Surveillance of Maternal Peripartum Complications Following Cesarean Section, New Jersey 1997-2005

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Abstract:

   Background: The last decade has seen a substantial rise in the utilization of cesarean delivery. Risks of certain peripartum complications have long been associated with cesarean delivery, such as post-operative infection, anesthesia complications, hemorrhage and embolism. The trend toward increasing cesarean utilization suggests that the incidence of those complications might also be on the rise. On the other hand, the impact of cesarean trends might be modified by changes in population health or improvements in obstetric care.

   Data and Methods: New Jersey Electronic Birth Certificate (EBC) files are linked to hospital discharge records for delivery and for readmissions up to 60 days postpartum. Complications available for analysis include postpartum infections, anesthetic and related post-operative complications, thrombosis and embolism, and postpartum hemorrhage.

   Findings: There has been an aggregate decline in most cesarean-related peripartum complications. Nonetheless, some impact can be attributed to increased cesarean utilization. The relative risks of peripartum complications associated with method of delivery have not changed over the period.

   Public Health Implications: The dramatic growth in cesarean delivery has been accompanied by no change or an absolute decline in complications usually associated with them.

Introduction

Nationally and in New Jersey, cesarean deliveries have been increasing steadily for a decade (1-5). Analysis of New Jersey birth records showed that the rate of cesarean delivery increased from 26.5% in 1999 to 35.3% in 2004, and the growth in cesareans without a trial of labor—a relatively rare event— nearly doubled that of cesareans after labor (4). The average annual rate of increase in cesarean delivery—6% per year— was fairly uniform across most obstetric and sociodemographic categories: first-time and multiparous mothers, singletons and multiple gestations, full-term and preterm deliveries, private insurance and Medicaid. Medical risk factors often hypothesized to drive the trend, such as preexisting hypertension and diabetes and advanced maternal age, were found to have little effect on the trend (5). This and other studies conclude that the shift to cesarean delivery is not primarily explained by population shifts in maternal/fetal risk factors— it more likely represents more aggressive management of those risks (6-14) and changes in physician attitudes and practice (15-16).

Risks of certain peripartum complications have long been associated with cesarean delivery (17-31), such as rehospitalization (24-25), post-operative infection (26-28), hysterectomy (29), and embolism (30-31). The trend toward increasing cesarean utilization suggests that the incidence of those complications might also be on the rise. On the other hand, the impact of cesarean trends might be obscured by other improvements in obstetric care.

This report addresses three related questions:

o Has there been an aggregate change in cesarean-related peripartum complications parallel to trends in cesarean delivery?

o If so, how much of that change can be attributed to increased cesarean utilization, versus other causes?

o Have the relative risks of peripartum complications associated with method of delivery changed over the period?

The data for this study is drawn from hospital records describing delivery and immediate re-hospitalization. While many acute and immediate complications are captured, conditions that arise later or are treated on an outpatient basis are not available for analysis here. Furthermore, neonatal complications will be considered in a companion report. This report, however, marks an important step in a comprehensive effort by the New Jersey Department of Health and Senior Services to understand the potential consequences of recent trends in cesarean delivery.

Methods

New Jersey Electronic Birth Certificate (EBC) files are linked to hospital billing records (UB-92 standard) for delivery and for readmissions up to 60 days postpartum. Probabilistic linkage was performed using AutoMatch (32-33). Records for all deliveries in New Jersey hospitals from 1997 to 2005 were included. Since the birth certificate files capture all births for the analysis period, we forego statistical inferences predicated on sampling variability. The public health significance of trend magnitudes and subgroup differences should be judged on clinical and public policy criteria.

Multiple gestation, gestational age (clinical estimate), malpresentation, parity and history of prior cesarean are taken from the birth record. New Jersey is unique in the availability of a direct measure of trial of labor for cesarean deliveries, validated by

recording of the length of labor.

Complications available for this analysis were reported on the hospital billing record. The ICD-9-CM codes used for ascertainment are listed in Table 1. These conditions were selected according to seriousness, relative frequency and likelihood of being detected proximate to delivery or to typically require re-hospitalization. An informal expert panel of three maternal and fetal medicine specialists reviewed our selection and coding decisions. We created a mixed "systemic complication" outcome code to represent many generic risks of surgery often cited in the literature. It combined anesthetic complications with comparable conditions such as shock and cardiac arrest, because the attribution of anesthetic as cause in such cases is often ambiguous and unreliable. We also combined thrombosis and embolism into one outcome.

