Maternal Peripartum Complications Associated with Vaginal Group B Streptococci Colonization

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The study was done to determine the risk of clinically diagnosed intra-amniotic infection (IAI) and postpartum endometritis (PPE) associated with vaginal group B streptococci (GBS) colonization. Pregnant women were enrolled in a cross-sectional, observational study from 1992 to 1996 in Houston (n = 908), Seattle (n = 2676), and Pittsburgh (n = 4338). Swab samples were obtained from the lower vagina of participants at admission for delivery and inoculated into selective broth and onto blood agar media. At the combined centers, 2.9% of the women (231/7922) had IAI, and 2.0% (157/7922) had PPE. The risk of IAI was higher for women with heavy GBS colonization (odds ratio [OR], 2.0; 95% confidence interval [95% CI], 1.1–3.7) than for those with light colonization (OR, 1.2; 95% CI, 0.7–1.8). The risk of GBS-associated PPE was not influenced by density of colonization (OR, 1.8; 95% CI, 1.3–2.7). These findings provide further evidence that GBS is associated with maternal intrapartum complications.

GBS has been associated with maternal peripartum complications; however, reports associating GBS with intra-amniotic infection (IAI) and postpartum endometritis (PPE) have presented conflicting findings. The evidence that GBS is associated with maternal infections includes isolation of GBS from blood and genital specimens of women with IAI and PPE and the association of vaginal colonization with an increased risk of PPE [3, 4]. A recent study examined the risk of high-density GBS vaginal colonization and IAI or PPE by evaluating women who had samples cultured within 2 weeks of delivery without receiving antimicrobial therapy [5]. Increased concentration of vaginal GBS colonization was associated with a stepwise increase in the risk of IAI infection but not PPE [5]. GBS identified in midpregnancy was not associated with IAI at delivery [6].

These findings suggest that our understanding of the risk of maternal peripartum infections associated with vaginal GBS colonization is incomplete. The timing of specimen collection, the site of specimen collection for culture, the density of colonization, and the number of cases of maternal complications all may be important factors in assessing risk. The purpose of this study was to determine the risk of IAI and PPE associated with GBS colonization at admission for delivery. Risks were determined for light and heavy GBS inocula from specimens obtained within 14 days of delivery.

Methods

Study groups. Women were enrolled at 3 clinical sites: Baylor College of Medicine, Houston (Ben Taub General Hospital, Methodist Hospital, St. Luke's Episcopal Hospital); University of Washington, Seattle (University of Washington Medical Center); and University of Pittsburgh, Pittsburgh (Magee-Womens Hospital). Each center used the same study design: a cross-sectional, observational study using convenience sampling. Before the study enrollment, the 3 clinical centers agreed to a uniform protocol that included methods for obtaining specimens, laboratory techniques for inoculating specimens into media and assessing GBS inoculum, a closed-form data-collection instrument for medical record review,
and inclusion criteria that defined IAI and PPE. A total of 8168 women were enrolled from 1992 through 1994 in Seattle (n = 2753), 1994 through 1996 in Houston (n = 918), and 1995 through 1996 in Pittsburgh (n = 4497). Participants were excluded from analysis if they had multiple gestations (n = 184), a scheduled cesarean delivery (n = 123), or incomplete medical records (n = 55); thus, 7806 of the 8168 women were available for analysis.

**Microbiology.** Specimens were obtained from women who were admitted to the labor and delivery unit with contractions or rupture of fetal membranes. Specimens were obtained by placing 2 Dacron-tipped swabs into the lower one-third of the vagina and rotating these 360°. The swabs then were placed into transport medium (Amies; Medical Media Laboratory, Troutdale, OR), which was stored at room temperature in the delivery units, and transported to the laboratory. Vaginal specimens were inoculated onto medium within 6–12 h of collection. Women whose specimens were obtained >2 weeks before delivery were excluded from the statistical models to estimate the risk of IAI and PPE associated with GBS (n = 120) but were otherwise included in the tables.

