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**Original Research**

# Maternal and Newborn Outcomes Following Waterbirth: The Midwives Alliance of North America Statistics Project, 2004 to 2009 Cohort

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**Introduction:** Data on the safety of waterbirth in the United States are lacking.

**Methods:** We used data from the Midwives Alliance of North America Statistics Project, birth years 2004 to 2009. We compared outcomes of neonates born underwater *waterbirth* (n = 6534), neonates not born underwater *nonwaterbirth* (n = 10,290), and neonates whose mothers intended a waterbirth but did not have one *intended waterbirth* (n = 1573). Neonatal outcomes included a 5-minute Apgar score of less than 7, neonatal hospital transfer, and hospitalization or neonatal intensive care unit (NICU) admission in the first 6 weeks. Maternal outcomes included genital tract trauma, postpartum hospital transfer, and hospitalization or infection (uterine, endometrial, perineal) in the first 6 weeks. We used logistic regression for all analyses, controlling for primiparity.

**Results:** Waterbirth neonates experienced fewer negative outcomes than nonwaterbirth neonates: the adjusted odds ratio (aOR) for hospital transfer was 0.46 (95% confidence interval [CI], 0.32-0.68; $P < .001$); the aOR for infant hospitalization in the first 6 weeks was 0.75 (95% CI, 0.63-0.88; $P < .001$); and the aOR for NICU admission was 0.59 (95% CI, 0.46-0.76; $P < .001$). By comparison, neonates in the intended waterbirth group experienced more negative outcomes than the nonwaterbirth group, although only 5-minute Apgar score was significant (aOR, 2.02; 95% CI, 1.40-2.93; $P < 0001$). For women, waterbirth (compared to nonwaterbirth) was associated with fewer postpartum transfers (aOR, 0.65; 95% CI, 0.50-0.84; $P = .001$) and hospitalizations in the first 6 weeks (aOR, 0.72; 95% CI, 0.59-0.87; $P < 0.001$) but with an increased odds of genital tract trauma (aOR, 1.11; 95% CI, 1.04-1.18; $P = .002$). Waterbirth was not associated with maternal infection. Women in the intended waterbirth group had increased odds for all maternal outcomes compared to women in the nonwaterbirth group, although only genital tract trauma was significant (aOR, 1.67; 95% CI, 1.49-1.87; $P < .001$).

**Discussion:** Waterbirth confers no additional risk to neonates; however, waterbirth may be associated with increased risk of genital tract trauma for women.
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*Keywords:* childbirth, complications, perineal trauma, safety, waterbirth

## INTRODUCTION

Waterbirth is highly controversial in the United States,[1–8] despite being an accepted practice in other high-resource nations.[9–12] Proponents of waterbirth cite anthropological evidence from Odent and Tjarkovsky regarding childbearing traditions that include immersion[13,14]; the maternal benefits of laboring in water, such as pain relief and reduced stress on tissues secondary to buoyancy[15,16]; the potential benefits to a neonate of being born into a warm, liquid environment similar to the amniotic fluid[17]; and a series of studies, mostly small and observational, suggesting no adverse effects for either the laboring woman or the neonate.[18,19] By contrast, in the spring of 2014, the American College of Obstetricians and Gynecologists (ACOG) and the American Academy of Pediatrics (AAP) jointly issued clinical recommendations advising strongly against allowing women to labor in water after the first stage of labor is complete.[3]

Waterbirth is generally defined as a neonate being intentionally born underwater. Provided that the neonate is promptly brought to the surface, it is thought that the *diving reflex*, which mechanically blocks the airway of submerged infants (although not older children or adults), will prevent the newborn from aspirating the water.[20] The category *waterbirth* does not include women who labor in water but give birth to their newborn into air. Laboring in water is considered safe; the current question in the literature is whether waterbirth is safe.[3]

