Association Between Method of Delivery and Maternal Rehospitalization

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Context  Despite nearly 4 million deliveries in the United States each year, minimal information exists on unintended health consequences following childbirth, particularly in relation to delivery method.

Objective  To assess the risk for maternal rehospitalization associated with cesarean or assisted vaginal delivery compared with spontaneous vaginal delivery.

Design  Retrospective cohort study of data from the Washington State Birth Events Record Database for 1987 through November 1, 1996.

Setting and Participants  All primiparous women without selected chronic medical conditions who delivered live singleton infants in nonfederal short-stay hospitals in Washington State (N=256795).

Main Outcome Measures  Relative risks (RRs) of rehospitalization within 60 days of cesarean or assisted vaginal vs spontaneous vaginal deliveries.

Results  A total of 3149 women (1.2%) were rehospitalized within 60 days of delivery. In logistic regression analyses adjusting for maternal age, rehospitalization was found to be more likely among women with cesarean delivery (RR, 1.8; 95% confidence interval [CI], 1.6-1.9) or assisted vaginal delivery (RR, 1.3; 95% CI, 1.2-1.4) than among women with spontaneous vaginal delivery. Cesarean delivery was associated with significantly increased risks of rehospitalization for uterine infection, obstetrical surgical wound complications, and cardiopulmonary and thromboembolic conditions. Among women with assisted vaginal delivery, significant increased risks were seen for rehospitalization with postpartum hemorrhage, obstetrical surgical wound complications, and pelvic injury.

Conclusions  Women with cesarean and assisted vaginal deliveries were at increased risk for rehospitalization, particularly with infectious morbidities. Effective strategies for preventing and controlling peripartum infection should be an obstetrical priority.

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ing birth to liveborn infants in civilian hospitals in Washington State from January 1, 1987, through November 1, 1996 (n = 278998). From this group we excluded women with unknown method of delivery (n = 13,237), multiple gestation (n = 4667), infants weighing less than 500 g (n = 206), or infants of unknown birth weight (n = 621). Because antenatal maternal morbidity may affect delivery method as well as postpartum rehospitalization likelihood, we also excluded 4172 women (1.6%) with the following medical conditions identified at the time of the delivery hospitalization: diabetes mellitus, cardiac disease, renal disease, chronic hypertension, human immunodeficiency virus, myasthenia gravis, Huntington chorea, multiple sclerosis, and systemic lupus erythematosus. Some women met more than 1 exclusion criterion, and after all exclusions were made, 256,795 subjects remained for analysis. The study was approved by the Human Subjects Review Committee at the University of Washington, Seattle, and the Human Research Review Board at the Washington State Department of Health, Olympia.

**Exposure Classification**

Deliveries were classified as cesarean if “cesarean” was checked on the birth certificate or any of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)”7 cesarean delivery procedure or diagnosis codes were coded on hospital discharge data. Deliveries were classified as assisted vaginal if “vacuum extraction” or “outlet forceps” were checked on the birth certificate or if any appropriate ICD-9-CM diagnostic or procedure codes were coded on the hospital discharge data. If birth certificate and hospital discharge data were in conflict about the method of delivery, the priority was set as follows: (1) any mention of cesarean was classified as cesarean, and (2) any mention of vacuum extraction and/or forceps in the absence of cesarean was classified as assisted vaginal delivery. Given these criteria, there were 54,074 women (21%) with cesarean delivery, 59,953 women (23%) with assisted vaginal delivery, and 142,768 women (56%) with spontaneous vaginal delivery available for analysis.

**Outcome Classification**

Maternal rehospitalization was defined as a hospital admission that occurred for any reason after discharge from the delivery hospitalization and within 60 days of delivery. Data on maternal postpartum rehospitalization were obtained for all women in the study cohort by linking BERD files with CHARS records of all nondelivery admissions to Washington State hospitals between January 1, 1987, and December 31, 1996, using a sequential deterministic algorithm based on the woman’s name, sex, date of birth, and ZIP code. Our choice to study rehospitalization within 60 days was based on previous findings that operative procedures and diagnoses of an initial hospitalization are more likely to influence early rehospitalization, while comorbid medical conditions are more likely to be associated with late rehospitalization (≥1 year).8

