay plus a nurse home visit after a vaginal delivery, and a 1996 Massachusetts early discharge law that was similar in scope to the 1998 federal statute. The authors used data on 20,366 mother-newborn pairs with normal vaginal deliveries between October 1990 and March 1998. They found that the reduced length of stay in this HMO and the increase in stay generated by the state law had little impact on subsequent medical encounters for jaundice or newborn feeding problems.[4]

In one of the most detailed studies to date, Meara *et al.* (2004) examined the impact of the Ohio early discharge law on the health of newborns in Medicaid. Unlike the California and federal statutes, the Ohio law covered Medicaid patients. Using Medicaid claims over the 1991 through 1998 period, the authors establish that the law decreased considerably the fraction of short postpartum stays but they showed a noticeable but not statistically significant drop in hospital readmission rates. The most innovative portion of this study was an examination of the efficacy of early post-discharge office visits. Using the fact that there is variation in the delay of an office follow-up visit generated by the day of the

[4] Madden *et al.* (2002) examined the impacts of the same two interventions as in the previous paragraph, but this article considered the impacts for more vulnerable subgroups such as mothers enrolled in Medicaid and mothers from low-income or low-education census tracts. This work generated results similar to their earlier work.

week the birth occurred, the authors find that a follow-up visit that occurred within three days of discharge generated statistically significant reductions in hospital re-admission probabilities.

Despite the large volume of research, there is still no consensus regarding the impact of short hospital stays on mothers and their newborns. A review of the literature by Britton *et al.* (1994) concludes that "heterogeneity and limitations of methodology and study design substantially limit conclusions that may be drawn from published studies (p. 291)." Braverman *et al.* (1995) concludes that "there is no clear evidence for the safety, efficacy, and effectiveness of the hospital and post-hospital practices that were previously standard. The current available literature provides little scientific evidence to guide discharge planning for most apparently well newborns and their mothers (p. 724)". A third review by Grullon and Grimes (1997) concludes that "The safety of early discharge is unclear (p. 860)" and "the current data do not support or condemn widespread use of early postpartum discharge in the general population (p. 860)."

There are three persistent problems noted by the authors of the literature reviews discussed above. First, samples sizes are often of an insufficient size to detect effects on outcomes that are rare in the population. Second, many of these studies lacked detailed control variables, especially measures of pregnancy complications. And third, few studies had experimental variation in the covariate of interest (postpartum length of stay). Our work addresses all three of these shortcomings.

Although there have been numerous studies on the impacts of short postpartum hospital stays, much of the literature has one or more of the shortcomings listed above. Studies such as Marbella *et al.* (1998) have large samples but limited controls and no quasi-experimental variation. Studies such as Malkin *et al.* (2000), Danielson *et al.* (2000), Kotagal *et al.* (1999), and Liu and Davis (1997), have large samples, excellent control variables, but no quasi experimental variation postpartum length of stay. Studies such as Meara *at al.* (2004), Madden *et al.* (2002) or Madden *et al.* (2004) have quasi-experimental variation and excellent control variables but samples that may be too small to make meaningful predictions about rare events like hospital re-admissions and neonatal mortality.

Our study deals with the three major concerns listed above. First, the law change occurred in California, a state with a large population, and we utilize data for approximately 3 million births in total, with more than half of these births occurring in the treatment period. Our study will therefore be the largest sample ever used to analyze the impact of postpartum length of stay on health outcomes. Second, although random assignment clinical trials are the gold-standard for inferring causal relationships, the number of observations necessary to eliminate a high Type II error rate for many low incidence outcomes makes clinical trails impractical for some questions. The best that one can hope to obtain is quasi-experimental variation in field data that mimics a clinical trial. As we demonstrate below, the California law change generated a large and immediate decline in the fraction of newborns and mothers discharged early provides just such variance. Third, in contrast to some previous studies, we examine the impact of early discharge for infants whose mothers experienced complications either during pregnancy or labor.

IV. Constructing the Analytic File

a. Data

The data set for this analysis is a specially linked administrative record data sets of all mothers and newborns discharged from non-federal hospitals in California from January 1, 1995 to December 31, 2000. The data set is generated and maintained by the State of California Office of Statewide Health Planning and Development (OSHPD) and created by linking patient discharge data sets with birth, death and fetal death certificate information.

Public-use versions of the patient discharge dataset contain demographic information such as the age, race, and sex of the mothers and newborns, information about the admission such as the length of stay, procedures used, diagnoses codes, the hospital charges, the type of insurance, and whether the patient died in the hospital. These discharge data sets also contain a code that identifies the hospital.

The linked patient discharge dataset with vital statistics birth file is a restricted-use version of the discharge data that contains all the information in the public use discharge record, plus the exact date and time of birth (and therefore the newborn's admission to the hospital), the zip code of residence, a

scrambled Social Security number, information from the birth file that identifies when and where a baby was born and information from the death file that identifies when and where a newborn died for up to one year after discharged. The scrambled Social Security number can be used to link the discharge record over time so as to construct re-admission rates for both mothers and newborns. We have the ability to measure re-admission rates for up to one year after discharge. The information from the birth and death files will allow us to identify whether a newborn died within a fixed time period after admission and discharge, not just whether they died in the hospital. Also, the developers of the data file have matched mothers to newborns allowing us to use characteristics of both mother and the newborn as covariates in multivariate regressions. During the six years in our data set, there are approximately 3 million births in total, with 1.68 million births occurring after the passage of the California law.

Although the early discharge laws impact the length of stay for both mothers and their newborns, in this analysis, we focus primarily on the outcomes of infants. We do this because adverse outcomes like readmission and mortality rates are higher for infants than mothers and as we demonstrate below, are samples are in most cases just large enough to produce statistical significance with these larger adverse outcome rates. Wei (2006) presents a full set of results for the mothers of these infants as well.

b. Outcome Variables

There are several outcome variables that we can utilize in the linked Hospital Discharge Data/Vital Statistics birth files that directly or indirectly measure the health of mothers and their newborns. The two most obvious outcomes are: the postpartum hospital length of stay and whether the mother and newborn were discharged early from the hospital. These variables can be used to directly measure the impact of the California law and federal law.

The hospital discharge data set measures length of hospital stay in days. Although the California and federal law requires that insurers pay for a minimum length of stay in hours, our data set does not have the hour of discharge and therefore, we cannot calculate this value. The intent of the law was to

provide mothers with the ability to stay an extra night in the hospital if they desired. Subsequently, the key outcome in our analysis is whether the infant was discharged early which is less than two nights for vaginal deliveries and less than four nights for c-sections.

As we noted in the literature review, one concern with early discharges is that health care providers may not have had sufficient time to detect certain conditions. We will exploit the linked nature of our data and construct a measure of whether the newborns were re-admitted to the hospital within a specified time period. In the Hospital Discharge Data/Vital Statistics birth files, the scrambled Social Security number can be used to link the discharge records of newborns over time. Researchers typically measure re-admissions within 7, 14 and 28-days of birth, and we will follow this convention. We will measure the re-admission rates with a dummy variable that equals 1 if a person is re-admitted within a particular number of days.

We will also use neonatal mortality rates as an outcome. In the linked data set, death records for the newborn have been linked to the discharge and birth record. For each newborn, we know whether they died within one year of birth, plus the cause and place of death. Following previous literature, we will use 28-day mortality rates for newborns.

The final outcome measure we will examine is total charges for both the mother and infant's hospitalization.[5] This variable is closely connected with postpartum hospital length of stay of mothers and newborns and the results will allow us to conduct a cost-benefit analysis of the early discharge law. In regression models, given the skewness of hospital charges, we will examine models where the dependent variable is measured in natural logs.[6]

c. Analysis Samples

Many previous analyses of the impact of early discharge on the health of newborns have restricted their attention to uncomplicated vaginal and c-section deliveries. The author surmise that few

[5] Total charges were converted into real 2000 dollars using the Consumer Price Index.

[6] Because some hospital stays are incredibly long and expensive, we will also experiment with using median regressions to eliminate the influence of outliers in the data set.

complicated deliveries will be discharged early so they focus on the deliveries most likely impacted by laws such as the federal statute. However, as we demonstrate below, we found that these laws significantly impacted the length of stay for complicated deliveries as well. Therefore, we work with four distinct subsamples: complicated and uncomplicated vaginal and c-section deliveries. There are a variety of ways to define complicated deliveries. One popular way is to use a specific DRG code for uncomplicated deliveries and there are codes for both mothers and newborns.[7] In our data set, we also have data from the birth record that can be used to define a complicated pregnancy/delivery as any one where the mother presented any one of 24 complications during pregnancy[8] or 23 complications during labor.[9] Although many patients whose DRG codes indicating a complicated delivery also identified complications on the birth record, the overlap was not perfect. Subsequently, we use both DRG code and detailed complication information from birth record to define complicated or uncomplicated birth. A birth is defined as uncomplicated if neither the DRG code nor the birth record identifies a complication.

We use ICD-9 procedure codes and data on the birth record to identify whether the mother delivered vaginally or by c-section. We restrict our attention to births covered by Medicaid or private insurance carriers, which captures about 95 percent of all births in the state over the period of analysis. Table 2 reports basic demographic information of mothers in our four samples, vaginal and c-section deliveries with and without complications. On average, based on our samples, women who had a cesarean delivery were older, more educated, and more likely to be black than women who had a vaginal delivery.