Vaginal specimens were assessed for GBS at the 3 clinical centers. The vagina was chosen as the most important site for sample collection for culture because the intrauterine exposure resulting in IAI and PPE is thought to be an ascending infection from the vagina to the intra-amniotic cavity. To culture for GBS, 1 swab was removed from the transport tube and inoculated onto a 5% sheep blood agar plate (Prepared Media Laboratories, Tualatin, OR) and into selective broth medium (Prepared Media Laboratories). Agar plates were streaked for 4 zones of isolation, incubated at 36–37°C in 5%–7% CO₂ for 24 h, and then visually inspected for β-hemolytic streptococci. If the original agar plate was negative for GBS growth, the selective medium was inoculated onto another blood agar plate and incubated for a further 24 h. Presumptive GBS were identified by latex agglutination (Pathodx; Diagnostics Products, Los Angeles) [7]. Women with vaginal specimens that were positive for GBS on the agar plate were categorized as having light colonization (growth in the first or second streak zone) or heavy colonization (growth in the third or fourth zone) and compared with women who were negative for GBS. Specimens that yielded GBS from broth medium only and were negative for GBS when subcultured onto solid medium were classified separately as broth positive only.

At the Seattle and Pittsburgh centers (n = 6944) specimens were also prepared for the isolation of *Escherichia coli* and for the diagnosis of bacterial vaginosis from a Gram’s-stained vaginal smear. These were studied because they have been associated with GBS [8] and to control for their potential influence in the analysis. Five percent sheep blood agar plates were streaked for 4 zones of isolation, incubated at 36–37°C in 5%–7% CO₂ for 24 h, and visually inspected for coliforms. *E. coli* was identified by use of standard biochemical testing [9]. A Gram’s-stained vaginal smear was prepared and evaluated by use of a microscope for the diagnosis of bacterial vaginosis. Bacterial morphotypes were identified and scored using the Nugent method [10].

**Definitions of outcomes.** The diagnosis of IAI was made retrospectively by review of medical records. Each record was reviewed for each element of the criteria. At the beginning of the study, the investigators from the data coordinating center and the clinical sites agreed on criteria for the definition of IAI on the basis of criteria used in previous studies [11], but the criteria were made more specific to enhance medical-record abstraction at the 5 participating hospitals. IAI was defined as fever (≥38°C for ≥2 h or ≥38.3°C once) during labor accompanied by at least 2 of the following: tachycardia (maternal, ≥100 beats/minute [BPM]; fetal, ≥160 BPM), uterine tenderness, purulent amniotic fluid, or elevated maternal peripheral white blood cell count (>15,000/mm³). The terminology intra-amniotic infection was used to be consistent with usage by other investigators [12] and to distinguish the clinical syndrome from bacterial invasion of the amniotic fluid or fetal membranes.

The diagnosis for PPE was made using the ICD-9 discharge diagnosis for PPE. This was decided upon after conducting 2 pilot studies to validate the ICD-9 discharge diagnosis of PPE. The pilot studies were conducted at the University of Washington Medical Center (n = 2495) and at the University of Pittsburgh (n = 183). A comparison of a standardized criteria for the diagnosis of PPE with the discharge diagnosis revealed a positive predictive value of 94%. The standardized criteria were postpartum temperature of ≥38.5°C in the first 24 h after delivery or ≥38°C for at least 4 consecutive hours ≥24 h after delivery accompanied by lower abdominal tenderness greater than expected and use of parenteral antibiotics. The ICD-9 discharge diagnosis was used for PPE after completing the 2 pilot studies because of the extremely high agreement between the standardized criteria and the discharge diagnosis.

Women could be diagnosed with IAI alone, PPE alone, or both. The risk factors for IAI and PPE were evaluated separately because of their different clinical implications, modes of intervention, and timing of potential intervention.

**Statistical analysis.** The frequencies of IAI or PPE among women with different demographic characteristics were compared by use of generalized χ² tests of statistical significance (table 1) [13]. The risk of IAI and PPE associated with reproductive characteristics was determined using an adjusted odds ratio (OR) from a logistic regression model (SPSS for Windows; SPSS, Chicago; tables 2, 3). Adjusted risks of IAI and PPE associated with vaginal GBS were estimated using ORs from a logistic model. A number of variables were evaluated for their confounding effect but not presented in the final model, to achieve a parsimonious model. The

