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Original Research

Maternal and Neonatal Outcomes in Hospital-Based Deliveries With Water Immersion

Abbey C. Sidebottom, PhD, MPH, *Marc Vacquier,* MS, *Kathrine Simon,* CNM, MS, *Whitney Wunderlich,* MA, *Patricia Fontaine,* MD, MS, *Dawn Dahlgren-Roemmich,* CNM, APRN, *Shannon Steinbring,* MPH, *Barbara Hyer,* MD, *and Lisa Saul,* MD

OBJECTIVE: To compare neonatal intensive care unit (NICU) or special care nursery admission for deliveries with water immersion compared with deliveries in the matched control group without water immersion. Secondary outcomes included adverse neonatal diagnoses, maternal infections, and perineal lacerations.

METHODS: We conducted a retrospective study using electronic health record data (2014–2018) from two health systems (eight hospitals), with similar clinical eligibility, associated with low risks of intrapartum complications, and implementation policies for waterbirth. The water immersion group included women intending waterbirth. Water immersion was recorded prospectively during delivery. The comparison population were women who met the clinical eligibility criteria for waterbirth but did not experience water immersion during labor. Comparison cases were matched (1:1) using propensity scores. Outcomes were compared using Fischer's exact tests and logistic regression with stratification by stage of water immersion.

RESULTS: Of the 583 women with water immersion, 34.1% (199) experienced first-stage water immersion only, 65.9% (384) experienced second-stage immersion, of whom 12.0% (70) exited during second stage, and 53.9% (314) completed delivery in the water. Neonatal intensive care unit or special care nursery admissions were lower for second-stage water immersion deliveries than deliveries in the control group (odds ratio [OR] 0.3, 95% CI 0.2–0.7). Lacerations were lower in the second-stage immersion group (OR 0.5, 95% CI 0.4–0.7). Neonatal intensive care unit or special care nursery admissions and lacerations were not different between the first-stage immersion group and their matched comparisons. Cord avulsions occurred for 0.8% of second-stage water immersion deliveries compared with none in the control groups. Five-minute Apgar score (less than 7), maternal infections, and other adverse outcomes were not significantly different between either the first- or second-stage water immersion groups and their control group.

CONCLUSION: Hospital-based deliveries with second-stage water immersion had lower risk of NICU or special care nursery admission and perineal lacerations than matched deliveries in the control group without water immersion.

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Committee Opinions from the American College of Obstetricians and Gynecologists' Committee on Obstetric Practice and the American Academy of Pediatrics[1,2] indicate water immersion during the first stage of labor is safe for women with full-term,

From the Care Delivery Research, Allina Health Clinics, Minnesota Perinatal Physicians, and Mother Baby Clinical Service Line, Allina Health, Minneapolis, Health Partners Institute, Minneapolis, Tri-County Health Care, Wadena, Health Partners Medical Clinic, St. Paul, and Measurement and Analysis Health Catalyst, Minneapolis, Minnesota.

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Corresponding author: Abbey C. Sidebottom, PhD, MPH, Care Delivery Research, Allina Health, Minneapolis, MN; email: abbey.sidebottom@allina.com.

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uncomplicated pregnancies and may confer benefits of pain relief, reduced analgesic need, and shorter labor. However, these statements identify an absence of well-designed studies to aid in the determination of the risks and benefits of water immersion during the second stage of labor.[2]

Given the demonstrated challenges of implementing randomized controlled trials for waterbirth and resulting bias,[3–5] observational studies and case summaries from varied settings (ie, birth centers, hospitals, or home births) are the primary source of information for assessment of safety or identification of possible complications.[1,4,6–8] Potential newborn complications include infections, respiratory distress, asphyxia, tub water aspiration, hyponatremia, difficulties in neonatal thermoregulation, seizures, and umbilical cord avulsion, which can lead to hemorrhage, shock, and increased neonatal intensive care unit (NICU) admission.[1,2,4–11] Many of the outcomes identified in case summaries are related to water aspiration by the neonate, whereas others may be related to cleaning and infection-control protocols.[1,2,12–14] Infections are the primary maternal complication of concern.[2]