[7] DRG 370 represents cesarean deliveries with complications, and DRG 372 represents vaginal deliveries with complications.
[8] These include such factors as pre-eclampsia, chronic hypertension, renal disease, Rh sensitivity, premature labor, sexually transmitted disease, Hepatitis B, low or high birth weight, less than 37 weeks gestation, plus others.
[9] These include such factors as seizure during labor, premature rupture of membrane, breech presentation, excessive bleeding, sepsis, cord prolapse, fetal distress, anesthetic complications, maternal blood transfusion, plus others.

V. Graphical Analysis of California Law and Federal Law

a. The Change in Postpartum Length of Stay

In Figure1, we plot the monthly fraction of newborns delivered vaginally without complications who were released early in each month. The first vertical line in September of 1997 indicates the first full month the California law was in effect and the second line at January 1998 indicates when the federal law became effective. Note that in Figure 1, there was a substantial and abrupt change in the private insurance time series during a short period between September 1997 and January of 1998. Before September of 1997, the fraction of newborns with private insurance that had a length of stay less than 2 days was relatively stable with a small drift downward. In August of 1997, 82 percent of newborns whose deliveries were paid for by private insurance had a postpartum length of stay less than 2 days. By February of the next year, just six months later, this number had fallen to 50 percent, a 32 percentage point decline and a 39 percent reduction. Early on in our sample, most insurance carriers knew the federal law would take effect in a 1998, but from Figures 1, it appears that few were adjusting 6 months prior to the law change. Therefore, the state law change caught insurance carriers by surprise and as a result, it took some time to adjust. Most carriers had a long lead time to prepare for the federal law and it appears from Figure 1 (and subsequent figures), that the adjustments to a longer length of stay occurred by the 1st quarter of 1998.

Notice also in Figure 1 that although neither the California nor the federal law covered births paid by Medicaid, there was a sudden and persistent drop in the fraction of newborns with stays of less than 2 days in this group as well. The drop was less dramatic, but the post-law rates for both insurance types converged rapidly after the law was passed. Wei (2006) examines in detail why there was a decline in the fraction of short postpartum stays in Medicaid and much of the decline appears to be due to the specific type of Medicaid managed care plans in California.

In Figure 2 we graph the early discharge rate for newborns who were delivered via uncomplicated cesarean section. In this figure, an early discharge is defined as a postpartum length of stay that was less than four days. Notice that starting in September of 1997 for those covered by private insurance, there

was a noticeable drop in the fraction of early discharges. In August of 1997, 90 percent of newborns delivered by cesarean section were discharged in less than 4 days. By the middle of 1999, this number had fallen anywhere from 14 to 16 percentage points. For cesarean deliveries, although the drop was much less dramatic, we do see a drop in the fraction of Medicaid births discharged early.

Figures 3 and 4 plot the early discharge rate for newborns after complicated vaginal and c-section deliveries, respectively. From Figure 3, we can see that before the laws, on average there were 67 percent mothers and newborns that were discharged early even for vaginal deliveries with complications. As was true for deliveries without complications, there was a substantial and abrupt drop in the early discharge rate in both September 1997 and January 1998 that are roughly the same size as the drops for uncomplicated deliveries. Complicated vaginal deliveries covered by Medicaid showed a similar but less dramatic drop in January 1998. In Figure 4, we find that for privately insured complicated c-sections, there was a 17 percentage point drop in the early discharge rate between August 1997 and February 1998.

These figures highlight a number of important facts. First, if a short postpartum stay does affect some outcomes such as hospital re-admissions, then the sharp and dramatic drop in short stays generated by the California law should provide an excellent opportunity to precisely estimate the magnitude of this effect. Second, deliveries covered by Medicaid were affected by the early discharge laws as well, eliminating this group as a potential control. Third, the timing of the change in time trends corresponded exactly with the effective dates of the state and federal law. Fourth, the federal law reduced early discharge rates for complicated deliveries by the same rate as for uncomplicated deliveries, even though the former group has substantially lower early discharge rates prior to passage of the federal law.

In a similar analysis to that in Figures 1-4, Wei (2006) examines whether there were time series changes in the fraction of infants covered by insurance, the fraction delivered by c-section, the fraction with mothers who had pregnancy-related or delivery complications. The laws were not associated with sharp changes in any of these outcomes.

b. Changes in Health Outcomes

In the next four figures, we plot the 28-day readmission rate of newborns for vaginal and c-section deliveries without complications (Figures 5 and 6), and the same deliveries with complications (Figures 7 and 8). In each of these figures, the month-to-month variation in 28-day readmission rate dwarfs any systematic change in readmission rates produced by the law, so it is difficult in these graphs to tell whether the law improved birth outcomes. There was however a noticeable increase in readmission rates in December of 1997, the fourth full month that the California law was in effect and the last month before the federal law took effect. One may be tempted to attribute this sharp increase in readmissions to the California law. But a closer inspection of the data suggests that something else was occurring. Notice that readmission rates always spike in the late autumn and early winter months during the flu season. The winter of 1997/98 was a particularly heavy flu season in California as was pointed out in a report released by OSHPD.[10] Flu complications are a common reason for readmission among infants.

The cyclic nature on newborn readmissions suggests that we must control for day-to-day environmental conditions that may alter readmission rates. For infants born on a particular day, we calculate the 28-day admission rate (defined as admissions per number of children) for those born 90 to 180 days ago. We allow this readmission rate to vary by type of insurance. Our use of children 90-180 days old does however mean that we lose the first six months of data in our analysis. [11]

In Figures 9 and 10, we average the 28-day readmission rate of newborns and older infants up to the month level and plot the series over time for vaginal deliveries under private insurance and Medicaid. These Figures show that the admission rates of slightly older infants is highly correlated with the 28 day readmission rate of newborns and both indexes demonstrates a sharp rise in admissions in December of 1997. We will use the admission index for older infants as a control variable in our model to capture the day to day variation in unobserved conditions that lead to changes in readmission rates.

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[10] The title of this report is *CALIFORNIA HEALTH CARE SYSTEM: OVERVIEW OF THE HOSPITAL/EMS CRISIS WINTER OF 1997-98*

[11] Use of the index as a covariate assumes that changes in early discharge rates produced by the state and federal law will have no impact on admission rates after 90 days of age. Results in Table 5 provide some evidence in support of this hypothesis.

VI. Econometric Model

a. A Reduced-Form Model

To estimate the impact of the law on birth outcomes, we would ideally use a difference-in-difference model, where we could compare the average length of stay of mothers and newborns before and after the California early discharge law went into effect, using a comparison group to identify what the time path of outcomes would have been in the absence of the intervention. Unfortunately for our research purposes, all states were treated in roughly the same time period by the Federal law. Likewise, the preliminary data above suggest that within California, the law impacted those not covered by the statute. Given the lack of any control group, we therefore use an interrupted time series model instead. This technique requires the modeling of a process underlying a time series of data and is used as a means of assessing the impact of a discrete intervention on a social process.

Interrupted time series models are sometimes difficult to implement for a variety of reasons. First, it is often difficult to measure precisely when an intervention became effective. Second, other events may contaminate the treatment effect. For this particular study, we are fortunate that the timing of the law change is exact, and the immediate and large impact of the law makes it difficult to argue that some other event explains the sudden and precipitous change in hospital length of stays for newborns.

The unit of analysis for this study will be a mother/newborn pair, and the key patient of interest is the newborn because prior studies have suggested their health is more likely to be affected by an early discharge. In the newborn models, we label the outcome variable of interest Y. Outcomes vary across patients, hospitals and time, which are indexed by i, k and t, respectively. The basic interrupted time series model is of the form

$$(1)\ Y_{ikt} = NEWBORN_{ikt}\beta_1 + PARENTS_{ikt}\beta_2 + HOSP_{ikt}\beta_3 + STATELAW_t*PAYER_i\alpha_1 + FEDLAW_t*PAYER_i\ \alpha_2 + HSAREA_k*HOSP_SIZE_k*PAYER_i*MTREND_t\beta_4 + HSAREA_k*HOSP_SIZE_k*PAYER_i\ \beta_5 + INDEX90180_t\beta_6 + MONTH_t + DAY_t + \varepsilon_{ikt}$$

NEWBORN and PARENTS are vectors of control variables that describe characteristics of the newborn (sex, race, ethnicity, the hour of birth), and the mother and father (s

uch as age, education, and the number of previous births) plus insurance status (PAYER). To control for seasonal patterns in re-admission rates, we include a set of twelve monthly fixed-effects, labeled as MONTH. There are also persistent differences in outcomes across hospitals with particular characteristics and we capture these with the vector HOSP. In this vector, we include dummy variables for hospital size (HOSP_SIZE),[12] ownership status[13], hospital service area (HSAREA)[14]. There may be variation within the week in some outcomes based on the day of admission, so we include a set of day of the week fixed-effects, labeled as DAY_t. Finally, to control for day-to-day conditions that may generate readmissions, we include the admission rate for infants 90 to 180 days of age. For an infant born on day t, we use as an index the number of admissions per child over the next 28 days for all children aged 90-180 days who were alive on that birth date. The variable ε_{ikt} is an additive error.