We present our analysis of trends in two stages. First, we present aggregate *incidence rates* for each complication in three components specific to method of delivery, with the

Table 1. ICD-9-CM Definitions

Major post-partum infection
      670.0   Major puerperal infections: Peritonitis,
                        septicemia, endometritis, pelvic sepsis…
      Excludes
      674.3   Wound-specific infections
      646.6   Genitourinary infections
Major systemic complications
      668.0-2   Anesthetic complications
      669.0-1   Maternal distress, shock
      669.3   Renal failure
      669.4   Cardiac arrest, anoxia…
Vascular complications
      671.4   Deep vein thrombosis, post-partum
      673   Embolism
Indicators of most severe hemorrhage and/or trauma:
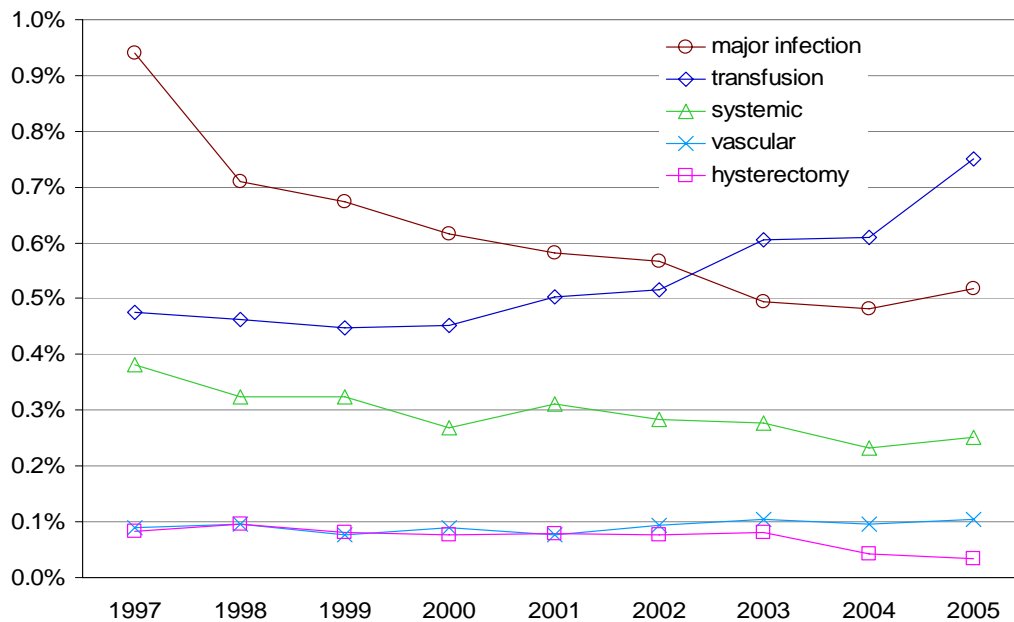   99.0   Transfusion
      68.3-7,9   Hysterectomy

same denominator for each: all live births in the year. During the period, annual live births matched and available for analysis ranged from 106,277 to 108,560. Incidence is presented as stacked bar graphs. The increasing volume of cesareans generally affects total incidence, so we present a second series as a line graph depicting method-specific *conditional rates*, where denominators are live births by method of delivery.

We were also concerned that in many cases cesarean delivery and an adverse event might be the result of the same underlying cause (34-39). To avoid such *confounding by indication*, our second series included only deliveries at low antepartum risk of cesarean and/or complication: singleton, 37+ weeks gestation, head down; no serious antepartum bleeding, severe hypertension, preeclampsia/eclampsia, uterine tissue abnormality; and no macrosomia. Repeat cesareans meeting these criteria were included. Varying combinations of these exclusion criteria are used by the Agency for Healthcare Research and Quality (AHRQ) in their hospital Quality Indicators program (40), and the popular HealthGrades Maternity Care report card (41). During the period, the annual number of these low-risk deliveries ranged from 84,110 to 87,036— on average 79.9% of all deliveries.

