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Diurnal Variation in Rates of Primary Emergent Cesarean Delivery: Physician Convenience, Hospital Setting and Abnormal Labor

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Diurnal Variation in Rates of Primary Emergent Cesarean Delivery: Physician Convenience, Hospital Setting, and Abnormal Labor

Loren Curtis Rauch

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Chapter One

Introduction and Summary

Physicians have unusual dual roles in the health care market, both providing health care services *and* setting the demand for their services. These dual, perhaps contradictory roles are acceptable if doctors provide medical care uniformly, rationally, and appropriately for only clearly identifiable medical needs. Unfortunately, health care practice patterns differ widely and vary by non-clinical factors. These variations waste health care dollars and cause iatrogenic disease (1). Medical practice variations associated with health care setting, and the possible mechanisms behind these variations, are of particular interest.

The purpose of this thesis is to investigate the effects of hospital organization and physician availability upon daily variations in hourly cesarean delivery rates. Cesarean section is an important and controversial example of medical practice variation, representing 4.5% of all hospital surgeries (2). Suggestive of inappropriate medical practices, rates of cesarean deliveries vary by many non-clinical factors, such as payment, maternal socioeconomic status, and hospital organizational factors such as ownership and teaching status (3-12). Especially provocative are suggestions that physician convenience influences medical decision making.

Ultimately, the individual physician decides whether to perform a cesarean delivery. Non-clinical variations give insight into influences on these physician decisions, and suggest possible interventions to modify physician practices. Specific assessments about the relative importance and roles of doctors, patients, and hospitals determine the most appropriate

interventions. Therefore, a better understanding of clinical decision making and the modifying effects of hospital organization will determine the most effective reforms.

Research Model

This thesis examines diurnal variations in rates of primary, emergent cesarean delivery in nulliparous women. Many of the factors causing daily variations in emergent cesarean delivery rates are relatively consistent between hospitals. Therefore, most of the differences in variations associated with hospital type should be due to physician behavior. This thesis explores a three-part model for medical decision making. First, the availability of the necessary resources influences clinical decisions. Second, hospital organization modifies the physician's response to non-clinical factors. Third, some medical situations are intrinsically more prone to medical practice variations.

(1) Clinical decisions, such as delivery by cesarean section, are a complex negotiation between perceived clinical need and the availability of necessary resources. This thesis assumes that the demand and availability of resources for cesarean delivery are not constant during the twenty-four hours of a day. This variation in demand and availability produces daily variations in rates of cesarean section. For example, patients at private and non-teaching hospitals are usually attended by private practice physicians, who generally follow each labor until delivery. These physicians have a convenience incentive at certain times to use or avoid cesarean delivery because of competing demands on their time.

(2) The hospital setting modifies the physician's response in two ways. First, the hospital's ownership and obstetrical teaching status will determine

the relative magnitudes of potential non-clinical influences such as financial reimbursement or schedule conflicts. For example, financial reimbursement levels do not affect directly the salaried resident and staff physicians at teaching and Kaiser hospitals, in contrast to private practice physicians. Also, private practice physicians commonly have possibly conflicting clinic appointments on weekdays, while staff and resident physician schedules try to avoid conflicts between office visits and attending deliveries. Second, the hospital type affects the ensuing sensitivity of the physician to these influences. Teaching and Kaiser hospitals subject physicians to more clinical review and oversight. By expecting physicians to justify every cesarean delivery, these institutional settings may make physicians less responsive to non-clinical incentives to deliver by cesarean.

(3) Some medical situations are more prone to medical practice variations due to more physician discretion and less clinical acuity. A continuum of labors of increasing clinical complexity exists between the clearly uncomplicated vaginal delivery and essential cesarean delivery. Practice variations are most likely to occur in the central, grayer zone. Thus, cesarean delivery for the relatively non-acute and discretionary diagnosis of abnormal labor should be more responsive to non-clinical influences than other more specific and acute diagnoses.

Summary of Thesis

Chapter Two of this thesis reviews relevant past research on cesarean delivery. Cesarean section, especially for the indication of abnormal labor, is an important example of medical practice variation. The high rates of cesarean delivery have resisted past policy efforts aimed at their control. The non-clinical patient, physician, and hospital factors associated with cesarean

delivery give insight into the influences on physician decision making, and suggest possible ways to curb the high rates of cesarean delivery.

Chapter Three reviews the supply and demand model for diurnal variations in cesarean delivery rates. Daily variations in rates of cesarean section occur because the demand and availability of resources for cesarean delivery are not constant during the day. Three important comparisons help to examine the specific effects of hospital setting and physician availability upon daily variations in cesarean delivery rates: private hospitals with Kaiser hospitals, hospitals having obstetrical residency programs with those without such programs, and weekday with weekend rates. This thesis will explore ten hypotheses of decision making derived from this model.

Chapter Four presents a methodology for investigating the effects of hospital setting and physician availability on daily variations in cesarean section rates. This analysis uses data from the 195,832 California singleton births in 1988 to nulliparous women delivering vaginally or by emergent cesarean in non-federal hospitals. The chapter also discusses the variables and statistical methods employed to examine the thesis' hypotheses.

The results reviewed in Chapter Five show a strong effect of physician availability on hourly cesarean section rates. Kaiser hospitals and teaching hospitals have lower rates, smaller weekend decrements, and less diurnal variations than other hospital types. Private hospitals had the highest overall rates, largest weekend decrements, and most diurnal variation. The rates at all hospitals are lowest in the early morning hours and highest in the evening. All hospital rates are also lower and have less variation on weekends. In all hospital types, physician convenience influenced the timing of emergent primary cesarean deliveries. The proportion of cesareans

performed for cephalopelvic disproportion follows a similar pattern, but fails to show greater variation.

Chapter Six discusses the implications of these findings. Despite several data and research design limitations, this study largely validates the ten hypotheses presented in Chapter Three. Other authors have looked for physician convenience in high evening rates of cesarean delivery for non-specific or non-acute conditions--yet failed to demonstrate any clear effects by physician convenience (13-15). This study demonstrates that the availability of physicians and resources has a significant influence on the timing of cesarean delivery. On weekdays, private practice physicians time their emergent cesarean deliveries to avoid conflicts with scheduled clinic appointments and to expedite evening deliveries. Kaiser physicians time their emergent cesarean deliveries to avoid conflicts such as noontime meetings and lunch, as well as nursing and physician shift changes. The rate of emergent cesarean delivery increases during times of many elective cesarean deliveries, demonstrating physician convenience is more important than competition for hospital resources in timing emergent deliveries.

This study demonstrates also that the hospital setting in which physicians practice modifies their response to such non-clinical factors. Factors common to both Kaiser and teaching hospitals (such as peer review, oversight, and scheduled work hours) serve to lower rates, decrease diurnal variations, and make physicians less responsive to convenience incentives. The research has several implications for health care policy and future research. First, interventions need to address the role of physician convenience in cesarean delivery by avoiding daytime schedule conflicts and by night coverage. Second, hospital staff scheduling patterns that foster diurnal variations in rates of cesarean delivery need to be elucidated and

modified. Third, the accountability mechanisms found in Kaiser and teaching hospitals decrease the elasticity of physicians to non-clinical convenience incentives. Finally, further research is needed into the nature and consequence of diurnal variations in rates of cesarean delivery.

Chapter Two

Abnormal Labor and Cesarean Childbirth

Overview

This chapter reviews relevant past research on cesarean section and abnormal labor. Cesarean delivery is an important and controversial example of medical practice variation because of its frequency and associated costs. Dystocia, the non-specific and non-acute diagnosis of abnormal labor, is a particularly important indication for cesarean delivery because its diagnosis and treatment are highly dependent upon clinical judgment. The possible clinical justifications for the increasing rates of dystocia and cesarean section for dystocia fail to account for the increases in rates. Instead, significant variations in cesarean section rates associated with non-clinical factors suggest inappropriate practice patterns and give clues to possible interventions. Such interventions have implicit assumptions about the role and importance of patients, doctors, and hospitals in medical practice decisions. To improve these interventions, analysts must understand, first, to what factors the physician-decision maker responds; second, how the health care setting modifies these responses; and, third, what indications for cesarean section are most subject to medical practice variation.

Cesarean Section and Dystocia

Cesarean section, the delivery of the fetus through an incision rather than through the birth canal, has been used since the days of the Roman empire (20). Physicians now perform cesarean deliveries to avoid a dangerous vaginal delivery that may compromise the fetus or mother.

However, only with 20th Century surgical advances (asepsis, anesthesia and surgical technique) and the development of antimicrobial therapies, has maternal survival been expected following a cesarean section (20,21). With its increasing safety, cesarean delivery is used for an increasing proportion of births.

This dramatic increase in cesarean section rates in the United States has raised concerns. Cesarean section rates in the United States have increased from 5.5% in 1970 to 24.7% in 1988. This is an increase of over 400% in 18 years (22-24). Cesarean section is now the most frequent surgical procedure performed in US hospitals, representing 4.5% of all hospital surgeries (2). Widespread consensus exists that this rate is excessive (19,21). Recently, the rates of cesarean delivery have started to decline (25).

The global cesarean section rate is a composite of several different indications. The major diagnoses for cesarean deliveries are repeat cesarean section (35%), dystocia (28%), fetal distress (10%), and breech presentation (10%) (33). Repeat cesareans are cesarean deliveries in women who have previously had a cesarean section. Thus, for the first or primary cesarean delivery, dystocia is the most common of these indications (21). *Dystocia* is defined as abnormal labor, derived from the Greek roots *dys* meaning "bad" and *tokos* meaning "birth". Causes of this pathological or difficult labor include an obstruction or constriction of the birth passage; an abnormal size, shape, or condition of the fetus; or abnormal uterine contractions. The diagnosis of dystocia serves as an indication for cesarean delivery by either preventing abdominal delivery or by threatening to compromise fetal or maternal health unless abdominal delivery is performed (21,52).

Dystocia comprises four diagnostic sub-categories: disproportion, obstructed labor, abnormal labor, and prolonged labor. *Disproportion* refers

to a situation where the size of the maternal pelvis is insufficient to accommodate the fetal head. *Obstructed labor* is arrested descent of the fetus in the birth canal. *Prolonged labor* refers to any situation with protracted, but not necessarily arrested, labor. *Abnormal labor* refers to functional problems with uterine contraction that delay descent. The most commonly reported of these are disproportion and prolonged labor (62).

The diagnosis and treatment of dystocia are problematic for three reasons. First, the cause of dystocia is not always known. Second, these conditions are interrelated, often overlapping, and difficult to separate. Third, there are many therapeutic responses besides cesarean delivery once dystocia is diagnosed.

Rate of dystocia. Of women without previous cesarean, about one-sixth deliver by cesarean. Dystocia accounts for 28% of these deliveries. About 60% of women with a principle diagnosis of dystocia deliver by cesarean (33,51,62). The 1981 National Institutes of Health (NIH) Consensus Development Task Force on Cesarean Childbirth incorrectly notes that the major contributor to increasing cesarean delivery rates is the diagnosis of dystocia. Over a wide range of time periods and locations, studies show that most of the increase has been due to repeat cesarean (26,33,53). Studies find that only 10% to 30% of the past decade's increase in cesareans is due to increases in cesarean section for dystocia (53,55,56). This increase in cesarean section for dystocia seems to be due to an increased *diagnosis* of dystocia rather than an increased rate of cesarean once dystocia is diagnosed (55).

However, while repeat cesarean section has been the largest contributor to the increase historically, clear recommendations are now being implemented (19). Thus, much of the recent decline in cesarean section rates has resulted from increasing vaginal birth after cesarean (25). In contrast,

dystocia remains inadequately characterized and addressed; while initially a smaller contributor to the overall rate increase, dystocia may prove more intractable in the future. For example, Anderson and Lomas (26) identified the diagnosis and management of dystocia and fetal distress as the two key factors that continue to "exert an upward pressure" on cesarean section rates in Ontario from 1986 to 1988.

Medical Practice Variation

Physicians have unusual dual roles in the health care market, both providing health care services *and* setting the demand for their services. Services prescribed by physicians represent as much as 80% of medical care expenditures (1). Doctors decide when to admit patients to a hospital, discharge them, use a diagnostic test, perform surgery, prescribe medications, or perform an emergent cesarean delivery. Until recently, the public has accepted physicians performing these dual, perhaps contradictory roles because they assumed that medical care provided by doctors was always rational and appropriate.

Beginning in the 1970s, however, researchers noted tremendous variations in physician decisions, first discovering the "small area variations" between geographical regions (27-29). For example, one national study found that 67 of 123 procedures examined varied more than three-fold when comparing high and low rate areas (30). Such medical practice variations have proven ubiquitous in medicine. Furthermore, medical practice variations are associated with many *non-clinical* factors, dispelling the notion that medical care is uniformly and rationally prescribed for only clearly identifiable medical needs. Research has found few adverse outcomes in the low use areas that would suggest under-treatment. Therefore, much of this

variation in medical care appears to be for inappropriately prescribed "excessive" care (1). The broader significance of this widespread medical practice variation is that health care decisions are not always rational. These variations waste health care resources and cause iatrogenic disease. As a result, there is a growing effort to control this epidemic of "excess" medical care.

Cesarean section. As the most common hospital surgical procedure in the United States, cesarean section is an important example of medical practice variation (2). Variations in rates of cesarean deliveries have been associated with non-clinical factors such as hospital ownership and teaching status, physician specialization, the race and income of patients, and the amount of medical reimbursement (3-12). Cesarean section is important to examine because of the medical, social, and economic controversy that surrounds it. Also, cesarean delivery is a useful model for studying physician decision making because it is a frequent, discrete and well-characterized episode for which data is readily available. Understanding how physicians decide whether to deliver by cesarean section can elucidate general principles of clinical decision making.

Why are the high rates and non-clinical variation of cesarean section of concern? Criticisms for the dramatic rise in cesarean deliveries have been from several different perspectives. First, a small but significant increase in *maternal mortality* has been associated with cesarean surgery, including anesthesia mishaps, pulmonary embolism, infection, and hemorrhage (21,31,41,81). Second, cesarean childbirth causes increased *maternal morbidity*, such as infection, fever and hemorrhage (ibid.). Hospitalization following a cesarean delivery is prolonged an average of 2.3 days (63), and convalescence after hospitalization is also prolonged (21). Third, these high

rates are *not justifiable clinically* since they do not result in better perinatal outcomes either over time or between health centers (34). Fourth, cesarean delivery can have *adverse psycho-social impacts* (82,83). Fifth, the physician and hospital costs of a cesarean delivery are approximately $5300, versus $2900 for a vaginal birth (64,65). Therefore, this excessive rate of cesarean section causes higher costs and iatrogenic disease without clear clinical benefit.

Numerous researchers have specifically criticized the increasing diagnosis of abnormal labor and subsequent use of cesarean delivery (21,36,37). Because of the dearth of clear clinical evidence, indications, or guidelines, the diagnosis of dystocia is relatively non-specific, subjective, and inclusive (as compared with the diagnosis of breech presentation, for example). Some researchers have charged it is a convenient *post hoc* diagnosis for cesareans performed for uncertain or clinically marginal reasons (21,38,39,53). For these reasons, dystocia may be a more sensitive example of medical practice variation than other primary cesarean indications. Therefore, abnormal labor needs examination because, first, it is the most common indication for primary cesarean deliveries; second, its diagnosis leaves the greatest room for clinical discretion and variation; and, third, it has been more resistant than other indications to recent efforts to control high rates of cesarean delivery.

Diagnosing Abnormal Labor

Dystocia or abnormal labor is defined in reference to normal labor. Normal birth is separated into the latent phase, when the cervix effaces and dilates to four centimeters, and the active phase of labor, which is divided into three stages. The first stage of the active phase of labor lasts until the cervix dilates completely. The second stage is the delivery of the fetus, and

the third stage is the delivery of the placenta. Using the schema proposed by Pauerstein (32), the latent phase begins once the cervix is effaced completely, bloody mucus is passed, or rupture of membranes occurs. The labor is in the active phase once the cervix dilates to four centimeters. This lasts until the cervix dilates completely. In contrast to its slower and more variable dilation during the active phase, the cervix is expected to dilate during active phase at least 1.2 centimeters per hour for nulliparas and 1.5 centimeters per hour for multiparas (40). Primary dysfunctional labor or protracted active phase may be diagnosed if the cervix dilates slower. If during active phase no change in the cervix occurs for 2 hours, secondary arrest of cervical dilation may be diagnosed.

The second stage of labor begins after complete dilation of the cervix. During this stage, if the descent of the fetus is slower than expected, then protracted descent is diagnosed. If the fetus does not descend for one hour, then descent is arrested. Also, one of these delays in delivery may be diagnosed as some form of uterine inertia. (32)

As diagnosis of dystocia secondary to prolonged labor or to abnormal forces of labor is labor-stage dependent, incorrect categorization of the stage of labor can lead to incorrect diagnoses of abnormal labor. Also, not only are such schemata difficult to apply clinically but also there is significant non-pathologic variation in labor and delivery. Furthermore, what is considered normal or pathologic labor depends upon the woman's parity and other obstetrical history. Therefore, the diagnosis of dystocia remains largely dependent upon the physician's subjective clinical judgments. In making these clinical judgments, the physician must consider other factors relating to the birth, such as the conditions of the fetus and mother, and the progress of the labor.

Non-acute and non-specific. Some indications for emergent cesarean delivery are more acute and specific than others. The need for cesarean delivery is unequivocal for clearly pathological conditions during labor. Acute medical emergencies, such as extreme fetal distress, require prompt surgical intervention. Often this is not true. Other possible indications for cesarean delivery such as dystocia are less acute, with multiple possible clinical responses: rest, hydration, ambulating, sedation, oxytocin, or cesarean.

Therefore, the delivery process exists on a continuum from the very clearly pathological needing immediate cesarean delivery to the completely normal and uneventful vaginal birth. The side of the spectrum with increased difficulties also includes more acute conditions and more specific diagnoses. The side of the spectrum with fewer clinical difficulties encompasses the less acute conditions and less specific diagnoses such as abnormal labor.

Even once the physician recognizes labor delays or abnormalities, multiple responses are possible. Choosing a response is a clinical judgment that depends upon the conditions of the birth and the practice patterns of the physician. There are no generally accepted guidelines for abnormal labor to aid the physician in deciding where along this clinical spectrum to draw the line between performing a cesarean delivery and attempting vaginal delivery. Furthermore, consistent implementation of guidelines is difficult because subjective clinical interpretations and judgments are necessary. So, for dystocia clear clinical guidelines are difficult both to develop *and* to apply.

Thus, the decision to perform a cesarean in the center, grayer region of this clinical spectrum is difficult, is highly dependent upon clinical judgment, and varies between physicians and different deliveries. Therefore, the effects of other factors such as non-clinical variables should be greater in this region;

cesarean deliveries with the diagnosis of abnormal labor will then have a more elastic response than cesarean delivery for other more acute or specific diagnoses.

Dystocia is also a non-specific diagnosis. Some diagnoses, like the various types of breech birth, are clear clinical diagnoses based upon the orientation and position of the fetus in the uterus. Different clinicians will have relatively consistent diagnoses of these conditions. In contrast, dystocia is a non-specific diagnosis that depends upon a clinical judgment of normal and abnormal labor. For example, different physicians may disagree about which labors are delayed.

Why the Increase in Cesarean Section?

Central to controlling the high rate of cesarean delivery is understanding its roots. Unfortunately, studies of cesarean section uncover a plethora of possible causes for the high rates--making analyses complex and interventions difficult. Reasons for the high rates of cesarean delivery are either clinical or non-clinical. Possible clinical (and therefore medically justifiable) reasons for the increase in rates are population-wide increases in clinical indications and new, medically indicated changes in labor management. Alternatively, if the increases cannot be explained by these factors, then they may be due to non-clinical factors that would suggest excessive rates and inappropriate patterns of practice. Such non-clinical reasons for the increase are medically unjustifiable.

Medical benefit. Some researchers suggest an increased emphasis on the fetal outcome (versus maternal outcome) has helped to drive the increase in rates of cesarean delivery (20,21). This changing emphasis may arise from the decreasing maternal risk associated with cesarean delivery (41), the

changing fertility patterns towards fewer children, and the cultural attitudes that emphasize increasingly perfect perinatal outcomes (42). If these changes are significant, then the increase in cesarean section rates is of medically benefit. However, there is no good evidence that the increasing proportion of cesarean deliveries has improved fetal outcomes. One retrospective study by Roemer et al. (43) found an association between prolonged labor and lower IQ scores. However, this study has significant flaws, including not controlling for medical complications, birth order, and the practice of routine repeat cesarean deliveries. Other studies fail to find any relationship between trials of labor or prolonged labors and adverse fetal outcomes (20,21,44).

Increase in indications. An increase in the clinical risk factors and other indications for cesarean delivery have increased the rates of cesarean delivery for dystocia. For example, increasing maternal age and decreasing parity have made small contributions to increasing rates of cesarean delivery (45), as has increasing fetal birth weight (46). However, despite small increases due to such population wide increases in medical indications, the 1981 NIH report notes that most cesarean deliveries are for non-macrosomic infants in vertex (head-down) presentation (21). Other studies also fail to find clinical justification for the high rates (34,36).

Management of labor. Thus, neither medical benefit nor an increase in medical indications completely explains the increased rate. Therefore, either the management of labor and/or non-clinical factors must also explain the high rate. New management of labor may lead to higher rates of cesarean delivery. The new management may include new techniques of labor management predisposing to dystocia, increased use of cesarean delivery in difficult clinical situations, or an over-diagnosis of dystocia. The increase in new techniques such as fetal monitoring (41,47), epidural analgesia (48), and

oxytocin (49) is implicated in the increase in cesarean delivery rates. For example, sophisticated technologies have increased the diagnosis of fetal distress and compromise, yet this improved sensitivity also results in decreased specificity. This results in more false-positives and more cesarean deliveries for dystocia (41). Sheehan (36), in contrast to Rosen et al. (49), found an inverse correlation between oxytocin use and cesarean delivery.

Since 1960s, obstetricians have increasingly managed childbirth; this "medicalization" and specialization of childbirth may have led to an increasingly interventionist mode of practice (50). Obstetrical residency training is de-emphasizing complex non-surgical maneuvers for difficult vaginal births. As a result a smaller proportion of obstetrician has adequate training in these (20,21). In recent decades, obstetricians have used cesarean delivery in situations when some type of extraction, version or forceps delivery might have been attempted previously. Obstetrical forceps have fallen out of favor because decreased training, the litigious medical environment, and the recognition of potential fetal risks involved, leaving cesarean section as the remaining option (41,51). Furthermore, declining obstetrical workloads in 1980s may have provided additional incentive for more liberal cesarean section use (2,22,23). Better, more aggressive management of dystocia may safely result in a large decrease in cesarean delivery rates (20,21,36).

Another reason for the increasing rates may be an over-diagnosis of dystocia. This is consistent with the findings by Gould et al. (3) and Stafford (4,12) that the increase in cesarean delivery for dystocia has been associated with an increase in diagnosis rather than the rate of cesarean given the diagnosis. The 1981 National Institute of Health Consensus Development Task Force recommended a reexamination of the diagnostic category for

dystocia because of increased cesarean delivery rates for dystocia without any demonstrable survival advantage. Also the Task Force suggested that the diagnosis of dystocia may be expanding to include less severe clinical conditions (21,53). For example, many authors stress the importance of confirming the diagnosis of active labor, so that the diagnosis of "failure to progress" not premature (20,21). The high rate may therefore partially result from confusion about guidelines and diagnosis of dystocia.

"Supra-Clinical" Reasons

Significant variations in cesarean section rates are associated with non-clinical factors such as patient, physician, and hospital characteristics. Statistical association is not equivalent to causality; Epidemiological criteria suggestive of a causal relationship are the strength and consistency of effect, whether a dose response relationship exists, and the plausibility of the effect. The consistent and dose-response effects of maternal socioeconomic status (SES), physician specialization and reimbursement, hospital size and ownership, and residency teaching status, strongly point to inappropriate utilization. These non-clinical variations are important clues to the important influences on physician decisions to deliver by cesarean. These variations also suggest that the hospital setting modifies these influences on doctors.

Patient factors

A number of patient characteristics are associated with cesarean delivery. These include maternal income, race, and demand. However, these factors are difficult to separate from physician and hospital factors.

Socioeconomic status. Lower SES and non-white ethnicity are consistently associated with lower cesarean delivery rates (3,6,9). In the most

refined study of SES, Gould et al. (3) found the rates of primary cesarean delivery to decrease consistently with median family income. In contrast to these primary cesarean studies, Stafford (5) notes that SES is not significantly associated with repeat cesarean section after adjusting for other demographic, clinical and hospital factors. Stafford suggests that "the distinct organizational milieus in which affluent and poor women give birth, rather than clinical management differences within the same health care setting, produce the association between SES and [repeat] cesarean section use". However, separating the effects of SES and organizational factors is difficult. Furthermore, VBAC and primary cesarean deliveries may respond to different factors. So, elucidating the effects of SES requires further study.

Patient demand. Some studies have noted a demand by the obstetrical patient for cesarean delivery. It is uncertain how much patient demand is independent of physician preferences, as the patients' knowledge largely comes from their physicians (1). Joseph et al. (60) note that the decision to attempt labor is a dual decision involving both the physician and patient. Kirk et al. (61) also find that private paying women have a greater influence upon their obstetric decisions than indigent care women. Therefore, the patient demand for cesarean delivery may be both greater and more influential among the wealthier payers with private insurance (the same patients with higher rates).

Physician factors

Physician factors associated with high cesarean delivery rates include obstetrical specialization, legal liability, reimbursement, and convenience. These associations give insight into the influences on physician practice patterns.

Obstetricians. There is a consistent relationship between high cesarean delivery rates and both the ratio of obstetricians to fertile women and the proportion of obstetrician-attended births (9). Since 1960s, obstetricians have increasingly managed childbirth. As noted above, obstetricians are more likely to use cesarean delivery. This medicalization and specialization of childbirth may have led increasingly to such an interventionist mode of practice (50).

Legal. Health care providers have often blamed obstetrical malpractice concerns beginning in the late-1970s for lowering the threshold for cesarean delivery (20,21,31,51). However evidence supporting this view is inconsistent (19,66,84).

Payment. Private insurance is consistently associated with increased cesarean rates (4,5,7,8,22). This association suggests that financial reimbursement influences rates, although some studies differ (6,66). Physicians respond to financial incentives (1). By paying obstetricians more for less work, fee-for-service reimbursement (at least indirectly) encourages them to perform cesareans. In response, many insurers have equalized reimbursement rates for vaginal and cesarean delivery. Consistent with an indirect influence of financial incentives, there are progressively lower cesarean delivery rates from private payers, to non-Kaiser capitated independent practice associations, to Medi-Cal, to Kaiser, and finally to Indigent Services and self-pay (4,5,12). These indirect influences may include physician selection and scheduling, review practices, and a congruence of physician and hospital interests (e.g., resulting in less pressure to control high cesarean delivery rates). University of California (UC) hospitals, with financial incentives similar to private hospitals, still have lower cesarean rates, which highlights the importance of other hospital factors (ibid.).

Post-delivery diagnosis. Another possible explanation for the increased rates of cesarean delivery is the retroactive or post hoc diagnosis of dystocia to explain a cesarean delivery of uncertain clinical justification. Physicians are under increasing pressure to justify every cesarean delivery. The diagnosis of dystocia is sufficiently imprecise and subjective that it may be assigned post-delivery to justify cesareans of uncertain clinical justification. Partly for this reason, Shiono et al. (53) warn that the discharge diagnosis may be used as a justification for cesarean section and not reflect the incidence of the disease.

Convenience. The diagnosis of dystocia may be a "diagnosis of convenience" for the physician. Private practice physicians generally attend the birth until the baby is delivered; cesareans speed up the delivery. Thus, the "convenience" of a speeded delivery may bias private practice physicians toward performing unnecessary cesareans. Physicians have the most incentive to do so during normal times of sleep (13-15), and when they have other scheduled demands such as office practice. These incentives would be less with group staffing and resident-staffed hospitals. Physician "convenience," as noted below, has been shown to have only a slight or negligible effect on rates of cesarean section for dystocia (ibid.).