Prior water immersion studies insufficiently address concerns regarding second-stage immersion for several reasons. First, the majority of waterbirth research was conducted outside the United States in varied settings with lack of information on protocols. Second, prior studies have varied inclusion criteria, definitions, and provide limited or no information on water immersion exposure as it relates to stage of labor.[1,2,15,16] Third, analysis has generally not been provided with stratification to identify how outcomes varied by stage of immersion.[15–23]

The purpose of this study is to examine whether neonatal and maternal outcomes, in U.S. hospital deliveries, differ for 1) women with water immersion in the first stage only and 2) women with water immersion during the second stage, when compared with clinically similar matched control deliveries without water immersion during labor.

METHODS

Data for this study come from two Minnesota health systems representing eight hospitals. Allina Health contributed data on water immersion and comparison cases at five hospitals from August 6, 2014, through June 30, 2018. Health Partners health system contributed data on women with water immersion from three hospitals from October 7, 2014, through April 11, 2016, but did not provide comparison cases owing to limited funding. Both waterbirth policies had similar exclusion criteria for waterbirth eligibility to limit to low-risk pregnancies (Box 1). All hospitals have sufficient birthing pools to ensure water immersion is available to all eligible women. Details on credentialing and clinical procedures are provided in Appendix 1, available online at http://links.lww.com/AOG/B950. Institutional review board (IRB) approval for this study came from both The Quorum Review IRB for Allina and HealthPartners IRB.

Women were included in the water immersion group if they intended a waterbirth delivery, met the clinical criteria for waterbirth, and began water immersion after admission. Women in the water immersion group were divided into two groups for outcomes analysis: 1) women with water immersion during the first stage of labor only and 2) women with water immersion during both the first and second stages of labor regardless of whether delivery was completed in the water. Women were identified for

Box 1. Waterbirth Eligibility Exclusions

- Prepregnancy BMI > 35
- < 37 weeks' gestation
- Hemoglobin < 10 g/dL
- Maternal temperature > 100.4°F
- Intrauterine growth restriction
- Multiple gestation
- History of severe postpartum hemorrhage (> 1000 mL)
- Bleeding or clotting disorders
- Habitual alcohol or drug use anytime in pregnancy or any alcohol or drug use in the third trimester
- Non-vertex fetal presentation
- History of shoulder dystocia
- Known placental abnormalities
- Hypertension in pregnancy
- Previous uterine surgery
- Diabetes (preexisting or gestational)
- Meconium in amniotic fluid
- Abnormal vaginal bleeding prior to birth
- Need for cervical ripening
- Oxytocin induction or augmentation
- Current MDRO or history of MDRO without 2 negative cultures
- Active herpes
- Current *C. difficile* infection
- Hepatitis B
- Hepatitis C
- HIV positive
- Need for parenteral or regional analgesia
- Use of nitrous oxide[a]

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BMI, body mass index; MDRO, multidrug-resistant organism.

[a]At HealthPartners hospitals, women who had used nitrous oxide prior to entering the tub were not excluded; however, no concurrent use of nitrous oxide was allowed while in the tub.

possible inclusion in the comparison group if they met the clinical eligibility criteria for waterbirth and did not receive water immersion during labor. The exception to this was the allowance of women who used analgesics. This exception was made owing to the high prevalence of analgesic use, making it challenging to accumulate a sufficiently large comparison group without pain medications. Additionally, women in the water immersion group who exited the tub before delivery also could have used analgesics after tub exit but before delivery. Women in either group who transitioned to cesarean delivery were excluded. All women consented for use of their health record data to be used for research in compliance with the Minnesota Health Records Act.

During the study period, there were 606 women who intended a waterbirth and who entered the waterbirth tub. Three were excluded as they did not meet the clinical criteria for waterbirth, and 20 were excluded who transitioned to cesarean delivery leaving a final sample of 583. There were 5,113 women who met the eligibility criteria for a waterbirth using electronic health record (EHR) data and who did not have any water immersion. Of these, 615 were excluded owing to cesarean delivery. The remaining 4,498 comparison pool was used to select 583 matched comparison cases (Fig. 1).