| Table 1. Demographic characteristics for 7806 women with intra-amniotic infection (IAI) or postpartum endometritis (PPE). |
| --- |
| Characteristic | n | IAI, no. (%) | P | PPE, no. (%) | P |
| City |  |  |  |  |  |
| Houston | 862 | 24 (2.8) | 22 (2.6) |  | 0.001 |
| Seattle | 2659 | 141 (5.3) | 45 (1.7) |  | 0.001 |
| Pittsburgh | 4285 | 65 (1.5) | 89 (2.1) |  | 0.001 |
| Age, years |  |  |  |  |  |
| <20 | 1004 | 38 (3.8) | 35 (3.5) |  | 0.001 |
| 20–24 | 1745 | 73 (4.2) | 40 (2.3) |  | 0.001 |
| 25–29 | 2032 | 51 (2.5) | 31 (1.5) |  | 0.001 |
| 30–34 | 1939 | 43 (2.2) | 24 (1.2) |  | 0.001 |
| ≥35 | 1086 | 25 (2.3) | 26 (2.4) |  | 0.001 |
| Race |  |  |  |  |  |
| White | 4881 | 122 (2.5) | 81 (1.7) |  | 0.001 |
| Black | 1409 | 50 (3.5) | 48 (3.4) |  | 0.001 |
| Hispanic | 789 | 26 (3.2) | 13 (1.6) |  | 0.001 |
| Asian | 419 | 18 (4.3) | 7 (1.7) |  | 0.001 |
| Other | 267 | 12 (4.5) | 5 (1.9) |  | 0.001 |
| Unknown | 41 | 2 |  |  | 0.001 |
Table 2. Reproductive characteristics for 7806 women with intra-amniotic infection (IAI) or postpartum endometritis (PPE).

| Characteristic                        | n    | IAI, no. (%) | Adjusted OR* (95% CI) | PPE, no. (%) | Adjusted OR* (95% CI) |
|---------------------------------------|------|--------------|-----------------------|--------------|----------------------|
| First pregnancy                       |      |              |                       |              |                      |
| Yes                                   | 2534 | 104 (4.1)    | 1.6 (1.2–2.1)         | 79 (3.1)     | 1.6 (1.1–2.2)        |
| No                                    | 5250 | 126 (2.4)    | 1.6 (1.1–2.2)         | 77 (1.5)     | 1.6 (1.1–2.2)        |
| Unknown                               | 22   | 0            | 0                     | 0            | 0                    |
| Premature rupture of membranes        |      |              |                       |              |                      |
| Yes                                   | 1113 | 68 (6.1)     | 2.5 (1.8–3.4)         | 32 (2.9)     | 1.3 (0.8–2.0)        |
| No                                    | 6354 | 139 (2.2)    | 1.6 (1.1–2.2)         | 114 (1.8)    | 1.3 (0.8–2.0)        |
| Unknown                               | 339  | 23           | 10                    | 10           | 10                   |
| Delivery at <37 weeks gestation       |      |              |                       |              |                      |
| Yes                                   | 1071 | 60 (5.6)     | 1.5 (1.1–2.2)         | 33 (3.1)     | 1.2 (0.7–1.8)        |
| No                                    | 6734 | 170 (2.5)    | 1.6 (1.1–2.2)         | 123 (1.8)    | 1.2 (0.7–1.8)        |
| Unknown                               | 1    | 0            | 0                     | 0            | 0                    |
| Cesarean delivery                     |      |              |                       |              |                      |
| Yes                                   | 1110 | 82 (7.4)     | 3.6 (2.7–4.9)         | 126 (11.4)   | 26.7 (17.7–40.4)     |
| No                                    | 6696 | 148 (2.2)    | 0.8 (0.5–1.3)         | 30 (0.4)     | 10                   |
| IAI                                   |      |              | 1.4 (0.9–2.0)         | 17 (1.1)     | 1.4 (0.9–2.0)        |
| Yes                                   | 230  | —            | 20 (8.7)              | 2.2 (1.2–3.8) |                      |
| No                                    | 7576 | —            | 136 (1.8)             |             |                      |

NOTE. OR = odds ratio; 95% CI = 95% confidence interval.
* Adjusted for all other variables in table.