Hospital factors

Ownership. Hospital factors found to influence cesarean section rates are ownership, teaching status, level of technology, and obstetrical volume. Ownership consistently modifies cesarean section rates, with proprietary hospitals having the highest rate, followed by private non-profits, and then by public institutions and Kaiser (4-6,9,10). Stafford (5) found that hospital ownership was a stronger predictor of VBAC than all patient clinical and demographic factors combined, noting that patients at private hospitals were the least likely to have a VBAC, followed by County, then University of

California and finally Kaiser hospital patients. The differential found by Haynes de Regt et al. (7) between private patients and "clinic" patients (attended by house officers) is probably a similar effect, which may help to explain the effect of teaching status noted below. The difference between proprietary and private non-profit hospitals is less but still substantial when the analysis adjusts for the proprietary hospitals smaller sizes, lower teaching levels, and smaller fractions of self-payers (5).

Health maintenance organizations have consistently lower rates (4-6). Studies in Californian find that only Kaiser HMOs have significantly lower rates of cesarean delivery than other payers; individual practice associations (IPAs) did not (4,76). This may reflect the need for *both* the capitation incentives to lower costs and the HMO organizational structure to promote these practices among participating physicians. IPAs foster the former, but lack the latter.

This HMO organizational structure is similar to that in a teaching hospital, with more peer review and oversight. These physicians are under greater pressure to justify each cesarean delivery and therefore are less responsive to other effects. Private practice physicians, in contrast, are relatively insulated from peer oversight.

Teaching status. Teaching status exerts a consistently conservative effect upon cesarean rates (5,10,12,54); one study even notes a "dose-response" with increasing intensity of teaching functions (5). These findings may reflect the teaching hospitals use of peer review, stronger organizational hierarchy, quicker adoption of new policies, and resident scheduling practices. Like HMOs, teaching hospitals may put physicians are under greater pressure to justify each cesarean delivery and therefore make them less responsive to other effects.

Technology. Studies differ on the effect of labor technology. Most find a positive correlation between neonatal intensive care units and technological sophistication and cesarean rates (5,9,10,47), while a few fail to find such associations (6). However, it is difficult to discern what NICU status means, as it may be confounded by many factors.

Obstetric volume. Past studies indicate a peak in rates at an obstetrical volume of about 500-1,000 births per year, with lower rates in high-volume centers (5,6,10) and in low-volume centers (10,22). This bimodal distribution suggests different processes in high and low volume hospitals. The larger volume may correspond to greater clinical expertise, more formal educational hierarchies allowing quicker dissemination of practice guidelines, 24-hour services allowing less aggressive intervention (66), or scheduling practices that minimize "convenience" incentives for cesarean delivery (13-15). The smaller hospitals may have less technological sophistication (6), fewer obstetricians, or less available services.

Interventions to Curb Excessive Rates

The excessive rate of cesarean section for dystocia is a difficult problem to address. None of the many solutions to curb the high rate of cesarean sections seem sufficient by itself. Stafford (19) identifies six areas of possible intervention to curb excessive use of cesarean sections: education and peer evaluation, external review, public dissemination of cesarean section rates, changing how doctors are reimbursed, changing how hospitals are paid, and medical malpractice reforms. Unstated definitions of the "problem" underlie each of these proposed interventions. Specific assumptions of how the medical care system functions lead to certain interventions being highlighted and others ignored. In particular, the relative importance and roles of

patients, doctors, and hospitals--and their potential responses to various incentives and sanctions--define the locus of intervention.

Patients

Individual-focused health education is always a popular public health initial intervention in the United States. Such interventions do not directly threaten any vested institutions (such as doctors, hospitals, government, or business); complements our market-justice, laissez-faire orientation; and appeals to values of personal control over health care. Thus, many public health problems are ascribed to individual behavior. Such a perspective emphasizes patient education to allow them to make "better choices". For example, Williams and Chen (10) recommend public dissemination of hospital-specific cesarean delivery rates as a method of influencing errant institutions and doctors to curb rates. This model posits that patients value a particular health outcome (no cesarean).

However, many patients may desire to have a cesarean because of the increased convenience, decreased pain and discomfort, and an ability to plan the delivery (60). Therefore, the high rates may reflect the desire by some obstetrical patients to have cesarean deliveries. This association is confounded, perhaps, because those practice environments with lower reimbursements and greater organizational controls are also where the patients are least likely to make such demands and their demands are less influential (61).

Changing patient preferences is difficult. However, patients may not be the key decision makers: Powerful and organized interests including doctors, hospitals, and the insurance industry, dominate the medical field. Consumers are comparatively powerless and unorganized. Not surprisingly, such patient oriented interventions are not very efficacious (19).

Doctors

In contrast to patient oriented interventions, provider oriented strategies are more problematic politically. As insurers, government, and health care administrators become increasingly concerned with the high costs of health care, however, the political will for such interventions has grown. The first patient oriented strategies attempted were the least controversial and most feasible: Physician education and later peer review.

The professional societies established the first clinical guidelines by the early-1980s. The 1981 National Institutes of Health Consensus Development Task Force on cesarean childbirth (21), which included consumers and government representatives, developed recommendations for changing clinical management. These recommendations included management of dysfunctional labor by rest, hydration, ambulating, sedation and oxytocin before considering cesarean delivery. Furthermore, the report emphasized the need for further research into the indications of dystocia, fetal distress, previous cesarean, and breech birth; and into the factors that affect progress of labor such as emotional support, ambulating, rest, sedation, and oxytocin (21). Yet the question remains of how to modify physician practices. Unfortunately, the simple dissemination of research findings has not in itself modified cesarean section rates (19,37,58). Lomas et al. (59) found simple audit and response to be ineffective to reduce routine repeat cesarean, unless local opinion leaders participated in educating their colleagues. Furthermore, Lomas et al. (37) note that the process of consensus development works best for decisions that are clearly definable and backed by a preponderance of evidence. In contrast, the authors note that simple guidelines are more feasible than specific recommendations for the diagnosis of dystocia and the decision to then delivery by cesarean.

Lacking clear clinical recommendations, many researchers have advocated physician education. Petitti (31) has suggested that a lag of five years will occur between practice change in teaching institutions and in the community. This lag reflects the time for a resident to complete training and establish a full community practice. For more prompt effects, outreach by teaching faculty to community physicians is necessary. Soumerai and Avorn (57) advocate using a health educational approach (so called "academic detailing") for such outreach. They advocate intensive and targeted physician education, so that physicians can be "encouraged to make more accurate and cost-effective clinical decisions" (57, page 549). However, such programs have yet to show much success (19).

Physicians respond to financial incentives (1). Because high reimbursement rates were associated with high cesarean rates, changes in physician reimbursement were advocated. Fee-for-service reimbursement may encourage obstetricians to perform cesareans as they are paid more for less work (85). Many providers have equalized reimbursement rates for vaginal and cesarean delivery. Again, these incentives have showed mixed effects, and may act only indirectly on providers, and of course do not affect salaried physicians (19).

Hospitals

Individual programs in hospitals have been effective. Myers and Geicher (12) describe a program at an inner-city hospital that lowered cesarean-section rates from 27.5% to 11.5% by using mandatory second opinions, objective criteria, and detailed review of all cesareans. These programs may depend upon formalized hierarchies found in teaching hospitals that allow greater organizational control over physician decision making (19). Yet such hierarchies exist mainly in HMOs, teaching hospitals,

and nationalized health care systems, but are notably absent in private hospitals. Furthermore, private practice physicians and private hospitals have higher rates of cesarean section, and HMOs and teaching hospitals have lower rates (5). Therefore, such strategies will have varying success depending upon the organizational setting in which the physicians practice: Such interventions may have limited scope as many physicians are in private practice. To target these physicians, insurance companies are using external audits and reviews of doctors. For example, Blue Shield of California now requires pre-admission authorization for all planned, non-emergency cesarean sections. Reimbursement review seems effective but insufficient (19).

Hospitals have also traditionally had a financial incentive to favor cesareans (12). A set-rate prospective reimbursement has been used. A prospective payment system has had a dramatic effect upon Medicare lengths of stay. Selective contracting with hospitals with lower rates is another strategy. Pre-paid obstetric plans, which have lower cesarean section rates than other plans, have also been advocated (5).

Conclusion

The excessive rates of cesarean section, particularly for dystocia, are a difficult problem to address. Interventions must be multi-factorial, targeting patients, doctors, and hospitals. However, to make health care reforms more effective, researchers need to understand the roles and relative importance of patients, doctors, and hospitals. Ultimately, the sum of the practice patterns of individual physicians determines the cesarean delivery rate. Non-clinical variations give insight into the factors that influence these physician practices, and thus suggest possible interventions to curb the high rates of cesarean delivery.

Researchers know that private hospital physicians have higher rates of cesarean delivery than public hospital and Kaiser physicians. However, researchers do not know how these distinct organizational milieus alter cesarean delivery rates or modify the effectiveness of interventions. Examining diurnal variations in cesarean delivery rates is a valuable way to answer these questions. Specifically, variations in hourly rates by hospital type, teaching status, and on weekends should give insight into physician decision making and the effects of hospital type.

Chapter Three

Diurnal Variations in Cesarean Section

Overview

This thesis posits that the rate of cesarean delivery varies throughout the day. The decision to deliver by cesarean section is a complex negotiation between the perceived need for cesarean delivery and the availability of the necessary resources such as staff and operating rooms. This thesis assumes that the demand and availability of resources for cesarean delivery are not constant during the twenty-four hours of a day. These diurnal variations in demand and availability of resources therefore cause daily variations in rates of cesarean section. This variation should be greatest for cesareans for non-acute and non-specific conditions, which are probably more responsive to the availability of resources.

Both the number of women in labor and their rate of diagnosis with the need for cesarean delivery determine the demand for cesarean section. The daily variations in demand therefore reflect circadian physiologic variations in labor, in both labor onset and medical complications. Resource availability then determines at what level of demand the cesarean deliveries are performed. Diurnal variations in resource availability reflect *hospital factors* such as shift organization and staff and resource availability; and *physician factors* such as daily regimes, schedules, and other demands.

When comparing diurnal variations in rates of cesarean delivery between hospitals, most of the above factors causing daily variations are probably relatively consistent. As noted below, three important comparisons therefore allow the examination of the specific effects of physician availability

and convenience upon daily variations in the rates of cesarean delivery: first, private hospitals with Kaiser hospitals; second, hospitals having obstetrical residency programs with those without one; and, third, weekday with weekend rates.

Diurnal Variation in Demand: Physiological Variation

Onset of labor. Diurnal variations in demand are determined by variations in labor onset and clinical complications. A number of studies find consistent circadian variations in labor onset. Labor tends to begin at night, peaking just after midnight (67-70). One series of 4,154 patients found that 62% had onset of labor between 9PM and 9AM, with a 2AM and 4AM peak of 14.3% (versus the 8.3% expected if random) (68). There is also a nighttime peak in admissions of women in labor, with 18.7% of women in one study admitted from 2AM to 5AM (versus the 12.5% expected if random) (67). This appears due to a circadian increase in uterine activity and contractions at night and a relative quieting of contractions during the day (70-72). Given the average duration of labor, this is consistent with the documented sinusoidal distribution of births with a daytime peak. These distributions vary between nulliparous and multiparous women because of their different average durations of labor (69).

By itself, this daytime increase in women in labor should not lead to increased rates of cesarean section because it is foreseeable and coincides with regular working hours. Yet, if this relative decrease in uterine contractility occurs even after the initiation of labor, then relative uterine atony and slowed progression of labor will occur during daytime and evening hours. This relative atony might then lead to more cesarean deliveries for failure to progress and ineffective uterine contractions. The latter effect is speculative,

of uncertain magnitude, and probably would only exist in those labors without oxytocin augmentation.

Medical complications. There are few studies of diurnal variations in medical complications. Variations in the numbers or severity of complications would cause a variation in the demand for cesarean section. Three hypothetical scenarios might cause a diurnally uneven distribution between complicated and uncomplicated births, and thus an uneven rate of cesarean section. First, complicated births and labors may occur more randomly during the day. Second, complicated births might also begin more often at night similar to the uncomplicated births, but then either last longer or need intervention sooner. Third, patients beginning labor at night may delay coming into the hospital until the morning hours (7AM or 8am). If upon admittance many patients are in need of surgical delivery, then the rate of cesarean delivery will increase. However, one study of 4,755 patients finds only 9% admitted between 7AM to 9AM, versus the 8% expected (67). This small anticipatable increase should not alter cesarean rates.

There is no literature confirming any of the above hypothetical scenarios, although one study notes a slight increase in neonatal mortality at night (73). This increase might be partially due to a nightly increase in obstetrical complications as speculated above, or to a multitude of other unrelated factors such as staffing variations. Two studies have found a nighttime increase of premature rupture of membranes (PROM), with 46% to 48% of PROM occurring from 12-midnight to 8AM, versus the 33% expected (67,68). Another study finds that the average duration of labor is shortest at night and over an hour longer during the evening (72), which may increase the evening rates of cesarean for failure to progress. It is uncertain whether complicated labors follow such a diurnal pattern. Even if any of these

hypothetical variations in rates exists, it should be relatively consistent between hospitals.

Diurnal Variation in Resource Availability: Hospitals & Physicians

Hospitals. Three hospital factors that may cause a diurnal variation in the availability of cesarean delivery are the number of patients presenting in need of cesarean, the capacity of the health center, and scheduling of shifts and physicians. First, the *number* of patients presenting in need of cesarean will vary. The hourly number of women needing cesarean is a function of the daily scheduling of elective cesareans. The routine induction of labor will similarly cause daily variation in times of delivery and rates of cesarean. There are variations also in the number of non-induced women presenting, for both physiological and patient factors. Second, the physical and staff *resources* for cesarean delivery partly depend on daily variations in the availability of resources necessary for cesarean delivery such as surgical suites. Also, there are daily variations in the availability of and competing demands upon the staff necessary for cesarean delivery, such as anesthesiologists and physicians. Third, the hospital organization of *shift times* may also encourage or discourage cesarean deliveries at particular times, such as during scheduled meals, conferences, or shift changes.

Physician factors. The physicians' daily schedules and regimes, primarily influenced by their types of practice, will largely determine their availability. For physicians with private practice patients, their daily regime includes regular times for sleep (night), for hospital rounds (8am), and for their private clinic patients (morning and afternoon). These daily demands differ on weekends and depend upon the physicians' on-call status. Kaiser physicians and obstetrical residents, in contrast, have scheduled shifts with

fewer competing responsibilities and scheduled night coverage. When compared to private practice physicians, Kaiser physicians and obstetrical residents should have schedules that are relatively consistent on weekends.

Physicians' availability also depends upon how many patients are in labor. Also, patients may request a cesarean more often at certain times of day (such as in late evening hours because they do not want "to go through another night"). Physicians will differ in their response to this demand, depending upon the relative importance of pleasing their patients and of clinically justifying each cesarean delivery (60,61).

Diurnal Differences in Cesarean Rates

The demand and availability factors noted above will cause diurnal variations in rates of cesarean delivery. However, there is no reason to assume the physiologically driven demand for cesarean delivery will differ across various hospital types. Thus, any relative diurnal differences between hospital types are probably due more to the availability of resources as determined by hospitals and physicians. The primary differences will probably occur between Kaiser and private hospitals, teaching versus non-teaching hospitals, and weekday versus weekends. The effects of these factors will probably be greatest with the more non-specific and less acute diagnoses, such as the abnormal labor diagnosis of cephalopelvic disproportion (CPD).

Kaiser hospitals. Of the above factors causing diurnal variations in rates of cesarean delivery, only the availability and scheduling of physicians, staff, and resources are likely to be significantly different between private and Kaiser hospitals. Therefore, in comparing private with Kaiser hospitals, diurnal rate differences between private and Kaiser hospitals will largely be due to the scheduling differences of physicians and staff at the two types of

hospitals. These differences should manifest themselves in three ways: private practice physicians will have more schedule conflicts, Kaiser hospitals should show greater effects from hospital shift schedules, and private practice physicians should have a more elastic response to non-clinical factors.

First, private practice physicians have more *competing time demands* than Kaiser physicians. In contrast to private practice physicians, Kaiser obstetricians do not have private clinic patients, and have scheduled night-shifts (less on-call convenience incentive). Also, six of eighteen of Kaiser hospitals are teaching hospitals, accounting for 43% of Kaiser births. Thus, obstetrical residents attend many Kaiser deliveries. Second, because of the consistency of times and activities among the California Kaiser hospitals, Kaiser rates should demonstrate more effects by *shift scheduling*. Nursing shifts are 7:30AM to 3:30PM, 3:30PM to 11:30PM, and 11:30PM to 7:30AM. Also, Kaiser's resident and physician staff have more regular activities and duties than private practice physicians. At Kaiser, obstetrical resident shifts are 7:30AM to 7:30AM, and teaching conferences and lunch is 12-noon to 1PM (78). Third, private practice physicians should have a *more elastic response* to non-clinical incentives. At Kaiser (as in teaching hospitals) there are greater institutional expectations to justify clinically all cesarean deliveries. For example, before a cesarean for failure to progress or CPD, residents must document adequate trials of labor with an intra-uterine pressure catheter (ibid.). This expectation makes Kaiser physicians less responsive to other non-clinical factors than private practice physicians. This is consistent with the finding that private hospital doctors are more responsive to patient preferences (60). Private patients are also more likely to express preferences (61).

Teaching hospitals. Teaching hospitals with obstetrical residency programs should behave differently than non-teaching hospitals for two reasons. First, like Kaiser hospital physicians, the residents have set schedules and thus fewer competing time demands than private practice physicians. Second, also like Kaiser physicians, teaching hospital residents can be expected to have a less elastic response to non-clinical demands due to their increased need to justify cesarean delivery. Because Kaiser hospitals already have many of the features of teaching hospitals (such as peer review and oversight), the effect of teaching status should be minimal on Kaiser hospitals.

Weekends. The important comparison between weekdays and weekends allows many variables affecting the diurnal variation in rates of cesarean delivery to be held constant. A primary difference in private hospitals is that during weekends private practice physicians no longer have competing time demands to see scheduled clinic patients. Therefore, at private hospitals the differences in the diurnal variation between weekends and weekdays should reflect differences in private practice physician scheduling and clinic demands. The total rates of cesarean delivery on weekends, ignoring diurnal variation, should be relatively lower on weekends due to general decreased availability of physicians and hospital staff and to relatively fewer cesareans performed for non-clinical convenience reasons. Also, however, the desire for free time on weekends may increase the incentive to expedite delivery with cesarean birth.

Physician Convenience & Diurnal Variation

Only three published studies have examined daily and weekly rates of cesarean delivery, with the thesis that temporal variations in rates may

indicate cesarean section for physician convenience (13-15). A study by Phillips et al. (15) at New York's Mount Sinai Hospital in 1979 and 1980 reported that cesarean sections for fetal distress occurred more often on weekdays. However, the researchers found no difference for cesareans for other indications such as failure to progress. Interestingly, the Phillips study did not analyze *daily* time variations until two letters in response described such variations. In his letter, Goodlin (17) noted an evening increase and an early morning decrease in cesarean sections for dystocia at "a hospital in northern California". In another letter, Poma (18) also noted having reviewed similar "data in a community hospital", finding temporal variations in vaginal and total births. Re-analyzing their data, the investigators tersely reported "only a minute difference" in temporal rates of cesarean between private and staff physicians (16).

In the first study to analyze both time-of-day and day-of-week variations, Evans et al. (13) found at four Chicago hospitals that "non-acute" cesarean sections were less frequent from 12-midnight to 8AM than at other times of day. As noted, less acute conditions such as abnormal labor should be more elastic. Cesareans defined as "acute" and "semi-acute" showed no significant variation over time. No Friday afternoon or Monday morning increases were noted, and delivery outcomes did not differ significantly by time of day. The non-acute indications were cephalopelvic disproportion (70%), dystocia, failed induction of labor and prolonged rupture of membranes. A similar study of several Canadian hospitals by Fraser et al. (14) found statistically significant increases in overall rates of cesarean section for dystocia from 6PM to 11:59PM as compared to other times of day, but only for patients with labor duration >16 hours.

The primary deficiency of these papers is low statistical power, which may have prevented them from finding existing differences or from doing a more refined temporal analysis. Phillips et al. (15) studied 6,212 deliveries, with 1,294 by cesarean. The sample used by Evans et al. (13) had 520 cesareans and 11,011 total deliveries. Fraser et al. (14) had a sample of 4,232 deliveries, of which 190 were by cesarean. In these studies, the average hourly number of cesareans ranged from 8 to 54. More statistical power is needed to examine hourly variations and indication-specific variations.

Also, these investigators did not examine inter-hospital variations. These comparisons would have allowed them to hold constant many of their variables responsible for diurnal rate variations. Such a comparative analysis can uncover differences between hospitals related to such factors as the presence of a teaching residency or HMO ownership. In the proposed analysis outlined in the next chapter, an improved methodology overcomes these problems.

Research Hypotheses

Ten hypotheses are proposed to explore the model presented above: first, resource availability affects rates of cesarean delivery (e.g., effects of physician convenience); second, cesarean delivery for the relatively non-acute and discretionary diagnosis of CPD is more elastic to non-clinical influences; and, third, the institutional setting modifies the response of physicians to non-clinical factors such as time of day.

Hypotheses:

1 The overall rates of elective and emergent cesarean delivery are highest for private and non-teaching hospitals.

2 *Daytime increases* occur in rates of *elective* cesarean deliveries.

3 *Diurnal variations* occur in rates of primary, *emergent* cesarean deliveries.

4 The *magnitudes* of these diurnal variations in primary, emergent cesarean rates are least for Kaiser hospitals and for hospitals with obstetrical residency teaching programs.

5 Weekend rates of *elective* cesarean delivery are lower than on weekdays.

6 Weekend rates of primary, *emergent* cesarean delivery are also lower.

7 The primary, emergent cesarean weekend rate differences are greatest in magnitude for both *private* and *non-teaching* hospitals.

8 The proportion of births by cesarean section for *CPD* show similar variations, by time, hospital, teaching status, and weekend.

9 Time, hospital, teaching status, and weekend exert *independent effects* on both the rates of primary, emergent cesarean delivery and of primary, emergent cesarean delivery for CPD.

10 Statistically significant *interactions* between time, hospital type, and weekend are consistent with resource availability and hospital setting modifying clinical decisions.

(1) Consistent with previous studies, the overall rates of elective and emergent cesarean delivery vary by *hospital* type and by *teaching status*. Private hospitals will have the highest rates and Kaiser hospitals the lowest. Also, hospitals with obstetrical residency teaching programs will have lower rates than hospitals without such programs. The effect of teaching status are less with Kaiser hospitals, as Kaiser hospitals already have staffing patterns relatively similar to teaching hospitals.

(2) *Diurnal variations* occur in rates of *elective* cesarean deliveries. Reflecting the scheduling practices of this elective surgical procedure, there will be generally higher rates during the day and lower rates at night. Also, there will be rate peaks at particular times of the day when surgical procedures are often scheduled, such as 8-10am. Kaiser hospitals will show

the greatest consistency in scheduling, reflecting their inter-hospital similarities.

(3) *Diurnal variations* occur in rates of primary, *emergent* cesarean deliveries. There will be generally higher rates during the day and lower rates at night, reflecting the diurnally varying effects of physiologic, physician, and hospital factors. Competing demands for staff and resources will also cause a decrease in rates when there are many elective cesarean deliveries.

(4) The *magnitude* of the diurnal variations in primary, emergent cesarean rates are (i) least for Kaiser hospitals and greatest for private hospitals, and (ii) least for hospitals with obstetrical residency teaching programs and greatest for those without such programs. Private practice physicians, who usually attend patients at private and non-teaching hospitals, generally follow each labor until delivery. These physicians therefore have a convenience incentive to expedite delivery with cesarean birth. Diurnal variation in private hospitals will also reflect the daily schedule conflicts of private practice physicians. For example, the rates will decrease during the usual appointment times of private patients. Kaiser hospitals and teaching hospitals will show less hourly variations because the attending and resident physicians follow staff schedules and have fewer competing time demands. Because of these similarities, teaching status will have less effect with Kaiser hospitals.

(5) During the weekend, rates of *elective* cesarean delivery are lower, reflecting staff and physician scheduling practices.

(6) During the weekend, rates of primary, *emergent* cesarean delivery are lower, reflecting the general decrease in weekend availability of physician and staff resources. Also, the rates of primary, emergent cesarean delivery

will demonstrate less diurnal variation when compared to weekday rates, reflecting fewer scheduling conflicts.

(7) These weekend rate differences for primary, emergent cesarean delivery are greater in magnitude and variations for both *private* and *non-teaching* hospitals than for Kaiser and obstetrical residency teaching hospitals. Teaching status will have less effect with Kaiser hospitals. The differences between weekday and weekend scheduling and time demands are greater for private practice physicians than for Kaiser, staff, and resident physicians.

(8) The proportion of primary, emergent cesarean delivery with the *diagnosis of CPD* show similar variations, by time, hospital, teaching status, and weekend. CPD is relatively non-acute, discretionary, and possibly post hoc diagnosis, and therefore will show a more elastic response to convenience incentives and other non-clinical influences upon cesarean delivery for this indication. Therefore, there will be an increased proportion of cesareans for this indication when cesarean delivery is most convenient for the physician.

(9) Time, hospital, teaching status, and weekend exert *independent effects* on both the rates of primary, emergent cesarean delivery and the proportion of primary, emergent cesarean deliveries with the diagnosis of CPD. These effects will remain statistically significant when controlling for potentially confounding effects such as non-coding, maternal age, birth weight, and parity.

(10) Statistically significant *interactions* between time, hospital type, and weekend are consistent with the above hypotheses of, first, resource availability influencing the rates of cesarean delivery (e.g., physician convenience); and, second, hospital setting modifying the response of physicians to non-clinical factors such as time of day and weekend. The rate

of *non-coding* will probably be greatest for late hours and weekend births, reflecting the decrease in staff at these times. Non-coding will also be greatest for public hospitals, which have fewer resources than private or Kaiser hospitals for record keeping. However, the number of non-coded births should be statistically insignificant.

Chapter Four

Data and Methods

Overview

This analysis used the 1988 California linked birth-death cohort records to evaluate the hypotheses presented in the preceding chapter. The characteristics of this database make it valuable for this analysis. To better examine diurnal variations, the analysis selected a sub-population of births. Diurnal variations and physician convenience probably vary by hospital ownership, teaching status, and on weekends. Cephalopelvic disproportion may be a more sensitive indicator of these effects. Statistical analyses will evaluate the significance of the diurnal variations, by time of day, hospital ownership, teaching status, and weekends. The data analysis uses two primary methods: quantifying the magnitude of variation by the coefficient of variation and evaluating the magnitude and statistical significance of time deviations by logistic regression. The potential limitations of this study probably do not limit the validity of the conclusions.

California Birth Records Data

This analysis uses the California 1988 linked birth-death cohort files. The California State Office of Data Retrieval and Analysis collects these data on each birth in the State. As noted by Stafford (55), four features of obstetrical practice facilitate data analysis: the high frequency of birth allows statistical power; birth is a well-defined, acute episode of care; the indications are relatively well-characterized; and, because birth is a vital-statistics event, the coding accuracy is relatively high and the statistics are readily available.

The advantages of examining California data are also four-fold. First, the large number of deliveries (538,030 in 1988) provides the large sample size necessary for evaluating diurnal variations in rates of cesarean delivery. In comparison, Glattre and Bjerkedal's sample of 617,015 represents all births in Norway over a ten year period (69). Second, data are available from linked birth, fetal, and infant death certificates. Third, the diverse California hospital system has the largest number of HMO-owned hospitals of any state. Finally, the cesarean section rate is similar to the national rate, and no special circumstances contraindicate generalizing the findings (74). Several disadvantages are the limited and predetermined variables, and the difficulty in insuring accuracy and completeness of the data coding.