**Statistical Analysis**

To examine the risk for maternal rehospitalization associated with assisted vaginal and cesarean delivery relative to spontaneous vaginal delivery, we used logistic regression to estimate relative risks (RRs), approximated by odds ratios and test-based 95% confidence intervals (CIs).9 The following variables, reported at the time of delivery, were examined for possible confounding effects: maternal age, maternal race/ethnicity, marital status, payer (Medicaid/uninsured, commercial, health maintenance organization, or other), hospital size, maternal smoking during pregnancy, infant’s birth weight, year of delivery, prepregnancy weight (data available for 1992-1996 only), and delivering hospital distance from state borders (≤50 miles, >50 miles). All potential confounding variables were considered for adjustment if their inclusion into any of the models changed the RR for maternal rehospitalization associated with method of delivery by 10% or more; only maternal age met this criterion. Interactions between method of delivery and maternal age and year of delivery were assessed with the likelihood ratio test. We used the 2-sample t test to compare the mean number of days from delivery until rehospitalization and the mean length of stay during rehospitalization among women who had assisted vaginal or cesarean delivery with that among women who had spontaneous vaginal delivery.

The associations between method of delivery and the risk of rehospitalization were further evaluated by examining 11 nonexclusive diagnosis groupings that could have a potential relationship with delivery mode. Rehospitalization ICD-9-CM diagnostic codes were reviewed and categorized independently by 2 obstetricians and 1 certified nurse-midwife who were unaware of subjects’ method of delivery. We used logistic regression with maximum likelihood estimation of RRs and 95% CIs to assess these associations.

**Subanalyses**

As rehospitalization may be attributable to the intrapartum events and obstetrical conditions surrounding labor rather than the method of delivery, in one subanalysis we examined the risk of rehospitalization with specific diagnoses among only the 213,895 women (83.2%) without obstetrical or intrapartum complications (premature rupture of membranes, preterm birth, chorioamnionitis, preeclampsia, eclampsia, abruptio placenta, placenta previa). Maternal length of stay during the birth hospitalization may affect a woman’s risk for rehospitalization. Therefore, in another subanalysis, we examined the risk for maternal rehospitalization associated with delivery method stratified by length of stay. We categorized maternal discharge as early (discharge ≤ 1 day after birth for vaginal deliveries and <3 days for cesarean delivery), intermediate (discharge on second day after birth for vaginal deliveries and between 3 and 5 days for cesarean delivery), and late (discharge >2 days after birth for vagi-
Several maternal, perinatal, and newborn characteristics differed by delivery method (TABLE 1). Women who had spontaneous vaginal delivery were younger, less likely to be married, more likely to be covered by Medicaid, and less likely to deliver at a high-volume hospital than women who had assisted vaginal or cesarean delivery. Infant birth weight also varied by mode of delivery. The highest percentage of low-birthweight infants (500-2499 g) was found among women with cesarean delivery, while women with assisted vaginal delivery had the lowest percentage. Additionally, women with cesarean delivery were more likely than women with vaginal delivery to have high-birthweight infants (≥4000 g). Obstetrical and intrapartum complication rates varied by method of delivery; women with cesarean delivery had the highest complication rates (TABLE 2).

A total of 3149 women (1.2% of the study cohort) were rehospitalized within 60 days of delivery. Rehospitalization discharge diagnosis groupings in order of frequency were: uterine infection (27.0%), postpartum hemorrhage (21.6%), gallbladder disease (18.8%), genitourinary complications (11.7%), breast infection (10.9%), obstetrical surgical wounds (8.2%), mental health (6.2%), cardiopulmonary complications (6.1%), thromboembolic complications (3.7%), pelvic injury (3.1%), and appendicitis (2.9%).