For the summary in Table 2, change in incidence is computed by fitting an exponential growth/decline curve; the average annual change is then extrapolated over nine years. This procedure efficiently uses all nine annual data points from 1997 to 2005.

To increase stability of estimates, we compute relative risks (in Figures 12 and 13) for three three-year time intervals: 1997-99, 2000-02 and 2003-05.

Figure 1. Post-Partum Complications, All Deliveries

Results

Figure 1 presents crude incidence rates for all five complications, aggregated for all deliveries and methods. Three— major infections, systemic complications, and hysterectomy— are on a consistently downward trend. Two— transfusion and vascular complications—trend upwards. Figures 2 through 11 present a more detailed picture.

Incidence of major infections declined strongly over the period, with an apparently stable share among all three methods of delivery (Figure 2). Because of the effects of

Table 2. Nine-year Change (Averaged) in Incidence of Complications, by Method of Delivery, Low Risk Deliveries				
	All low risk deliveries	Vaginal delivery	Cesarean w/ trial of labor	Cesarean /no trial of labor
Major infection	-44%	-47%	-54%	-63%
Systemic complication	-35%	-52%	-54%	-55%
Vascular complication	26%	4%	14%	-2%
Hysterectomy	-70%	-76%	-86%	-70%
Transfusion	94%	62%	66%	146%

change in delivery method, we need Figure 3 to confirm that, among what we define as low-risk deliveries, conditional rates of major infection indeed fell *within* vaginal deliveries and both types of cesarean, by very similar degrees. Table 2 presents overall rates of change for each outcome.

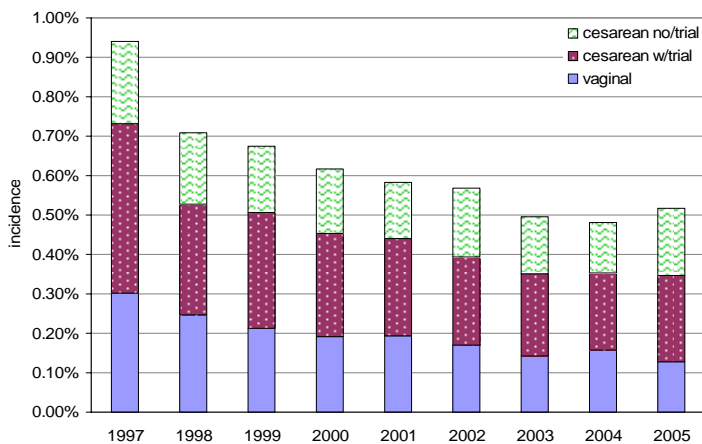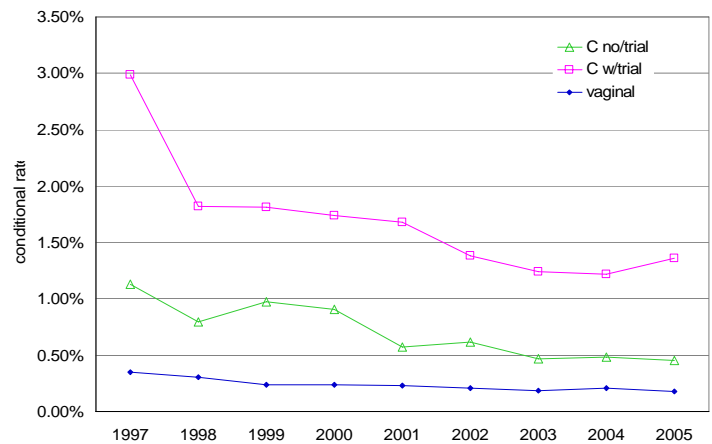**Figure 2. Major Infection by Method of Delivery, All Deliveries**

Figure 3. Major Infection, Low-risk Deliveries

Incidence of systemic complications— severe shock, renal failure, cardiac arrest, etc., whether or not directly attributed to anesthetic— also declined (Figure 4), except for relatively constant incidence associated with no-trial cesarean. Conditional rates declined within all three methods (Figure 5), and in similar magnitude to infections (again Table 2). The clear conclusion is that the increase in volume of no-trial cesarean deliveries cancelled out the decline in systemic complications within that group.