Published reports of outcomes following waterbirth in the United States currently consist solely of case series[1,2,4,5,21–24] rather than studies with robust designs and adequate power. However, there are several cohort studies from Europe describing waterbirth outcomes,[25–35] nicely summarized by Nutter et al in a recent review.[19] The results of these studies collectively suggest that waterbirth is not associated with an increased risk of morbidity for the newborn (eg, low Apgar score, neonatal intensive care unit [NICU] admission, neonatal injury, or death), although small sample sizes hinder comparisons for all but the most common events.[18,19] Regarding maternal outcomes, previous literature suggests women do not experience an increase in perineal trauma, infection, or hemorrhage.[18,19] Nonetheless, it can be argued that both the US population and US health care system are unique, and thus results from Europe might not be generalizable to the

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## Quick Points

- ✦ Using data collected from the Midwives Alliance of North America Statistics Project (MANA Stats 2004-2009), this study reports waterbirth outcomes for a large sample of midwife-attended births occurring at home and in birth centers in the United States (N = 18,343 women); 35% of the women (n = 6521 women; 13 sets of twins) had a waterbirth.
- ✦ Neonates of women who had a waterbirth were less likely to experience a low 5-minute Apgar score, neonatal transfer to the hospital, and hospitalization or neonatal intensive care unit admission in the first 6 weeks when compared to nonwaterbirth neonates.
- ✦ For women, waterbirth was associated with decreased odds of hospitalization, either immediately postpartum or within the first 6 weeks, but increased odds of genital tract trauma.
- ✦ Waterbirth was not associated with increased risk of maternal infection.

United States. The purpose of this study, therefore, was to report waterbirth outcomes from a large sample of midwife-led births occurring at home and in birth centers in the United States.

## METHODS

### Data Source and Sample Description

The data for this study come from the Midwives Alliance of North America Statistics Project, commonly referred to as MANA Stats.[36] MANA Stats is an ongoing, Web-based data collection effort designed to capture complete courses of care from the medical records of women who have had midwife-led pregnancies and births. Any midwife, regardless of birth setting, is eligible to contribute data. However, in practice, most MANA Stats records are for planned home or planned birth center births (97.6% for the years 2004-2009) attended by certified professional midwives (CPMs) in the United States. Of the births in the 2004 to 2009 MANA Stats dataset, 73% of the births were attended by CPMs.[36]

A midwife who is a MANA Stats contributor enters data on all women in her care from the first prenatal visit through the final visit, which is usually at 6 weeks postpartum. Midwives are required to preregister or log patients into the MANA Stats system early in care, before the outcome of the pregnancy is known. This prospective logging helps to ensure that all births from participating midwives are captured, regardless of outcome, thus reducing selection bias in the sample.

Women give informed consent allowing their deidentified data to be included in MANA Stats, and the consent includes explicit permission for the data to be used for research. Should a woman decline consent, her data are not included, but this decision to decline consent would occur early in pregnancy and thus could not be affected by pregnancy outcome. In practice, very few women decline this consent; based on practice data reported by midwives, we estimate that MANA Stats captures 97% of births attended by midwife contributors.[36] The high rate of maternal participation in this population is not unique to the MANA Stats dataset; it has also been reported in other studies enrolling women planning home and birth center births.[37,38]

The institutional review board at Oregon State University approved this analysis, which uses MANA Stats data for births that occurred between 2004 and 2009. Evidence of reliability and validity of the MANA Stats 2004 to 2009 dataset, as well as detailed data collection protocols, is presented elsewhere.[36]

We limited our sample to births that were planned home births or planned birth center births at the onset of labor wherein the neonate was actually born in the intended setting (ie, no intrapartum transfer to a hospital occurred). Thus, excluded from the sample were the data from women who planned a hospital birth and from those for whom a hospital birth was not planned but occurred following an intrapartum transfer (Figure 1).