In multivariate models adjusted for maternal age, women with cesarean or assisted vaginal delivery had significantly elevated risks of rehospitalization with several specific diagnoses. In general, the pattern of increased risk for rehospitalization with specific diagnoses was greatest among women with cesarean delivery (TABLE 3). Compared with women who had spontaneous vaginal delivery, women who had cesarean delivery were more likely to be rehospitalized with uterine infection (RR = 2.0; 95% CI, 1.7-2.4), gallbladder disease (RR = 1.5; 95% CI, 1.3-1.9), genitourinary tract conditions (RR = 1.5; 95% CI, 1.2-2.0), obstetrical surgical wound complications (RR = 30.2; 95% CI, 18.8-47.4), cardiopulmonary conditions (RR = 2.4; 95% CI, 1.8-3.4), thromboembolic complications, and still significantly increased rehospitalization risk was also seen among women with assisted vaginal delivery (RR, 1.3; 95% CI, 1.2-1.4). Among women who were rehospitalized, the mean number of days from delivery until rehospitalization was statistically significantly lower among women with cesarean (20.4 days, P=.001) or assisted vaginal deliveries (21.1 days, P=.007) than among women who had spontaneous vaginal delivery (23.3 days). Additionally, the mean length for the subsequent hospital stay was significantly higher for women who had cesarean delivery (3.9 days) compared with women who had spontaneous vaginal delivery (3.3 days) (P=.01). Mean length of stay was identical for women rehospitalized after assisted vaginal and spontaneous vaginal delivery.

In logistic regression models adjusted for maternal age, women with cesarean delivery were more likely than women with spontaneous vaginal delivery to have high-birthweight infants (≥4000 g). Obstetrical and intrapartum complication rates varied by method of delivery; women with cesarean delivery had the highest complication rates (TABLE 2).

### Table 1. Demographic Characteristics of Primiparous Women and Their Singleton Live Births by Method of Delivery at Time of Birth Hospitalization, Washington State, 1987-1996

<table>
<thead>
<tr>
<th>Birth Weight, g</th>
<th>Spontaneous Vaginal Delivery, No. (%)</th>
<th>Assisted Vaginal Delivery, No. (%)</th>
<th>Cesarean Delivery, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000-1499</td>
<td>9096 (26.4)</td>
<td>3868 (26.8)</td>
<td>1290 (28.9)</td>
</tr>
<tr>
<td>1500-1999</td>
<td>11 030 (29.9)</td>
<td>4794 (33.4)</td>
<td>1470 (32.3)</td>
</tr>
<tr>
<td>2000-2499</td>
<td>21 422 (59.9)</td>
<td>7874 (55.1)</td>
<td>1744 (38.5)</td>
</tr>
<tr>
<td>≥2500</td>
<td>11 970 (34.7)</td>
<td>4980 (35.2)</td>
<td>1384 (30.2)</td>
</tr>
</tbody>
</table>

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dions (RR = 2.5; 95% CI, 1.5-3.5), and appendicitis (RR = 1.8; 95% CI, 1.3-3.0). Conversely, women with cesarean delivery had a decreased risk of rehospitalization with pelvic injury (RR = 0.4; 95% CI, 0.2-0.8). Compared with women who had spontaneous vaginal delivery, women who had assisted vaginal delivery had significantly increased risk of rehospitalization for postpartum hemorrhage complications (RR = 1.3; 95% CI, 1.1-1.5), genitourinary tract conditions (RR = 1.4; 95% CI, 1.1-1.8), obstetrical surgical wound complications (RR = 2.4; 95% CI, 2.4-7.3), and pelvic injury (RR = 2.5; 95% CI, 1.6-3.7). Admission for breast infection or mental health diagnoses was not associated with method of delivery. We repeated the analyses presented in Table 3 among women without obstetrical or intrapartum complications, with identical results (data not shown).

Finally, in one analysis stratified by maternal length of stay during the birth hospitalization, the RR for rehospitalization among women with early or late discharge status were unchanged from the prior analyses (data not shown). However, slightly decreased risks for rehospitalization (cesarean delivery, RR = 1.6, 95% CI, 1.4-1.8; assisted vaginal delivery, RR = 1.1, 95% CI, 1.0-1.2) were seen among women discharged during the intermediate time interval.

**COMMENT**

To our knowledge, this is the first US population-based study to report specifically on the risk of maternal postpartum rehospitalization associated with method of delivery among a large cohort of primiparous women without prior identified high-risk medical conditions. For clinicians and women who are deciding whether operative vaginal delivery or abdominal delivery should be chosen, our data provide insights into the relative degree of maternal risk of the 2 approaches. While only 1.2% of subjects developed subsequent medical problems severe enough to warrant rehospitalization within 2 months of delivery, we found an 80% increase in postpartum rehospitalization risk among women with cesarean delivery, and a 30% increase in risk among those with assisted vaginal delivery.