Data for this study come from the EHR through data extract and chart review. Data collection was guided by a common data dictionary designed to provide clarification of inclusion and exclusion criteria, with definitions of each study measure as well as the uniform coding of variable values. Modifications were made by both health systems to their EHR (both use Epic products) before the study period to provide a comparable data documentation process during delivery with regard to waterbirth intention, immersion status, and exit timing. Research informatics personnel conducted data extracts to pull study data from each system's data warehouse in accordance with the study data dictionary. Definitions of specific measures, as specified in the study data dictionary, used International Classification of Diseases codes as well as specific flowsheet rows in the delivery navigator of each health system's EHR. Chart reviews were conducted by a subset of the authors (certified nurse midwives) on all water immersion cases to ensure waterbirths were being conducted according to hospital policies and to validate data extracted from the EHR and to fill in any missing data from the extract with information in the notes. Chart reviewers also used descriptive data from note fields to supplement or clarify measures documented in extractable fields.

Measures about the delivery experience included delivery mode (vaginal or cesarean), labor augmentation, intravenous (IV) pain medication use, and epidural use. Water immersion-specific measures included whether the women exited the tub before

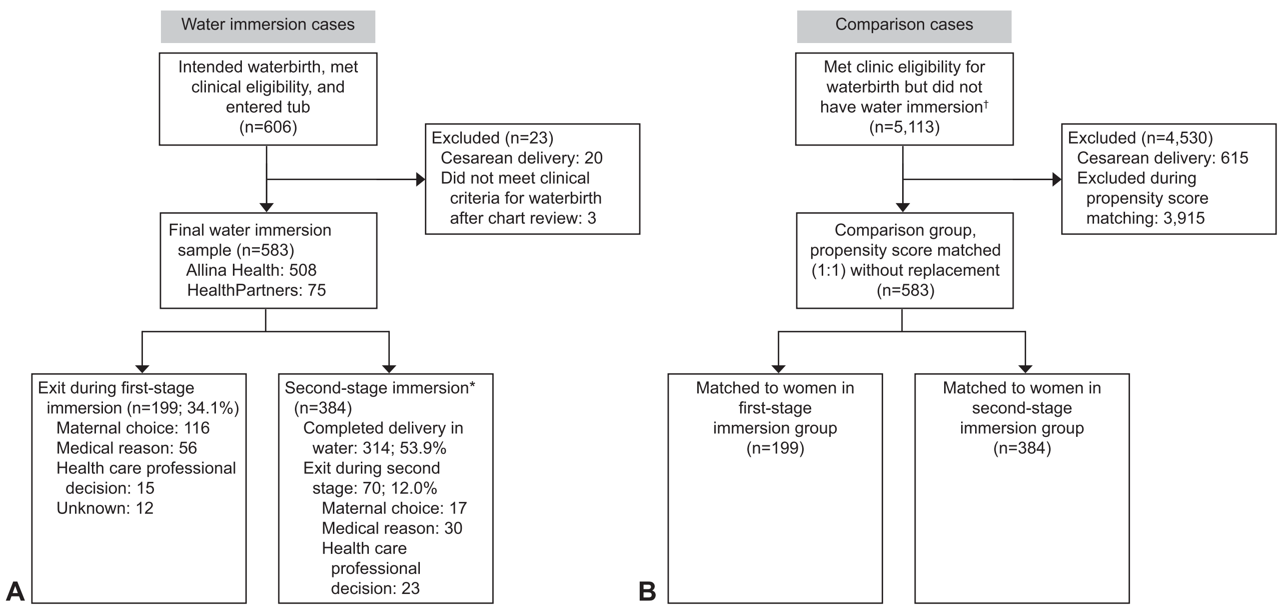

Fig. 1. Final study sample classified by water immersion and tub exit reasons. Water immersion cases (**A**) and comparison cases (**B**). *In tub for first and second stages. †Allina Health electronic health record data only.
Sidebottom. Hospital-Based Deliveries With Water Immersion. Obstet Gynecol 2020.

delivery or completed delivery in the tub, and timing of tub exit for those exiting the tub (first stage or second stage).