The two main sources of cesarean delivery data are hospital discharge abstracts and birth records. Hospital discharge abstracts, collected for all hospital admissions including postpartum discharges, are rich in clinical diagnoses and procedures. Birth records generally have less clinical information, but were chosen for this analysis because they include relevant obstetrical information not found in hospital discharge abstracts such as parity, gravidity, birth weight, and, particularly, time of birth. Appendix One notes the variables from the linked birth-death cohort records used in this analysis.

Population Studied

Patients. To study emergent, primary cesarean delivery rates, the analysis includes all singleton vaginal or non-elective cesarean deliveries to nulliparous women in non-Federal Californian hospitals during the calendar year of 1988. When examining primary, emergent cesareans, the analysis excludes all women with previous births, non-singleton births, previous

cesarean delivery, or repeat or elective cesarean coded. Nulliparous women have a higher rate of cesarean delivery, and limiting the analysis to this population helps to control for differences in obstetrical populations between hospitals. The denominator excludes elective primary cesarean births because their large diurnal variation will markedly affect combined hourly rates. Also excluded from the analysis are births without type of delivery coded (1,135 births, 0.211% of the total), with unspecified cesarean delivery coded (758, 0.141%), births without time of birth coded (247, 0.046%), and without a hospital coded (8,356, 1.55%). All records had the date of birth entered. Thus, the sub-sample used for the analysis represents 36.4% of the recorded births in California for 1988.

Included in the numerator are only those births with primary, emergent cesarean coded. The total numerator includes 42,284 primary, emergent cesarean deliveries and the denominator includes 195,832 births. So, the global cesarean delivery rate for this population is 21.59%. Patients are not randomly distributed between hospitals. Therefore, some variations in patient mix can be expected. However, this analysis does not adjust for case mix after limiting itself to vaginal and primary, emergent cesarean deliveries in nulliparous women.

Variable Definition

Several variables need further definition to facilitate analysis of the research hypotheses: cesarean delivery, hospital ownership, obstetrical residency teaching status, weekend versus weekday, cephalopelvic disproportion, times of convenience, and diurnal variation.

Cesarean delivery. This analysis uses the timing of cesarean delivery to elucidate non-clinical influences on practice patterns. To analyze physician

decision making, this study examines only emergent cesarean deliveries. Elective cesarean delivery, in contrast, is a scheduled surgical procedure and so will instead reflect scheduling practices. Furthermore, the study only examines primary cesareans because of the large clinical differences for repeat cesarean and vaginal birth after cesarean. There are seven codes for type of delivery in the California 1988 birth records. For cesarean deliveries, elective primaries are coded as "1", elective repeats are "2", non-elective primaries are "3", non-elective repeats are "4", and unspecified cesarean births are "5". Vaginal birth is coded as "0". Unknown or not reported deliveries are left as blank or coded as "9". For the rate of elective, primary cesareans, the numerator is limited to code "3" (non-elective primary cesarean), and the denominator to "3" and "0" (vaginal birth). Also, the analysis calculates the total hourly number of cesarean deliveries (the sum of births coded 1-5) to examine competition for hospital and staffing resources.

Hospital ownership. Central to the analysis is determining whether the attending physician is in private practice. Ideally for this study, one needs information about the staffing pattern of the physician attending each birth. As this information is not available in the 1988 birth records, the analysis infers the physician's status from the hospital's ownership and obstetrical teaching status. A central assumption to this study is that private practice physicians predominantly attend births at private and public hospitals, and staff physicians attend births in Kaiser hospitals. Physicians at private and public teaching hospitals will include a mixture of private practice and residents and staff physicians.

The analysis categorizes births as either public, private, or Kaiser hospital births. Public hospitals are defined as ownership status "2" (state), "3" (county), "4" (city), or "5" (district). Private hospitals are those coded "6"

(private non-profit) or "7" (private proprietary). Kaiser hospitals were defined by twenty-eight specific hospital codes. Excluded were federal hospitals (coded as "1"), unlicensed private medical facilities ("8"), unlisted child bearing centers ("9"), and home births ("0").

Teaching status. Categorization of hospitals by their obstetrical residency teaching status further refines the above distinction. There are thirty-one California hospitals with such programs in 1988: fourteen public hospitals, eleven private hospitals, and six Kaiser hospitals. The study defines a teaching hospital as one with an accredited residency teaching program in obstetrics/gynecology for 1987-1988 according to the Accreditation Council for Graduate Medical Education (75). Specifically, the analysis assumes that private practice (non-staff) physicians will attend most births at private hospitals without an obstetrical residency program. However, at any particular birth in hospitals with teaching programs, the type of physician in attendance is unknown: either a resident or private practice physician might attend any specific birth. Furthermore, the hospital-specific rates of cesarean delivery do not account for the relative numbers of births attended by residents versus other physicians. This misclassification exerts a conservative bias.

Weekends. This analysis defines the weekend from 6AM Saturday morning up to 6AM Monday morning. The early morning hours on any one day may reflect the previous evening rather than the ensuing day. Therefore, 12-midnight to 6AM Saturday is treated as an extension of the weekday (Friday night) and 12-midnight to 6AM Monday as an extension of the weekend (Sunday night).

Cephalopelvic disproportion. The 1988 birth records data only include the dystocia diagnosis of cephalopelvic disproportion (CPD). Therefore, this

analysis of birth records uses CPD as the surrogate for dystocia. As noted above, non-acute and non-specific diagnoses for cesarean delivery are of special interest as they may be more responsive to non-clinical variations and thus a more sensitive indicator of physician convenience and availability.

This analysis uses the proportion of births by cesarean with the diagnosis of CPD. In theory, there are two rates of interest: the rate of diagnosis of CPD, and the rate of primary, emergent cesarean when there has been a diagnosis of CPD. The product of these is the overall rate of cesarean for CPD, which should be consistent between physicians once maternal characteristics are controlled. These rates can be calculated by one's unit of analysis. If these rates are negatively correlated, it suggests no post hoc coding bias or inappropriate use of cesarean for CPD. If the rate of diagnosis of CPD is higher because the criteria for its diagnosis are looser, then lower rates of cesarean given the diagnosis of CPD are expected. If these rates are positively correlated, however, it suggests a post hoc coding bias or excessive use of cesarean delivery for CPD. Physicians with higher proportions of cesarean deliveries can be expected to be performing cesareans for proportionally more non-acute and non-specific conditions such as CPD. Also, these practitioners may assign some deliveries the post hoc diagnosis of CPD. They will therefore have a higher rates of both the diagnosis of CPD and cesarean delivery given the diagnosis of CPD.

In the birth record data used for this study, the rate of cesarean delivery given the diagnosis of CPD is approximately 95%. Thus, CPD is being used almost exclusively as an indication for cesarean delivery in the birth records. Therefore, separating the rate of diagnosis and rate of cesarean delivery becomes problematic. So, the analysis only examines the proportion deliveries for cesarean performed for CPD.

Convenient times. As noted above, diurnal variations in resource availability reflect not only hospital factors but also physician factors such as daily regimes, schedules, and patient or other demands. Convenient times for cesarean delivery are when physicians do not have these other competing demands or soon before an anticipated conflict will occur. Competing demands with a predictable diurnal variation include sleep (night time); private practice physicians' private clinic patients (weekday, day-time, and schedule-dependent); other patients needing cesarean delivery (especially during times when elective cesareans are scheduled); and during usual times of vacation (weekends, holidays). The three important comparisons by hospital ownership, teaching status, and weekend allow the examination of the effects of physician availability and convenience on daily variations in cesarean delivery rates.

Variation

The evaluation of variation is central to this thesis. After the sub-sample's diurnal rates are determined for each hospital ownership and teaching category, a method is needed to quantify the magnitudes of variation. Two relative measures of variation are used in this analysis: the coefficient of variation and the scaled range. The coefficient of variation is the standard deviation divided by the sample mean. This method is similar to that employed in analyzing medical practice variations (78-80). The second measure is the absolute range of hourly rates divided by the mean.

The use of the coefficient of variation exerts two conservative biases on the rejection of the null hypotheses. The first conservative bias results from using a relative rather than absolute measure of variation. Most likely, the different hospital categories will have different average rates of cesarean

delivery. An absolute measure of variation should be used if hospitals with higher average rates are expected to have absolute rate variations similar to hospitals with lower average rates. Yet, if the absolute variations are expected to be greater in high rate hospitals, then the measure should be scaled to the overall rate.

Hospitals with higher average rates are also those suspected of greater medical practice variations: This thesis posits that those hospitals commonly associated with high cesarean delivery rates (private, non-teaching) will also be those with the greatest diurnal rate variations. Therefore, absolute measures of rate variation will be more sensitive indicators of diurnal rate variations than relative measures of variation. The two most common absolute measures of variation are standard deviation and variance. However, this thesis uses the more conservative assumption that the measure of rate variation should be scaled to the overall rates of cesarean delivery.

The second conservative bias arises because part of the variation measured by the coefficient of variation is due to random sample variations. The random variation component of the coefficient of variation will therefore be greatest in those hospital categories with the fewest births. However, this bias will again be conservative because those hospitals suspected of the greatest variation (private hospitals) have the most births, and those hospitals expected to have the least diurnal variation (Kaiser hospitals) have the fewest. Also, the weekend samples will have approximately two-fifths the number of weekday births and therefore should have a larger random component expressed in their coefficients of variation. As these weekend samples are hypothesized to have less variation than weekday samples, this also results in another conservative bias.

These measures of variation will be applied to hourly rates and to the rates for the six time periods described below (nighttime, morning, mid-morning, lunch, afternoon, and evening). There are three advantages to examining variations by using these time periods rather than hourly rates. First, by isolating daytime variations, the time periods may be more sensitive to the effects of daytime convenience incentives and schedule conflicts. Second, these blocks naturally smooth the data and reduce the contribution of random variations noted above. Third, the smaller number of time periods facilitates the analysis and interpretation of the data. However, these time periods were not defined a priori. Instead, the larger time blocks were defined by this investigator to capture the significant variations noted with the fewest time periods. Therefore, measures using these time periods may be biased. For this reason, the results are presented by the original one hour time periods for emergent cesarean delivery. For cesarean performed for CPD, random variation is more problematic because of the numbers are smaller. Therefore, these coefficients of variation will use the six time blocks.

Descriptive and Analytic Methods

Overview of the data. The total numbers of births and indication-specific cesarean delivery rates will be calculated for the sub-sample and complete data set. The initial analysis identifies the total number of hospitals with at least one delivery by the sub-sample population. The overall primary, emergent cesarean delivery rates are calculated by ownership and teaching status. The number of births excluded will also be calculated to estimate the potential magnitude of confounding.

Diurnal variation. The analysis of diurnal variation will first classify births by hour of delivery. For example, the 1-2AM block includes all births

occurring from 1:00:00AM to 1:59:59AM. These hourly rates of elective and primary, emergent cesarean delivery will be computed for all hospitals, by hospital ownership and teaching status. Then, to facilitate logistic regression analysis of differences in these rates, the time periods will be shortened to six blocks: 1AM-7AM, 7-10AM, 10-12noon, 12-3PM, 3-5PM, 5PM-1AM. Rates for these time periods will be calculated and compared between hospitals (by hospital ownership, by teaching status, and specifically for private hospitals without residency programs). Odds ratios and associate confidence intervals and p-values will be computed with the 1-7AM time period as the reference. The statistical significance will be determined using logistic regression, as noted below. The coefficients of variation will be compared.

Week versus weekends. Weekend versus weekday rates for primary, emergent cesarean will be assessed by hospital ownership and teaching status. Then, as above, these will be analyzed by time of day. For each category (by hospital ownership, teaching status), the six daily weekends and weekday rates will be compared to evaluate statistically significant differences in weekday versus weekend rates. A 95% confidence interval is calculated for the difference in rates (delta-p) using the formula:

$$\text{delta-p} \pm (1.96)*[(p_1)(1-p_1)/(n_1)+(p_2)(1-p_2)/(n_2)]^{-1/2}$$

The coefficients of variation will be compared for weekend and weekday rates also.

CPD. As noted above, this analysis uses only the rate of cesarean performed for CPD, ignoring the rates of diagnosis of CPD and of cesarean once CPD has been diagnosed. The complete analysis noted above for primary, emergent cesarean (by hospital, teaching status, hour, and weekend) will be repeated for these rates. These will be compared to the values determined for all primary, emergent cesareans to determine whether

cesarean performed for CPD is more elastic than overall emergent cesarean delivery.

Non-coded data. The magnitude of confounding by non-coded and excluded data needs to be determined. First, the absolute number of non-coded births will be calculated. If there is the possibility of significant confounding, a series of two-by-two chi square contingency tables will be formed: *Private hospital* by no-code cesarean (codes 9 & 5) & no-code hour; *Kaiser hospital* by no-code cesarean & by no-code hour; *Late hour* by no-code cesarean & by no-code hospital. These relative risks and confidence intervals will be evaluated to identify any possibly confounding association with no-codes and exclusions.

Logistic Regression

Unit of analysis. The statistical significance of the above differences will be validated by using a logistic regression of rates both of primary, emergent cesarean delivery and of primary, emergent cesarean delivery performed for CPD. There are two potential units of analysis for such a regression: the individual hospital rates, or the delivery. With the hospital as the unit of analysis, the proportion (p_i) of deliveries by cesarean can be calculated for each hospital. Then, an ordinary least squares regression can be performed of using the natural logs of ($p_i/1-p_i$) as the outcome variables. However, this method is problematic with these data because large differences in coding exist between hospitals. For example, five hospitals with over one-thousand singleton vaginal deliveries to nulliparas recorded an emergent cesarean delivery rate of less than 0.5%. One of these recorded no such cesarean deliveries despite 1,113 vaginal births to nulliparous women. Given the delivery codes used to define the sub-sample ("0" vaginal birth, and "3"

primary, emergent cesarean delivery), most likely these aberrant hospitals are consistently coding primary, emergent deliveries differently (for example, as "1" elective primary, or as "5" unspecified cesarean delivery). Also, such hospital-specific rates must be weighted by hospital size.

The second method of analysis is a logistic analysis treating the birth as a dichotomous outcome variable: cesarean or no-cesarean. This measure is less influenced by coding variations between hospitals because each hospital's births are randomly distributed throughout the day. So, while hospital coding variations may modify estimates of total rates, these differences are less likely to bias the hourly rate variations. Also, unlike an analysis of hospital-specific rates, a regression with birth as the unit of analysis does not need to control for hospital differences in number of deliveries. Furthermore, it prevents outlier hospitals from skewing the sample. For these reasons, the logistic regression uses the delivery as the unit of analysis.

Risk adjusting. This analysis does not risk-adjust rates for independent variables such as maternal risk factors, age, race, fetal birth weight and parity. This omission should not substantially alter the results for three reasons. First, by selecting only nulliparous women with singleton deliveries, the study directly controls for parity and multiple births, and excludes women with previous cesarean delivery. Second, by excluding elective cesarean deliveries, many clinical complications are excluded. The physician will schedule an elective cesarean delivery if a potentially serious maternal or fetal complication of labor is anticipated. Therefore, the sub-sample of vaginal and emergent cesarean deliveries has already been risk-adjusted by the attending physician.

Third, the rates are not adjusted for independent variables such as fetal birth weight and maternal age and race, as the study is concerned only with

temporal variation in rates, not in global rates. Furthermore, relative rather than absolute measures of overall variation are used. In order to substantially confound the results, these independent variables would need to (i) be independently associated with the different hospital types (as determined by ownership and teaching status), (ii) have a diurnal pattern different from births without such factors, and (iii) both of these need to be of sufficient magnitude.

To determine retrospectively whether these factors are significant confounders, these factors can be added to a regression equation and evaluated for statistical significance. The regression equation can use of significant hospital, time, and interaction parameters, as determined by stepwise logistic regression. For example, an explanatory variable for births to women under 18 years old can be added to the logistic model. Then the parameter can be judged to not confound the analysis if the parameter fails to reach statistical significance, to alter the values of the other parameters, or to add explanatory power to the model. Alternately, the difference of the -2 log likelihood can be compared as a chi square statistic.

Analysis. The analysis uses the SAS programming language on VM/CMS. As noted above, rates are evaluated by six time periods: 1AM-7AM, 7-10AM, 10-12noon, 12-3PM, 3-5PM, and 5PM-1AM. Hospital ownership, teaching status, weekend, and time are treated as dichotomous dummy variables. A PROC SUMMARY procedure can abstract these data to seventy-two lines (ownership: 1-3, teaching: 0-1, time: 1-6, weekend: 0-1). PROC LOGISTIC can then evaluate the model (events/trials), with frequency equal to the number of births. The alternative PROC LOGISTIC model (event), where event equals "0" or "1", incorrectly determines some statistics.

For each explanatory variable entered in the model, PROC LOGISTIC estimates a slope parameter (b_i), standard error (SE), and a chi square probability (p-value). The p-value determines the statistical significance of the variable. The cesarean rate is determined from the parameter (b_i) by the formula, $(100\%/[1+e^{-(b_i)}])$. Odds ratios are calculated by the formula, $OR_i = e^{(b_i)}$. The 95% confidence intervals are estimated with these formulae by using, $b_i \pm 1.96*(SE)$

Individual models will be used to examine interaction and statistical significance. Logistic regression by relevant dichotomous variables allows evaluation of the statistical differences in calculated proportions. For example, to evaluate the effect of teaching status on public, private, and Kaiser hospital rates, a logistic regression stratified by hospital ownership can be run of the model (event/trial = teaching status). The difference in rates are calculated from the slope parameters. As noted above, confidence intervals are found with the standard errors. The chi square p-values evaluate the significance of these differences. In a similar way, the differences can be evaluated for weekends, hospital ownership, and time of day.

Multiple interaction terms will also be examined (ownership-weekend-hour, for example). These interaction terms allow the evaluation of many of the hypotheses noted in Chapter Three. Many of these can be confirmed by statistically significant interaction terms. For example, a key finding consistent with an effect by physician convenience on cesarean delivery is a significant interaction between hospital ownership and time of day and/or weekend.

Chapter Five

Results

California, 1988

There were 538,030 recorded births in California in 1988. There were 122,872 cesarean deliveries, of which 35% were elective cesareans, 52% were emergent primary cesareans, 12% were emergent repeat cesareans, and fewer than 1% were unspecified cesarean deliveries. There were 195,832 in-hospital, appropriately coded, singleton, vaginal or emergent cesarean deliveries to nulliparous women. Of these, 42,284 were primary, emergent cesarean deliveries, giving an overall cesarean delivery rate of 21.59%. The calculations in this chapter refer to this sub-sample.

Overall Rates

Ownership. Consistent with other studies, private hospitals had the highest cesarean rate and Kaiser hospitals the lowest. Three-hundred thirty-three hospitals had at least one birth to the sub-sample of women. Of the study's sub-sample, 231 private hospitals had 126,108 births, or 64.4% of the total; 84 public hospitals had 48,385 births, or 24.7%; 18 Kaiser hospitals had 21,339 such births, making up 10.9%. The primary, emergent cesarean rates to nulliparous women by hospital ownership were: private 24.5%, public 16.8%, and Kaiser 15.2%. These differences are statistically significant, $p < 0.0001$ (Table One).

Teaching. In 1988, thirty-one non-military hospitals had teaching residency programs in obstetrics and gynecology (75). Of these, fourteen were public hospitals, eleven were private hospitals, and six were Kaiser hospitals.

Only 12% of private hospital births were at hospitals with teaching programs. In contrast, 44% of public hospital births and 43% of Kaiser hospital births were in teaching facilities (Table Two).

As predicted in Chapter Three, the rates were consistently lower in teaching hospitals, although this difference only reaches significance for public hospitals. Teaching hospitals as a whole had a primary, emergent cesarean delivery rate of 17.2%, compared to a rate of 23.0% for non-teaching hospitals. Furthermore, the effect of teaching status on cesarean delivery rates differs for each hospital type. For private hospitals, rates of primary, emergent cesarean delivery were 24.6% for hospitals without an obstetrical residency program, versus 24.1% for teaching hospitals. At public non-teaching hospitals, the rate was 19.5% versus 13.3% at teaching hospitals. At Kaiser non-teaching hospitals, the rate was 15.2% versus 15.1% at teaching hospitals. Therefore, teaching hospital rates were 0.5% lower for private hospitals (CI = -2.4% to 1.2%, $p = 0.20$), 6.2% lower for public hospitals (-6.9% to -5.6%, $p < 0.0001$), and 0.1% lower for Kaiser hospitals (-1.0% to 0.9%, $p = 0.91$) (Table Three).

Weekends. The rates on the weekend were consistently lower than weekday rates for all hospital types. The total primary, emergent cesarean delivery rate on weekdays was 22.3%, which is 2.7% higher than the weekend rate of 19.6%. The decrease in rates on weekends differed by hospital ownership. At private hospitals, the weekday rate was 25.2% versus a weekend rate of 22.5%. At public hospitals, the weekday rate was 17.5% versus a weekend rate of 14.8%. At Kaiser hospitals, the weekday rate was 15.5% versus a weekend rate of 14.3%. Thus, the weekend decrements by ownership were: private hospitals 2.7% (-3.3% to -2.2%, $p < 0.0001$), public

hospitals 2.7% (-3.4% to -2.0%, $p < 0.0001$), and Kaiser hospitals 1.3% (-2.3% to -0.6%, $p = 0.019$) (Table Four).

The weekend decrement differed by teaching status for each hospital type, with teaching hospitals having a smaller weekend decrement. Teaching hospitals had an average weekend decrement of 2.4%. Non-teaching hospitals had an average weekend decrement of 2.7%. Similarly, public, private and Kaiser teaching hospitals had smaller weekend decrements than their non-teaching counterparts. Stratified this way, however, these weekend decrements are only statistically significant for private non-teaching and public non-teaching hospitals: Private non-teaching hospitals had a decrement of 2.9% ($p < 0.0001$), and public non-teaching hospitals had a decrement of 3.5% ($p < 0.0001$). Private teaching hospitals had a non-significant decrement of 3.0% ($p = 0.65$). Public teaching hospitals had a weekend decrement of 1.6% ($p = 0.13$). Kaiser hospitals had a weekend decrement of 2.3% ($p = 0.49$) for teaching hospitals and 0.5% ($p = 0.49$) for non-teaching hospitals (Table Five).

Diurnal Variation

California 1988. As found by other investigators (69), the hourly number of births varied significantly and peaked during the day. By hour, the greatest proportion of deliveries (30,122) occurred at 7 to 8AM. The smallest (18,795) occurred at 1 to 2AM. Other daytime peaks were 12noon (27,137) and 5-6PM (23,680). The hourly coefficient of variation is 0.133 for these births (Figures 1-2).

Elective primary and repeat cesareans showed more diurnal variation than total births. They range from a low of 580 at 3-4AM to a high of 7,645 at 8-9AM. Another daytime peak of 3,565 occurs at 12-1PM This differed little by

hospital type, although private hospitals had the greatest variation and Kaiser hospitals the least. The hourly coefficients of variation for elective cesareans are: total 0.87, private 0.92, public 0.81, and Kaiser hospitals 0.72 (Figure 3-5).

Sub-sample births. The emergent primary cesarean rate showed less variation than the elective cesareans. Births in the sub-sample also had a nighttime low (6,549 at 4-5AM) but peak at 6-7PM (9,893). Stratified by hospital ownership, the pattern is similar. Private hospitals have a similar peak at 6-7PM (6,638 births) and reach a nadir at 6-7AM (3,916 births). The private hospitals also had a relative peak at 1-2PM (6,203). Public hospitals also peak at 6-7PM (2,350) and reach a nadir at 3-4AM (1,764). Kaiser hospitals peak at 5-6PM with 1,007 births and drop to 785 at 6-7PM. Interestingly, private hospitals show more hourly variation. The minimum and maximum hourly incidence rates by hospital ownership are: private 3.1%-5.3%, public 3.7%-4.9%, and Kaiser hospitals 3.7%-4.7%. The hourly coefficients of variation for total births by hospital ownership are: total 0.134, private 0.168, public 0.084, and Kaiser hospitals 0.075 (Figures 6-8).

The rates of emergent cesarean delivery, by hour of day and by the six time periods discussed above, also show significant diurnal variation ($p < 0.0001$ by chi square test of homogeneity). The hourly rate for all births ranges from a low of 15.5% at 4-5AM to a high of 26.2% from 10-11PM. This range of 10.8% compared to a mean of 21.6% gives a ratio of range to mean of 0.50. The hourly coefficient of variation is 0.149 (Figure 9).

Ownership. Stratified by hospital ownership, the diurnal cesarean rates still show significant diurnal variation. As predicted, private hospitals have the greatest range and largest coefficient of variation in hourly rates and Kaiser hospitals the least. Also, the cesarean rates consistently were lowest in the early morning hours and highest in the late evening. The hourly rate for

private hospital births range from a low of 17.0% at 4-5AM to a high of 29.9% from 10-11PM. This 12.9% range and 24.5% mean give a range to mean ratio of 0.52. The hourly rate for public hospital births range from a low of 12.3% at 3-4AM to a high of 21.4% from 9-10PM. This 9.1% range and 16.7% mean give a range to mean ratio of 0.54. The hourly rate for Kaiser hospital births range from a low of 12.3% at 4-5AM to a high of 20.0% from 11-12PM. This 7.7% range and 15.2% mean give a range to mean ratio of 0.51. Coefficients of variation are 0.15 for public hospitals, 0.16 for private hospitals, and 0.11 for Kaiser hospitals (Table Six). (For the following discussions, refer to Figures 10-13 for private hospitals, Figures 14-18 for public hospitals, and Figures 18-20 for Kaiser Hospitals.)

These diurnal variations also are statistically significant by logistic regression analysis by the six time blocks. Private hospitals show a diurnal pattern consistent with an effect by physician convenience, as the rates have relative troughs during the usual times of private practice clinic appointments. Diurnal variations in private hospitals reflect the daily schedule conflicts of private practice physicians, with relatively lower rates during private patient appointment times. Their cesarean rates reach a nadir in the early morning, then increase in the morning, drop again mid-morning drop, increase at lunch time, drop again in the late afternoon, and finally peak in the evening. As compared to the 1 to 7AM 19.3% rate, the increases in rates for the other time blocks are statistically significant ($p < 0.0001$). From 7 to 10AM, the private hospital rate of 25.2% gives an odds ratio (OR) of 1.4 (1.4-1.5). Then from 10 to 12noon the rate decreases to 21.8%, OR = 1.2 (1.1-1.2). From 12 to 3PM the rate increases to 25.3%, OR = 1.4 (1.4-1.5). Again, the rate decreases to 22.1% from 3 to 5PM, OR = 1.2 (1.1-1.3). Finally, the highest rate of 28.1% occurs from 5 to 1AM, OR = 1.6 (1.6-1.7).

Like the private hospitals, the *public* hospital cesarean rate also shows morning, lunch time, and evening increases, although the magnitude is smaller. The 1 to 7AM rate is 13.4%. The odds ratios by time period are 1.3 (1.2-1.4) for 7 to 10AM, 1.2 (1.1-1.3) for 10 to 12noon, 1.3 (1.2-1.4) for 12 to 3PM, 1.4 (1.2-1.5) for 3 to 5PM, and 1.5 (1.4-1.7) for 5 to 1AM (all $p < 0.0001$, except for 12 to 3PM $p = 0.0007$). In contrast, *Kaiser* hospital cesarean rate increases are only statistically significant for 10 to 12noon (17.0%, OR = 1.23, $p = 0.0058$), and 5 to 1AM (16.2%, OR = 1.16, $p = 0.003$). Other rates were not statistically different from the early morning rates (Table Seven).