Women with cesarean delivery had significantly increased risks of rehospitalization with several specific diagnoses. Our most notable result was a 30-fold risk associated with obstetrical surgical wound infection; however, the rate of rehospitalization for wound infection among women with cesarean delivery was still quite low (4/1000 cesarean procedures). Because surgical wounds occur in every instance among women with cesarean delivery and episiotomy does not occur with every spontaneous vaginal delivery, a higher risk for rehospitalization for surgical wound

### Table 2. Obstetrical and Intrapartum Complications of Primiparous Women and Their Singleton Live Births by Method of Delivery at Time of Birth Hospitalization, Washington State, 1987-1996

<table>
<thead>
<tr>
<th>Rehospitalization Diagnosis</th>
<th>Spontaneous Vaginal Delivery, Incidence (n = 142,768)</th>
<th>Assisted Vaginal Delivery, Incidence (n = 59,953)</th>
<th>Cesarean Delivery, Incidence (n = 54,074)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%)[*]</td>
<td>No. (%)‡</td>
<td>No. (%)‡</td>
</tr>
<tr>
<td>Premature rupture of membranes</td>
<td>11,064 (7.8)</td>
<td>4,331 (7.2)</td>
<td>5,208 (9.6)</td>
</tr>
<tr>
<td>Preterm birth (&lt;37 wk)</td>
<td>11,217 (7.9)</td>
<td>3,377 (5.6)</td>
<td>4,436 (8.2)</td>
</tr>
<tr>
<td>Chorioamnionitis</td>
<td>1,457 (1.0)</td>
<td>1,083 (1.8)</td>
<td>2,749 (5.1)</td>
</tr>
<tr>
<td>Preeclampsia/eclampsia</td>
<td>727 (0.5)</td>
<td>422 (0.7)</td>
<td>1,467 (2.7)</td>
</tr>
<tr>
<td>Abruptio placenta</td>
<td>984 (0.7)</td>
<td>475 (0.8)</td>
<td>1,080 (2.0)</td>
</tr>
<tr>
<td>Placenta previa</td>
<td>82 (0.1)</td>
<td>43 (0.1)</td>
<td>400 (0.7)</td>
</tr>
</tbody>
</table>

*Except for placenta previa among women with assisted vaginal delivery, all differences in complication rates for operative deliveries relative to spontaneous vaginal delivery were significant (P < .01).

### Table 3. Incidence of Rehospitalization for Specific Diagnoses and Risk Associated With Operative Delivery Among Primiparous Women Compared With Spontaneous Vaginal Delivery, Washington State, 1987-1996