Because we do not have a natural control group that was unaffected by the law changes, we must capture the time series in postpartum length that would have occurred in the absence of the California with time trends. We are aided by the fact that the pre-law and post-law trends are very similar as Figures 1-4 demonstrate. Taking the aggregate data for Figure 1 and regressing the fraction of early discharges in private insurance on a time trend, dummies for the state and federal law, plus a time trend for the four months of the state law, we obtain an R^2 of 0.98. To eliminate any secular trend in the data, we include a monthly trend $MTREND_t$ that equals 1 if the birthday of newborn is in January of 1995, 2 in February,

[12] We break hospitals up into 6 groups based on average monthly number of cases. HOSP_SIZE=1 if average monthly case<=20; HOSP_SIZE=2 if 20 <average monthly case<= 50; HOSP_SIZE=3 if 50 <average monthly case<= 100; HOSP_SIZE= 4 if 100 <average monthly case<= 150; HOSP_SIZE=5 if 150 <average monthly case<= 300; HOSP_SIZE=6 if average monthly case>300.

[13] For hospital ownership variable, it is classified into 11 categories: 1=church, 2=non profit corporation, 3=no profit other, 4=individual investor, 5=partnership investor, 6=corporation investor, 7=state, 8=county, 9=city/county, 10=city, 11=district.

[14] We use 14 health service areas defined by the U.S. Department of Health and Human Services for the state of California. Health service areas are sometimes single counties (e.g., Los Angeles and Orange county) but in many cases, areas include multiple counties.

etc. We allow the monthly trend to vary by the health service area, hospital size, and the source of payment of delivery.

The key variables in the model are the vectors α_1 and α_2 that measure the impact of the state and federal respectively. The variable STATELAW equals 1 from August 27, 1997 through December 31, 1997, while FEDLAW equals 1 from January 1, 1998 and on. In each regression, we allow the effects of the law to vary across patients with private insurance and Medicaid.

There are two continuous outcomes (length of stay in days and dollars of total charges) and three sets of outcomes that are dichotomous (early discharge, re-admission and neonatal mortality). For models with continuous outcomes, we will estimate ordinary least squares, and for discrete models, we will estimate logistic regression models.[15] In all models except quantile regression estimates below, we control for possible autocorrelation in errors by allowing for arbitrary correlation in errors within a hospital over time.

We titled this section 'a reduced-form model' for a particular reason. The California law changed two things at once. First, it required insurance carriers to provide coverage for longer postpartum hospital stays. Second, it required insurance carriers to provide coverage for a follow-up visit for mothers who, after consulting with their physician, were discharged from the hospitals early. Therefore, the estimated impact of the law contained in coefficients (α_1 and α_2) captures both of these changes. This distinction is potentially important. Suppose that a) early discharge increases the chance of a hospital readmission, b) early follow-ups of patients released early eliminate this risk, and c) everyone released early has a follow-up visit. In this case, the coefficients on α_1 and α_2 will both be zero since the harm from an early discharge was compensated for by the office follow-up visit. Previous research from California has

[15] We can also add hospital-specific fixed-effects to the model. In the initial regression models, we estimate all models via OLS even though some outcomes are dichotomous. However, later on in the paper, we compare OLS results to logistic regression results for these discrete outcomes. There are many hospitals in the data set and estimating a nonlinear model like a logistic regression with hospital fixed effects is subject to the problem of incidental parameters (Chamberlain, 1984). The observations per hospital preclude us from using a conditional logistic regression. Therefore, to directly compare results, we do not include hospital fixed-effects in the basic regression models. The linear probability estimates are however not sensitive to whether we include hospital fixed-effects or not.

demonstrated, however, that this is probably not a concern.[16] Although in principal α_1 and α_2 capture both effects, any impact we estimate is likely to be driven primarily by the change in length of stay and not an increase in early follow-up visits.

b. Two-Stage Least-Squares Estimate

We argued in the previous section that the health benefits from the law are likely to be driven by longer postpartum length of stays and not the mandated coverage for early follow-up visits after an early discharge. We quantify the size of the relationship between postpartum length of stay and adverse outcomes by using the information from the reduced-form models in a more structured way. Specifically, we use the adoptions of the federal and state laws as instrumental variables for length of stay in a two-stage least squares (2SLS) model to obtain consistent estimates of the impact of length of stay on medical outcomes.

To more formally outline this model, note that one question of interest is the impact of length of stay on 28-day readmission rates. We can model this statistically with the following 'structural' equation of interest:

$$(2)\quad 28DAY_{ikt} = X_{ikt}\beta_1 + LOS_{ikt}\,\delta_1 + \varepsilon_{1ikt}$$

Where for simplicity, we include all the covariates from equation (1) into one vector X. The key covariate in this regression is LOS which measures postpartum length of stay of newborns in days. As we noted above, equations such as (2) have been estimated by a number of authors but we suspect that $cov(LOS_{ikt}, \varepsilon_{1ikt}) > 0$ so OLS estimates of δ_1 will be biased towards zero.

Two-stage least squares estimation requires that a researcher identify a variable that exogenously changes the endogenous covariate of interest (LOS) but has no direct impact on health (28DAY). In this

[16] Galbraith *et al.* (2003) surveyed 2,828 mothers in California in 1999 and found there was no difference in the percentage of newborns with an early follow-up (within 2 days of discharge) between those discharge early and those discharged later.

case, the instruments are the enforcement dates for the state and federal law. As Figures 1 – 4 indicate, the federal law clearly changed hospital length of stay and for the reasons mentioned above it is plausible that this change was exogenous. For this particular study, we are fortunate that the timing of the law change is exact, and the immediate and large impact of the law makes it difficult to argue that some other event was explaining the sudden and precipitous change in hospital length of stays for newborns. Likewise, so long as we properly control for the secular trends in the outcome, the instruments should not generate any omitted variables bias in the outcome equation of interest.[17]

VII. Results

a. Reduced Form Model Regression Results

Table 3 presents the results of equation (1) – the reduced-form model for infants using four subsamples, vaginal and cesarean deliveries without and with complications. We initially report results for four outcomes: percent discharged early, length of stay in days, 28 days readmission, and log total inpatient charges (charges for the infants plus the mother). We estimate all models as linear regressions although these two outcomes – discharged early and 28 day readmission – are dichotomous.

For privately insured vaginal deliveries without complications, we find that the California and federal law reduced early discharge rates of newborns by 16 percentage and 31 percentage points, respectively, with the later result being 38 percent of the pre-law rates. The standard errors on these estimates are incredibly small and the results are statistically significant at conventional levels.[18] Interestingly, the federal law had only a slightly smaller impact on vaginal deliveries with complications although the mean discharged early is 14 percentage points lower in this later group. For c-section

[17] Our key outcomes (re-admissions and neonatal mortality) are both discrete and the key covariate of interest (length of stay in days) is continuous. A 2SLS model where we instrument for LOS will therefore not mimic the data generating process well. This model could be estimated by maximum likelihood models where the outcome is discrete and the endogenous variable of interest is continuous (Evans, Oates and Schwab, 2002; Evans, Farrelly and Montgomery, 1998). However, given the size of the data set and the number of covariates in the model, this model will be difficult to estimate. Angrist (2001) has however demonstrated that two-stage least squares models applied to limited and discrete dependent variables replicate treatment effect parameters from more complicated maximum likelihood models.

[18] References to statistically significant estimates assume a p-value of 0.05 or below.

deliveries, the federal law is estimated to reduce early discharge rates by 12 and 14 percentage points respectively, privately insured c-section deliveries with and without complications, respectively. In general, the effect of the state law is about half the impact of the federal law for those with private insurance. Although neither law applies to Medicaid births, the federal law reduced early discharges of vaginal births by 12 percentage points in both samples, and again, both of these results are statistically significant at conventional levels, The state law is estimated to not have reduced early discharges for c-sections by a statistically significantly amount in either sample.

In the next column of results, we report average change in length of stay measured in days and the results in this column parallel those for the discharged early outcome. For vaginal deliveries covered by private insurance, the federal law increased average length of stay by 0.36 days among uncomplicated deliveries and by 0.44 days for those with complicated deliveries, and both estimates are statistically significant. The corresponding numbers for the Medicaid population are 0.15 and 0.21 days (both statistically significant), which are roughly 40 percent of the values of the federal law. Among c-section deliveries covered by private insurance, the federal law increased average stays by a statistically significant 0.43 days for uncomplicated deliveries and 0.73 days for complicated deliveries, while the impact of the state law was half as large for uncomplicated deliveries and two-thirds as large for complicated c-sections.

In the third set of results for each subsample, we report results for the 28-day readmission equation. If longer stays reduce readmission rates, then we should see reductions in these rates after passage of the state and federal laws. For vaginal deliveries without complications, we observe a statistically insignificant drop in readmissions rates of 0.06 percentage point after the passage of the federal law for privately insured and 0.03 percentage point for those covered by Medicaid. In contrast, for the same subsample, we observe a statistically significant *increase* in readmissions after passage of the state law for both insurance types. This could be attributed to the law but alternatively, this could be due to the fact we cannot control perfectly for the large spike in admissions that is observed in December of 1997 during the severe flu season in California.

For vaginal deliveries with complications, we observe reductions in readmission rates after the state and federal law and for both insurance types, but the results are only statistically significant for Medicaid patients after the federal law. Among those with private insurance delivered by c-section, there was a statistically significant drop in readmission rates of a half of a percentage point after the passage of the federal law, and the coefficient is statistically significant in the uncomplicated sample but the estimate in the complicated sample has a t-statistic of -1.42.

In the final column of results for each subsample, we estimate a model of log charges which is the total charges paid for both the mother and her infant. Among those with private insurance, the passage of the federal law is estimated to increase charges by eight to 10 percent for vaginal births, 4.7 percent for uncomplicated c-section deliveries and 6.1 percent for complicated c-section deliveries. The federal law increased Medicaid charges by 2 percent for vaginal deliveries and the state law increased payments for privately insured patients by a similar amount.