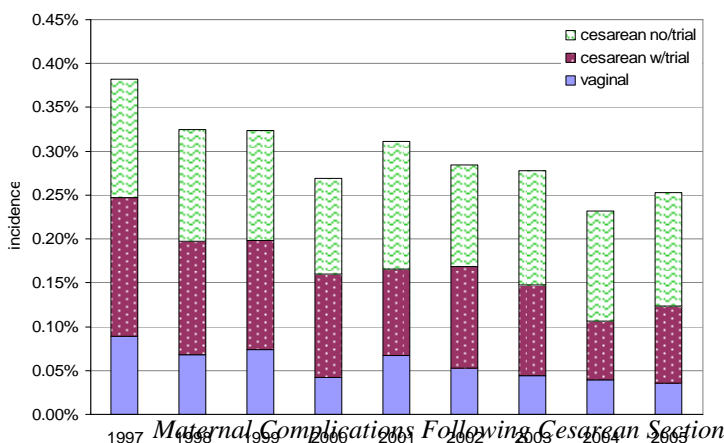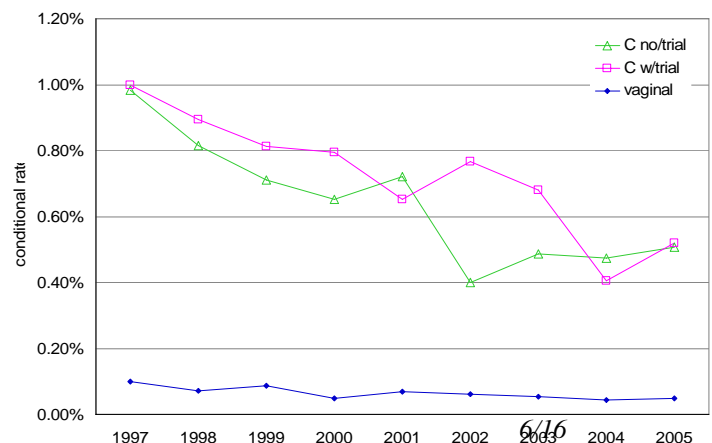**Figure 4. Systemic Complication by Method of Delivery, All Deliveries**

Figure 5. Systemic Complication, Low-risk Deliveries

Maternal Complications Following Cesarean Section

In contrast, incidence of vascular complications increased over the period (Figure 6), most associated with no-trial cesareans. Again, this was due to increased volume, since method-conditional rates showed no consistent trend by delivery method (Figure 7).

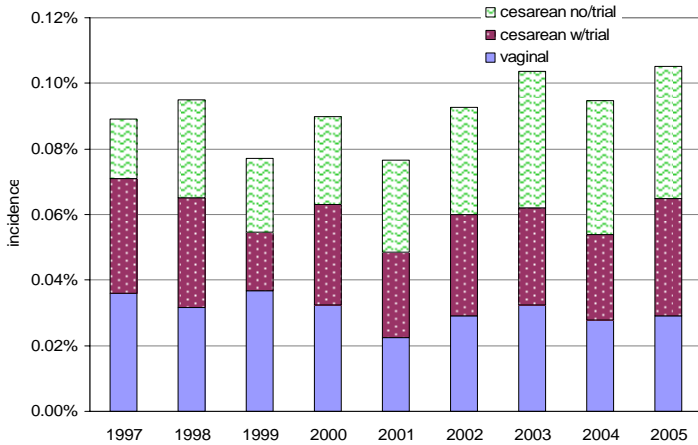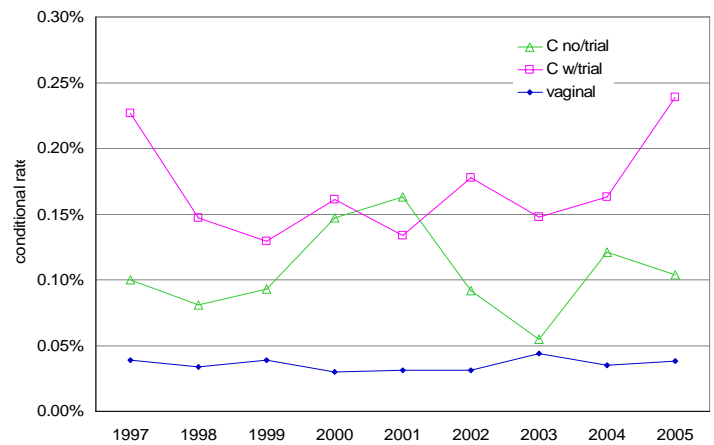**Figure 6. Vascular Complication by Method of Delivery, All Deliveries**

Figure 7. Vascular Complication, Low-risk Deliveries

Incidence of hysterectomy was stable through most of the period, driven by a strong increase in incidence among no-trial cesareans (Figure 8). The conditional rates (Figure 9) show a gradual decline within vaginal deliveries and cesareans with a trial of labor throughout the period, and a more volatile trend within no-trial cesareans.