<table>
<thead>
<tr>
<th>Rehospitalization Diagnosis</th>
<th>Spontaneous Vaginal Delivery, Incidence (n = 142,768)</th>
<th>Assisted Vaginal Delivery (n = 59,953)‡</th>
<th>Cesarean Delivery (n = 54,074)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%)[*], Adjusted RR (95% CI)‡</td>
<td>Incidence, Adjusted RR (95% CI)‡</td>
<td>Incidence, Adjusted RR (95% CI)‡</td>
</tr>
<tr>
<td>All diagnoses</td>
<td>10.0, 1.3 (1.2-1.4)</td>
<td>17.0, 1.8 (1.6-1.9)</td>
<td></td>
</tr>
<tr>
<td>Uterine infection</td>
<td>2.9, 1.2 (1.0-1.5)</td>
<td>5.2, 2.0 (1.7-2.4)</td>
<td></td>
</tr>
<tr>
<td>Postpartum hemorrhage</td>
<td>2.4, 1.3 (1.1-1.5)</td>
<td>2.9, 1.2 (1.0-1.5)</td>
<td></td>
</tr>
<tr>
<td>Gallbladder</td>
<td>2.2, 1.2 (1.0-1.5)</td>
<td>2.8, 1.5 (1.3-1.9)</td>
<td></td>
</tr>
<tr>
<td>Genitourinary</td>
<td>1.3, 1.4 (1.1-1.8)</td>
<td>1.7, 1.5 (1.2-2.0)</td>
<td></td>
</tr>
<tr>
<td>Obstetrical surgical wounds</td>
<td>0.1, 4.2 (2.4-7.3)</td>
<td>3.9, 30.2 (18.8-47.4)</td>
<td></td>
</tr>
<tr>
<td>Breast infection</td>
<td>1.0, 1.1 (0.8-1.5)</td>
<td>0.9, 1.0 (0.7-1.4)</td>
<td></td>
</tr>
<tr>
<td>Mental health</td>
<td>0.7, 1.0 (0.7-1.4)</td>
<td>0.9, 1.3 (0.9-1.8)</td>
<td></td>
</tr>
<tr>
<td>Cardiopulmonary</td>
<td>0.6, 1.1 (0.7-1.6)</td>
<td>1.3, 2.4 (1.8-3.4)</td>
<td></td>
</tr>
<tr>
<td>Thromboembolic</td>
<td>0.3, 1.1 (0.7-1.8)</td>
<td>0.9, 2.5 (1.5-3.5)</td>
<td></td>
</tr>
<tr>
<td>Pelvic injury</td>
<td>0.3, 2.5 (1.6-3.7)</td>
<td>0.1, 0.4 (0.2-0.8)</td>
<td></td>
</tr>
<tr>
<td>Appendicitis</td>
<td>0.3, 1.4 (0.9-2.5)</td>
<td>0.5, 1.8 (1.3-3.0)</td>
<td></td>
</tr>
</tbody>
</table>

*The incidence is expressed as the number of rehospitalizations per 1000 women with singleton live births by method of delivery.
†Assisted vaginal delivery refers to delivery with the use of vacuum extraction, forceps, or both.
‡Relative risks (RRs) were adjusted for maternal age at first birth. CI indicates confidence interval.
§Includes complications of obstetrical surgical wounds.
|| Includes disruption of perineal wound, pelvic hematoma, thrombosed hemorrhoids, fistula of genital tract, and abscess of rectal region.
DELIVERY METHOD AND POSTPARTUM REHOSPITALIZATION

infection may be expected among women with cesarean delivery. Other studies evaluating women during the birth hospitalization or outside the hospital setting have also found uterine infection, obstetrical surgical wound complications, cardiopulmonary, and thromboembolic conditions to be more common among women with cesarean delivery.10-13 Our finding of increased risk of rehospitalization for gallbladder disease among women with cesarean delivery has not been reported previously, but postoperative acute cholecystitis has been associated with other types of intra-abdominal surgery.14-16 Factors related to abdominal surgery and the development of subsequent gallbladder disease include stasis of bile with high viscosity induced by dehydration, hypovolemia, fever, anesthesia, and narcotics, all of which may be associated with cesarean delivery. We also found an 80% increased risk of rehospitalization for appendicitis among women with cesarean delivery, an association not noted in previous research. Since infection has been reported as a possible risk factor for appendicitis, a plausible explanation is that the manipulation of abdominal contents during the cesarean delivery may exacerbate an existing subclinical infection.17

While rehospitalization following cesarean delivery was nearly twice as common as rehospitalization following vaginal delivery, at 17 per 1000 the cesarean rehospitalization rate was still substantially lower than rehospitalization rates seen following hysterectomy (range, 26-52 per 1000).18 The lower postoperative rehospitalization rate we found is likely due to the younger age and healthy presurgical condition of our study population.

Our study is the first to examine associations between assisted vaginal delivery and postpartum rehospitalization. Among women with vaginal delivery, we found that those whose deliveries were assisted by forceps or vacuum extraction had a greater likelihood for rehospitalization, particularly with adverse perineal outcome diagnoses. Notably, these associations were not confounded by infant birth weight. The mechanical trauma associated with assisted vaginal delivery has been reported in previous studies to result in anal sphincter tears, sulcus lacerations, anal incontinence, urinary incontinence, and pain on intercourse, measured during the birth hospitalization or on an outpatient basis.3,19-22 Our findings indicate that the level of trauma can be severe enough to necessitate postpartum rehospitalization.