Results

Vaginal colonization with GBS was present in 1689 (21.6%) of the 7806 women enrolled: 5.2% had heavy colonization, 9.9% had light colonization, and 6.5% had positive results in liquid medium only. The demographic characteristics of women with IAI or PPE were described for all enrollment centers combined (table 1). The overall frequency of IAI was 2.9%; however, IAI was more frequent in Seattle and less frequent in Pittsburgh. The frequency of PPE was 2.0% and was quite similar among the three cities. Younger women were more likely to have either IAI or PPE. IAI was more frequent among women of any ethnic minority. PPE was more frequent among African-American

Table 3. Management of labor for 3518 women with intra-amniotic infection (IAI) or postpartum endometritis (PPE) in Seattle and Houston.

| Characteristic                          | n    | IAI, no. (%) | Adjusted OR* (95% CI) | PPE, no. (%) | Adjusted OR* (95% CI) |
|-----------------------------------------|------|--------------|-----------------------|--------------|----------------------|
| Hours of labor                          |      |              |                       |              |                      |
| ≥24                                     | 355  | 38 (10.7)    | 2.0 (1.2–3.5)         | 9 (2.5)      | 1.3 (0.5–3.5)        |
| 7–23                                    | 1858 | 78 (4.2)     | 1.0 (0.6–1.6)         | 34 (1.8)     | 1.1 (0.5–2.3)        |
| 0–6                                     | 959  | 31 (3.2)     | 1.1 (0.6–1.9)         | 11 (1.1)     | 1.1 (0.5–2.3)        |
| Unknown                                 | 346  | 18           | 13                    | 13           | 13                   |
| Hours of membrane rupture               |      |              |                       |              |                      |
| ≥24                                     | 303  | 39 (12.9)    | 2.9 (1.6–5.1)         | 5 (1.7)      | 0.8 (0.2–2.6)        |
| 7–23                                    | 1167 | 85 (7.3)     | 2.9 (1.8–4.5)         | 40 (3.4)     | 2.4 (1.2–4.8)        |
| 0–6                                     | 1886 | 32 (1.7)     | 17 (0.9)              | 17 (0.9)     | 17 (0.9)             |
| Unknown                                 | 162  | 9            | 5                     | 5            | 5                    |
| Internal monitoring                     |      |              |                       |              |                      |
| Yes                                     | 1119 | 83 (7.4)     | 1.4 (0.9–2.0)         | 33 (2.9)     | 1.9 (1.1–3.5)        |
| No                                      | 2387 | 81 (3.4)     | 34 (1.4)              | 34 (1.4)     | 34 (1.4)             |
| Unknown                                 | 12   | 1            | 0                     | 0            | 0                    |
| Intrapartum antimicrobial administration|      |              |                       |              |                      |
| Yes                                     | 615  | 99 (16.1)    | 6.9 (4.7–10.0)        | 36 (5.9)     | 4.7 (2.6–8.3)        |
| No                                      | 2903 | 66 (2.3)     | 31 (1.1)              |              |                      |

NOTE. OR = odds ratio; 95% CI = 95% confidence interval.
* Adjusted for all other variables in table.
women and had a similar frequency among all other racial or ethnic subgroups.

The reproductive characteristics of women with IAI and PPE are summarized in table 2. The ORs presented are adjusted for all of the other variables in the table because they were statistically significantly related to IAI and PPE. Women who were having their first pregnancy, whose membranes ruptured before contractions, who delivered preterm, and who had an operative delivery were more likely to have IAI. Women having their first pregnancy were also more likely to develop PPE. However, premature rupture of membranes and preterm delivery did not increase the risk of PPE. Most (81%) cases of PPE followed a cesarean delivery. Women with IAI were more likely to develop PPE compared with women not having their labor complicated with IAI. However, only 20 women (13%) with PPE developed this complication following IAI. The combined frequency of maternal peripartum infectious complications was 4.6% (366 cases).

The management of labor for women with IAI and PPE is shown in table 3. Information was available from only 2 of the 3 cities, Houston and Seattle (n = 3518). Prolonged (>24 h) labor was associated with IAI but not with PPE. Prolonged membrane rupture (>24 h) was associated with both IAI and PPE. Internal fetal monitoring was not associated with the development of IAI; however, monitoring increased the risk of having PPE. Labor complicated by IAI was frequently managed with administration of antimicrobials. Sixty percent (99/165) of women with signs and symptoms of IAI received antimicrobials during labor, but in many cases this was after the recognition of the signs and symptoms of IAI. Intrapartum antimicrobials were administered frequently to women who later developed PPE (36/67, 54%).