Given the skewness in total charges, the least square regression results in Table 3 can be distorted by some large outliers in the charges distribution. For the reduced form model having log total charge as dependent variable, we also estimate quantile regressions models at the 25^{th}, 50^{th}, and 75^{th} percentile of the conditional distribution in log charges. The quantile regression results are reported in Table 4.[19] In general, because the law is impacting the lower tail of the length of stay distribution, we would expect larger reduced-form estimates on the treatment effect dummies for lower conditional quantiles and this is exactly what we find. Looking at the results for those with private insurance among vaginal deliveries without complication, the federal law is estimated to increase costs by 9.6, 9 and 8 percent at the 25^{th}, 50^{th}, and 75^{th} percentile, respectively. In all three cases, the parameter estimates are forty to fifty times larger than standard errors. For uncomplicated c-section deliveries paid by private insurance, the federal law increases costs by 5, 4 and 2 percent across the three conditional quantiles. Notice that mean estimates from Table 3 for the federal law among the privately insured is slightly lower than the median estimates in Table 4 among vaginal deliveries, but this ordering is reversed for c-section deliveries.

[19] We are unable to allow for within-hospital correlation in errors in the quantile regression models.

Much of the literature in this area examines 28-day readmission rates as a key outcome but we can calculate 7 and 14 day readmission rates as well. As we shorten the follow up after birth, the incidence rate falls considerably. Linear probability models tend to generate marginal effects similar to estimates from logit models but only when the mean outcome is some distance from zero or one. In the case, the small rate of 7 and 14 day readmissions necessitates that we estimate a logit model for these outcomes.

Table 5 reports the reduced-form logistic regression models where the outcomes of interest are initially the 7, 14, and 28 day readmission rate for infants and in the table, we report the 'average treatment effect' which is the estimated change in the logistic CDF when the law dummies are turned on and off. The results in Table 5 indicate the federal early discharge law had no statistically significant effect on readmission rates for either privately insured or Medicaid vaginal delivery patients. In contrast, the state law is estimated to generate statistically significant increases in readmission rates for these same patients. As we explained before, this could be fact that we are not controlling completely for the day-to-day fluctuations in admission rates wuith our admission index.

Looking at the impacts of the federal law for privately insured vaginal deliveries with complications and c-sections without complications, we see a number of interesting results. First, the logit marginal effect in the 28-day readmission equation is nearly identical to the linear probability estimates in Table 4. Second, the coefficients for the 7, 14 and 28-day readmission rates are nearly identical meaning that for these samples, ALL of the problems generated by short hospital stays will manifest themselves within seven days. However, in all three samples, especially for c-sections with complications, the coefficient on the (federal law x private insurance) variable increases monotonically as one move from the 7-day, 14-day and 28-day equations. In this final model, we generate a coefficient that is statistically significant at the 90 percent confidence level.

In the final column of each section of results, we also report logit estimates where the outcome of interest is the 28-day mortality rate for newborns. Across the four samples, neonatal mortality is anywhere from 6 per 10,000 to 45 per 10,000 so this adverse outcome is very rare. We see some

evidence that for those experiencing the largest increase in length of stay (privately insured patients impacted by the federal law), there is a decline in mortality in two of four samples but none of the estimates are statistically significant at conventional levels.

b. 2SLS Regression Results

The reduced-form estimates presented in the previous three tables represent the 'intention to treat' impacts of the state and federal law. In this section, we generate estimates of the impact of the law on those treated by calculating 2SLS estimates of equation (2). As we noted above in Table 1, those most likely to have longer hospital stays are also those most likely to experience a 28-day readmission. If the unobserved characteristics of mothers and their infants that predict 28-day readmission rates are correlated with length of stay in the same direction as these observed characteristics, then OLS estimates of equation (2) are biased towards zero.

In the first third of Table 6, we report OLS estimates of equation (2) to form a baseline to which we can compare 2SLS results. In this model, the 28-day readmission dummy variable is the outcome of interest and key covariate is length of stay measured in days. The estimated impact of an additional day in the hospital is fairly uniform across the samples, ranging from a low of .12 percentage points for vaginal deliveries with complications to .22 percentage points for c-sections without complications.

In the next third of the table, we report 2SLS estimates that use four instruments for postpartum length of stay: the federal and state laws interacted with Medicaid and private insurance. In three of our four samples, the results are negative and the estimates are larger in absolute value, which is consistent with the selection bias story we outlined above. In the vaginal delivery sample without complications, the 2SLS estimates suggest that an additional day in the hospital will reduce 28-day readmission rates by 0.09 percentage points, but by OLS, an additional day in the hospital will reduce 28-day readmission rate by 0.13 percentage point. For this sample, the results are not consistent with our story that OLS estimates are biased towards zero. This could be caused by the fact that we are using both state and federal law as instrumental variables, and there are significant positive effects of state law on readmission rates. For

vaginal deliveries without complications, the 0.764 p value of 2SLS regression estimate means that, at conventional statistical levels, what we can conclude is that even with 1.7 million observations, we do not have enough power to reject the null hypothesis that the length of stay coefficient is zero.

In contrast, the coefficients on length of stay in the other three samples are all large and statistically precise at much lower p-values. For vaginal deliveries with complications and both c-section samples, we estimate that an additional day of stay reduces 28-day readmission rates by about 1 percentage point. These are large numbers. In the vaginal delivery with complication sample and in the c-sections samples without and with complications, the ratio of the 2SLS estimate divided by the sample mean is 0.297, 0.20, and 0.119, respectively. Across these same samples, these estimates are statistically different from zero at the p-values of 0.054, 0.093, and 0.158, respectively.

The p-values on the test of over-identifying restrictions in the final three models are all comfortably in excess of 0.05 but the estimate for the uncomplicated vaginal delivery sample is very small. This is to be expected given the reduced-form estimates in Table 3. Given the imperfect controls for cyclic variation in readmission rates, we find in reduced-form models that the state law actually increased readmission rates. Since the test of over-identifying restrictions can also be though of as a test of the null hypothesis that the 2SLS estimates are identical regardless of the instrument set used, we would expect to reject the null with test since the federal instruments is predicting a positive benefit of an additional day of stay whereas the other instruments predict a negative effect.

The problems with the four months when only the state laws were in effect is illustrated with the final column of Table 6 where we delete these four months from the sample and only use the federal law interacted with insurance coverage as instruments. Now in all four samples, the estimates are negative and larger in absolute value, which is consistent with the selection bias story we outlined above. In these models, the p-values on the 2SLS coefficients across the four samples are not 0.647, 0.05, 0.115 and 0.086, respectively. Also, the p-values on the test of over-identifying restrictions are now all incredibly small with three in excess of 0.95. For vaginal deliveries without complications, we still do not have enough power to reject the null hypothesis that the length of stay coefficient is zero.

VIII. Conclusion

In this paper, we use a large change in postpartum length of stay generated by the passage of a state and federal law to examine the effect of longer stays on the health of newborns. We show that the impact of the induced increase in length-of-stay varied substantially across patients with the increase largest for vaginal deliveries and patients covered by private insurance. However, we find large changes in length of stay for Medicaid patients who were not covered by the law and for patients whose mothers experienced complications during pregnancy or labor. In all, the federal law is estimated to reduce the fraction of vaginally delivery newborns covered by private insurance by 27 to 30 percentage points privately insured c-section delivered infants by 12 to 14 percentage points.

At the same time, we witnessed reductions in the fraction of babies with 28-day readmission rates. 2SLS estimates suggest that for children whose mothers had cesarean deliveries or had complications during pregnancy or labor, an extra day in the hospital will reduce readmission rates by one percentage point which is 30 to 10 percent of sample means. In contrast, we do not find any statistically significant medical benefit for infants whose mothers had vaginal deliveries without complications.

It is worth noting that there are a number of limitations to the current study. First, we are studying only one state. To the extent that the effect of these laws differed in other states the results presented here may not generalize. Second, the length of stay for deliveries covered by Medicaid increased despite the fact that the law technically did not apply to them. We leave for future work an explanation why Medicaid followed the private market in this context although they were not required to do so. Finally, we do not have the detailed information about follow-up visits for early discharge deliveries, and thus can only speculate that the reductions in readmission rates are produced by longer stays and not the subsequent follow-up visit.