These cases were excluded for 2 reasons. First, during the research years (2004-2009), very few hospitals in the United States offered the option of giving birth underwater.[39] Second, hospital births are almost always the most complicated pregnancies and labors in the MANA Stats database; the majority of contributors to the project specialize in home or birth center birth and transfer care to hospitals only when complications arise.[40] Thus, including women with more complicated pregnancies or labors resulting in the transfer of care to a hospital-based provider, either before or during labor, combined with the reduced likelihood of encountering the exposure, would have introduced bias in the direction of making waterbirth appear safer relative to nonwaterbirth. Mother–newborn dyads who transferred to the hospital during the postpartum period were retained in the sample because, if in fact waterbirth itself introduces risk (eg, infection, respiratory distress), we would expect to see more women and newborns with immediate postpartum newborn or maternal complications requiring transfer and possible hospitalization following waterbirth. We also excluded 12 singleton pregnancies for which the waterbirth variable was missing. Applying these inclusion criteria resulted in a sample size of 18,397 neonates (N = 18,343 pregnancies), as shown in Figure 1.

### Variables

The main exposure, waterbirth, was collected as a 3-level categorical variable. To the question "Baby born underwater?" the midwife had 3 answer options: "no"; "yes"; or "intended, but not born underwater." Throughout this article, we refer to these categories as nonwaterbirth, waterbirth, and intended waterbirth, respectively.