The primary outcome measure was admission to either NICU or special care nursery as a combined measure of elevated care. We also examined individual measures of admission to either NICU or special care nursery. Secondary neonatal outcomes included cord avulsion during delivery, fetal blood loss affecting newborn, and 5-minute Apgar score (less than 7 or 7 and higher). Additionally, specific conditions were identified and combined into a single composite measure: respiratory distress, anemia, sepsis, hypoxic ischemic encephalopathy, asphyxia (including fetal distress and fetal placental problems as possible indications of asphyxia), and death. Diagnosis codes were the source of definition for these diagnostic conditions. Possible cord avulsions were identified through a broad set of International Classification of Diseases codes related to a variety of cord conditions. Charts were reviewed to confirm cases of avulsion. Secondary measures of maternal outcomes included perineal lacerations (measured as none, first-, second-, third-, or fourth-degree; also dichotomized as none compared with any, and none through second-degree compared with third- and fourth-degree for some analyses) and maternal chorioamnionitis infection.

Women in the water immersion group were matched to women in the comparison group based on propensity scores derived from a logistic regression model predicting the likelihood of waterbirth (exposed) compared with no water immersion (control) during labor and matched without replacement using a 1:1 ratio with a caliper of 0.2. Independent variables included in the model were continuous measures of mother's age and weeks of gestation completed at delivery, race (categorical, see Table 1), and dichotomous measures of ethnicity, preferred language, marital status, parity, type of health care professional at delivery, epidural use, labor augmentation, and IV pain medication use. These variables were selected owing to possible associations with the primary outcome, and because the distribution of some of these measures differed between the water immersion group and the pool of eligible comparison cases before matching.

Demographic and clinical characteristics of women in the water immersion group and the matched comparison group were compared using χ^2 and *t* test statistics. Missing data are included as a category when applicable. For outcomes analysis, women with water immersion were categorized into stage of immersion: first stage only (for women exiting in the first stage); and, second stage (for women who exited in the second stage or who completed delivery in the water). Outcomes were compared between each water immersion group and their matched control group using Fisher exact tests and logistic regression. Some outcomes with very few events were excluded from regression analyses (Apgar score, cord avulsions, and maternal infections).

RESULTS

After propensity score matching, women in each immersion group were compared with their matches. Women with first-stage water immersion only (n=199) did not differ from matched deliveries in the control group (n=199) for any measures except type of health care professional at delivery and gestational age (Table 1). For women with second-stage immersion (n=384) and their matched comparison women in the control group (n=384), several measures had small differences in distribution (eg, age, ethnicity, and language) and others had larger differences (eg, race, health care professional at delivery, epidural, IV pain medication, labor augmentation, and parity). Of women in the water immersion sample, 34.1% (n=199) exited the tub during the first stage of labor, 12.0% (n=70) exited during the second stage of labor, and 53.9% (n=314) completed delivery in the water (Fig. 1).

The proportion of deliveries with NICU or special care nursery admission was significantly lower for women with second-stage immersion (2.9%, 95% CI 1.4–5.1%) than for women in the control group (8.3%, 95% CI 5.8–11.6%) (Table 2), with an odds ratio of 0.3 (95% CI 0.2–0.7) (Table 3). There was no difference in NICU or special care nursery admissions for deliveries with first-stage immersion only compared with matched deliveries in the control group.

Of the secondary neonatal outcomes examined, there were no significant differences between either water immersion group and matched deliveries in the control group (Tables 2 and 3). Although cord avulsions were not significantly different, it is important to note that they occurred only in deliveries with second-stage water immersion (0.8%, 3/384) (Table 2). One of the major concerns with cord avulsion is fetal blood loss. There were no cases of fetal blood loss affecting the newborn in our study population.