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Figure 1: %Postpartum Length of Stay of Newborns Less than 2 days
Vaginal Deliveries without Complications

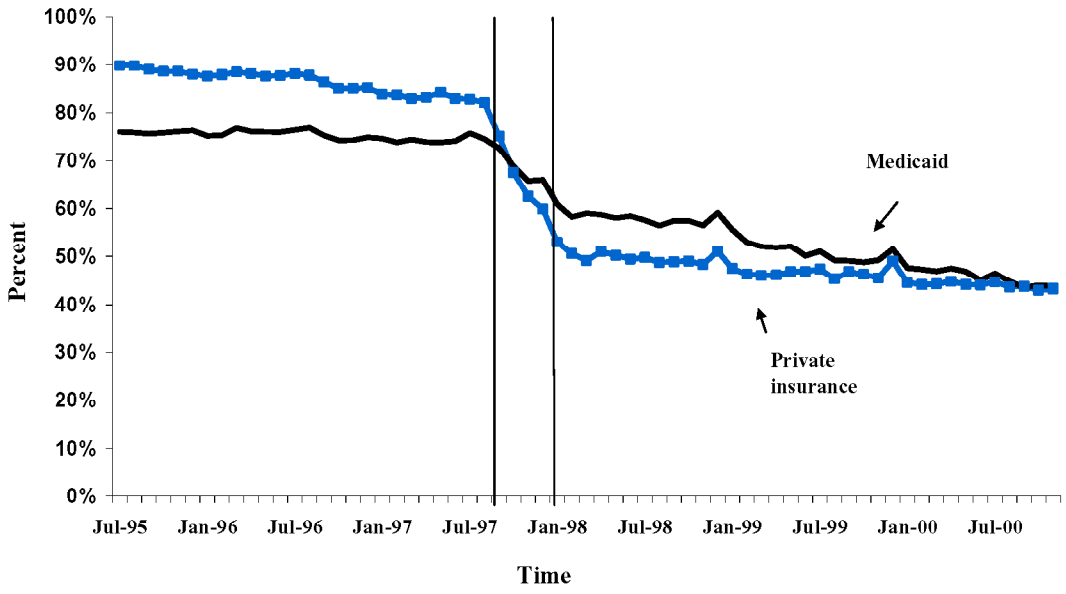


Figure 2: %Postpartum Length of Stay of Newborns Less than 4 days
C-section Deliveries without Complications

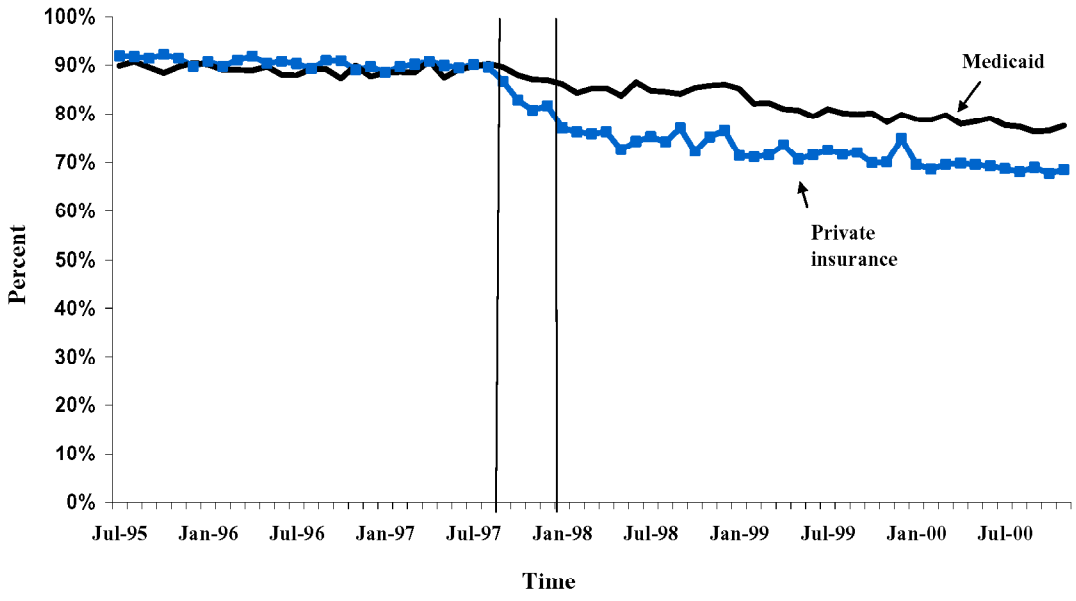


Figure 3: %Postpartum Length of Stay of Newborns Less than 2 days
Vaginal Deliveries with Complications

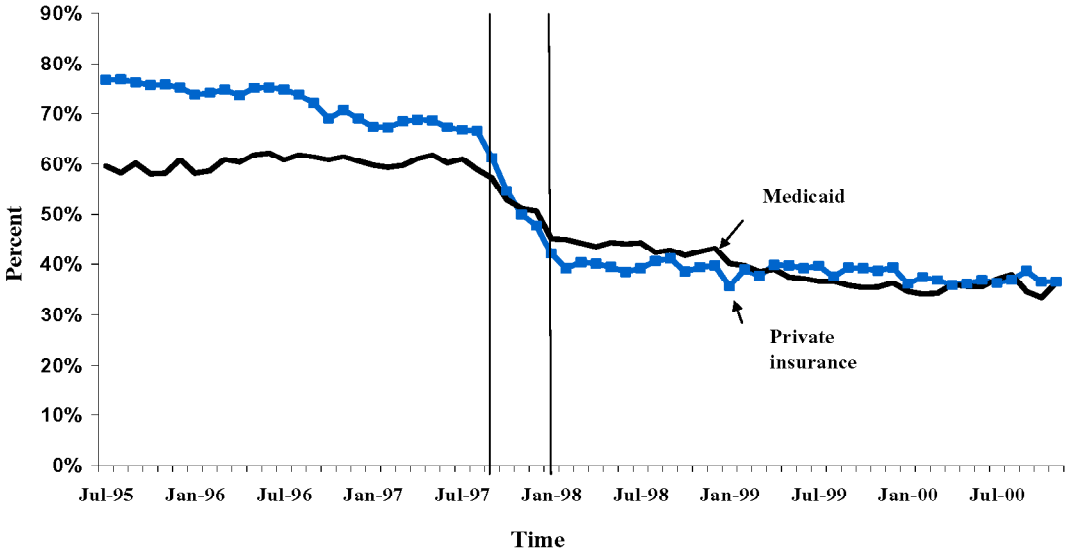


Figure 4: %Postpartum Length of Stay of Newborns Less than 4 days
C-section Deliveries with Complications

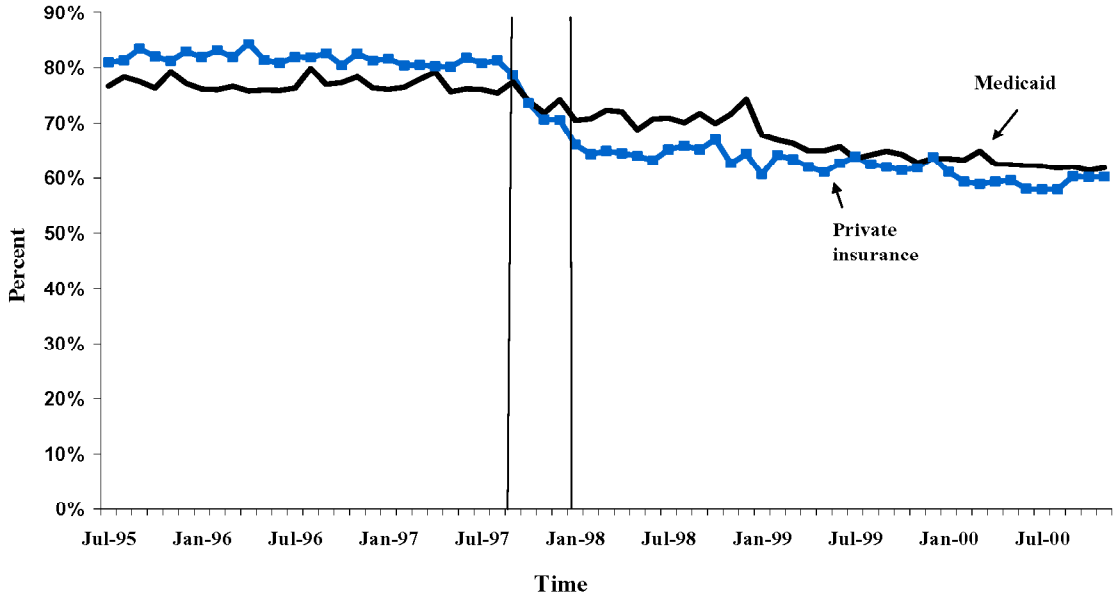


Figure 5: 28 Day Readmission Rate of Newborns
Vaginal Deliveries without Complications

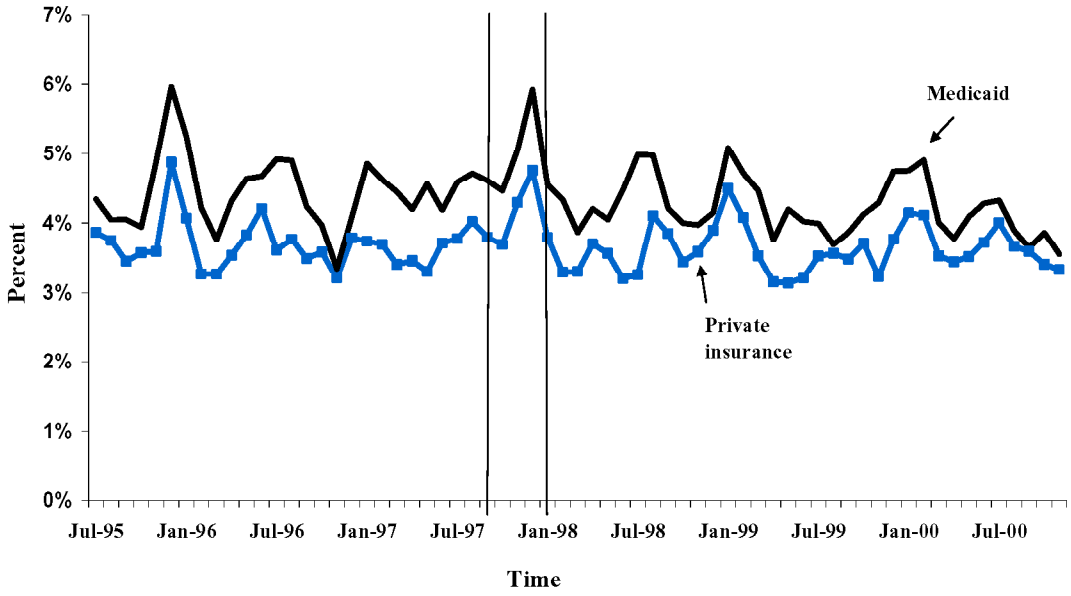


Figure 6: 28 Day Readmission Rate of Newborns
C-section Deliveries without Complications