Figure 8. Hysterectomy by Method of Delivery, All Deliveries
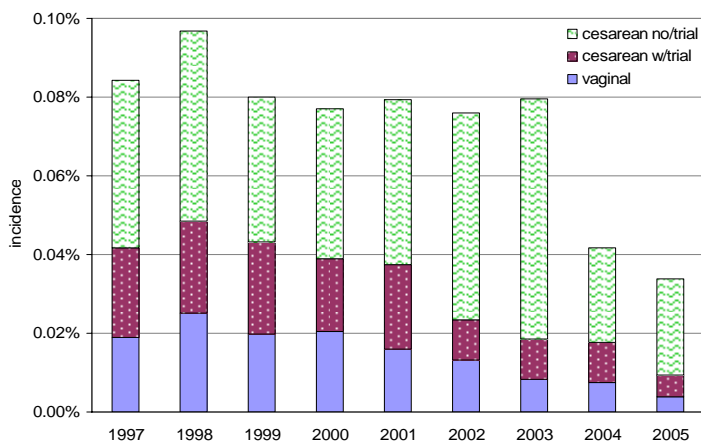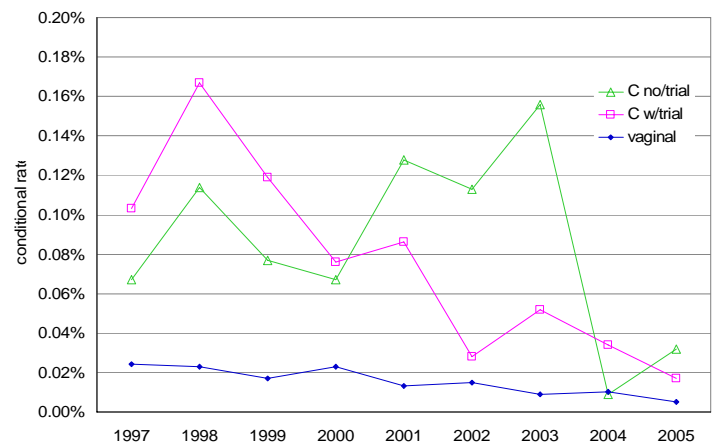

Figure 9. Hysterectomy, Low-risk Deliveries

Incidence of transfusion increased dramatically, especially after 1999 (Figure 10). Conditional rates increased strongly in all categories (Figure 11), but at more than double the pace among no-labor cesareans. Half of transfusions were associated with post-partum hemorrhage, hysterectomy, hematoma or trauma (data not shown).

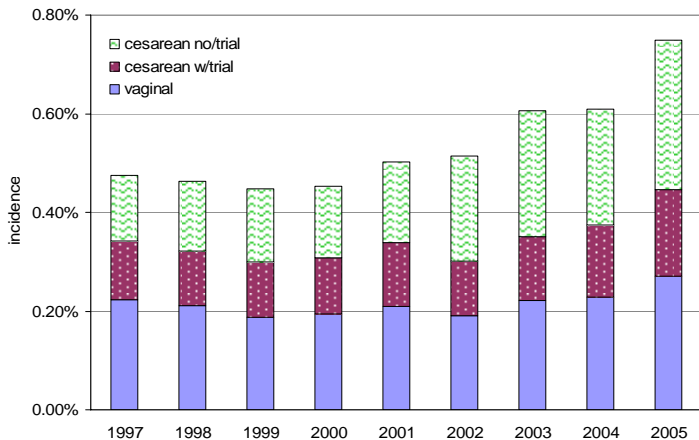**Figure 10. Transfusion by Method of Delivery, All Deliveries**