The risk for IAI and PPE associated with the density of vaginal GBS colonization was assessed by use of logistic models (tables 4, 5). In the models determining the risk of IAI associated with GBS, city of enrollment was used as a controlling variable because it was associated with the frequency of IAI and of GBS colonization, and it influenced the point estimate of risk. The number of births (parity) was used as a controlling variable in models of IAI because it has been consistently associated with this intrapartum complication in previous studies [6] and changed the point estimate of risk. Bacterial vaginosis and vaginal E. coli colonization were controlled in the analysis to provide a risk estimate independent of their influence. Ethnic or racial origin and age were evaluated as controlling variables because they have been associated with IAI, GBS, or both; however, they had no influence on the magnitude of the risk. The reproductive variables of premature rupture of membranes, preterm delivery, cesarean delivery, and prolonged labor and rupture of membranes were not associated with GBS colonization (data not shown). Consequently, when they were evaluated as confounding variables, they did not change the risk of IAI associated with GBS. The adjusted risk of IAI was lowest among women with the lowest density of colonization when GBS was isolated in broth medium only (OR, 0.6; 95% CI, 0.3–1.3); it was higher in women with light colonization (OR, 1.2; 95% CI, 0.7–1.8) and was highest among those with high density or heavy colonization (OR, 2.0; 95% CI, 1.1–3.7).

The risk of PPE was determined for women with colonization detected by broth medium (OR, 0.6; 95% CI, 0.3–1.5) and for those with light (OR, 1.8; 95% CI, 1.2–2.8) and heavy colonization (OR, 1.8; 95% CI, 1.0–3.2). The risk of PPE was similar for women with light and heavy GBS colonization. The risk of PPE associated with GBS after combining light and heavy colonization was 1.8 (95% CI, 1.3–2.6; table 5). The risk of PPE associated with GBS was then adjusted for first pregnancy, but the point estimate of risk did not change further after adjusting for age, race, city of enrollment, bacterial vaginosis, or E. coli colonization. The risk of PPE associated with GBS colonization was very similar for women with cesarean (OR, 1.9; 95% CI, 1.2–2.9) or vaginal delivery (OR, 2.3; 95% CI, 1.1–4.8).

### Table 4. Risk of intra-amniotic infection (IAI) associated with vaginal group B streptococci (GBS) colonization in 7806 women.

| GBS                        | n   | IAI, no. (%) | Adjusted OR 95% CI |
|----------------------------|-----|-------------|--------------------|
| Colonization               |     |             |                    |
| Heavy (3–4+)               | 406 | 15 (3.7)    | 2.0 (1.1–3.7)      |
| Light (1–2+)               | 776 | 30 (3.9)    | 1.2 (0.7–1.8)      |
| Isolated in broth medium   | 507 | 9 (1.8)     | 0.6 (0.3–1.3)      |
| Negative                   | 6117| 176 (2.9)   | Reference          |

NOTE. OR = odds ratio; 95% CI = 95% confidence interval.

* Risk was estimated after adjusting for city, parity, bacterial vaginosis, and Escherichia coli colonization (n = 6818). Women whose specimens were obtained >2 weeks before delivery (n = 120) were also excluded.

### Table 5. Risk of postpartum endometritis (PPE) associated with vaginal group B streptococci (GBS) colonization in 7806 women.

| GBS                        | n   | PPE, no. (%) | Adjusted OR (95% CI) |
|----------------------------|-----|-------------|----------------------|
| Light or heavy colonization| 1182| 38 (3.2)    | 1.8 (1.3–2.6)        |
| Isolated in broth medium   | 507 | 6 (1.2)     | 0.6 (0.3–1.5)        |
| Negative                   | 6117| 112 (1.8)   | Reference            |

NOTE. OR = odds ratio; 95% CI = 95% confidence interval.

* Adjusted for first pregnancy (n = 7784). Women whose specimens were obtained >2 weeks before delivery (n = 120) were also excluded.

* Adjusted risks were 1.8 for both light and heavy colonization when considered separately; therefore, they were combined.
of IAI than reported from other hospital-based studies. The frequency (2%) of PPE also was lower than the frequency noted by other investigators [5]. The frequency of GBS colonization among pregnant women was 21.6%, which is similar to colonization rates (18%–26%) found by other investigators using liquid and solid media [5, 16, 17].