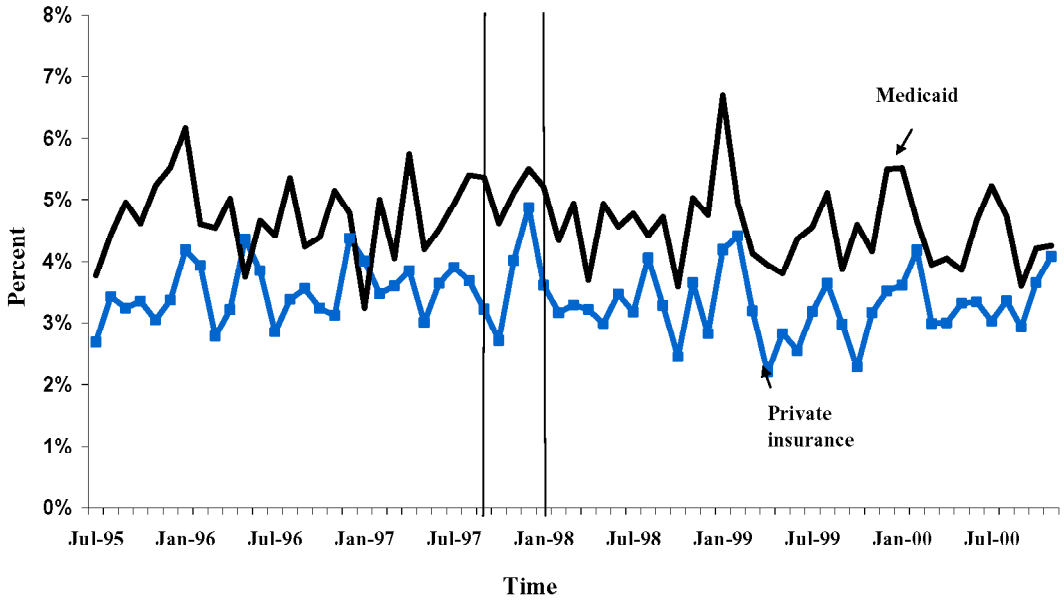


Figure 7: 28 Day Readmission Rate of Newborns
Vaginal Deliveries with Complications

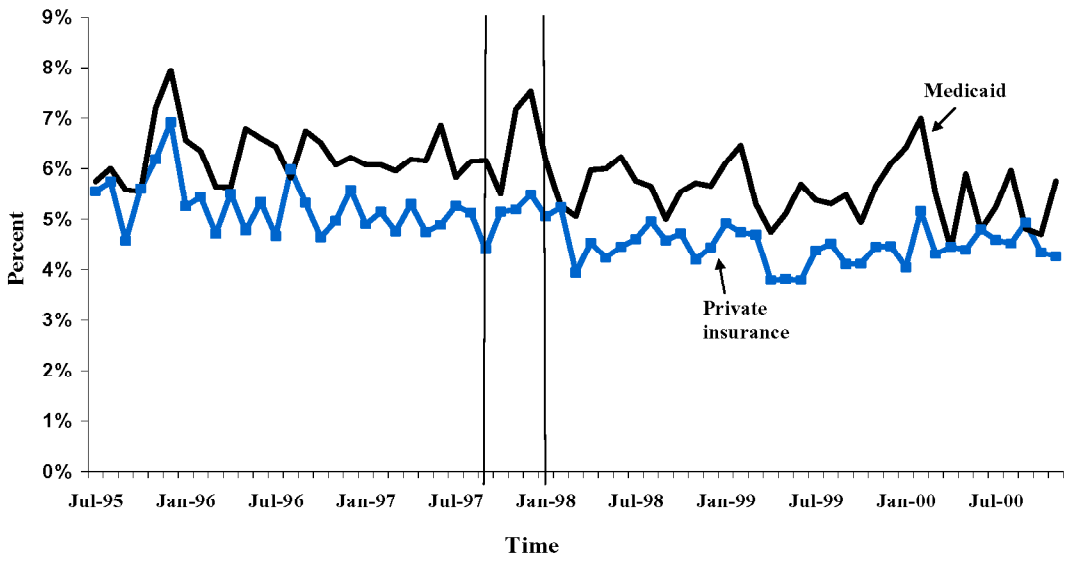


Figure 8: 28 Day Readmission Rate of Newborns
C-section Deliveries with Complications

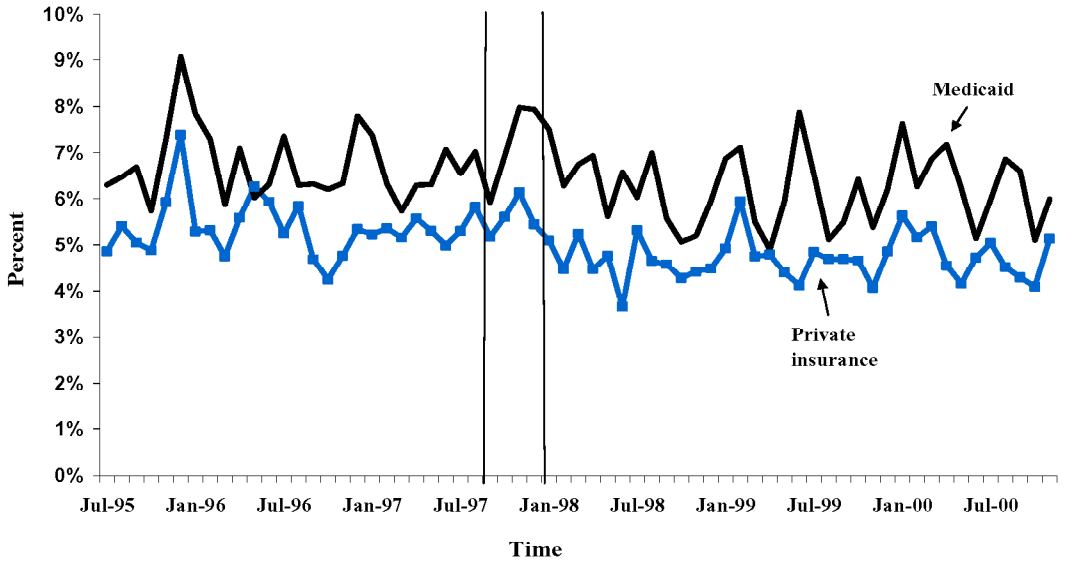


Figure 9: Newborn's 28 day Redmission Rate and 90-180 Year Old 28 days Hospital Admission Rate Normal Vaginal Deliveries and Private Insurance

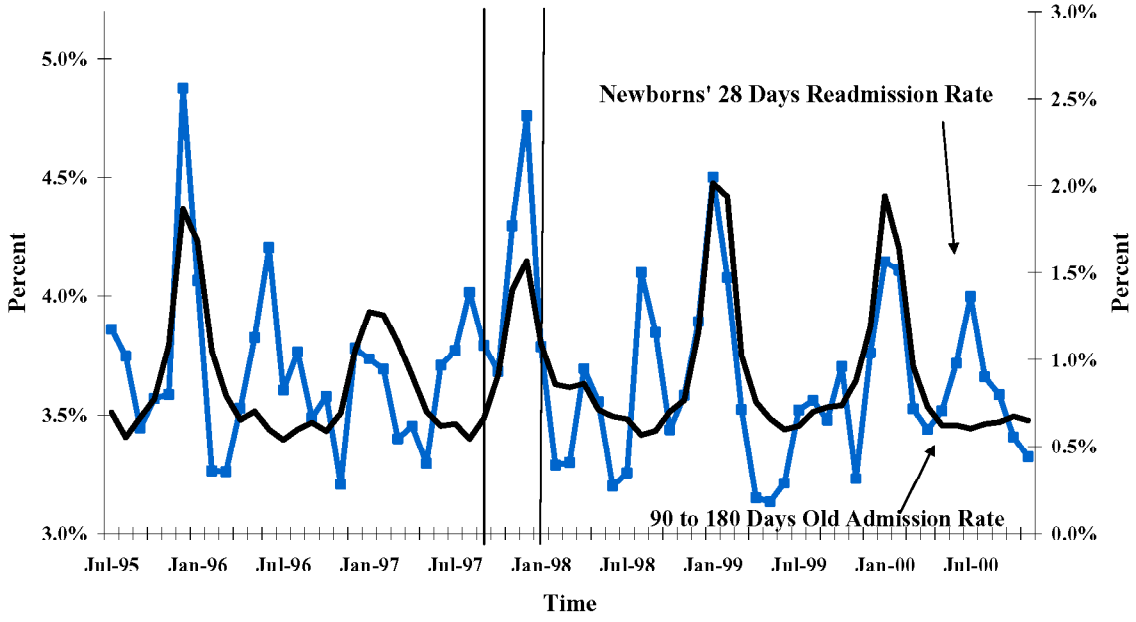


Figure 10: Newborn's 28 day Redmission Rate and 90-180 Year Old 28 days Hospital Admission Rate Normal Vaginal Deliveries and Medicaid