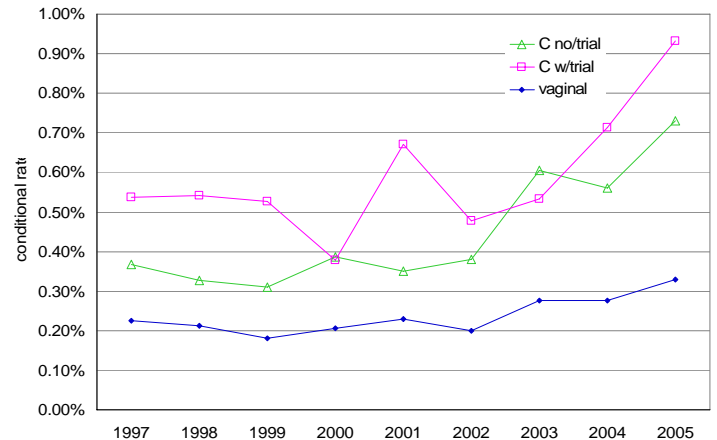**Figure 11. Transfusion, Low-risk Deliveries**

Figure 12 presents the relative risk of each complication for a cesarean delivery after trial of labor, compared to vaginal delivery. To simplify, we include only "low-risk" deliveries, as defined for conditional rates. While the differences for each complication are substantial in every three year interval, there is no consistent pattern of change. Figure 13 presents the contrast between cesarean without trial of labor and vaginal delivery.

Figure 12. Relative risk: Cesarean after trial labor v. Vaginal delivery
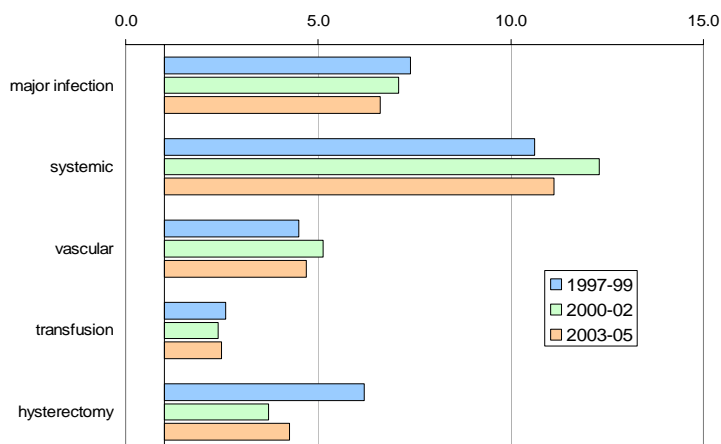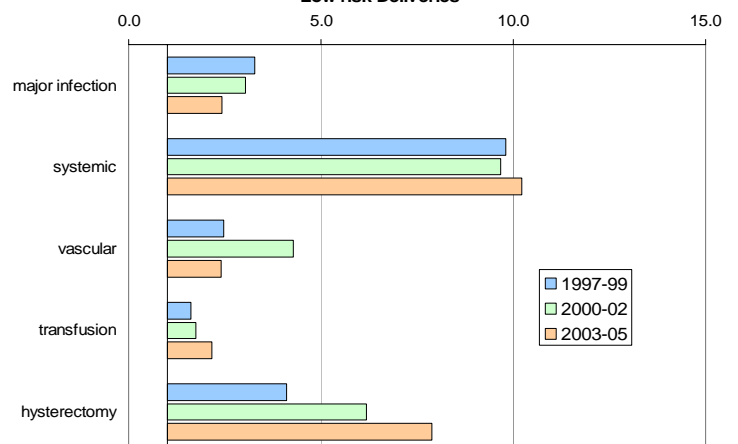**Low-risk Deliveries**

Figure 13. Relative risk: Cesarean without trial labor v. Vaginal delivery
Low-risk Deliveries

Discussion

All other things equal, we would expect the steady rise in the utilization of cesarean delivery to increase the incidence of associated maternal and neonatal complications. Formally, we would call this common sense expectation a *mixture model*: for each outcome the *aggregate incidence rate* r(t) for the population is the *average* of delivery-method-specific *conditional risk*s (r_j), *weighted* by the distribution of births among those delivery methods (p_j where j denotes the delivery method).

$$r(t) = \sum r_j \cdot p_j(t)$$

In this simplest version of the mixture model, the method-specific risks are assumed to be constant over time. Then the aggregate incidence varies with time because the distribution of delivery methods varies. In our bar-graphs, r(t) represents the total height of each vertical bar-stack; that height is clearly the sum of the segments in the stack, which depict each of the $r_j \cdot p_j$ terms in the mixture equation. Annual estimates for r_j appear in the line-graphs.