Weekends. When separated by weekend and weekday, the diurnal variations are different. For private hospitals, the daytime variations related to daily schedule clinic conflicts disappear during weekends: the weekend rates lack the dramatic peaks at 7 to 10AM, 12 to 3PM, and 5PM to 1AM; on the weekend (Figure 9). Only the 10 to 12noon and 3 to 5PM rates of 20.8% and 22.1% are significantly elevated over the early morning rate of 18.1%. For the weekend, the odds ratios are 1.0 (95% CI 0.9-1.1) for 7 to 10AM, 1.2 (1.1-1.4) for 10 to 12noon, 0.9 (0.8-1.0) for 12 to 3PM, 1.3 (1.1-1.4) for 3 to 5PM, and 0.9 (0.8-1.0) for 5 to 1AM. The weekend decrements in rates were -1.6% (-4.1/1.0) for 1 to 7AM, -8.6% (-11.6/-5.6) for 7 to 10AM, -0.6% (-4.3/3.0) for 10 to 12noon, -10.2% (-12.8/-7.5) for 12 to 3PM, +0.6% (-2.8/4.1) for 3 to 5PM, and -12.8% (-14.5/-11.2) for 5 to 1AM.

Public hospitals had less dramatic weekend differences. None of the weekend rates were significantly different than the early morning rate of 12.0%. The weekend decrements in rates were -1.8% for 1 to 7AM, -3.5% for 7 to 10AM, -2.7% for 10 to 12noon, -6.0% for 12 to 3PM, -6.0% for 3 to 5PM, and -9.4% for 5 to 1AM.

The difference between Kaiser weekday and weekend rates failed to reach significance. Also, stratified this way, on weekdays only the 10 to 12noon rate of 17.9% and the 5 to 1AM rate of 16.2% are significantly elevated above the early morning rate of 14.5%. On the weekend, none of the rates are significantly elevated above the early morning rate of 13.7% (Table Eight).

The difference in coefficients of variations by weekend also differed by ownership. Private hospitals had the largest decrease in variation on weekends, and Kaiser hospitals had a small non-significant increases in the coefficients of variation for the weekend (Table Nine).

Teaching. Stratified by teaching status, public and private teaching hospitals show a decrease in the diurnal variations and the weekend differences. The patterns of the public and private non-teaching hospitals are relatively consistent, and appear more like Kaiser hospitals in rate variations than their non-teaching counter parts. Public and private non-teaching hospitals show an accentuation of their weekday diurnal variations. Kaiser teaching hospitals and non-teaching hospitals show little difference, although the teaching hospitals have greater diurnal variations (Table Nine).

Cephalopelvic Disproportion

The rate of cesarean given the diagnosis of CPD was approximately 95%. The total rates of cesarean delivery for CPD by hospital ownership were: private 8.9%, public 4.8%, and Kaiser 6.1%. These rates also showed significant diurnal variations, with coefficients of variation by ownership greatest for public hospitals and least for private hospitals: private 0.238, public 0.284, and Kaiser 0.241 (Figure 21).

Rates for CPD also decreased in teaching hospitals. As with overall rates of emergent cesarean, public hospitals had the greatest teaching

decrement, -5.0% (95% CI -5.4,-4.7). The teaching decrement was -1.5% (-2.0,-1.1) for private hospitals, and -3.3 (-3.9,-2.7) for Kaiser hospitals. Rates for CPD also decreased on weekends for public and private hospital. The weekend decrement was -0.5% (-0.8,-0.1) for private hospitals. Public hospitals had the greatest weekend decrement, -1.0% (-1.4,-0.6). The weekend decrement was +0.3 (0.4,1.0) for Kaiser hospitals (Table 11) (Table Eleven; Figures 22-27).

Counter to theory, the coefficients of variation were greatest in public hospitals and nearly equal in private and Kaiser hospitals. Furthermore, the coefficients of variation actually increased in teaching hospitals, with a difference for teaching hospitals of: private +0.022, public +0.052, and Kaiser hospitals -0.031. In contrast, weekend coefficients of variation did decrease for cesarean delivery for cephalopelvic disproportion. The weekend changes were private -0.026, public -0.101, and Kaiser hospitals +0.015 (Table Twelve).

Coding Errors

Of the three-hundred thirty-three hospitals, twenty-six had less than sixteen births to the study population of women--ten public hospitals, seventeen private hospitals, and one Kaiser hospital. There were 55 births to these facilities, with a cesarean delivery rate of 22%. As no hospitals had sixteen to thirty births, there seems to be a natural split. Hospitals with fewer than sixteen births probably do not have a regular labor and delivery department and so perhaps should be excluded from the analysis as atypical. However, they are included.

Excluded from the analysis were births without type of delivery coded (1,135 births, 0.21% of the total), with unspecified cesarean delivery coded (758, 0.14%), births without time of birth coded (247, 0.05%), and without a hospital coded (8,356, 1.6%). All records had the date of birth entered. The number of

non-coded births, by birth hour, ranged from 34 to 68, with a mean of 46.4 and standard deviation of 7.7. Given the small numbers of non-coded births and the lack of a strong diurnal pattern, these omitted records are not likely to affect the analysis significantly.

Chapter Six

Discussion and Conclusions

Overview

This study demonstrates that resource availability significantly affects the timing of cesarean delivery. These results are consistent with the hypotheses that variations in availability of physicians and resources affect diurnal rates of cesarean delivery, and that the institutional settings in which physicians practice affect their response to such non-clinical factors. While other authors have examined diurnal variations in cesarean delivery related to physician convenience, they failed to clearly demonstrate these effects.

This study has several data and research design limitations, including the absence of several useful data elements, potential problems with data quality, no specific information on the attending physicians, and the exclusion of potentially important data from this analysis. However, these shortcomings should not change the conclusions of this investigation.

Consonant with past research, this study demonstrates the importance of non-clinical factors in physician decision making. While many factors play a role in diurnal variations in cesarean delivery rates, these findings suggest that physician availability or convenience plays a significant role, and that the organizational setting within which physicians practice modifies these effects. The study largely validates the ten hypotheses presented in Chapter Three. The findings of this research have important implications for health care policy. Future research is proposed to evaluate further the significance of diurnal variations in rates of cesarean delivery.

Research Findings

Hypothesis 1 The overall rates of elective and emergent cesarean delivery will be highest for private and non-teaching hospitals.

Consistent with previous studies, the overall rates of emergent cesarean delivery are highest in private hospitals (24.5%). Public hospitals had intermediate rates (16.8%), and Kaiser hospitals had the lowest rates (15.7%). In addition, hospitals with obstetrical residency teaching programs had lower emergent primary cesarean rates than similar hospitals without such programs. The effect of teaching status was least for Kaiser hospitals (-0.1%), and greatest for public hospitals (-6.2%).

Unexpectedly, teaching status had a smaller effect upon private hospitals than upon public hospitals. The small decrease (-0.49%) associated with teaching status is not significant for the 12% of private hospital births at teaching hospitals. As not all births at teaching hospitals are attended by residents, this smaller effect may simply reflect a smaller proportion of births delivered by residents in teaching hospitals under private ownership, and a greater proportion by private practice physicians.

Kaiser hospitals and teaching hospitals have low rates for similar reasons, including peer review, the expectation to justify every cesarean delivery, and shift staffing patterns. Therefore, as expected, teaching status has little additive effect upon Kaiser hospitals.

Hypothesis 2 *Daytime increases* will occur in rates of *elective* cesarean deliveries.

Hypothesis 3 *Diurnal variations* will occur in rates of primary, *emergent* cesarean deliveries.

Hypotheses 2 and 3 are largely confirmed by the results. This study found marked diurnal variations in the rates of cesarean delivery, with higher rates during the day and lower rates at night. Also, there are daytime rate peaks at particular times corresponding to times of physician availability. Both private and public hospitals show increases around 8am, lunch time, and after regular working hours. Rates at all three hospital types were highest in the evenings and lowest in early morning hours. This probably reflects both a desire to avoid attending labor into the early morning hours and a physiologic variation in labor (69).

Counter to one aspect of Hypothesis 3, however, rates of emergent cesarean are not decreased during times of elective cesarean deliveries. The opposite is true: Both rates are elevated at similar times. At private hospitals in particular, these times are when physicians are the most available. Therefore, this finding strongly suggests that physician availability is more important in timing cesarean delivery than competition for hospital resources such as staff and operating rooms.

Hypothesis 4 The *magnitude* of these diurnal variations in primary, emergent cesarean rates will be least for Kaiser hospitals and for hospitals with obstetrical residency teaching programs.

The magnitudes of these variations are different between hospitals, as hypothesized. As determined by the coefficients of variation, the magnitude is (1) least for Kaiser hospitals and greatest for private hospitals, and (2) least

for hospitals with obstetrical residency teaching programs and greatest for those without such programs. Teaching and Kaiser hospitals have low variation for similar reasons: fewer physician convenience incentives and more physician oversight to prevent over-utilization of cesarean delivery. For this reason, teaching status has little effect upon Kaiser hospital physicians.

Hypothesis 5 Weekend rates of *elective* cesarean delivery will be lower than on weekdays.

Hypothesis 6 Weekend rates of primary, *emergent* cesarean delivery will also be lower.

Hypothesis 7 The primary, emergent cesarean weekend rate differences will be greatest in magnitude for both *private* and *non-teaching* hospitals.

During the weekend, rates of primary, emergent cesarean delivery are lower. The weekend effect is greater for private hospitals, and smaller for public and Kaiser hospitals. This weekend effect is least for teaching hospitals of all types. By ownership, the weekend decrement by teaching status is 2.3% for private, 1.9% for public, and 0.4% for Kaiser hospitals.

These findings also support the contention that Kaiser hospitals are very similar to teaching hospitals--in staff scheduling, peer review, and physician expectations. For this reason, teaching status has little effect on Kaiser hospitals. Organizationally, Kaiser teaching and non-teaching hospitals are very similar: Kaiser obstetrical residents and non-teaching staff physicians are also relatively similar in the degree of oversight and convenience incentives.

Evaluation by coefficients of variation shows that private hospital weekend rates of primary, emergent cesarean delivery demonstrate less diurnal variation than weekday rates. Public hospitals had a smaller decrease in variation, and Kaiser hospitals an increase in variation on weekends. These differences correspond to the physician convenience incentives. Private practice physicians have many weekday schedule conflicts, but few on the weekends. Kaiser hospitals are less affected by the weekday patient scheduling conflicts.

Diurnal variation in private hospitals reflected the daily weekday schedule conflicts of private practice physicians, with relatively lower rates during usual late morning and early afternoon private patient appointment times (7-10am, 12-3pm). Private practice physicians are most available to perform cesareans during morning rounds, during lunch, and after work. These specific diurnal variations disappear on weekends, confirming their association with private practice clinic scheduling. Similarly, Kaiser hospital had lower rates when cesarean delivery is inconvenient due to nursing and physician shift changes or to the regular midday meetings and lunchtime.

Hypothesis 8 The proportion of births by cesarean section for *CPD* will show similar variations, by time, hospital, teaching status, and weekend.

Rates of cesarean delivery for CPD were highest in private hospitals and lowest in public hospitals, counter to hypothesis One and the results for total emergent cesarean deliveries. As anticipated, in public and private hospitals the rates of cesarean for CPD increased in non-teaching hospitals and decreased on weekends. In Kaiser hospitals, these effects were reversed.

As measured by the coefficients of variation, these rates of primary, emergent cesarean delivery for CPD showed greater variations, by time, hospital, teaching status, and weekend, than the overall rates of primary, emergent cesarean delivery. This may be due to the greater magnitude of random error expressed in these coefficients as the number of events became smaller.

However, by decreasing in non-teaching public and private hospitals, the coefficients of variation did not conform to the original expectations. The coefficients of variation did decrease on weekends for public and private hospitals. These mixed results fail to confirm the hypothesis that cesarean delivery for CPD would serve as a more sensitive measure of medical practice variations. Further analysis is needed to determine these results are problematic because of the data, methodology, or theory.

Hypothesis 9 Time, hospital, teaching status, and weekend will exert *independent effects* on both the rates of primary, emergent cesarean delivery and of primary, emergent cesarean delivery for CPD.

Hypothesis 10 Statistically significant *interactions* between time, hospital type, and weekend will be consistent with resource availability and hospital setting affecting clinical decisions.

Logistic regression demonstrated that time, hospital, teaching status, and weekend had independent effects on the rates of primary, emergent cesarean delivery and on the proportion of primary, emergent cesarean delivery with the diagnosis of CPD. Interaction terms are also significant, conforming the above hypotheses.

Study Limitations

There are several potential limitations of this study. To evaluate diurnal variations in rates or cesarean delivery, a large sample is needed. The

use of publicly available birth records data, while a statistically powerful and efficient approach, has four main disadvantages: limited data on physician and insurer; questions about data quality; no control of risk; and limited data on patient and birth.

Physician and insurer. There is a limited range of data elements available. The analysis infers the physician's practice pattern and insurance payer from the hospital of birth's ownership and teaching status. This indirect method may incorrectly classify some births, even in the restricted categories of Kaiser hospitals and non-teaching private hospitals. It prevents a refined analysis of births at the mixed hospitals where both private practice physician and resident attended births. When analyzing the effect of teaching status, this exerts a conservative bias.

Past studies have highlighted the importance of payer in medical practice patterns, including those for cesarean delivery (3-12). As these data are absent for the 1988 birth records, this study cannot determine payer status. However, one can infer that private hospitals and non-teaching hospitals have more private insurance patients, and that Kaiser insurance covers Kaiser hospital births. Finally, the data have limited information on medical complications and diagnoses. This limited case-mix adjustment and more refined cesarean indication-specific analyses.

Data quality. There are potential problems with consistency in coding and in non-coded variables and completeness. The variability in hospital-specific rates suggests large differences in coding between hospitals. This variability mainly affects the determination of overall rates. If coding varies by hospital type, then assessing overall rates is inappropriate from these data. However, the study is mainly concerned with diurnal variations in rates. As

long as these differences in hospital coding are not independently associated with time of day, any confounding of diurnal variation is minimal.

Also of concern are non-coded variables, which are excluded from the analysis. These exclusions may confound the diurnal variations in rates of cesarean delivery. To confound the results substantially, the non-coded values need to be independently associated with the different hospital categories, have a diurnal pattern different from correctly coded births, and both of these effects need to be of significant magnitude. Fortunately, the small number of non-coded variables relevant to the analysis and their lack of marked diurnal variation renders any confounding statistically insignificant.

Another concern about the data is it is from 1988. The use of four-year-old data, while not unusual in health services research, may limit generalizing this study's conclusions, because of the dramatic changes occurring in patterns of cesarean childbirth.

Control of risk. This study does not directly control for risk. Because of this, no definitive determination can be made of "excess" cesarean deliveries. However, the study controls for risk indirectly, as noted, by limiting the analysis to diurnal variations in non-elective singleton deliveries to nulliparous women. In particular, the duration of labor is not determinable.

Patient and birth. There are few data elements for labor complications. This limits the analysis of cesarean section by indication. Also, no information is available for duration of labor. Without this variable, few conclusions are possible about the important indications of prolonged labor and failure to progress. This omission is significant because these indications are likely to be associated with "convenience".

Interpretation of the Results

The results of this investigation largely confirm the ten hypotheses presented in Chapter Three. The results also validate past research indicating the prominent role of non-clinical factors in medical decision making. In addition, these results allow the examination of several specific aspects of medical practice variation. These results are consistent with the hypothesized model of decision making: 1) resource availability affecting rates of cesarean delivery (e.g., effects of physician convenience); 2) the institutional setting affecting the response of physicians to non-clinical factors such as time of day; and, 3) cesarean delivery for the relatively non-acute and discretionary diagnosis of CPD showing more elasticity to non-clinical influences.

Convenience and Availability

Demand. The supply and demand model for cesarean delivery presented in Chapter Three is validated through these results. The demand for cesareans seemed to be relatively constant and consistent between health care centers. As found by other authors (68,69), there were diurnal variations in the numbers of nulliparous women giving birth by non-elective means. However, these variations were modest and relatively consistent between hospitals. The also was little evidence for acute changes in clinical severity. Consistent with other research (69), there was a generally sinusoidal distribution in cesarean deliveries, with an evening peak and nighttime low. The consistency of this nighttime low suggests that it may partly reflect less complicated deliveries. This is consistent with research showing increased uterine contractions and shorter durations of labor at night (72). However, these variations in *demand* do not explain the variations associated with weekends, with specific daytime hours, and with hospital ownership and

teaching status. These variations show that physician convenience and availability influence the timing of cesarean delivery.

Private practice physicians. The weekday non-Kaiser hospital rates reflect the desire of physicians to avoid cesarean delivery during private practice clinic hours. There are relatively lower rates during private patient appointment times. These daytime variations disappear during weekends, confirming that these variations are due to weekday scheduled private patient appointments. Not only do the daytime variations decrease on weekends when there are no scheduled clinic appointments, but also the weekend rates are lower. These findings are supported by the decrease in diurnal variation on weekends (as measured by coefficients of variation), and by the smaller magnitude of these effects in non-Kaiser teaching hospitals, where proportionally fewer physicians are in private practice. Kaiser physicians also respond to convenience incentives. Although their schedules attempt to avoid conflicts between clinic patients and attending labor, other factors such as shift changes influence the hourly rates of cesarean delivery.

Nighttime. As noted above, the nighttime decrease in rates of cesarean delivery is partly physiologic (72). However, private practice physicians usually attend patients at private and non-teaching hospitals. These private practice physicians generally follow each labor until delivery and therefore have a convenience incentive to expedite delivery by performing a cesarean section. These incentives explain the relatively greater evening peak and early morning decrease in rates at non-Kaiser and non-teaching hospitals.

Weekends. All hospitals had lower rates on weekends. The low weekend rates of primary, emergent cesarean delivery reflect the general decrease in the weekend availability of physician and staff resources necessary for cesarean delivery. Also, the weekend rates of primary, emergent cesarean

delivery demonstrate less diurnal variation when compared to weekday rates, reflecting reduced competing scheduling demands on physicians.

Electives. Counter to the research Hypothesis Three, the rates of elective and emergent cesarean delivery were elevated during the same hours. This suggests that competition for operating room and hospital staff resources are less important than the availability of physicians.

Organizational Setting

These results are also consistent with an important effect by health care organizational setting physician behavior and response to non-clinical influences. The hospital setting, in this thesis specified by ownership and teaching status, has two effects upon the convenience incentives for the timing of cesarean delivery as discussed in this thesis. First, the hospital setting can change the incentives upon the physician. Certain incentives are peculiar to specific hospital environments, as noted above. Private practice physicians have weekday schedule conflicts which influence their timing of cesarean delivery. Although they lack such conflicts, Kaiser physicians are influenced by shift changes and meal hours. Second, the hospital setting determines the responsiveness of the physicians to convenience incentives. The difference in responsiveness between hospital settings can be ascertained through the physician responsive to convenience incentives that are common between all hospitals: the nighttime and weekends.

Private hospitals. Physicians at private hospitals have greater variations in diurnal rates as measured by coefficients of variation. These variations suggest both the increased presence of convenience incentives and a greater response to such incentives. The presence of incentives unique to private practice physicians is noted above. These private practice physicians

also have increased elasticity to convenience incentives, as demonstrated by the greater weekend and nighttime decrements at private hospitals.

Teaching hospitals. Due to the increase in resident-attended labors, both public and private teaching hospitals show a diminution of the weekday variations related to private practice physician schedule conflicts. Teaching hospitals also demonstrate a decreased response to common incentives such as nighttimes and weekends as shown by smaller rate decrements than their non-teaching counterparts. The teaching hospitals also demonstrate less diurnal variation as measured by the CV of hourly rates. Teaching status probably did not affect private hospitals as much as public hospitals because a smaller proportion of the private hospital's deliveries are attended by residents.

Kaiser hospitals. Kaiser hospitals had consistently lower rates and less variation than public and private hospitals. Kaiser hospital rates also showed smaller decrements for the weekend and nighttime. There is also decreased variations as measured by coefficients of variation, and smaller changes in variation on weekends, or in teaching hospitals.

As noted, the weekend differences in magnitude and variations of primary, emergent cesarean rates are greatest for both private and non-teaching hospitals, as compared to Kaiser and obstetrical residency teaching hospitals. Teaching status has less effect with Kaiser hospitals because the staffing patterns and oversight mechanisms of their physicians are similar to those of residents in teaching hospitals.

Cephalopelvic Disproportion

The overall rates of primary, emergent cesarean delivery for CPD failed to be consistent with previous findings and to show greater elasticity. The coefficients of variation are larger than those of total primary emergent

cesarean. However, the utility of this indication for cesarean delivery in the 1988 birth records appeared limited. The utility of cesarean delivery for CPD may be limited by variations in coding and small numbers. Further analysis is needed to determine whether this is the fault of the data, methodology, or theory.

Conclusions

The present study not only confirms past research indicating the importance of non-clinical factors in medical practice, but also has important implications for public policy and future research.

Interventions

This study has three important implications for interventions aimed at lowering cesarean section rates. Such interventions cannot simply focus on physician education, for this ignores the important roles of health care organization and physician availability suggested by this thesis.

First, as the magnitudes of diurnal variation are positively correlated with high rates of cesarean delivery, these variations may be causing increased use of cesarean delivery. Because there is no control of clinical factors, this analysis cannot ascertain whether these variations result in excess cesarean deliveries or merely redistribute cesareans temporally. However, several reasons suggest that these variations reflect an increased proportion of surgical delivery. The diagnosis of failure to progress, if made prematurely, will probably cause higher cesarean rates. Some of these cesarean births, if allowed to continuing in labor, may have been vaginal deliveries. Also, deciding to deliver abdominally to avoid later schedule conflicts may cause the physician to under use other therapeutic modalities that may have allowed safe vaginal delivery. Finally, the strong correlation between high

rates and high variation (private hospitals, non-teaching hospitals, weekdays versus weekends) all suggest, but do not prove, a causal relationship between high cesarean delivery rates and large diurnal variations in rates due to physician convenience.

Therefore, physician convenience may play a substantial role in the high cesarean delivery rates at private and non-teaching hospitals. Changes in staffing patterns, to both reduce daytime schedule conflicts and nighttime conflicts with the need to sleep, may help to reduce the high rates of cesarean delivery at private and non-teaching hospitals.

Second, hospital staff scheduling patterns that foster diurnal variations in rates of cesarean delivery need to be elucidated and modified. Such effects are probably not limited to Kaiser hospitals. This analysis could only demonstrate them their because of the consistency of Kaiser's staffing patterns and the relative absence of other convenience incentives. Interventions need to set schedules for obstetrical nurses and staff so as to equalize the convenience of cesarean delivery throughout the day.

Third, the accountability mechanisms found in Kaiser and teaching hospitals, such as the peer review, should be expanded to other hospital settings. These systems decrease the elasticity of physicians to non-clinical convenience incentives. Conversely, the lack of effect of teaching status upon Kaiser hospitals suggest that little benefit is accrued from redundant interventions. Any intervention based upon peer review may have less effect in Kaiser and teaching hospitals. Similarly, economic incentives will be less influential at Kaiser or teaching hospitals.

Fourth, specific diagnoses, such as CPD for cesarean delivery, may be especially susceptible to non-clinical influences and therefore medical practice variation. However, in these data the utility of cesarean delivery for CPD is

limited by variations in coding and small numbers. As discussed above, further evaluation of diagnostic information may reveal other diagnoses prone to non-clinical influences. These diagnoses are of interest as statistically sensitive indicators of medical practice variation and as important areas for health policy intervention.

Future Research

While this study demonstrated significant diurnal variations in rates of cesarean delivery that differed by organizational setting and teaching status, unanswered questions remain. Two key questions for future research are: 1) Why are there variations? 2) Are these excessive or redistributed cesareans?

Variations. The roles of patient, doctor, staff, and convenience in diurnal variations need to be further assessed. Research into medical practice patterns needs to elucidate the nature of physician convenience and availability incentives, the relative elasticity of specific medical procedures to non-clinical influences, and the modifying influences of organizational setting on non-clinical incentives. Furthermore, future research needs to account for the multitude of factors that affect availability of physicians and health care resources to prove a significant role for physician convenience.

For example, the decrease in nighttime rates may reflect either natural physiologic changes in labor or a relative lack of availability of necessary anesthesiology support. The latter hypothesis can be tested by comparing nighttime rates of cesarean delivery at large, urban hospitals where anesthesia is relatively available at night with births at smaller, rural hospitals.

Excess. As no adjustment is made for maternal clinical characteristics, the analysis cannot determine how much the higher rates for some hospital categories (such as proprietary and non-teaching hospitals) are due to different patient populations rather than inherent practice variations. To

discern whether these are excess or redistributed cesareans, future research needs to control for clinical complexity by hospital ownership, teaching status, weekend, and hour. Then, these rates can be directly compared between hospitals.

Ongoing research. Given the importance of the individual practice style of physicians in cesarean delivery rates (77), more specific information is needed on the expected payer for the delivery. This will improve the inference about the type of physician attending the delivery. For example, private insurance patients are more likely to have private practice physicians, and indigent patients to have resident and staff physicians. Ongoing research by the author using 1989 California birth records data is attempting to address these issues. In addition, unique identifier codes are being added to some health care data bases. When this is added to the California Births Records, the diurnal variations in individual physicians can be calculated.

Several methods can improve the statistical power of this analysis. This analysis assumes that cesarean rates should be equal throughout the day. Alternatively, a sine curve can be fitted to the data. Also, instead of treating teaching status as dichotomous variable it can be converted to a continuous variable by making it the proportion of births at a hospital that are attended by the residents. This may not be necessary because of the increased detail of payer and diagnostic variables in 1989 birth-cohort records. These data will allow more specific analysis of the mechanisms behind the observed variations.

Conclusion

Medical practice variations waste health care dollars and cause iatrogenic disease (1). Cesarean section is an important and controversial

example of medical practice variation. A better understanding of clinical decision making and the modifying effects of hospital organization helps to determine the most effective reforms. This thesis validates a three-part model for medical decision making. First, the availability of the necessary resources influences clinical decisions. Daily variations in rates of cesarean section occur because the demand and availability of resources for cesarean delivery are not constant during the day. An especially provocative finding is the influence of physician convenience on the timing of cesarean delivery. Second, hospital organization modifies the physician's response to non-clinical factors. Third, some medical situations may be intrinsically more prone to medical practice variations. These findings have important implications for health care policy and future research.

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TABLES

Emergent Primary Cesarean Section in Nulliparous Women, California 1988

Table One:
Cesarean Rate by Hospital Ownership

Hospital Ownership	Number of Hospitals	Number of Births	Cesarean Rate
Private	231	126,108	24.5%
Public	84	48,385	16.8%
Kaiser	18	21,339	15.7%
Total	333	195,832	21.6%

Table Two:
Teaching Hospitals by Ownership: Deliveries as a Percent of Total.

Hospital Ownership	Number of Teaching Hospitals	Number of Births	Births as a Percent of the Total
Private	11	15,108	12.0%
Public	14	21,474	44.4%
Kaiser	6	9.213	43.2%

Emergent Primary Cesarean Section in Nulliparous Women, California 1988.

Table Three:
Differences in Cesarean Rates by Teaching Status and Hospital Ownership

HOSPITAL	Non-Teaching	Teaching	Change (95% CI)	P-value
Private	24.6%	24.1%	-0.5% (-2.4/1.2)	0.20
Public	19.5%	13.3%	-6.2% (-6.9/-5.6)	<0.0001
Kaiser	15.2%	15.1%	-0.1% (-1.0/0.9)	0.91

Table Four:
Weekday and Weekend Differences in Cesarean Rates by Hospital Ownership

HOSPITAL	Weekday	Weekend	Change (95% CI)	P-value
Private	25.2%	22.5%	-2.7% (-3.3/-2.2)	<0.0001
Public	17.5%	14.8%	-2.7% (-3.4/-2.0)	<0.0001
Kaiser	15.5%	14.3%	-1.3% (-2.3/-0.6)	0.019

Emergent Primary Cesarean Section in Nulliparous Women, California 1988.