The composite measure of other adverse neonate-specific outcomes (ie, respiratory distress, anemia, sepsis, hypoxic ischemic encephalopathy, asphyxia, or death) was not significantly different in any of the water immersion groups compared with deliveries in

Table 1. Comparison of Women Intending a Waterbirth and Who Labored in Water With Matched Comparisons Without Water Immersion, Stratified by Stage of Immersion, August 6, 2014–June 30, 2018

Characteristic	Water Immersion in 1st Stage Only (n=199)	1st Stage Matched Comparisons (n=199)	*P*	Water Immersion in 2nd Stage (n=384)	2nd Stage Matched Comparisons (n=384)	*P*
Age (y)	29.6±4.7	29.7±5.2	.879	31.0±4.3	30.0±5.0	.004
Race						
African American	7.0 (14)	11.1 (22)	.493	2.6 (10)	8.1 (31)	.002
Native American	0.5 (1)	0.0 (0)		0.5 (2)	0.3 (1)	
Asian	3.0 (6)	4.5 (9)		1.6 (6)	4.2 (16)	
Native Hawaiian or Pacific Islander	1.0 (2)	0.0 (0)		0.3 (1)	0.3 (1)	
White	83.9 (167)	79.9 (159)		91.7 (352)	83.1 (319)	
Multiple	0.5 (1)	0.5 (1)		0.3 (1)	0.3 (1)	
Missing	4.0 (8)	4.0 (8)		3.1 (12)	3.9 (15)	
Ethnicity						
Hispanic	9.1 (18)	9.6 (19)	1.000	4.4 (17)	8.9 (34)	.020
Preferred language						
English	97.0 (193)	95.0 (189)	.445	98.2 (377)	94.8 (364)	.017
Marital status						
Married or life partner	78.4 (156)	75.9 (151)	.633	84.9 (326)	77.1 (296)	.008
Single, divorced, or separated	21.6 (43)	24.1 (48)		15.1 (58)	22.9 (88)	
Parity						
0	57.8 (115)	47.7 (95)	.056	29.7 (114)	43.0 (165)	<.001
1 or more	42.2 (84)	52.3 (104)		70.3 (270)	57.0 (219)	
Delivery professional specialty						
CNM	74.9 (149)	60.3 (120)	.003	84.4 (324)	76.3 (293)	.006
Physician	25.1 (50)	39.7 (79)		15.6 (60)	23.7 (91)	
Gestational age at delivery (wk)	39.6±1.0	39.3±1.1	<.001	39.5±1.2	39.5±1.1	.605
Labor augmentation	21.1 (42)	18.6 (37)	.615	2.1 (8)	12.8 (49)	<.001
Epidural	41.7 (83)	38.2 (76)	.539	1.3 (5)	25.8 (99)	<.001
IV pain medication	22.1 (44)	18.1 (36)	.381	0.5 (2)	14.1 (54)	<.001

CNM, certified nurse midwife; IV, intravenous.
Data are mean±SD or % (n) unless otherwise specified.

the control group (Tables 2 and 3). However, because the proportion of these adverse outcomes was higher in deliveries with first-stage immersion (5.0%, 95% CI 2.4–9.0%) than in the comparison group (1.5%, 95% CI 0.3–4.3) (Table 2), we conducted further analysis to examine these cases. Because the group of women with first-stage immersion includes a higher proportion of women who were asked to leave the water, either for a specific medical reason (eg, meconium, category II fetal tracing, need for augmentation, excessive vaginal bleeding, shoulder dystocia, maternal hypertension, maternal fever, tight nuchal cord) or decision of a health care professional, relative to the second-stage immersion group, a sensitivity analysis was conducted to examine whether the difference in adverse outcomes could be a result of this selection process. Of the 199 deliveries with first-stage immersion, 116 (58.3%) women left because of maternal choice, 56 (28.1%) were asked to exit the water for a medical reason, 15 (7.5%) left because of decision of the health care professional, and 12 (6.0%) were missing data on the reason for exit. We divided the first-stage exit group into those who exited for a medical reason or because of the decision of a health care professional (n=71) and those who exited for maternal choice or were missing exit reason (n=128). There were 10 deliveries coded as having one of the adverse outcomes included in the composite measure in this first-stage water immersion group. Of these, four occurred among deliveries when the reason for exit was maternal choice or missing (3.1%) and the other six occurred among women exiting for

Table 2. Neonatal and Maternal Outcomes for Women Intending Waterbirth With Water Immersion in First Stage and Second Stage Compared With Matched Comparisons Without Water Immersion