The trend in vascular complications most closely corresponded to expectations from the simple mixture model. Change in risk was relatively modest within each method of delivery. Overall incidence increased during the period, primarily due to increased cesarean deliveries. Consideration of other complications tells a different story, however.

For major infections, systemic complications and hysterectomy, the simple mixture model is quite misleading: dramatic changes have occurred to risks for these complications in the past decade within all methods of delivery. We can quantify the impact of that deviation from the model by a simple exercise of extrapolation: what

would the mixture equation predict if r_j were allowed to vary over time, but p_j remained constant? Among what we have called low-risk deliveries—singleton, full term, head down with no serious prenatal complications— the rate of cesarean delivery after a trial of labor was 11.5% during 1997-99, and the no-trial cesarean rate was 7.4%. If cesareans had remained stable at that level, we would project (in Table 3) that major infections and hysterectomies would have experienced about the same trend. But under that stability assumption, systemic complications would have declined 52% by 2005, not the observed 35%, and vascular complications would have increased 5%, not the actual 26%. In the first case, the effect of increasing cesarean delivery has been obscured by other (unexplained) declines in risk. In the latter case, cesarean delivery explains the entire increase.

Utilization of transfusion increased in the aggregate and also increased substantially within each method of delivery. The trend accelerated after 2001, and the rate of increase was higher for cases not coded for post-partum hemorrhage (data not shown). According to our constant-mixture scenario, transfusions would have increased 69%, not 94% as observed.

These mixture model calculations are the best answer to our second question regarding the aggregate impact of rising cesarean rates on complications. The answer to

Table 3. Projected Change in Incidence of Complications, Assuming No Increase in Cesarean Delivery, Low Risk Deliveries		
	Actual average rate of change (Table 2)	Re-weighted rate of change
Major infection	-44%	-49%
Systemic complication	-35%	-53%
Vascular complication	26%	5%
Hysterectomy	-70%	-77%
Transfusion	94%	71%

the third question, "Is cesarean delivery a safer choice now?" is answered by the relative risks, which have not changed substantially over the period. While an average woman has an absolutely lower risk of many important complications, she still experiences the same relative increase in risk— for systemic complications, a ten-fold increase— when undergoing a cesarean, with or without a trial of labor. This is a precise way of saying what was clear from the line-graphs— in no case is the risk of complication lower for cesarean now than it was for vaginal delivery ten years earlier. If there has been a "paradigm shift" justifying broader utilization of cesarean delivery, it is not justified by a relative shift in maternal benefits.

The declines in the risk of major infection and systemic complications are parallel, and hence essentially independent of method of delivery. We do not know what set of technical improvements in prenatal and delivery care could account for this generalized reduction in risk. More practitioners doing more procedures often has a positive impact on safety, but this hypothesis could only explain the trend for cesarean deliveries, but not the parallel declines within vaginal deliveries. In 1997 ACOG/AAP instituted new guidelines on antibiotic prophylaxis in response to concerns about group-B streptococcus (42); this possibly produced a much broader maternal and neonatal benefit. Comparable hypotheses relating to systemic complications and hysterectomy have not emerged in the literature. For example, we are not aware of any change in the standard of care that would account for increased rates of transfusion (43). Hopefully this epidemiological report will foster more focused investigation.

A systematic cost-benefit analysis of cesarean delivery is beyond the scope of this report. It seems clear, however, that the absence of an epidemic of cesarean-related

maternal complications, at least in New Jersey, should not eliminate our concerns. Since the size and composition of the population of women undergoing a cesarean delivery is changing substantially, our knowledge about the costs and benefits of cesarean delivery is at least out of date and perhaps subject to some revision. Among the limitations to this study that must be addressed are: complications that are likely to be treated in out-patient settings, sequelae that develop over much longer time frames, measurement of non-medical sequelae, and more reliable indicators of planned and elective cesarean delivery.

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