Table Five:

Weekday and Weekend Differences in Cesarean Rates by Hospital Ownership and Teaching Status

HOSPITAL	Teaching Program	Weekday Rate	Weekend Rate	Difference	P-value
Private	No	25.3%	22.6% (22.0-23.2)	-2.7%	<0.0001
Private	Yes	24.9%	24.5% (20.3-23.5)	-0.4%	0.65
Public	No	20.4%	17.0% (16.0-18.0)	-3.5%	<0.0001
Public	Yes	13.7%	12.2% (11.0-13.5)	-1.6%	0.13
Kaiser	No	15.3%	14.8% (13.5-16.3)	-0.5%	0.49
Kaiser	Yes	15.8%	13.9% (11.6-15.6)	-1.9%	0.093

Emergent Primary Cesarean Section in Nulliparous Women, California 1988.

Table Six:
Coefficients of Variation for Total Births, Elective, and Emergent Cesareans by Hospital Ownership

Hospital	All Deliveries CV	Elective Cesarean CV	Emergent Cesarean CV
Private	0.17	0.92	0.16
Public	0.08	0.81	0.15
Kaiser	0.08	0.72	0.11

Emergent Primary Cesarean Section in Nulliparous Women, California 1988.

Table Seven:

Odds Ratios and 95% C.I. of Rates Compared to 1-7am Rate by Hospital Ownership:

PRIV.	1-7am	7-10am	10-12	12-3pm	3-5pm	5-1am
Rate	19.3%	25.2%	21.8%	25.3%	22.1%	28.1%
Odds Ratio	**1.0**	**1.4** (1.4-1.5)	**1.2** (1.1-1.2)	**1.4** (1.4-1.5)	**1.2** (1.1-1.3)	**1.6** (1.6-1.7)
P-value	- -	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
PUBLIC						
Rate	13.4%	16.3%	15.5%	16.8%	17.2%	19.2%
Odds Ratio	**1.0**	**1.3** (1.2-1.4)	**1.2** (1.1-1.3)	**1.3** (1.2-1.4)	**1.4** (1.2-1.5)	**1.5** (1.4-1.7)
P-value	- -	<0.0001	<0.0001	0.0007	<0.0001	<0.0001
KAISER						
Rate	14.3%	13.80%	16.99%	14.72%	14.20%	16.20%
Odds Ratio	**1.0**	**0.96** (0.8-1.1)	**1.23** (1.1-1.4)	**1.04** (0.9-1.2)	**0.99** (0.9-1.2)	**1.16** (1.1-1.3)
P-value	- -	0.59	0.0058	0.58	0.95	0.003

P-value is significance of difference between the rate and 1-7am rate.

Table Nine:

Hourly Coefficients of Variation by Hospital Ownership, Teaching Status, and Weekday vs. Weekend

	Total Coefficient of Variation	Weekday Coefficient of Variation	Weekend Coefficient of Variation	Difference (C.I)	No Teach. Coefficient of Variation	Teaching Coefficient of Variation	Difference (C.I)
Private	0.16	0.170	0.136	-0.034 (-.038/-.030)	0.165	0.115	-0.049 (-.055/-.044)
Public	0.15	0.159	0.147	-0.012 (-.019/-.005)	0.182	0.105	-0.078 (-.084/-.072)
Kaiser	0.11	0.118	0.177	+0.059 (.048/.070)	0.144	0.136	-0.009 (-.018/.001)

Emergent Primary Cesarean Section in Nulliparous Women, California 1988.

Table Ten:

Rates, Odds Ratios, and 95% C.I. Compared to 1-7am Rate by Hospital Ownership and Obstetrical Teaching Status for Weekday and Weekend

OWNERSHIP Teaching	1-7am Week-Day Rate	1-7am Week-End Rate	7-10am Week-Day OR CI	7-10am Week-End OR CI	10-12 noon Week-Day OR CI	10-12 noon Week-End OR CI	12-3pm Week-Day OR CI	12-3pm Week-End OR CI	3-5pm Week-Day OR CI	3-5pm Week-End OR CI	5-1am Week-Day OR CI	5-1am Week-End OR CI
PRIVATE Non-Teaching	19.5% --	17.9% --	1.5 1.4-1.6	1.0 0.8-1.1	1.1 1.0-1.2	1.3 1.1-1.5	1.5 1.4-1.6	0.9 0.8-1.0	1.1 1.0-1.2	1.3 1.2-1.5	1.7 1.7-1.8	0.9 0.8-1.0
PRIVATE Teaching	21.0% --	19.8% --	1.3 1.1-1.4	0.9 0.7-1.3	1.3 1.1-1.5	0.7 0.5-1.0	1.3 1.1-1.4	0.8 0.6-1.1	1.2 1.0-1.3	1.1 0.8-1.5	1.4 1.2-1.5	0.9 0.7-1.2
PUBLIC Non-Teaching	15.6% --	13.0% --	1.3 1.2-1.5	1.2 1.0-1.6	1.1 0.9-1.3	1.2 0.9-1.7	1.4 1.2-1.5	1.0 0.8-1.3	1.4 1.2-1.6	1.0 0.8-1.4	1.8 1.6-1.96	0.9 0.6-1.2
PUBLIC Teaching	12.1% --	11.1% --	1.1 0.9-1.3	0.9 0.7-1.3	1.2 1.0-1.5	1.0 0.7-1.4	1.2 1.0-1.4	0.9 0.6-1.2	1.3 1.1-1.5	0.9 0.7-1.4	1.2 1.1-1.4	1.0 0.8-1.3
KAISER Non-Teaching	14.2% --	14.2% --	1.0 0.8-1.3	0.6 0.4-0.9	1.2 0.9-1.5	0.9 0.6-1.4	1.1 0.9-1.3	1.1 0.8-1.7	1.1 0.8-1.3	1.1 0.7-1.6	1.2 1.0-1.4	1.1 0.8-1.5
KAISER Teaching	14.8% --	13.1% --	1.1 0.9-1.4	0.9 0.6-1.5	1.4 1.1-1.9	0.8 0.5-1.3	1.1 0.9-1.4	1.0 0.6-1.5	0.9 0.7-1.2	0.9 0.5-1.6	1.1 0.9-1.3	1.0 0.7-1.4

Note:

Weekend is defined as 6am Saturday Morning to 6am Monday Morning.
Confidence intervals represent 95% error bands.

Table Eleven:

Rates and 95% CIs for Cesarean Section with the Diagnosis of Cephalopelvic Disproportion by Hospital Ownership: Teaching versus Non-teaching Hospitals, and Weekday versus Weekend

CPD Rates	Teaching Rate	Non-Teaching Rate	Difference (95% CI)	Weekday Rate	Weekend Rate	Difference (95% CI)
Private	7.5%	9.1%	+1.5 (1.1,2.0)	9.0%	8.6%	-0.5% (-0.8,-0.1)
Public	2.0%	7.0%	+5.0% (4.7,5.4)	5.1%	4.1%	-1.0% (-1.4,-0.6)
Kaiser	4.1%	7.4%	+3.3 (2.7,3.9)	5.9%	6.2%	+0.3% (0.4,1.0)

Table Twelve:

Coefficients of Variation and 95% CIs for Cesarean Section with the Diagnosis of Cephalopelvic Disproportion by Hospital Ownership: Teaching vs. Non-teaching Hospitals, and Weekday vs. Weekend

CPD CVs	Teaching CV	Non-Teaching CV	Difference (95% CI)	Weekday CV	Weekend CV	Difference (95% CI)
Private	0.199	0.178	-0.022 (-.029,-.015)	0.187	0.167	-0.026 (-.031,-021)
Public	0.264	0.212	-0.052 (-.060,-.044)	0.239	0.138	-0.101 (-.108,-.094)
Kaiser	0.196	0.227	+0.031 (.020,.031)	0.168	0.184	+0.015 (.004,.026)

FIGURES

FIGURES

Figure 1

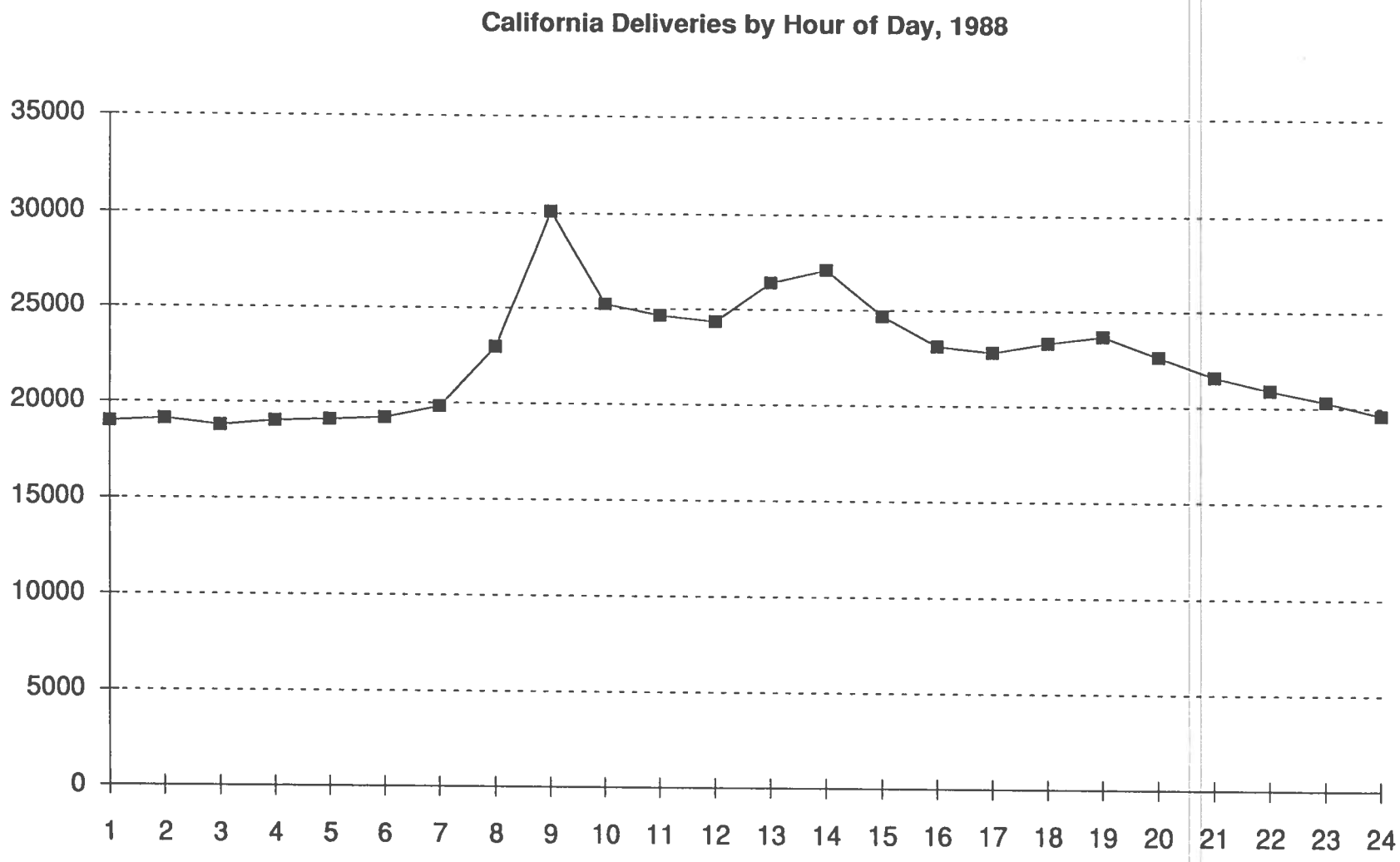

California Deliveries by Hour of Day, 1988
35000
30000
25000
20000
15000
10000
5000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Figure 2

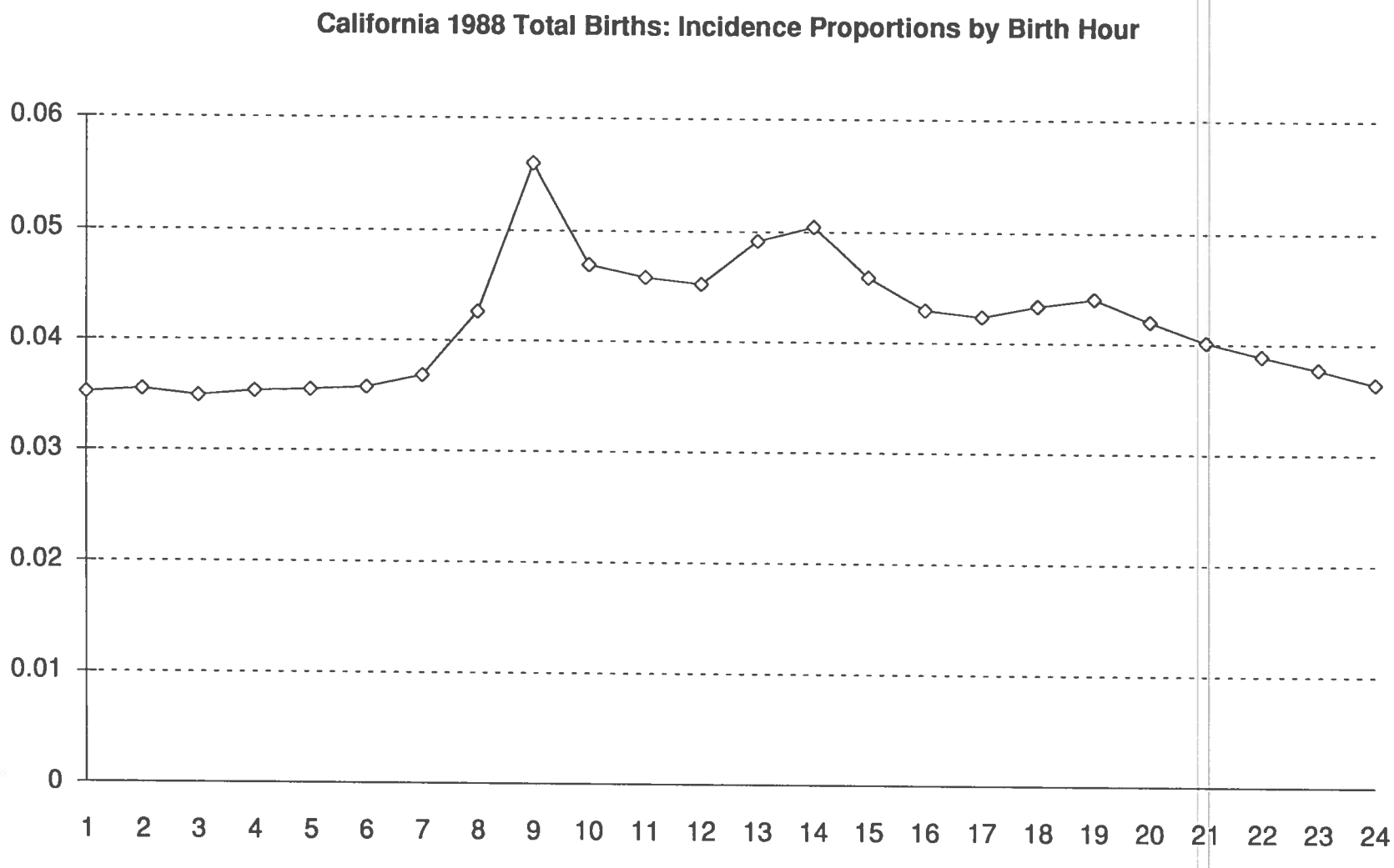

California 1988 Total Births: Incidence Proportions by Birth Hour
0.06
0.05
0.04
0.03
0.02
0.01
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Figure 3

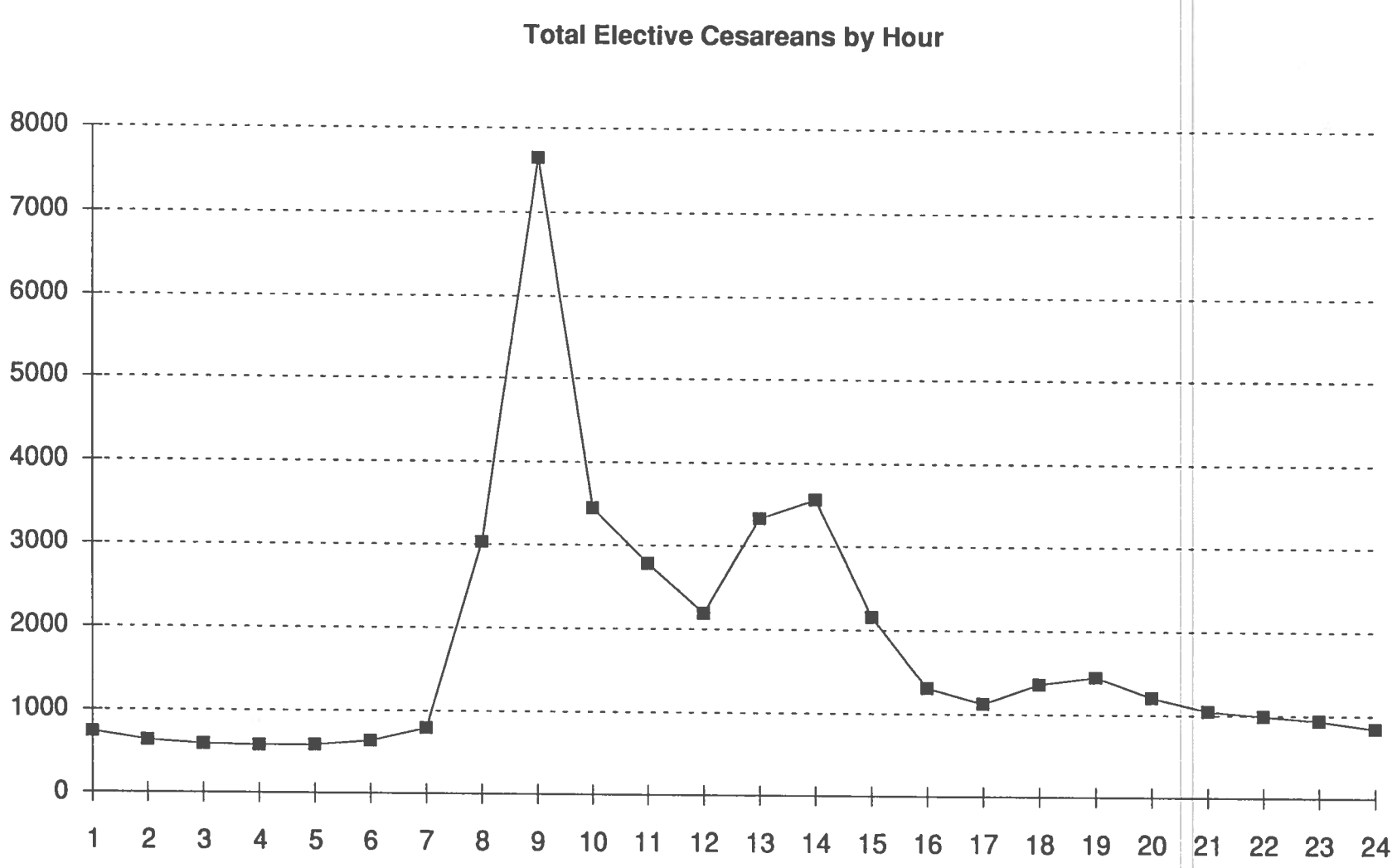

Total Elective Cesareans by Hour
8000
7000
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Figure 4

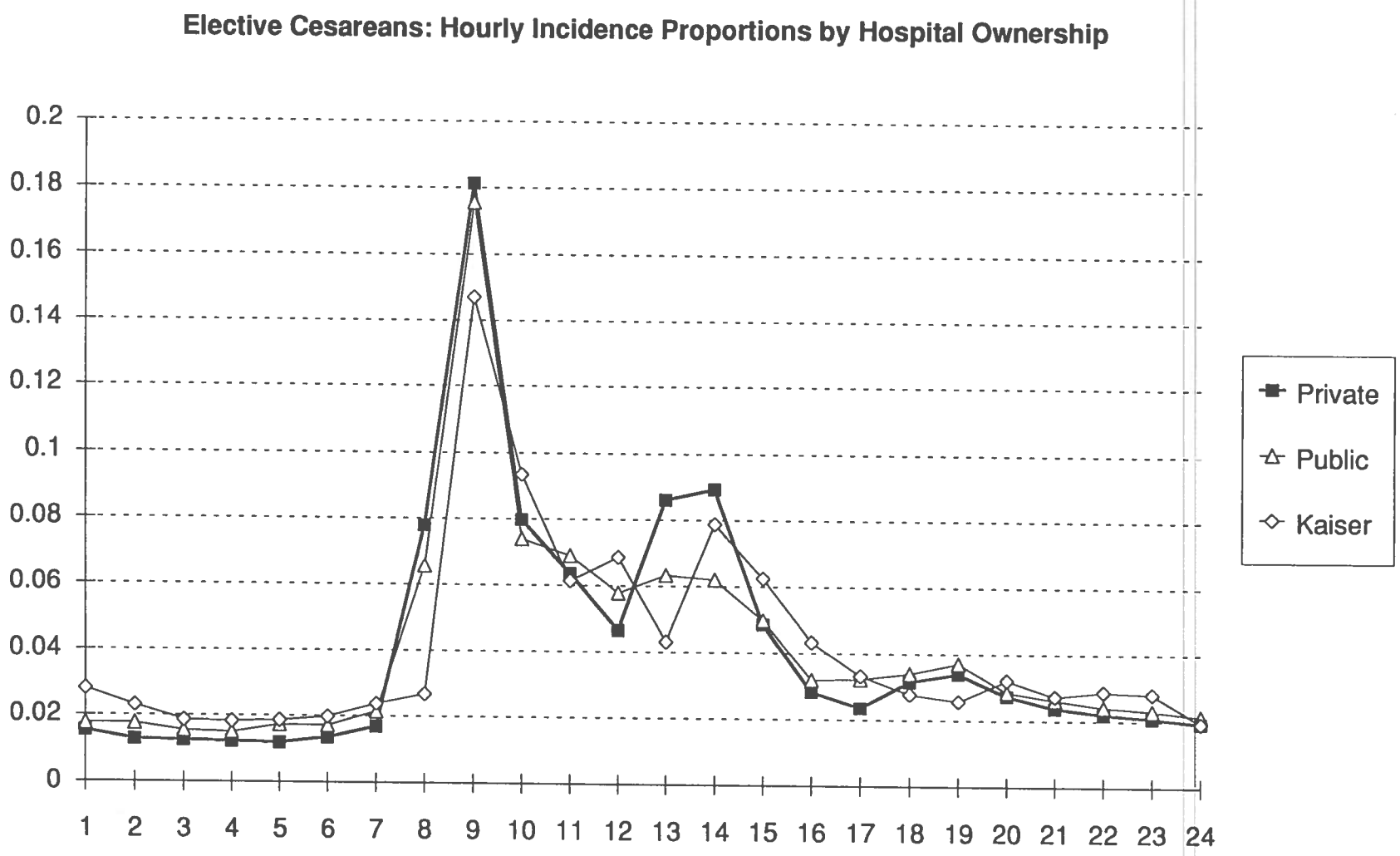

Elective Cesareans: Hourly Incidence Proportions by Hospital Ownership
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Private
Public
Kaiser

Figure 5

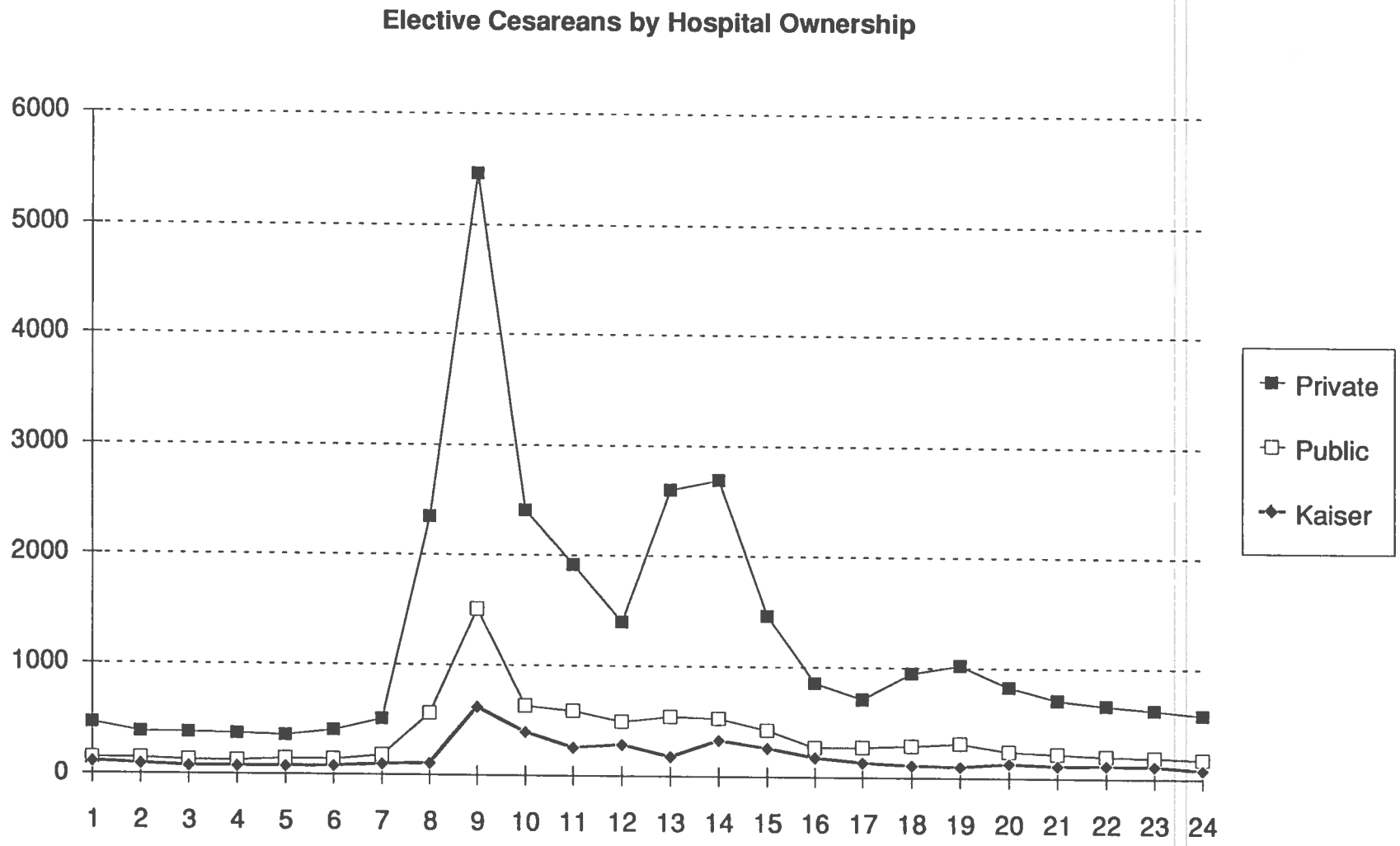

Elective Cesareans by Hospital Ownership
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Private
Public
Kaiser