Outcome	Water Immersion 1st Stage Only (n=199)	1st Stage Matched Comparisons (n=199)	*P*	Water Immersion in 2nd Stage (n=384)	2nd Stage Matched Comparisons (n=384)	*P*
Primary outcome						
NICU or SCN admission	9.6 (19) (5.8–14.5)	7.5 (15) (4.3–12.1)	.591	**2.9 (11)** (1.4–5.1)	**8.3 (32)** (5.8–11.6)	**.001**
Secondary outcomes						
Neonatal outcomes						
5-min Apgar score less than 7	1.0 (2) (0.1–3.6)	1.0 (2) (0.1–3.6)		0.5 (2) (0.1–1.9)	0.3 (1) (0.0–1.4)	
Cord avulsion	0.0 (0) (N/A)	0.0 (0) (N/A)		0.8 (3) (0.2–2.3)	0.0 (0) (N/A)	
Composite measure of adverse events*	5.0 (10) (2.4–9.0)	1.5 (3) (0.3–4.3)		1.3 (5) (0.4–3.0)	1.3 (5) (0.4–3.0)	
Maternal outcomes						
Perineal laceration (any)	66.3 (132) (59.3–72.9)	69.4 (138) (62.4–75.7)		**55.2 (212) (50.1–60.3)**	**70.1 (269) (65.2–74.6)**	
Perineal laceration by degree						
Not severe (none, 1st, 2nd)	95.0 (189) (91.0–97.6)	96.0 (191) (92.2–98.2)		98.7 (379) (97.0–99.6)	96.9 (372) (94.6–98.4)	
Severe (3rd, 4th)	5.0 (10) (2.4–9.0)	4.0 (8) (1.8–7.8)		1.3 (5) (0.4–3.0)	3.1 (12) (1.6–5.4)	
Chorioamnionitis	0.5 (1) (0.0–2.8)	0.0 (0) (N/A)		0.0 (0) (N/A)	1.0 (4) (0.3–2.6)	

NICU, neonatal intensive care unit; SCN, special care nursery; N/A, not applicable.
Data are % (n) (95% CI) unless otherwise specified.
Bold indicates significant difference at $P<.05$.
* Composite (neonatal-specific) measure includes respiratory distress, anemia, sepsis, hypoxic ischemic encephalopathy, asphyxia, and death.

medical reasons or health care professional decision (8.5%), indicating the higher adverse outcomes measure in the first-stage immersion group is a result of the higher representation of women with medical indications for exiting the water than the other study groups.

Chart reviews were conducted on the 10 deliveries with these adverse outcomes in the first-stage immersion group. Reviews identified that four of the six women exiting for medical reasons or health care professional decision were due to meconium. Other women were identified who had labor complications after exiting the water, or outcomes were attributed to labor management decisions after exiting the water, as well as a case of respiratory distress due to a tracheomalacia of the newborn. Of these 10 first-stage immersion cases, five neonates were admitted to NICU, one was admitted to the special care nursery, and four did not receive a higher level of care.

Perineal lacerations were examined using two measures. The first was a dichotomous measure of none compared with any laceration. The proportion of women with any laceration was significantly lower in those with second-stage immersion (55.2%, 95% CI 50.1–60.3%) than the comparison group (70.1%, 95% CI 65.2–74.6%, odds ratio 0.5, 95% CI 0.4–0.7) (Tables 2 and 3). This measure did not differ for first-stage immersion cases. We also categorized lacerations as not severe (none, first-, and second-degree) compared with severe (third- and fourth-degree). This measure of laceration severity did not differ for either of the water immersion groups. Chorioamnionitis occurred in only one delivery in the water immersion group (exiting in the first stage). There were no cases in the second-stage group (Table 2).

DISCUSSION

The purpose of this study is to contribute to the limited research regarding safety of second-stage water immersion during labor and delivery in the United States. Our study found no higher risk of NICU or special care nursery admissions occurring in deliveries with first- or second-stage water immersion. There were no significant differences for other secondary outcomes and maternal infection. We found lower risk of perineal lacerations for women with second-stage immersion.