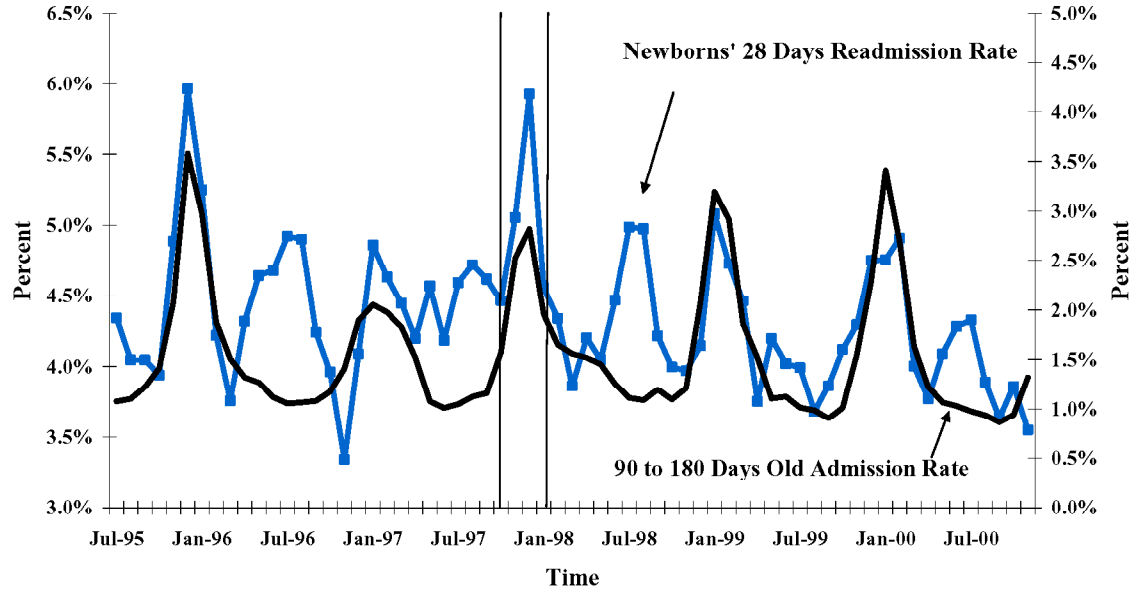


Table 1
OLS Estimates of Length of Stay and Logit Estimates of 28-Day Readmission Equations
Newborns in California Private/Medicaid Sample, 1995-1996

OLS Parameter Estimate or Marginal Effect

	Vaginal Deliveries		C-sections			Vaginal Deliveries		C-Sections	
	LOS	28-day Readmit.	LOS	28-day Readmit.		LOS	28-day Readmit.	LOS	28-day Readmit.
Covariates	(1)	(2)	(1)	(2)		(1)	(2)	(1)	(2)
Private	-0.3079	-0.0055	-0.3353	-0.00641	Married	-0.1525	0.0002	-0.2247	0.00003
Insurance	(0.0129)	(0.0003)	(0.0514)	(0.0007)		(0.0119)	(0.0003)	(0.0472)	(0.0006)
Non-profit hospital	-0.3609	-0.0002	-0.1389	0.0006	Mother ≤ 20 years	-0.4392	-0.00005	0.2129	0.0103
	(0.0157)	(0.0004)	(0.0640)	(0.0007)	of age	(0.0242)	(0.0006)	(0.0898)	(0.0014)
For-profit hospital	-0.4290	-0.0019	-0.6868	-0.0016	Mother 21-25 years	-0.3836	-0.0006	-0.2005	0.00003
	(0.0184)	(0.0005)	(0.0723)	(0.0009)	of age	(0.0211)	(0.0005)	(0.0730)	(0.0010)
Boy	0.1191	0.0056	0.0562	0.0045	Mother 26-30 years	-0.2630	-0.0007	-0.2979	-0.0023
	(0.0100)	(0.0002)	(0.0395)	(0.0005)	of age	(0.0197)	(0.0005)	(0.0651)	(0.0009)
0 complications	-3.5362	-0.0151	-7.7511	-0.0255	Mother 31-35 years	-0.1497	-0.00006	-0.1765	-0.0045
during pregnancy	(0.0814)	(0.0009)	(0.2162)	(0.0013)	of age	(0.0201)	(0.0005)	(0.0642)	(0.0010)
1 complication	-2.2407	0.0008	-4.7291	-0.0004	White, non-Hispanic	-0.1172	0.0010	-0.2165	0.0026
during pregnancy	(0.0829)	(0.0010)	(0.2213)	(0.0014)		(0.0130)	(0.0004)	(0.0513)	(0.0009)
2 complications	-1.9378	0.0026	-3.0720	0.0057	Black, non-Hispanic	0.4360	-0.0025	1.1868	-0.0026
during pregnancy	(0.0901)	(0.0014)	(0.2438)	(0.0020)		(0.0222)	(0.0008)	(0.0819)	(0.0015)
0 complications	-1.7962	-0.0087	-1.4601	-0.0089	Other race, non-	0.0068	0.0024	0.2498	-0.0003
during delivery	(0.0399)	(0.0006)	(0.0704)	(0.0009)	Hispanic	(0.0169)	(0.0006)	(0.0689)	(0.0013)
1 complication	-1.7728	-0.0037	-1.8587	-0.0053	Mother < HS	0.1261	-0.0017	-0.0899	0.0002
during delivery	(0.0496)	(0.0011)	(0.1065)	(0.0017)	education	(0.0198)	(0.0005)	(0.0759)	(0.0010)
2 complications	-1.2634	0.0009	-1.2082	0.0006	Mother HS education	0.0660	-0.0010	-0.2032	-0.0006
during delivery	(0.0428)	(0.0007)	(0.0731)	(0.0009)		(0.0175)	(0.0004)	(0.0651)	(0.0009)
No previous births	0.2152	0.0053	-0.9158	-0.0070	Mother some college	0.0448	0.0001	-0.1615	-0.0024
	(0.0185)	(0.0004)	(0.0720)	(0.0009)	education	(0.0175)	(0.0005)	(0.0643)	(0.0010)
1 previous birth	-0.0222	-0.0017	-0.8449	-0.0027	Observations	754,107	754,107	205,625	205,625
	(0.0176)	(0.0004)	(0.0700)	(0.0009)	Mean of outcome	1.6950	0.0450	4.4162	0.0535
2 previous births	-0.0757	-0.0027	0.6587	0.0007	R^2/-2 Log like.	0.0222	0.0086	0.0344	0.0169
	(0.0187)	(0.0005)	(0.0746)	(0.0010)					

Note: Standard errors in parenthesis. Other covariates include month and year dummy variables. The reference categories are Medicaid insurance, government hospital, girls, 3 or more complications during pregnancy or delivery, unmarried mothers, and mothers aged 36 or more who are Hispanic and with a college education.

Table 2
Sample Descriptive Statistics of Mothers
July 1995 – Dec 2000

	Deliveries without complications		Deliveries with complications	
	Vaginal	C-sections	Vaginal	C-sections
Mothers				
Mean age	27.72	29.25	27.60	29.03
% Less than High School	32.44%	29.65%	29.08%	26.72%
%White	81.13%	81.57%	79.34%	79.33%
%Black	6.10%	7.18%	7.24%	8.18%
%Hispanic	45.50%	45.52%	39.46%	39.54%
Mean Previous # of Births	1.05	1.21	1.05	0.96
Observations	1,359,308	238,553	504,029	326,173

Table 3
Reduced-Form Regressions, Private Insurance and Medicaid Deliveries in California,
July 1995 through December 2000

	LOS < Mandated Time	LOS in Days	28-Day Readmit.	Log Total Charges	LOS < Mandated Time	LOS in Days	28-Day Readmit.	Log Total Charges
	Vaginal deliveries without complications (1,359,308 Observations)				Vaginal deliveries with complications (504,029 Observations)			
Federal law x	-0.3088	0.3609	-0.0006	0.0875	-0.2715	0.4371	-0.0037	0.1034
Private insurance	(0.0176)	(0.0202)	(0.0012)	(0.0155)	(0.0201)	(0.0686)	(0.0033)	(0.0203)
Federal law x	-0.1079	0.1488	-0.0003	0.0219	-0.1253	0.2138	-0.0056	0.0228
Medicaid	(0.0120)	(0.0200)	(0.0013)	(0.0143)	(0.0150)	(0.0812)	(0.0026)	(0.0183)
State Law x	-0.1629	0.2164	0.0036	0.0349	-0.1602	0.2216	-0.0024	0.0289
Private Insurance	(0.0135)	(0.0180)	(0.0012)	(0.0098)	(0.0132)	(0.0596)	(0.0029)	(0.0161)
State law x	-0.0142	0.0375	0.0044	-0.0091	-0.0359	0.0084	0.0001	-0.0174
Medicaid	(0.0084)	(0.0156)	(0.0015)	(0.0121)	(0.0110)	(0.0717)	(0.0032)	(0.0175)
Mean of Y	0.8093	1.3196	0.0406	8.6168	0.6659	2.2555	0.0571	8.9355
R-squared	0.2571	0.0466	0.0035	0.3309	0.2184	0.0209	0.0089	0.2298
	C-section deliveries without complications (238,553 Observations)				C-section deliveries with complications (326,173 Observations)			
Federal law x	-0.1189	0.4305	-0.0055	0.0476	-0.1400	0.7289	-0.0061	0.0612
Private insurance	(0.0144)	(0.0755)	(0.0028)	(0.0149)	(0.0144)	(0.1311)	(0.0043)	(0.0242)
Federal law x	-0.0049	0.1356	-0.0014	-0.0118	-0.0193	0.3531	-0.0044	-0.0168
Medicaid	(0.0093)	(0.0608)	(0.0029)	(0.0153)	(0.0092)	(0.1345)	(0.0043)	(0.0165)
State Law x	-0.0492	0.2669	-0.0001	0.0237	-0.0656	0.5700	0.0014	0.0205
Private Insurance	(0.0107)	(0.0787)	(0.0029)	(0.0117)	(0.0098)	(0.1287)	(0.0037)	(0.0185)
State law x	0.0149	0.0142	0.0027	-0.0240	0.0084	0.1453	0.0024	-0.0348
Medicaid	(0.0080)	(0.0866)	(0.0031)	(0.0155)	(0.0086)	(0.1218)	(0.0040)	(0.0156)
Mean of Y	0.8983	3.2112	0.0408	9.4327	0.7955	4.6239	0.0597	9.6565
R-squared	0.1090	0.0299	0.0074	0.2785	0.1073	0.0361	0.0159	0.2064