Figure 6

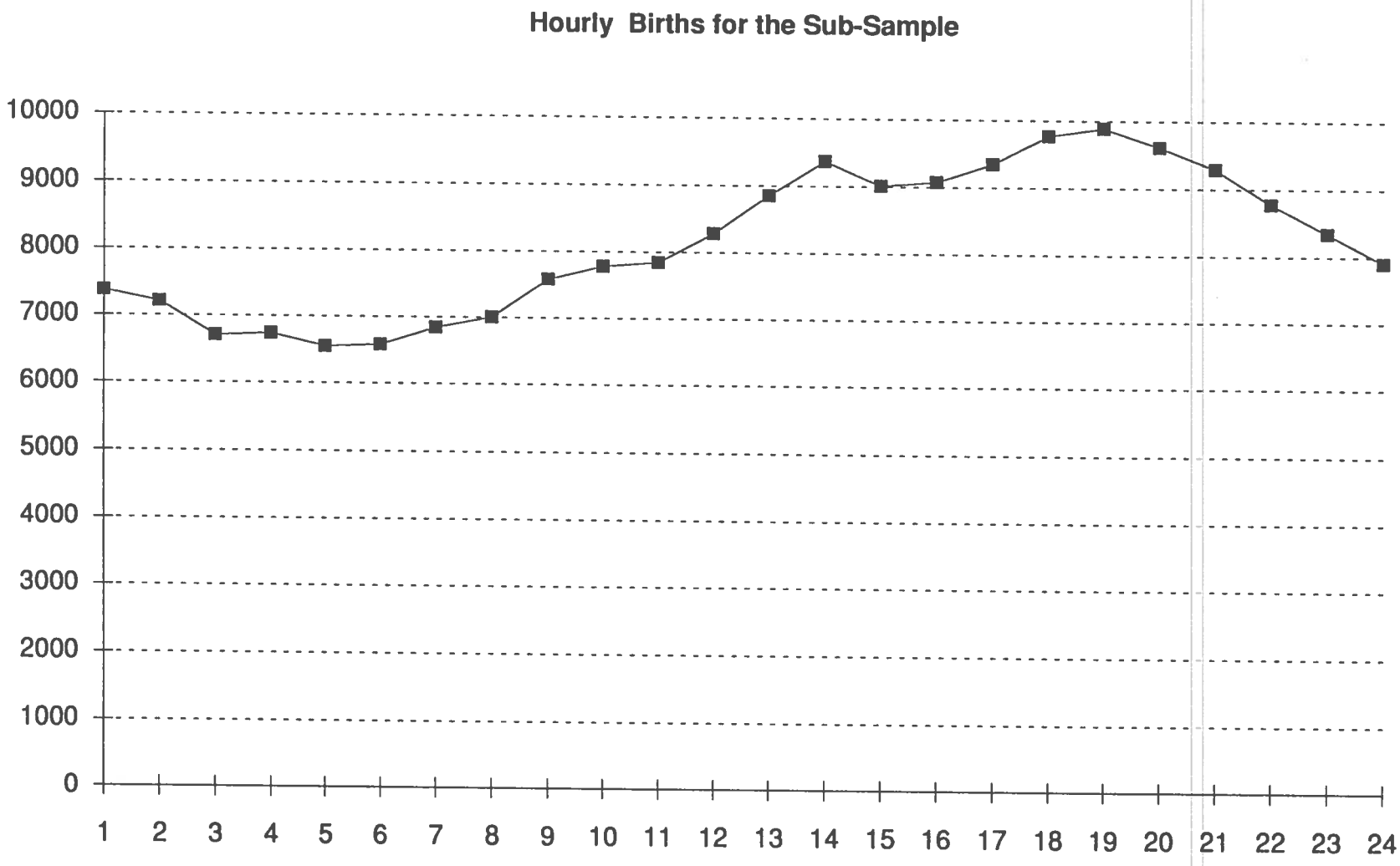

Hourly Births for the Sub-Sample
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Figure 7

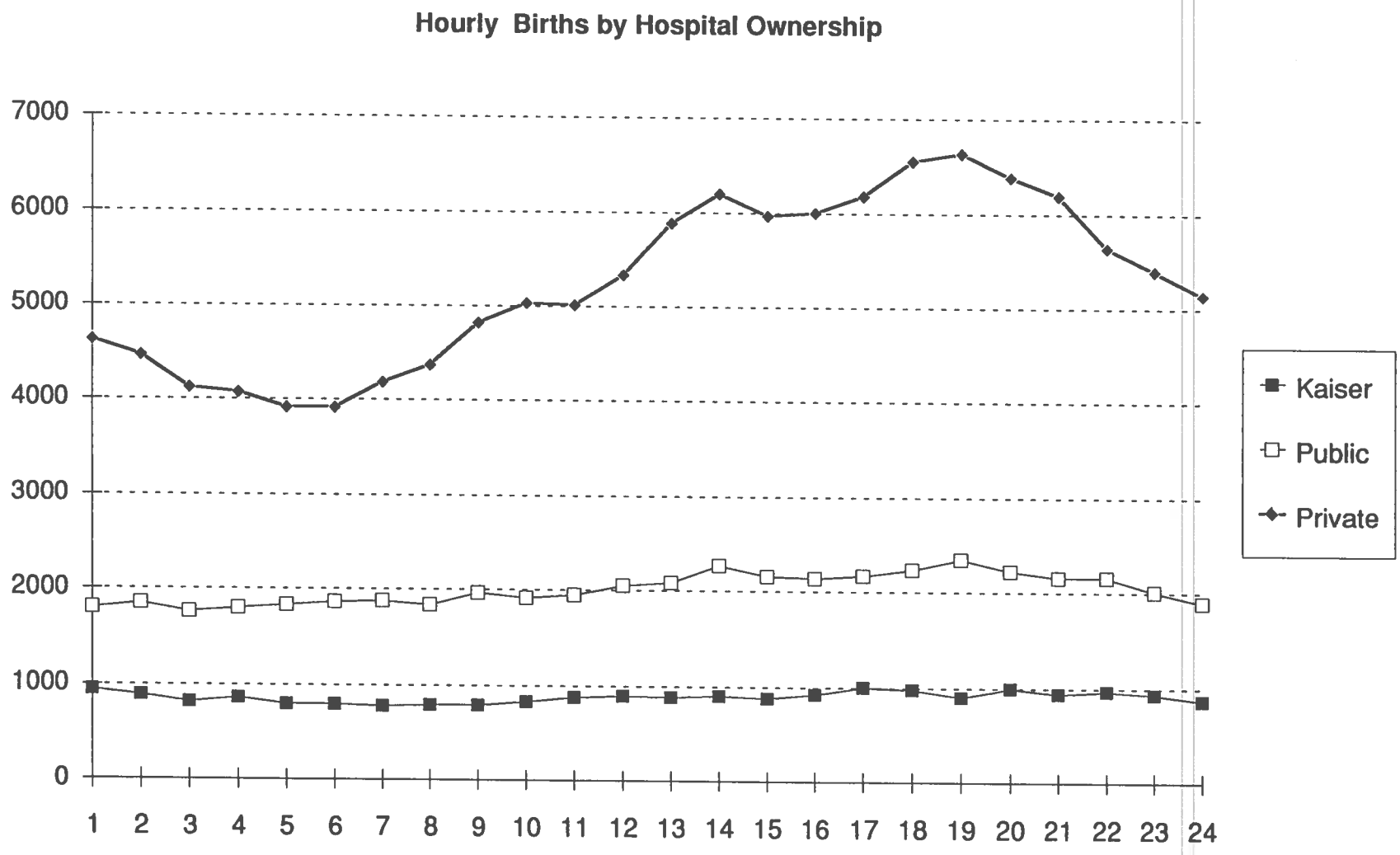

Hourly Births by Hospital Ownership
7000
6000
5000
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Kaiser
Public
Private

Figure 8

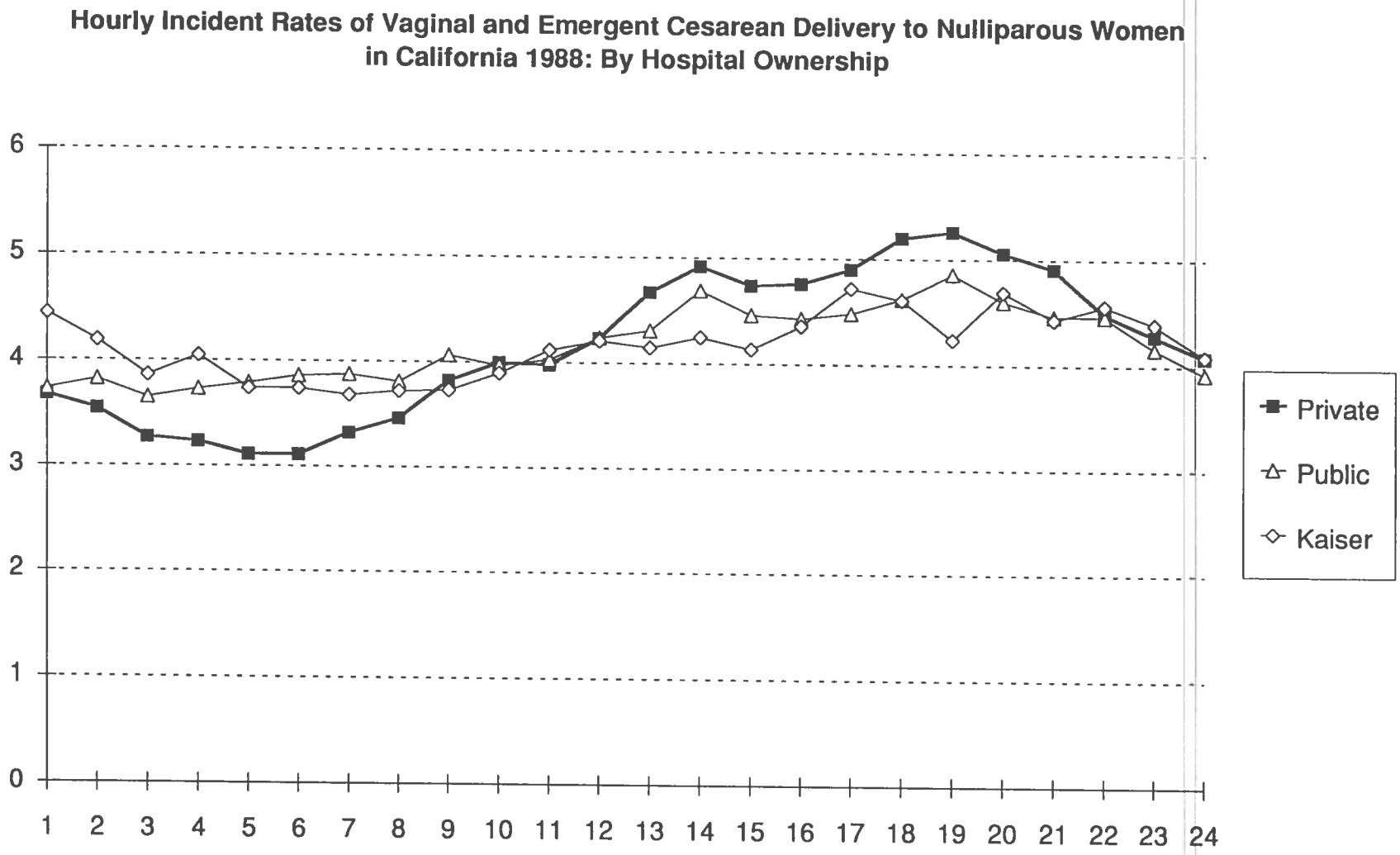

Hourly Incident Rates of Vaginal and Emergent Cesarean Delivery to Nulliparous Women in California 1988: By Hospital Ownership
6
5
4
3
2
1
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Private
Public
Kaiser

Figure 9

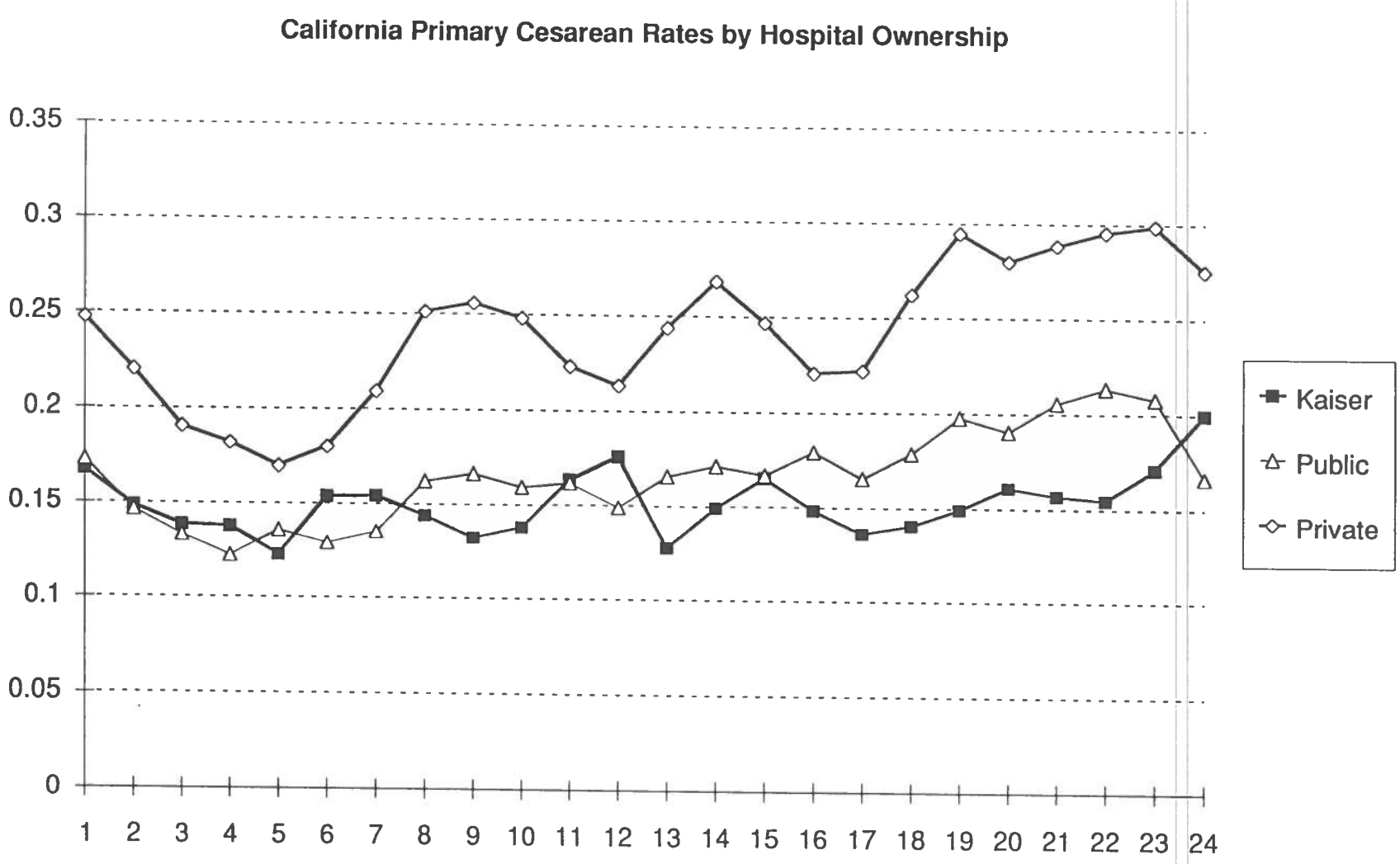

California Primary Cesarean Rates by Hospital Ownership
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Kaiser
Public
Private

Figure 10

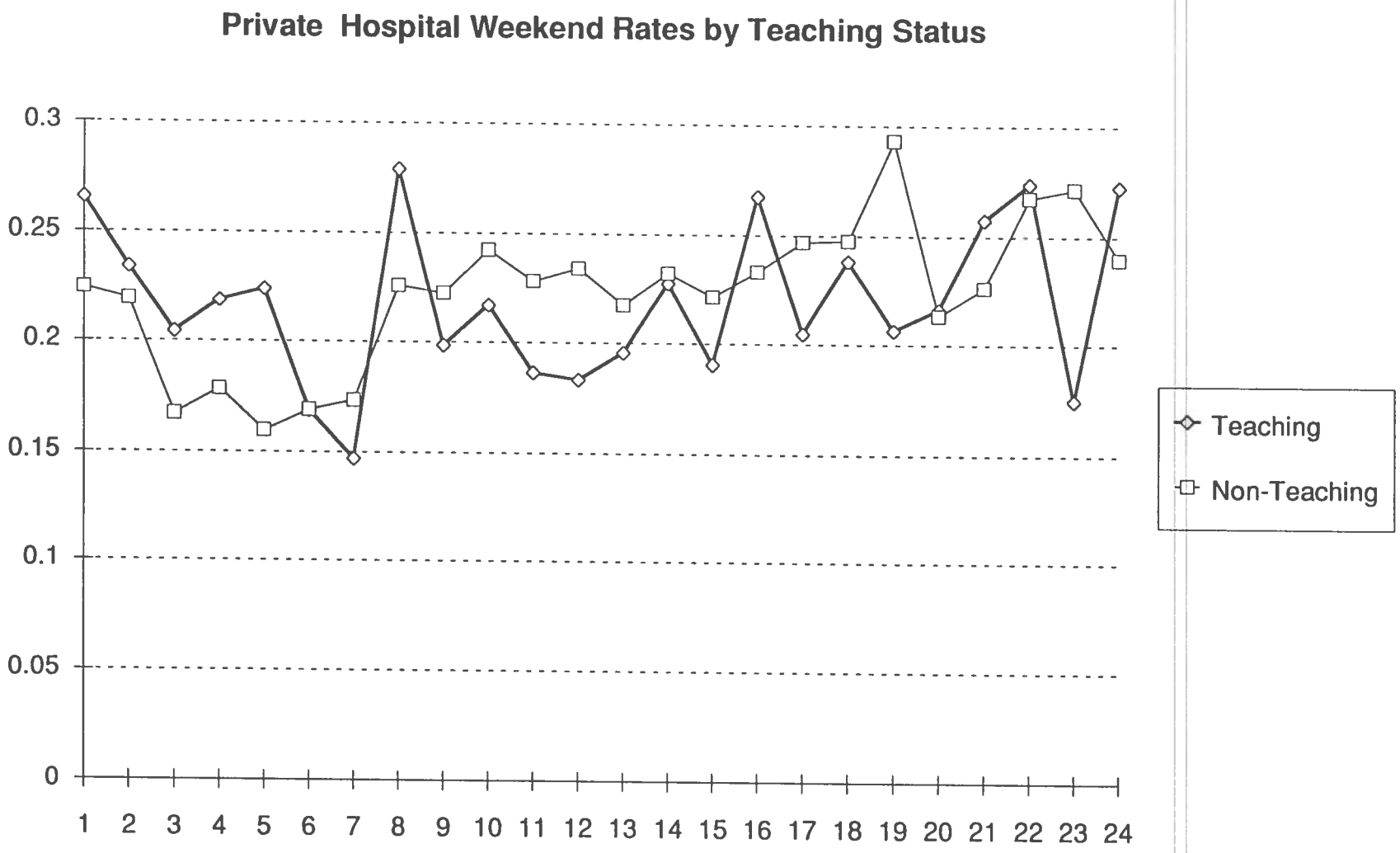

Private Hospital Weekend Rates by Teaching Status
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Teaching
Non-Teaching

Figure 11

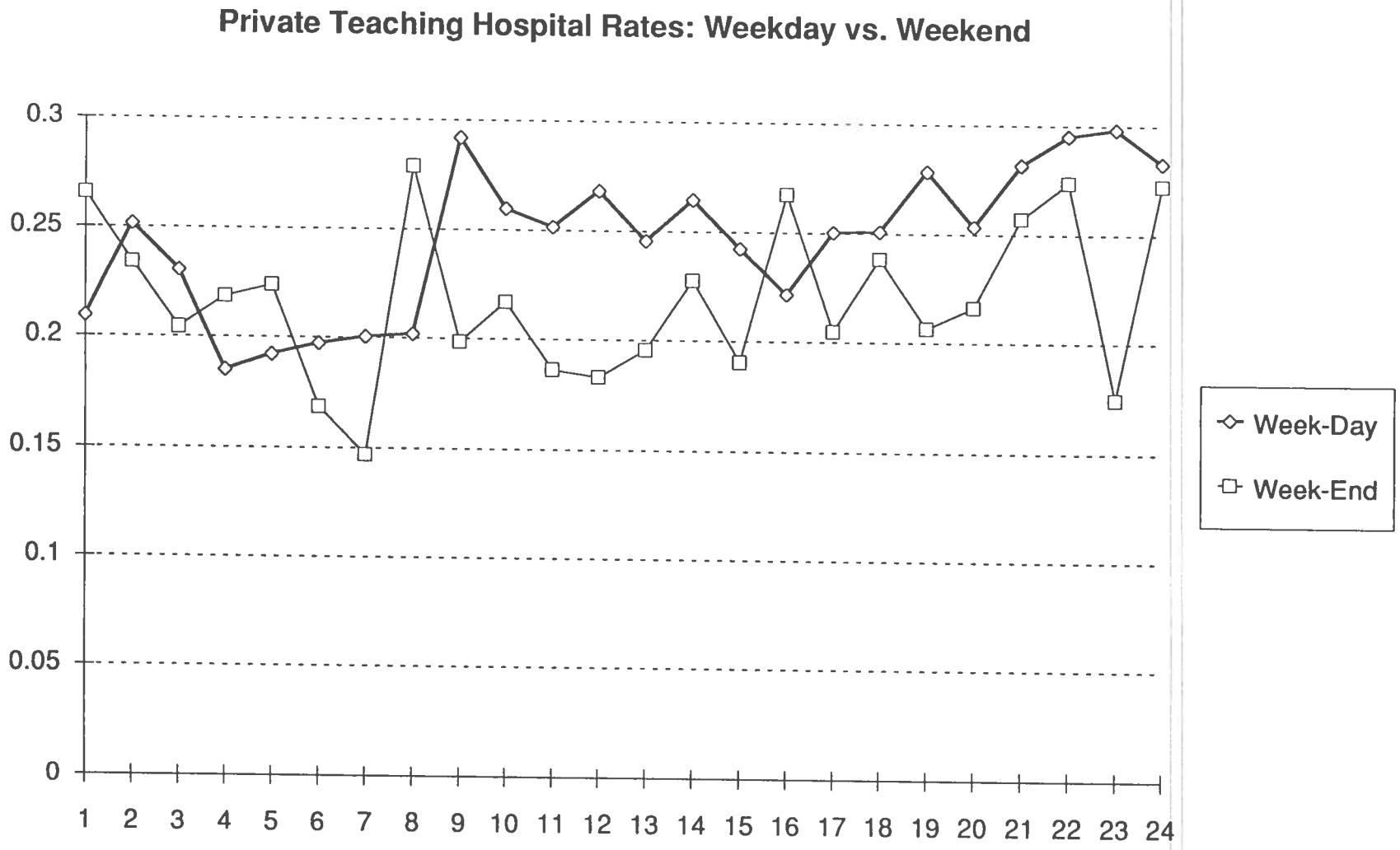

Private Teaching Hospital Rates: Weekday vs. Weekend
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Week-Day
Week-End

Figure 12

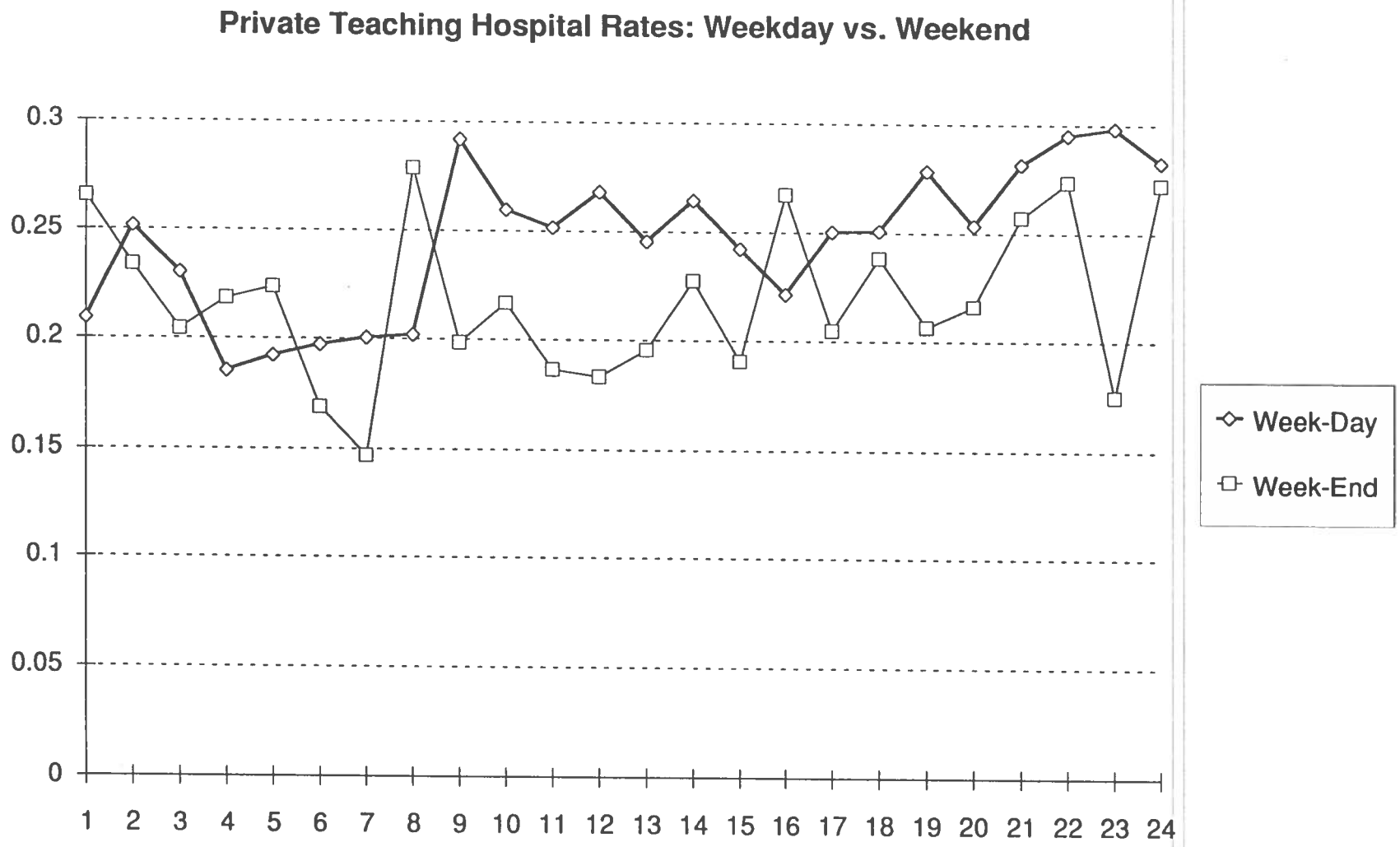

Private Teaching Hospital Rates: Weekday vs. Weekend
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Week-Day
Week-End

Figure 13

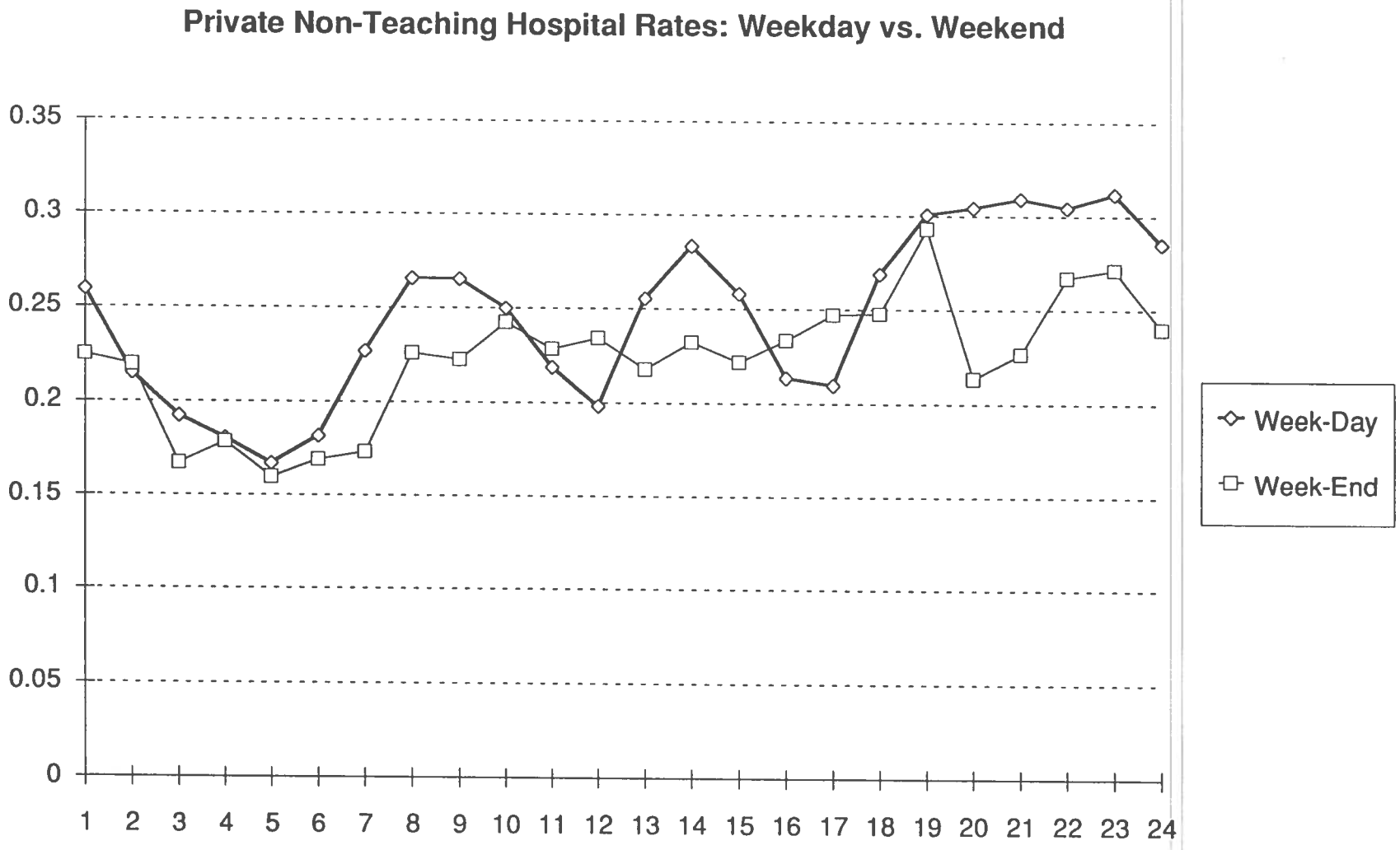

Private Non-Teaching Hospital Rates: Weekday vs. Weekend
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Week-Day
Week-End