Use of birth certificate and hospital discharge data to investigate the associations between delivery method and rehospitalization has beneficial aspects. Linked datasets allowed us to use an entire state’s cohort of low-risk primiparous women giving birth to live singletons over a 10-year period, providing an adequate number of subjects to examine specific diagnoses, including both puerperium and nonpuerperium ICD-9-CM diagnostic codes. Our findings indicate that the health consequences women face following childbirth are not captured within the puerperium diagnostic codes alone. Our data linkage process also provided for ascertainment of maternal rehospitalization that occurred anywhere in Washington State, thus avoiding the inaccurate estimation of risk of rehospitalization with certain diagnoses that may occur in site-specific studies. We found that 21% of women were rehospitalized to a hospital other than the original delivery hospital. These women were less likely to be readmitted for uterine infection or obstetrical surgical wounds and more likely to be readmitted with mental health diagnoses.

Data derived from vital statistics and administrative records may be limited in accuracy or completeness. In this study, we have some assurance that there was minimal misclassification of method of delivery, as previous research indicates that 99.8% of cesarean and 92.1% of assisted vaginal deliveries are correctly classified using Washington State–linked birth certificate-hospital discharge files.23 Nonetheless, we were limited in our ability to distinguish between forceps and vacuum extraction–assisted deliveries because in our dataset the most frequently used ICD-9-CM diagnostic code for operative vaginal delivery was 669.5 (forceps or vacuum extractor). As vacuum extraction results in less maternal trauma than forceps-assisted delivery and perineal trauma also differs by type of forceps used, our inability to separate the procedures may have obscured differential intervention outcomes.23,24 Further, the extent of perineal morbidity associated with vacuum-assisted delivery has been reported to increase when episiotomy accompanies the procedure.25 Although the ICD-9-CM coding provided information on episiotomy and lacerations, the small number of women rehospitalized for adverse perineal outcomes was not sufficient to allow stratification on this variable.

Increased risk of maternal postpartum rehospitalization may be attributed to factors other than delivery method, and these factors may influence delivery method as well. We attempted to isolate the effect of the delivery method in 2 ways. We limited our analysis to primiparous women, eliminating the potential confounding effect of prior method of delivery. We also excluded from all analyses women with preexisting medical conditions that could have predisposed them both to operative delivery and rehospitalization, and in one subanalysis we included only women without obstetrical or intrapartum complications. It is still possible that, given the same level of morbidity, women with cesarean delivery were more likely than those women with spontaneous vaginal delivery to be rehospitalized. However, the longer mean length of rehospitalization stay among women with cesarean delivery argues against this interpretation.

Our findings suggest several ways to improve women’s postpartum health. The use of safe, clinically appropriate strategies known to reduce cesarean delivery likelihood among primiparous women would provide primary prevention of cesarean-related morbidity. Examples include provision of trained social support in labor, a larger role of midwives, low-dose bupivacaine epidural when labor pain management is nec-
cessory, second-opinion requirements on the necessity of cesarean delivery, and selective external cephalic version and mobiurbation near term for breech presentation.26-30 Among women with cesarean delivery, one strategy to prevent operative delivery-related morbidity is improvement of peripartum care management. The likelihood of postcesarean endometritis or wound complications may be reduced by limiting the number of vaginal examinations during labor, use of assisted spontaneous placenta removal (external uterine massage and gentle cord traction), and antibiotic prophylaxis if labor or rupture of membranes has occurred.11,12 Additionally, antepartum detection and treatment of genit al tract infections (especially bacterial vaginosis and group B streptococcus) may reduce postpartum infection.13,14 Finally, attention to clinical measures recommended for the prevention or minimization of the mechanical trauma associated with assisted vaginal delivery (selectively substituting vacuum extraction for forces, restricting the use of episiotomy, and using effective suction techniques) may decrease risk of pelvic injury or wound complications among this group.15-18

In addition to marking serious postpartum morbidity, maternal rehospitalization carries substantial consequences in and of itself, including high economic costs, the disruption of early parenting, and increased family burden. Identification of factors that can amend rehospitalization risk remains a complex undertaking. Our most important finding, that women with cesarean and assisted vaginal delivery were at increased risk for rehospitalization with infectious morbidities, suggests that even more rigorous attention to effective peripartum infection prevention and control strategies should be an obstetrical care priority.

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