There were three studies we found that provided analysis somewhat comparable with stratification of outcomes by stage of immersion or that provided

Table 3. Neonatal and Maternal Outcomes for Deliveries With Water Immersion in First Stage and Second Stage Compared With Matched Comparisons Without Water Immersion

	Water Immersion in 1st Stage Only vs Matched Group (n=398)	Water Immersion in 2nd Stage vs Matched Group (n=768)
Primary outcome		
NICU or SCN admission	1.3 (0.6–2.6)	**0.3 (0.2 - 0.7)**
Secondary outcomes		
Neonatal outcomes		
5-min Apgar score less than 7	1.0 (0.2–5.8)	1.7 (0.2–12.7)
Composite measure of adverse events*	3.1 (0.9–10.6)	1.0 (0.3–3.3)
Maternal outcomes		
Perineal laceration (any)	0.9 (0.6–1.3)	**0.5 (0.4–0.7)**
Severe perineal laceration (3rd- or 4th-degree)	1.3 (0.5–3.3)	0.4 (0.1–1.2)
Chorioamnionitis	3.0 (0.1–74.5)	0.1 (0.0–2.0)

NICU, neonatal intensive care unit; SCN, special care nursery.
Data are odds ratio (95% CI).
Bold indicates significant difference at $P<.05$.
* Composite (neonatal-specific) measure includes respiratory distress, anemia, sepsis, hypoxic ischemic encephalopathy, asphyxia, and death.

neonatal outcomes stratified by women completing water birth and those who exited water before delivery.[17,18,24] One Swiss study included 368 women interested in water immersion (after retrospective exclusion of cesarean or assisted deliveries). Analysis compared water delivery (n=89), temporary water immersion (n=133), and spontaneous delivery without water immersion (n=146). There was no significant difference between the three groups with regard to NICU admission, clinical signs of infection in newborn or mother, or Apgar scores. A second study in a single hospital in England analyzed data by three groups: nonimmersion, first-stage immersion, and waterbirth. The only neonatal outcomes reported were Apgar scores. They did find higher incidence of Apgar scores less than 6 at 1 minute in the first-stage immersion group relative to the waterbirth group and the nonimmersion group. They provide the additional explanation that "one-third of the first-stage immersion group left the tub because of apparent signs of fetal distress (ie, fetal heart rate changes or meconium)."[24] A third study with similar stratification examined cases with waterbirth (n=58), water labor (n=61), and neither (n=111) from a hospital-based midwifery practice in the United States.[18] Although the study had a small sample size, they found no differences in the adverse neonatal outcomes examined.

Several recent reviews and meta-analyses have been conducted that have examined neonatal outcomes of waterbirth.[16,25,26] Many studies included in the meta-analyses were identified as having small sample sizes and methodologic flaws that may contribute the potential risk of bias.[25,26] One meta-analysis ranked the studies using a quality-assessment tool, and 17 of 29 studies received a lower quality ranking[25]; another concluded that there is insufficient high-level evidence to guide practice in the area of waterbirth.[16] In the context of these limitations, the meta-analyses' findings all identified no increased risk of adverse neonatal outcomes (infant mortality, NICU or special care nursery admissions, Apgar scores, respiratory distress, or infection) associated with waterbirth.[16,25,26] One of the meta-analyses focused exclusively on studies that were hospital-based and contributed a new analytical approach to examine whether conclusions changed when studies with high risk for bias were excluded. Findings of this additional analysis also indicated no increased adverse neonatal outcomes.[26] With regard to maternal outcomes, our study found lower risk of perineal lacerations in the second-stage immersion group. This association has also been identified in other studies examining waterbirth compared with nonwaterbirth vaginal deliveries.[15,22,23,27,28] In addition, we found no difference in maternal infections, which has been identified in other recent studies.[15,27,29]