Note: Standard errors reported in parentheses allow for arbitrary correlation in errors within a hospital over time. Sample means are for the pre-law period. Unreported covariates include fixed effects for age group, race, education and ethnicity of mother; race and education of father, sex and birth hour of newborns, 90-180 days old 28 days admission index, day of the week, month, hospital ownership, plus time trends that vary by health service area, payer, and hospitals size, and corresponding lower order interaction terms.

Table 4
Quantile Regression Results, Log(Total Charges) Equation,
Private Insurance and Medicaid Deliveries in California,
July 1995 through December 2000

	Q=0.25	Q=0.50	Q=0.75	Q=0.25	Q=0.50	Q=0.75
	Vaginal Deliveries without Complications (1,215,666 observations)			Vaginal Deliveries with Complications (410,824 observations)		
Federal Law* Private Insurance	0.0957 (0.0017)	0.0921 (0.0017)	0.0816 (0.0022)	0.1134 (0.0036)	0.1073 (0.0039)	0.0821 (0.0056)
Federal Law* Medicaid	0.0425 (0.0017)	0.0461 (0.0017)	0.0508 (0.0022)	0.0556 (0.0037)	0.0515 (0.0040)	0.0476 (0.0056)
State Law* Private Insurance	0.0218 (0.0023)	0.0291 (0.0023)	0.0377 (0.0029)	0.0345 (0.0048)	0.0410 (0.0052)	0.0221 (0.0074)
State Law* Medicaid	-0.0118 (0.0022)	-0.0012 (0.0022)	0.0077 (0.0029)	-0.0165 (0.0047)	-0.0080 (0.0052)	0.0068 (0.0073)
Pseudo R^2	0.2361	0.2395	0.2308	0.1977	0.1803	0.1457
	Cesarean Deliveries without Complications (223,098 observations)			Cesarean Deliveries with Complications (285,001 observations)		
Federal Law* Private Insurance	0.0499 (0.0036)	0.0420 (0.0033)	0.0212 (0.0049)	0.0524 (0.0034)	0.0426 (0.0041)	0.0371 (0.0074)
Federal Law* Medicaid	0.0140 (0.0036)	0.0149 (0.0034)	0.0108 (0.0050)	0.0095 (0.0035)	0.0140 (0.0042)	0.0044 (0.0076)
State Law* Private Insurance	0.0083 (0.0047)	0.0080 (0.0044)	0.0046 (0.0066)	0.0045 (0.0044)	0.00001 (0.0053)	-0.0015 (0.0096)
State Law* Medicaid	-0.0309 (0.0048)	-0.0178 (0.0045)	-0.0122 (0.0068)	-0.0205 (0.0047)	-0.0219 (0.0057)	-0.0417 (0.0103)
Pseudo R^2	0.2165	0.2288	0.2171	0.1783	0.1618	0.1327

Note: Standard errors are reported in parentheses. Unreported covariates include fixed effects for age group, race, education and ethnicity of mother; race and education of father, sex and birth hour of newborns, 90-180 days old 28 days admission index, day of the week, month, hospital ownership, plus time trends that vary by health service area, payer, and hospitals size.

Table 5
Reduced-Form Regressions Logistic Regressions of Infant Readmission and Mortality Models, California Privately Insured and Medicaid Patients, July 1995 through December 2000

	7-day readmission	14-day readmission	28-day readmission	28-day mortality	7-day readmission	14-day readmission	28-day readmission	28-day mortality
	Vaginal deliveries without complications (1,359,308 Observations)				Vaginal deliveries with complications (504,029 Observations)			
Federal law x	-0.0006	-0.0003	-0.0006	0.00007	-0.0026	-0.0029	-0.0037	-0.0007
Private insurance	(0.0010)	(0.0011)	(0.0013)	(0.0001)	(0.0030)	(0.0031)	(0.0034)	(0.0004)
Federal law x	0.0010	0.0005	-0.00005	-0.000006	-0.0030	-0.0032	-0.0047	0.0004
Medicaid	(0.0011)	(0.0011)	(0.0012)	(0.0001)	(0.0024)	(0.0023)	(0.0023)	(0.0004)
State Law x	0.0018	0.0028	0.0042	0.0002	-0.0031	-0.0024	-0.0012	0.0001
Private Insurance	(0.0009)	(0.0010)	(0.0011)	(0.0001)	(0.0024)	(0.0026)	(0.0028)	(0.0004)
State law x	0.0022	0.0026	0.0041	0.0002	-0.0036	-0.0017	0.0007	0.0003
Medicaid	(0.0011)	(0.0012)	(0.0013)	(0.0001)	(0.0024)	(0.0024)	(0.0026)	(0.0004)
Mean of Y	0.0237	0.0299	0.0406	0.0006	0.0385	0.0452	0.0571	0.0020
	C-section deliveries without complications (238,553 Observations)				C-section deliveries with complications (326,173 Observations)			
Federal law x	-0.0045	-0.0052	-0.0057	-0.0003	-0.0039	-0.0044	-0.0060	0.0003
Private insurance	(0.0026)	(0.0029)	(0.0032)	(0.0005)	(0.0042)	(0.0043)	(0.0044)	(0.0007)
Federal law x	-0.0009	-0.0008	-0.0009	-0.0004	-0.0008	-0.0006	-0.0032	0.0003
Medicaid	(0.0024)	(0.0025)	(0.0026)	(0.0006)	(0.0032)	(0.0034)	(0.0037)	(0.0008)
State Law x	-0.0016	-0.0015	0.0012	-0.0008	0.0011	0.0028	0.0032	0.0003
Private Insurance	(0.0027)	(0.0030)	(0.0031)	(0.0008)	(0.0028)	(0.0030)	(0.0034)	(0.0008)
State law x	0.0022	0.0045	0.0030	0.0004	0.0028	0.0033	0.0033	-0.0004
Medicaid	(0.0021)	(0.0023)	(0.0025)	(0.0006)	(0.0030)	(0.0031)	(0.0032)	(0.0008)
Mean of Y	0.0235	0.0295	0.0408	0.0019	0.0415	0.0477	0.0597	0.0044

Note: Standard errors reported in parentheses allow for arbitrary correlation in errors within a hospital over time.. Sample means are for the pre-law period. Unreported covariates include fixed effects for age group, race, education and ethnicity of mother; race and education of father, sex and birth hour of newborns, 90-180 days old 28 days admission index, day of the week, month, hospital ownership, plus time trends that vary by health service area, payer, and hospitals size, and corresponding lower order interaction terms.

Table 6
2SLS Estimates of 28-Day Readmission Equation,
Private Insurance and Medicaid Deliveries in California,
July 1995 through December 2000

Covariate	Deliveries without complications		Deliveries with complications	
	Vaginal	C-sections	Vaginal	C-sections
	OLS estimates, 28-Day Readmission as dependent variable			
LOS	-0.0013	-0.0022	-0.0012	-0.0017
	(0.0002)	(0.0003)	(0.0001)	(0.0002)
Observations	1,359,150	238,437	503,795	325,811
	2SLS Estimates, 28-Day Readmission as dependent variable (Using Federal Law*Private Insurance, Federal Law*Medicaid, State Law*Private Insurance and State Law*Medicaid as instruments)			
LOS	-0.0009	-0.0121	-0.0114	-0.0071
	(0.0031)	(0.0063)	(0.0068)	(0.0050)
	[0.764]	[0.054]	[0.093]	[0.158]
Observations	1,359,150	238,437	503,795	325,811
P-value on test of Overid. restrictions	0.0000	0.6686	0.5320	0.1038
	2SLS Estimates, 28-Day Readmission as dependent variable (Deleting data for 9/1997 through 12/1997 and using Federal Law*Private Insurance, Federal Law*Medicaid as instruments)			
LOS	-0.0015	-0.0126	-0.0108	-0.0087
	(0.0033)	(0.0064)	(0.0069)	(0.0051)
	[0.647]	[0.05]	[0.115]	[0.086]
Observations	1,275,833	224,769	472,971	306,444
P-value on test of Overid. restrictions	1	0.9995	0.3633	0.9509

Note: Standard errors reported in parentheses allow for arbitrary correlation in errors within a hospital over time. Unreported covariates include fixed effects for age group, race, education and ethnicity of mother; race and education of father, sex and birth hour of newborns, 90-180 days old 28 days admission index, day of the week, month, hospital ownership, hospitals size, plus time trends that vary by health service area and payer, and the corresponding lower order interaction terms.