Maternal vaginal colonization with GBS during pregnancy has been intensively studied, to determine the most efficacious and efficient method to prevent neonatal exposure and progression to invasive infection with attendant morbidity and mortality. Few studies have examined the corollary question of whether maternal vaginal colonization during pregnancy may be associated with maternal peripartum infectious complications such as IAI and PPE. GBS has been isolated from the amniotic fluid more frequently among women with signs and symptoms of IAI than from controls [18]. Further, among women with signs and symptoms of IAI, GBS was isolated at similar frequencies among women with and without low-birthweight infants [19]. These studies provide very direct evidence that amniotic fluid GBS may be one of the etiologic agents for IAI.

Our study and 2 previous studies [5, 6] examined the question of whether vaginal GBS colonization is associated with IAI or PPE. Yancey and colleagues [5] reported that vaginal GBS was associated with IAI, with an increased risk attributable to light (OR, 1.9; 95% CI, 1.0–3.7), moderate (OR, 2.6; 95% CI, 1.3–5.2), and heavy colonization (OR, 3.2; 95% CI, 1.5–6.6). In the primary features of the findings, our study is confirmatory, showing that heavy colonization with GBS increased the risk of IAI. However, our findings differ slightly from those of Yancey et al. [5] because, unlike us, they found an increased risk associated with light and moderate colonization. These differences leave unanswered the question as to whether light colonization is a risk for IAI or PPE. The ORs estimated in the 2 studies for light colonization (OE, 1.2; 95% CI, 0.7–1.8 vs. OR, 1.9; 95% CI, 1.0–3.7) are not statistically significantly different. These slight differences in estimated risk could be accounted for by differences in the hospitals’ policies concerning GBS prophylaxis or the change in policies for GBS prophylaxis over the past few years.

Krohn and colleagues [6] studied the risk of IAI associated with GBS detected at weeks 26–28 of gestation up to 3 months before delivery. No increased risk of IAI was associated with GBS colonization when there was a long interval between testing and delivery. Investigators examining the intermittent nature of GBS colonization during pregnancy have shown that women may acquire or lose colonization in the last trimester, so that specimens obtained at the end of the second trimester have inadequate predictive value for colonization at delivery [16, 20]. This may explain why a study based on specimens obtained in midpregnancy did not find an increased risk of IAI associated with vaginal GBS colonization [6].

The present study provides evidence that GBS is associated with an increased risk of IAI. Among the entire study population of close to 8000 women enrolled from three cities, there was a 2-fold increased risk for women with high-density colonization to develop IAI. The risk of PPE associated with GBS was not dependent upon density of colonization. There was an 80% increased risk (95% CI, 1.3–2.7) associated with any growth of GBS. Vaginal colonization with GBS intrapartum is thought to expose the amniotic cavity, a normally sterile site, to bacterial inoculum during delivery. Whether the mother develops IAI or PPE may be dependent on when during intrapartum events the upper tract exposure occurs and on the mother’s local defense mechanisms and the timing of intrapartum antimicrobials. We suspect that the mechanisms of upper genital tract exposure to GBS is similar for IAI or PPE and that the development of IAI or PPE represents the result of timing and host defenses in individual cases. Yancey et al. [5] did not find an increased risk of PPE associated with GBS after adjustment for prolonged labor and prolonged rupture of membranes. Our findings agreed with theirs before adjustment for prolonged labor and rupture of membranes; however, in our study, prolonged labor and prolonged rupture of membranes was not associated with GBS colonization, nor did adjustment for it decrease the risk of IAI or PPE attributable to GBS. The findings from this large study, which combined the results from 5 participating hospitals, may represent a more generalizable assessment of risk than any 1 previous smaller study. The limitations of a large, observational study in which women were enrolled for 4 years at 5 different hospitals are that policies on GBS prophylaxis varied among the hospitals, changed over time, and could not be controlled by study investigators.

The findings from this study indicate that GBS vaginal colonization is a risk factor for maternal peripartum infection. Therefore, screening women for GBS during pregnancy and intrapartum prophylaxis for the prevention of neonatal sepsis may also benefit women by preventing their peripartum complications of IAI and PPE. The degree to which disease reduction actually occurs needs to be evaluated further in studies to assess the efficacy of intervention on maternal morbidity.

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