In this study sample, prevalence of cord avulsion was 0.8% in deliveries with second-stage water immersion, compared with none among matched deliveries in the control group. Cord avulsions have been identified as a complication in other water immersion studies.[9,19,22,30,31] One review estimated the rate to be 3.10 avulsions per 1,000 water deliveries and estimated, based on four studies contributing data, that approximately 23% of those cases lead to NICU admissions and 13% were neonatal hemorrhage requiring transfusion.[9] Some studies with cord avulsions reported no NICU admission or transfusions required, and no studies reported long-term adverse effects.[9,22] The three cases in our water immersion group with cord avulsion were not associated with any adverse outcomes, NICU admissions, or transfusions. In our study, all three cases with cord avulsions occurred in the first year (2014) of the study period. All three of these cases were identified shortly after delivery through a quality-assurance process. Two of these occurred in deliveries that happened in water, and one occurred during delivery out of the water. One case occurred when a mother carried the newborn to bed before cutting the cord, initiating a change in education for all health care professionals involved in waterbirth. Specifically, the new education teaches that the cord must be cut before exiting the tub. The newborn is then handed (if medically stable) to be held by the partner. The mother is then returned to bed, and the newborn can then be returned to the mother. The registered nurses are empowered as a part of the team with this safety check-and-balance system. No subsequent cord avulsions were seen in the subsequent 4 years of the study.

One concern identified in the analysis of prior studies[26] is the potential influence of the heterogeneity of clinical waterbirth policies and procedures could have on outcomes in prior studies. This highlights the need to conduct research that can discern effects from different protocols. The American College of Obstetricians and Gynecologists indicates that facilities that offer immersion should establish rigorous protocols for candidate selection, tub maintenance and cleaning, monitoring of women and fetuses, and moving women from tubs if maternal or fetal concerns or complications develop.[2] The current study took place in the context of sites with such policies in place as well as a strong credentialing program (Appendix 1, http://links.lww.com/AOG/B950). As such, our findings are likely most generalizable to hospital-based deliveries with comparable clinical eligibility criteria, implementation protocols, and credentialing standards. Our sites also operate a quality-assurance program that includes case review for all deliveries with water immersion (regardless of whether the neonate was born under water). This quality-assurance process monitors outcomes and identify needs to retrain staff and updating of policies and procedures.

The findings of this study should be interpreted within the context of specific limitations and strengths. First, the observational, retrospective design presents data of patients who self-selected into attempting delivery in water or no water immersion. As such, there may be some bias owing to the variability in the types of patients selecting into these conditions. Although randomized controlled trials are the preferred study design to examine outcomes of medical treatments and avoid such potential bias, prior attempts at such a design for water immersion left substantial bias with regard to actual water immersion exposure, especially in the second stage. Relative to other observational studies on water immersion, our study provides some design improvements. First, exposure to water immersion is clearly defined and documented by stage, with analysis conducted accordingly. Second, the comparison population was matched using propensity scores to address the potential confounding between the two study populations. A meta-analysis of 39 hospital-based comparative studies of waterbirth found that only 10 studies conducted matching of water immersion and comparison populations on limited characteristics (commonly parity or parity and age), otherwise, there was no attempt to control for confounding.[26] We found one other recent study from the United States that also matched waterbirth and comparison cases.[23]

Our sample size of 583 women with water immersion and 384 with second-stage immersion provides a substantially larger sample than many prior studies. Despite the larger sample size, some secondary outcomes are still relatively rare, and the nonsignificant findings for these outcomes should be interpreted in the context of limited statistical power. Selection of our sample also improves on some potential selection bias identified in earlier studies. As identified in one meta-analysis,[26] the retrospective identification of both waterbirth and comparison samples in prior studies may have introduced selection bias. Specifically, many studies identified study participants based on completion of a waterbirth, which requires women not to have experienced any of the exclusion criteria for a waterbirth delivery (such as meconium stained fluid or abnormal fetal heart rate), who would have been excluded at some point during labor from completing a waterbirth. Our study attempted to reduce this bias and provide the full picture of water immersion as well as comparison population experiences by selecting based on criteria throughout pregnancy and labor. Findings may not be generalizable to water immersion protocols taking place in other settings such as birth centers, home births, other countries, or even hospital-based programs in the United States with water immersion protocols that differ significantly from our study sites. These findings occurred in the context of a U.S. hospital–based setting with strict waterbirth eligibility criteria to ensure inclusion of only low-risk pregnancies, comprehensive training and credentialing procedures, and clinical policies based on best practices.

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