Figure 14

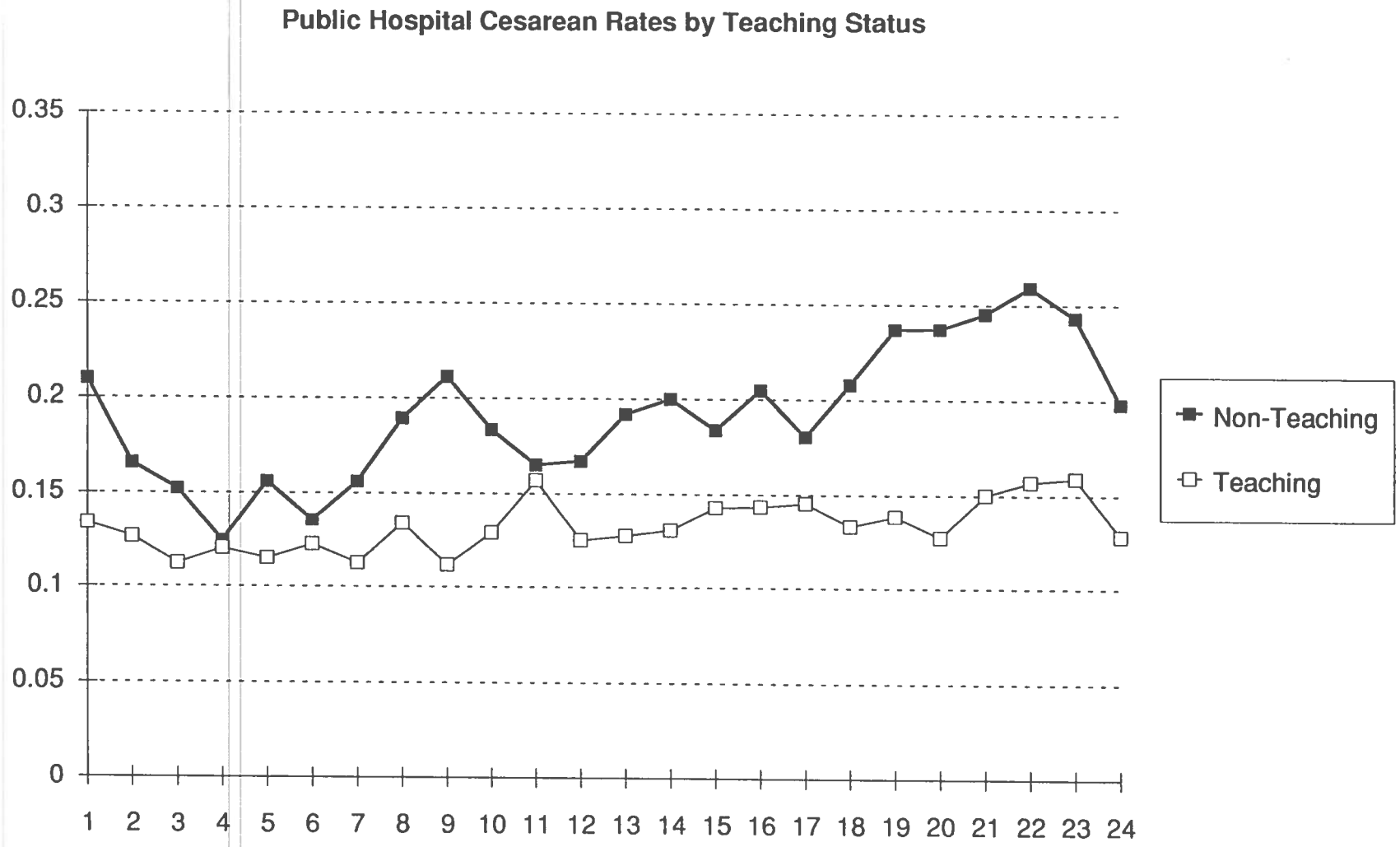

Public Hospital Cesarean Rates by Teaching Status
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Non-Teaching
Teaching

Figure 15

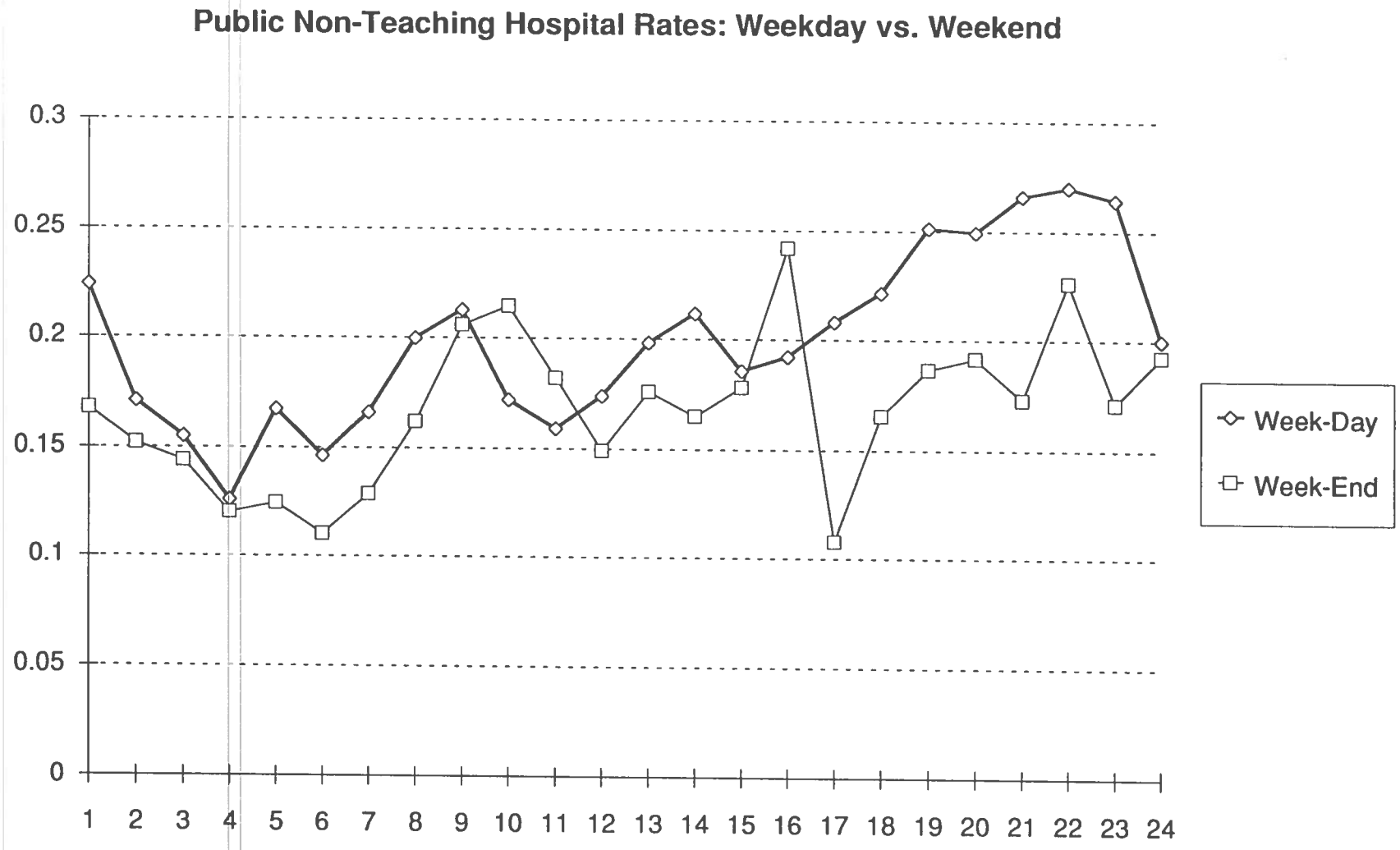

Public Non-Teaching Hospital Rates: Weekday vs. Weekend
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Week-Day
Week-End

Figure 16

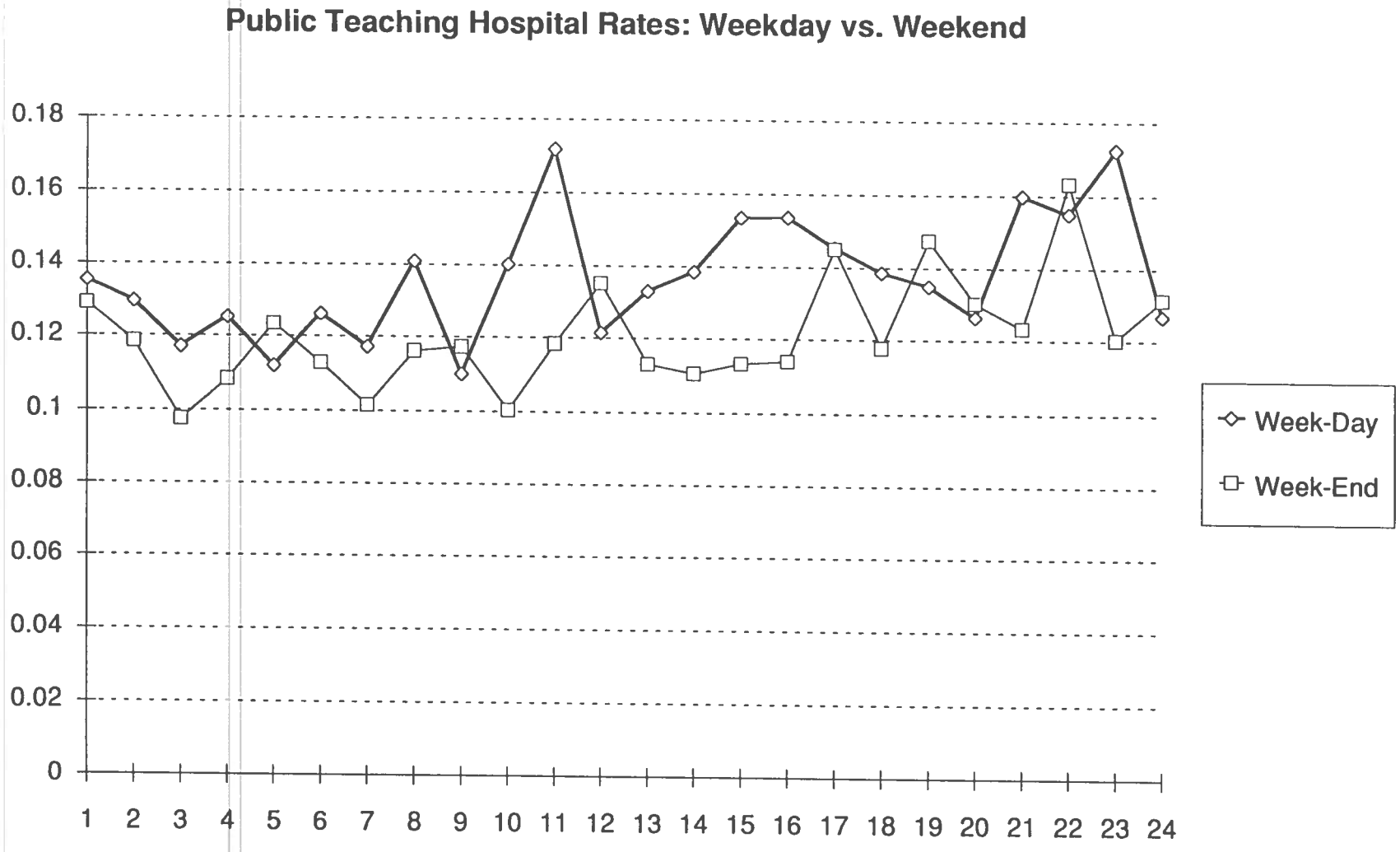

Public Teaching Hospital Rates: Weekday vs. Weekend
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Week-Day
Week-End

Figure 17

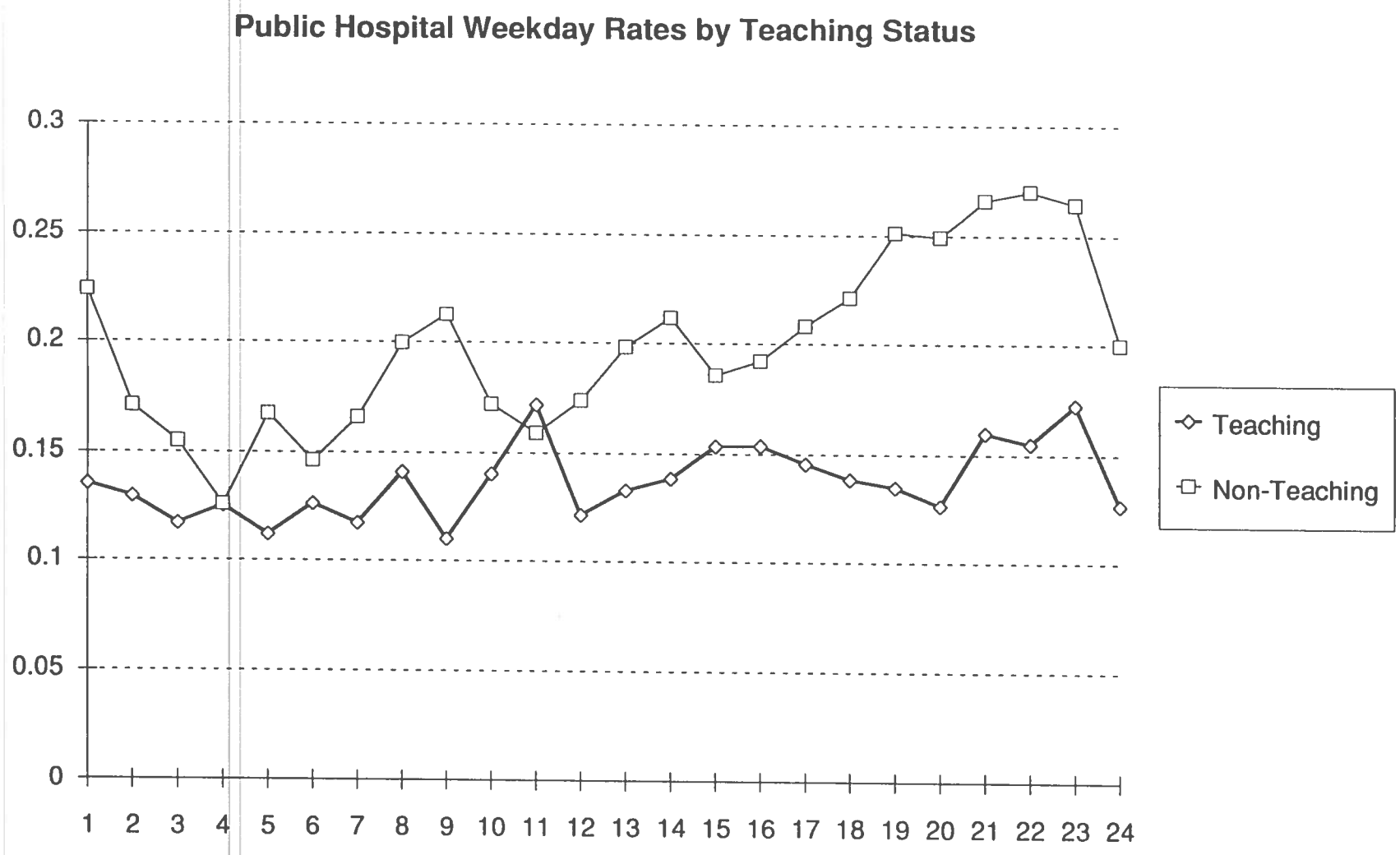

Public Hospital Weekday Rates by Teaching Status
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Teaching
Non-Teaching

Figure 18

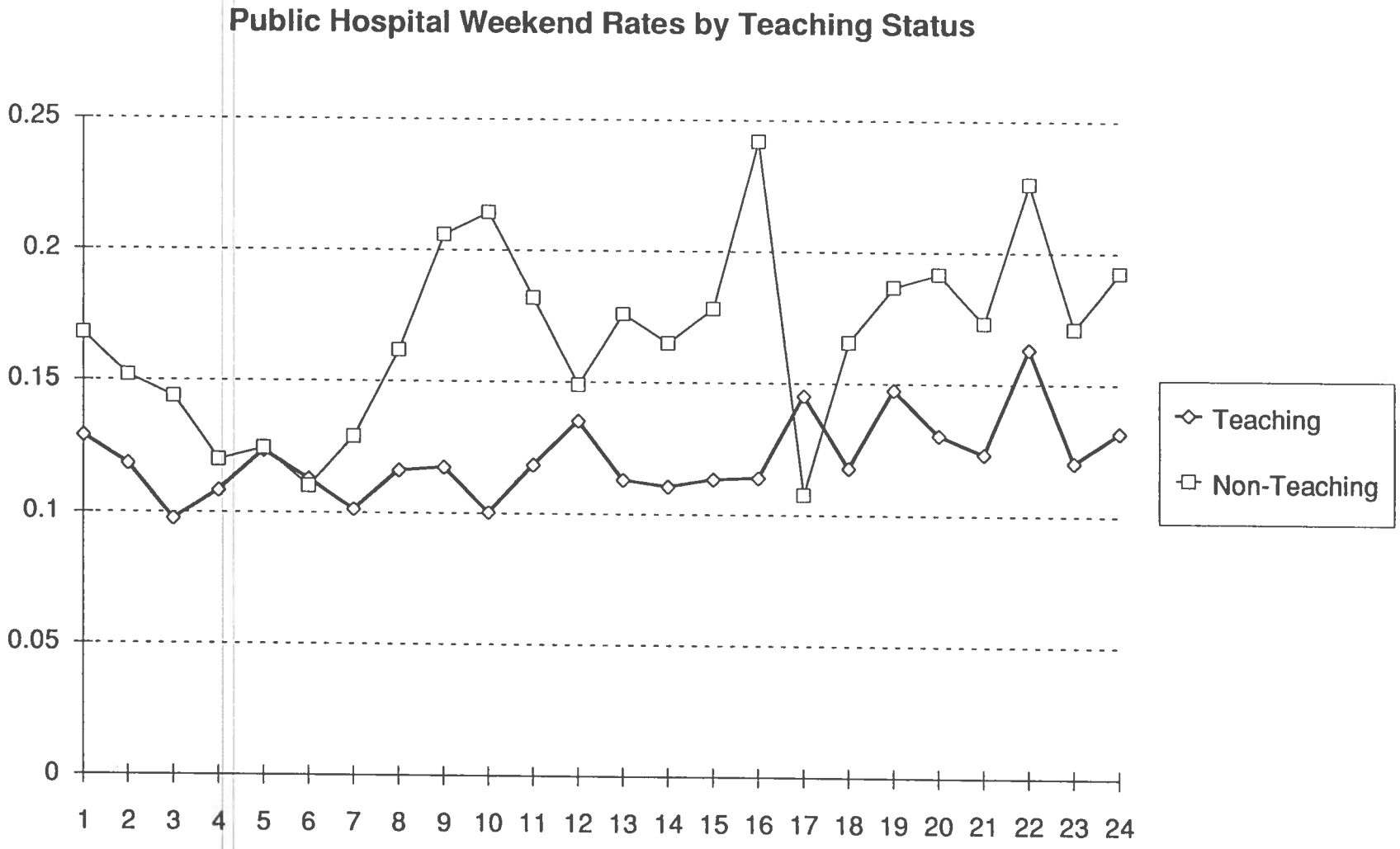

Public Hospital Weekend Rates by Teaching Status
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Teaching
Non-Teaching

Figure 19

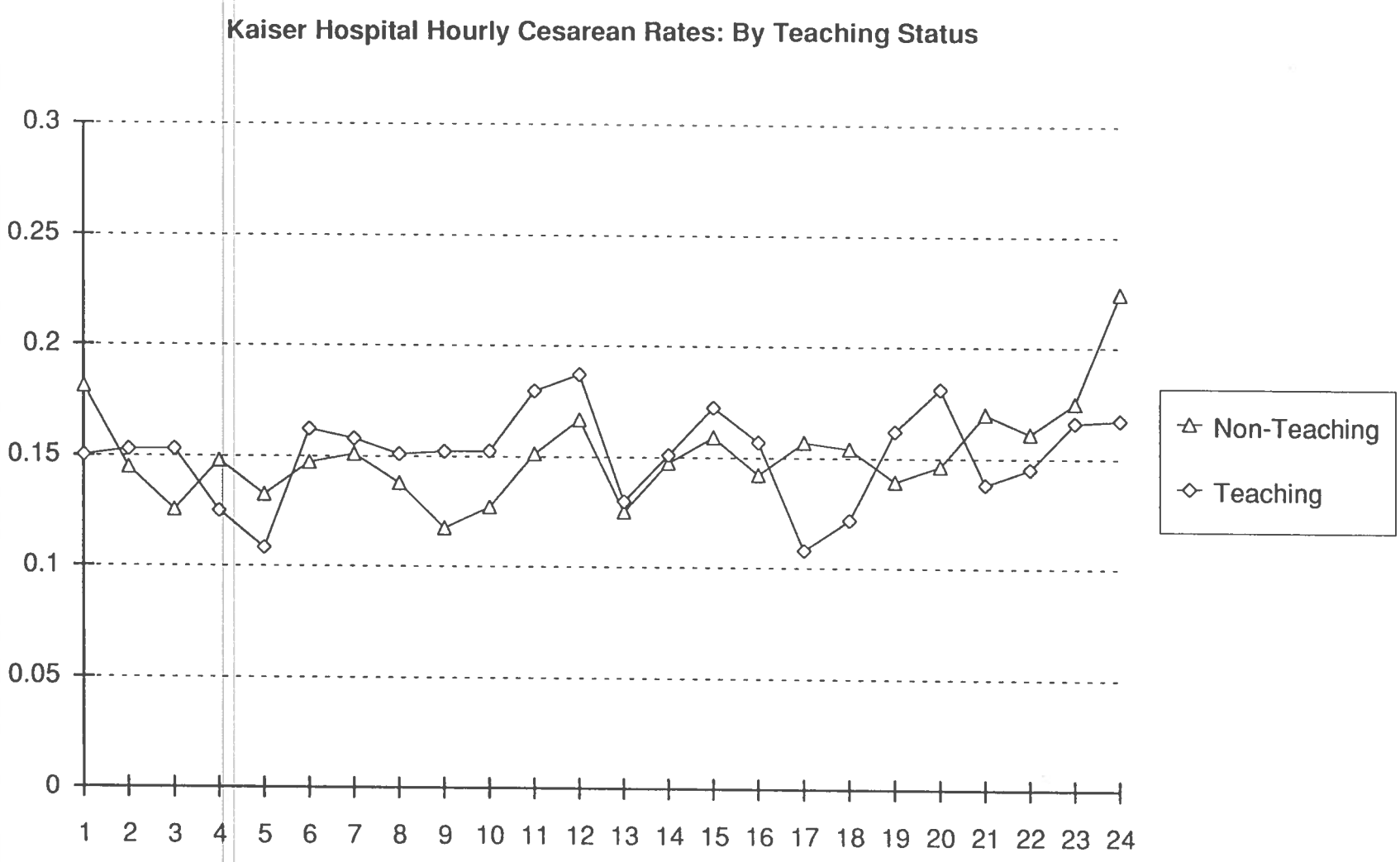

Kaiser Hospital Hourly Cesarean Rates: By Teaching Status
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Non-Teaching
Teaching

Figure 20

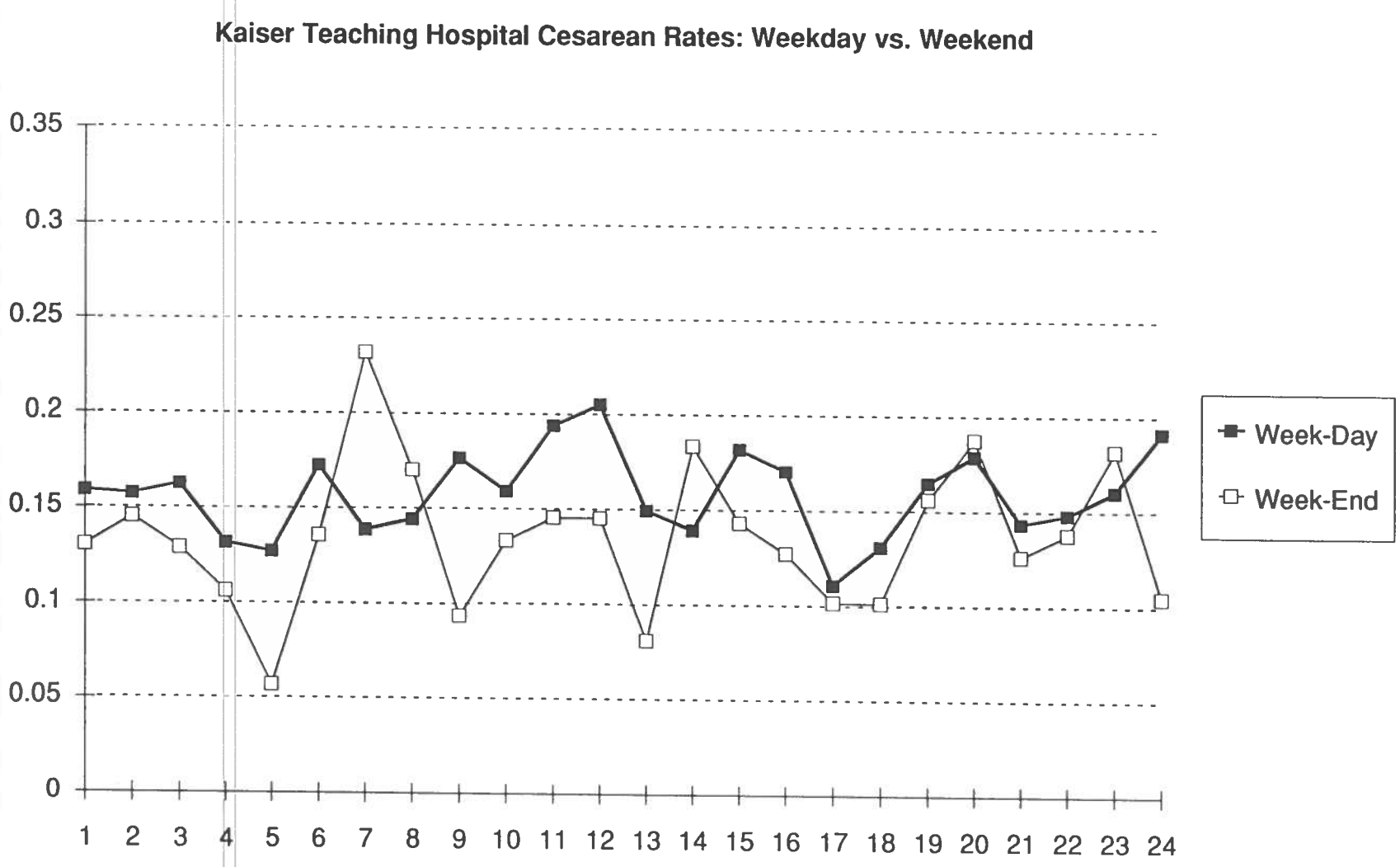

Kaiser Teaching Hospital Cesarean Rates: Weekday vs. Weekend
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Week-Day
Week-End

Figure 21

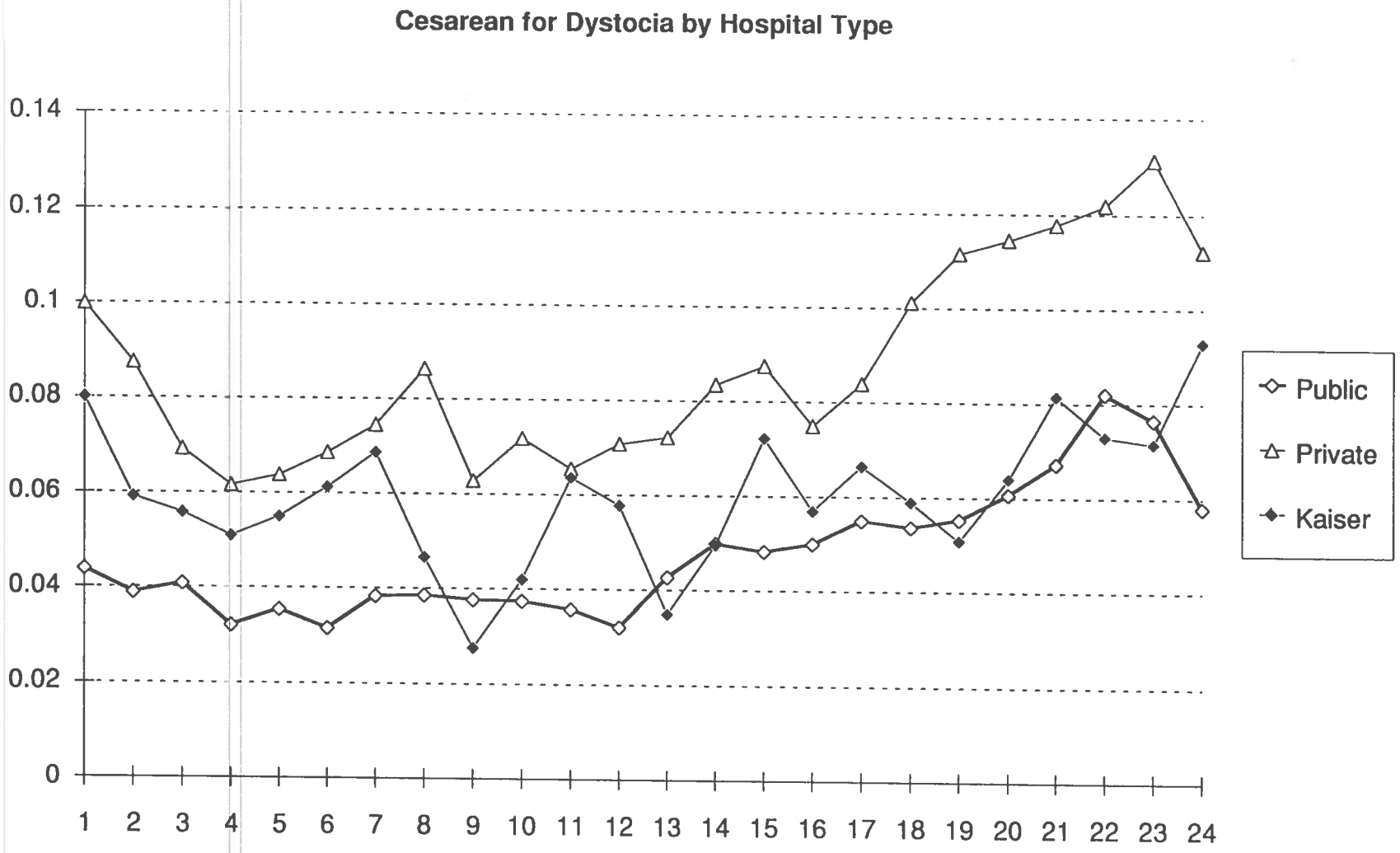

Cesarean for Dystocia by Hospital Type
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Public
Private
Kaiser

Figure 22

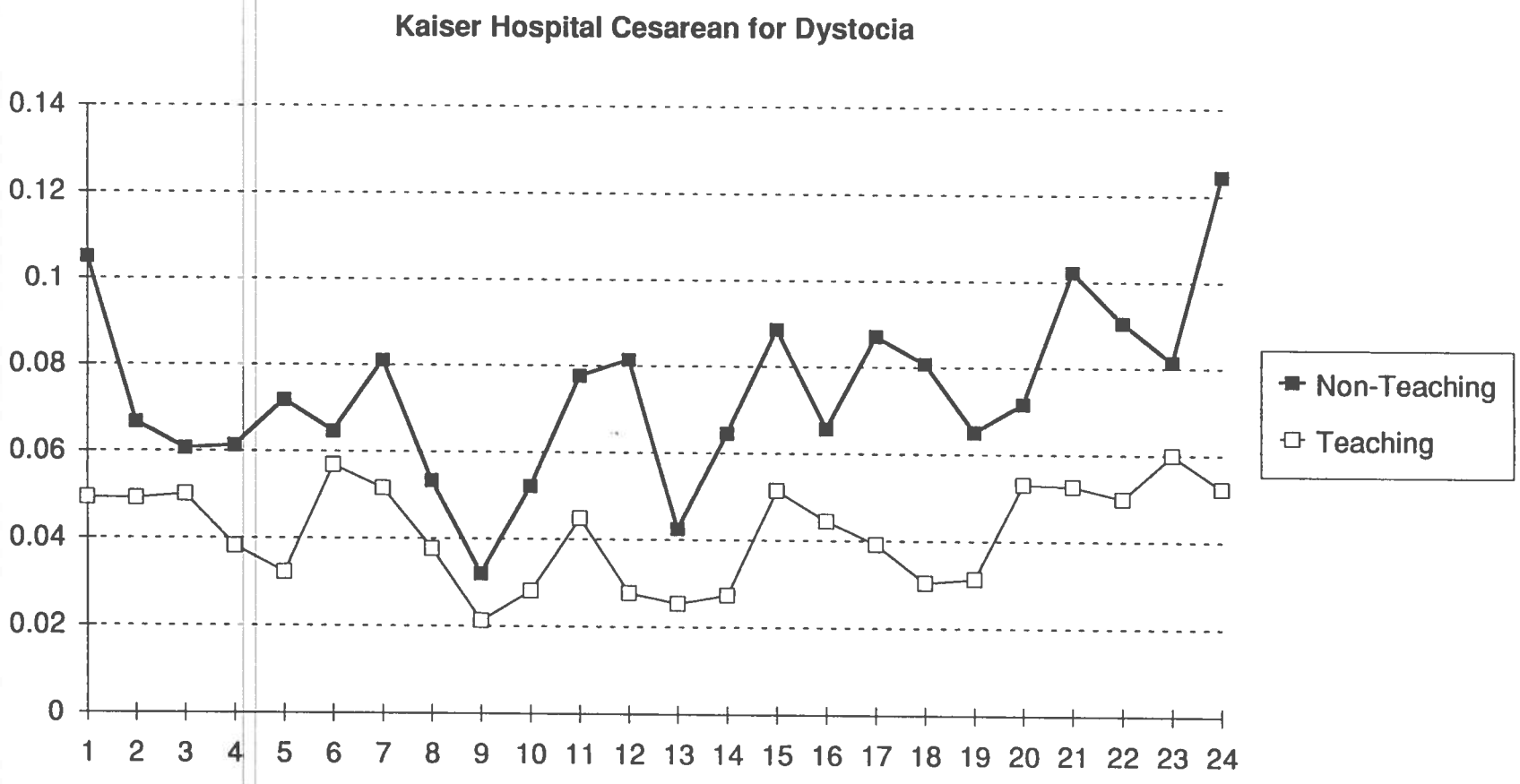

Kaiser Hospital Cesarean for Dystocia
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Non-Teaching
Teaching

Figure 23

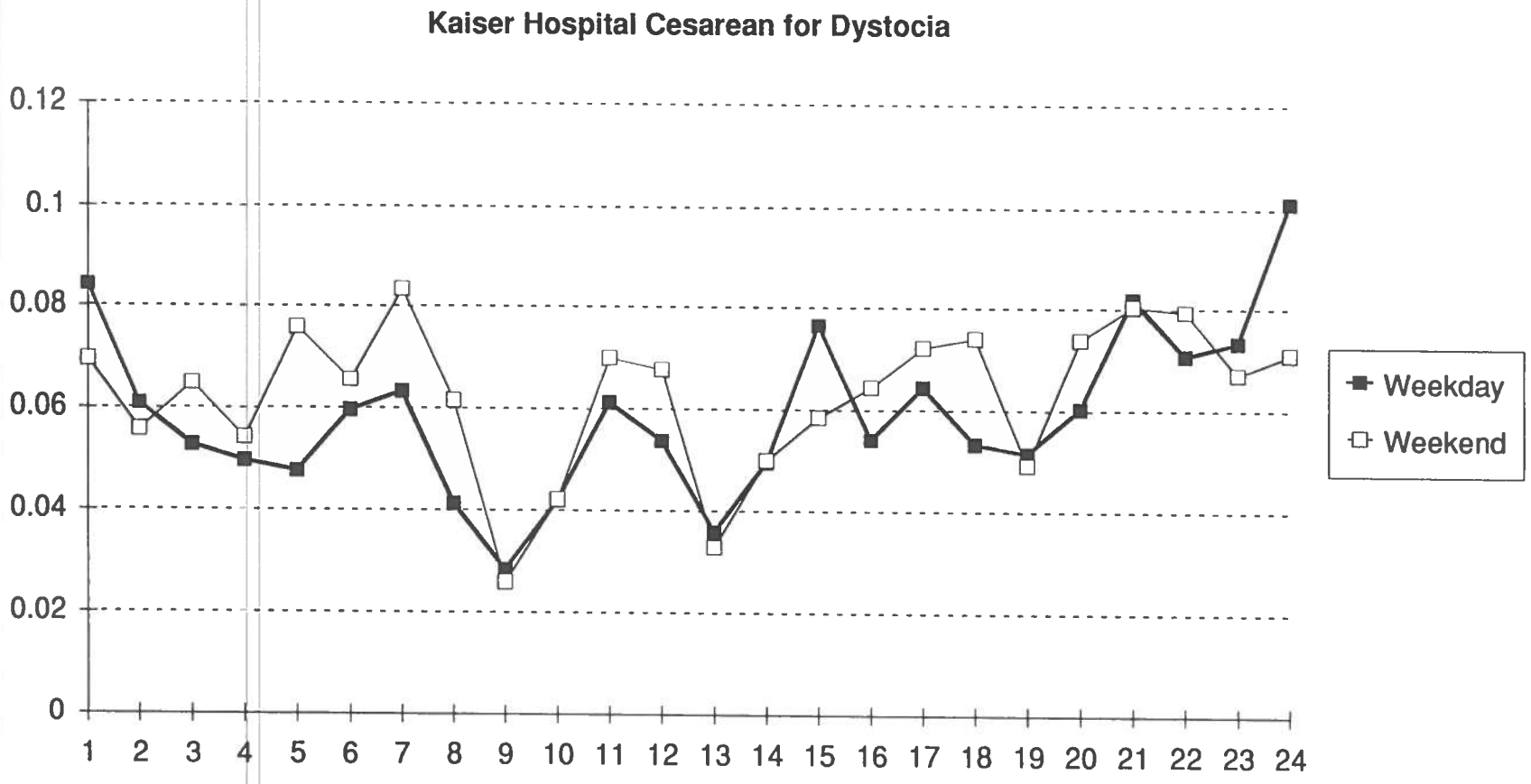

Kaiser Hospital Cesarean for Dystocia
0.12
0.1
0.08
0.06
0.04
0.02
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Weekday
Weekend

Figure 24

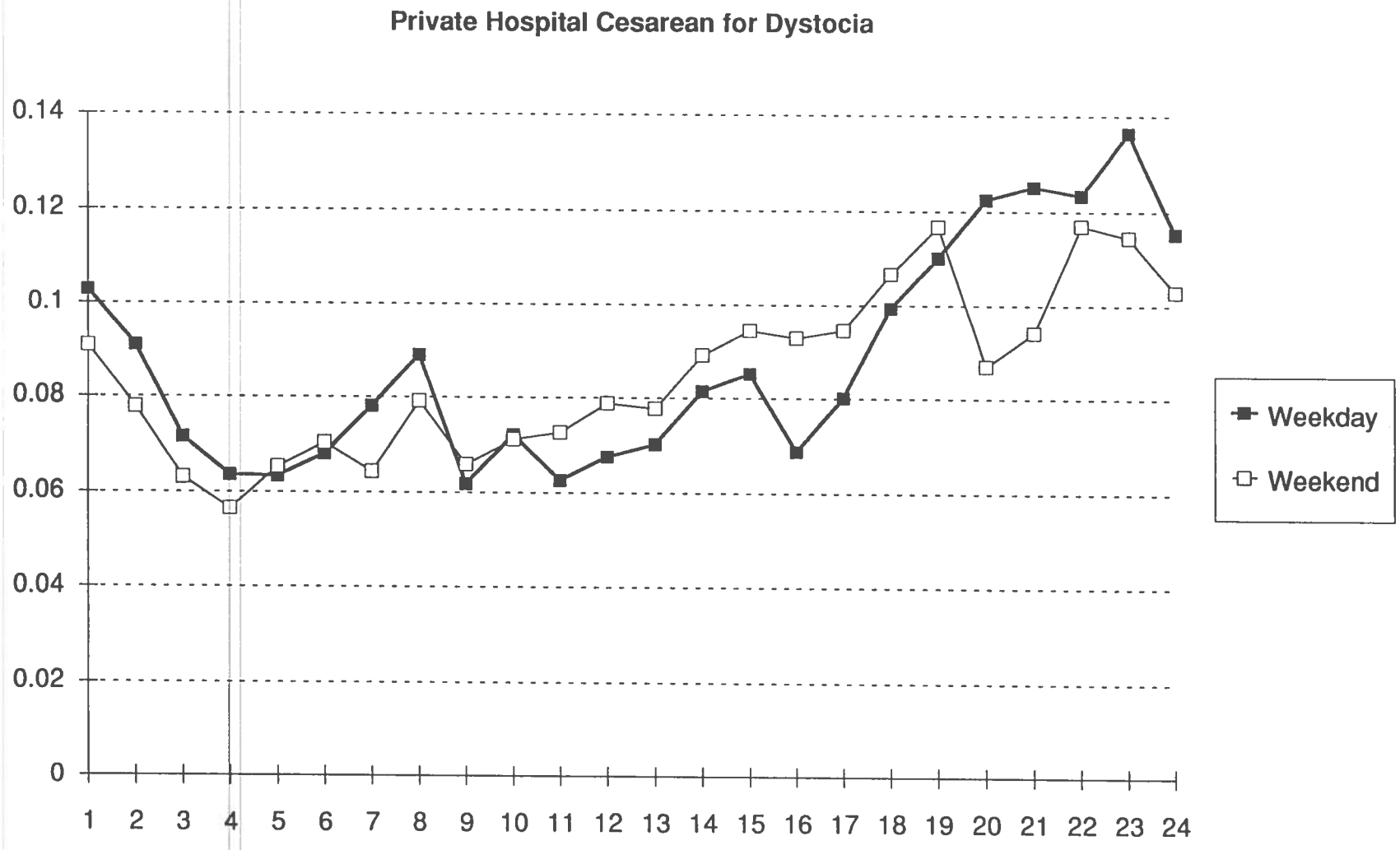

Private Hospital Cesarean for Dystocia
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Weekday
Weekend

Figure 25

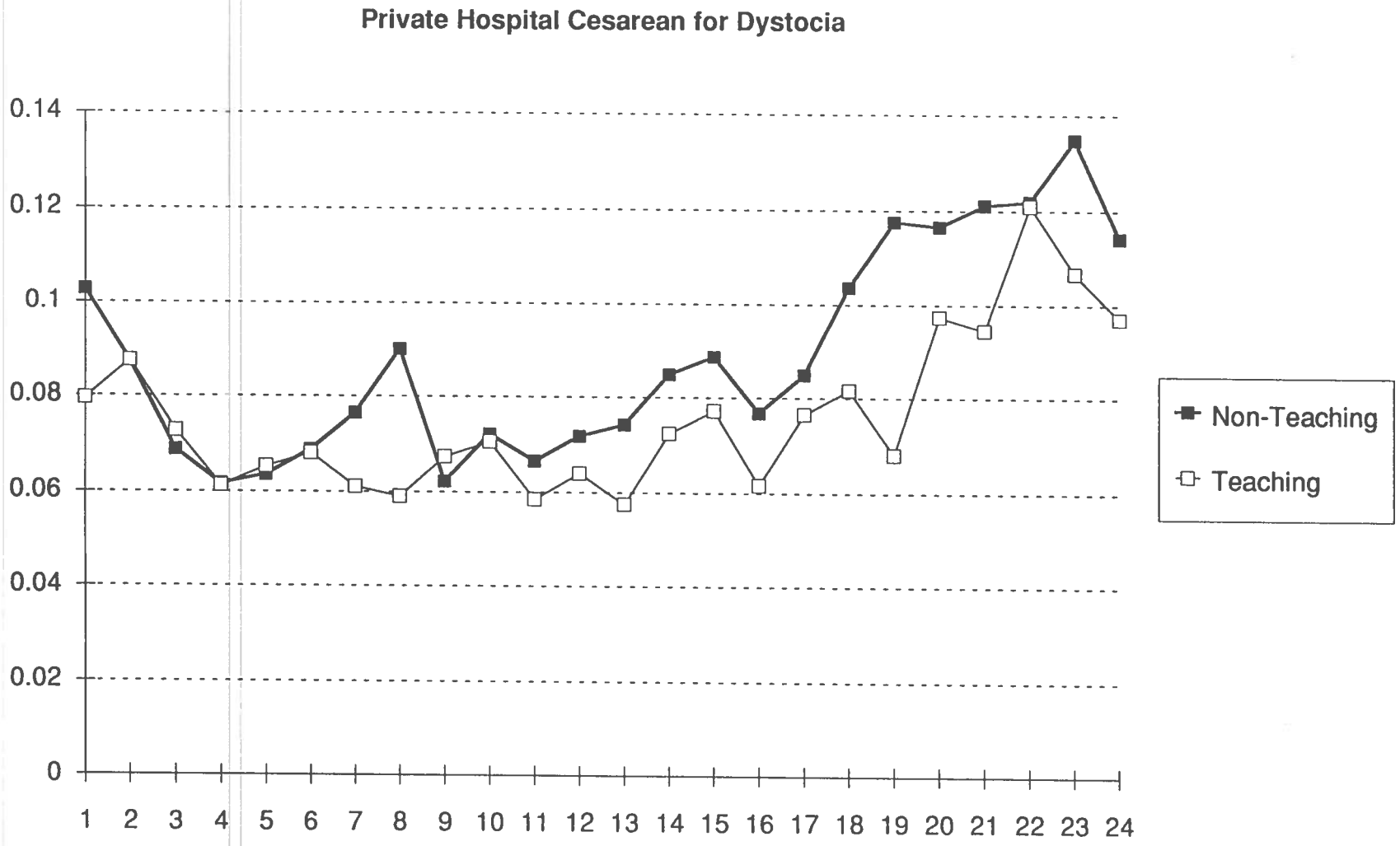

Private Hospital Cesarean for Dystocia
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Non-Teaching
Teaching

Figure 26

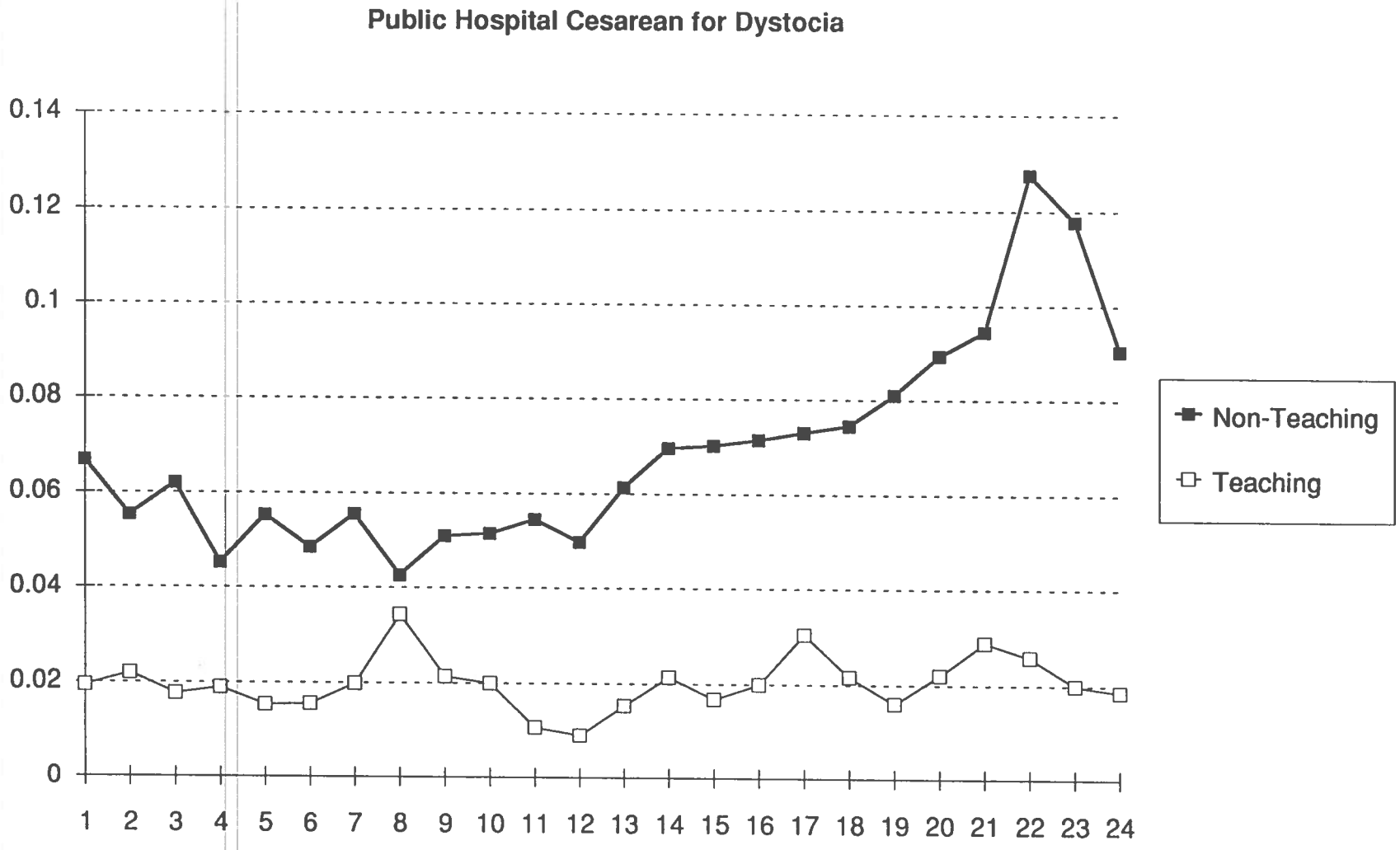
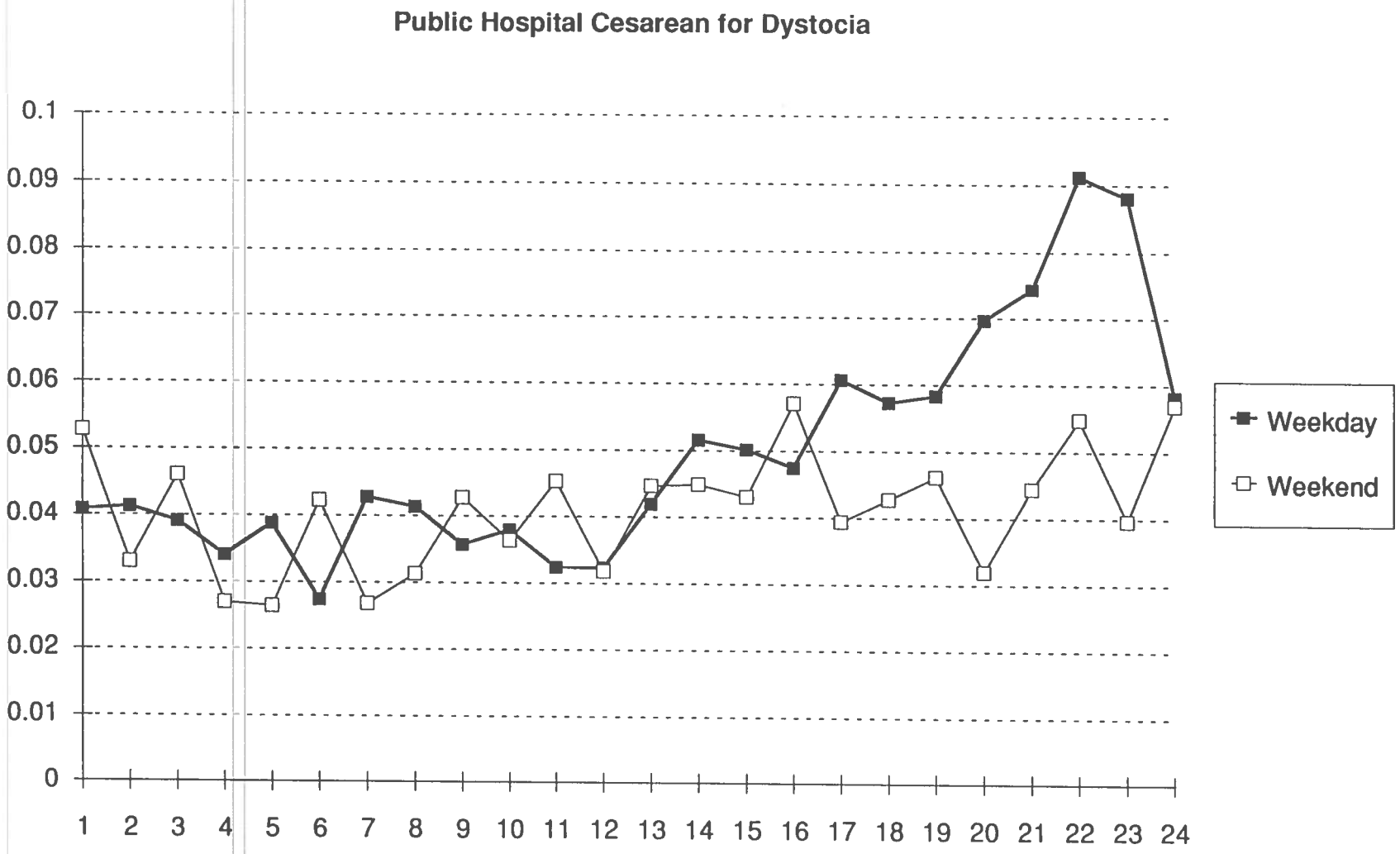

Public Hospital Cesarean for Dystocia
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Non-Teaching
Teaching

Figure 27


Public Hospital Cesarean for Dystocia
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Weekday
Weekend