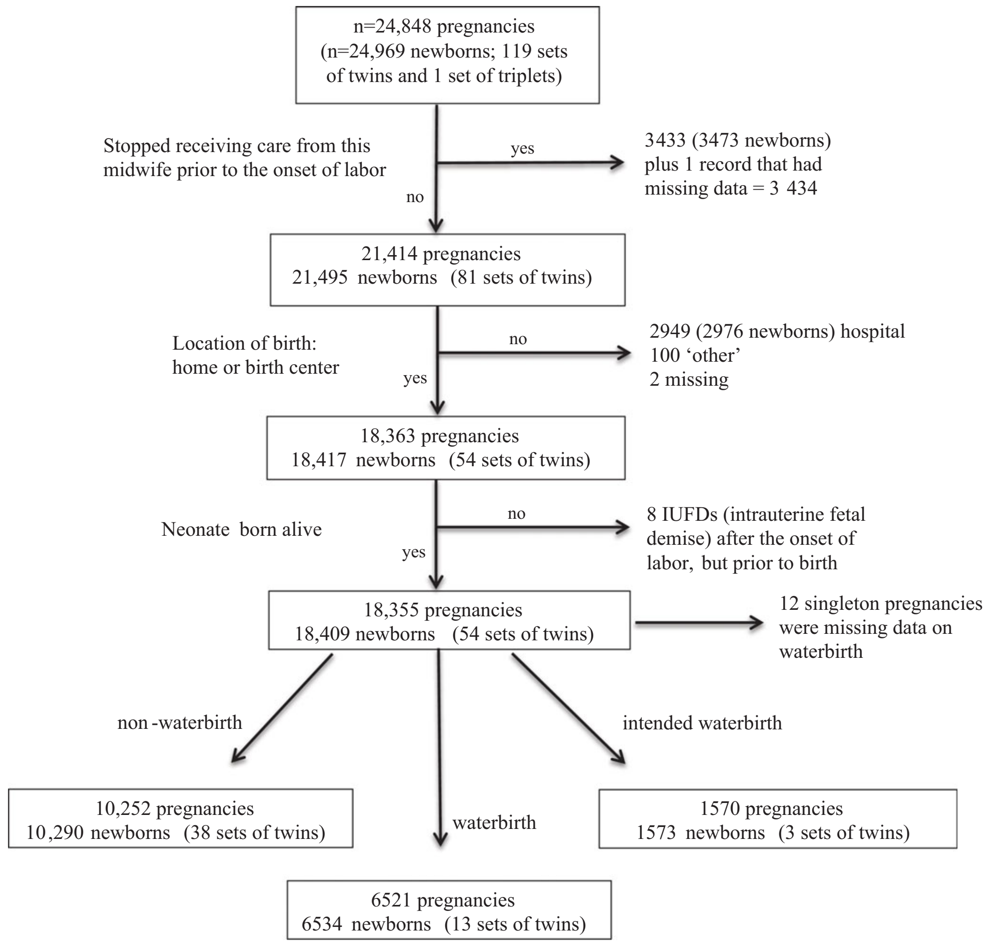


**Figure 1.** **Sample size delimitation. Begins with all records entered into MANA Stats for birth years 2004 to 2009. Women who changed providers (ie, stopped receiving care from the midwife filling out the data form) prior to the onset of labor are excluded. Some of these women may be included as separate records if they changed providers to another MANA Stats contributor; however, many developed a complication requiring maternity specialty care and therefore would not be included. Also excluded are women who did not give birth at home or at a birth center, and mother—fetus dyads if the fetus died prior to birth. All numbers are counts of singleton pregnancies, unless otherwise indicated.**

Abbreviation: MANA Stats, Midwives Alliance of North America Statistics.

Neonatal outcomes included a 5-minute Apgar score of less than 7 (yes/no), postpartum transfer to the hospital for a newborn indication (referred to hereafter as *neonatal transfer*, yes/no), any infant admission to the hospital during the first 6 weeks of life (yes/no), and any NICU admission during the first 6 weeks of life (yes/no). Although we knew the number of events would be small based on our previous work with this dataset,[33] we also included early (prior to 7 completed days of life) and late (at least 7 completed days of life, but not yet 28) neonatal deaths as end points.

Maternal outcomes included postpartum reproductive tract infection at any time during the first 6 weeks postpartum (presence of: uterine infection, urinary tract infection, or delayed perineal healing/infection), postpartum transfer for a maternal indication (referred to hereafter as *postpartum transfer*; yes/no), any maternal admission to the hospital during the first 6 weeks postpartum (yes/no), and genital tract trauma. The degree of genital tract trauma was evaluated first as a simple dichotomous variable and then further as a multilevel nominal variable with the following categories: none, episiotomy only, first- or second-degree perineal only, third- or fourth-degree perineal only, mild labial only, more severe labial only (defined on the data collection form as *required repair*), other trauma requiring repair, trauma at multiple sites, and trauma not otherwise specified. The latter category consisted of women for whom the midwife indicated that, yes, there was trauma, but then did not answer the follow-up questions regarding location and severity.

For the neonatal and postpartum transfers, midwives were able to indicate multiple indications for transfer. It is therefore possible that one mother–newborn dyad could have experienced both a postpartum transfer and a neonatal transfer if, for example, the midwife indicated both "extensive laceration repair requiring anesthesia" and "evaluation of congenital anomalies" as reasons for transfer.

## Analysis

We used logistic regression to analyze all dichotomous outcomes (5-minute Apgar score of $< 7$, neonatal transfer, NICU admission, infant hospitalization in the first 6 weeks, postpartum transfer, postpartum reproductive tract infection, maternal hospitalization in the first 6 weeks, dichotomized trauma). Directed Acyclic Graph (DAG) methodology[41,42] was used to determine potential confounders. Directed acyclic graphs are a type of causal model that allow the researcher to determine a complete set of potential confounders that maximizes use of available data while simultaneously reducing bias that would result from adjusting for highly collinear covariables. The DAG/causal model that we drew for this analysis is available from the authors on request; as a result of the DAG analysis, we controlled for primiparity in all models.

The 3-level waterbirth exposure variable was entered into the models as a nominal variable, with nonwaterbirth as the reference category. Our results are thus presented as adjusted odds of a given outcome for waterbirth compared to nonwaterbirth and, separately, adjusted odds of a given outcome for intended waterbirth compared to nonwaterbirth.

As expected, cell counts were very low for the neonatal death outcomes. Thus, for these outcomes we report the raw data but did not calculate adjusted odds ratios and corresponding 95% confidence limits.

For the multilevel nominal outcome (genital tract trauma), we used multinomial (ie, not ordered) logistic regression and controlled for primiparity. No trauma was the reference category. Data were analyzed using SPSS 19.0.0.1 (IBM Corp, Armonk, NY) and S-Plus Version 8.1 (Tibco Spotfire, Seattle, WA).

## RESULTS

We report results from 18,343 births, which included 18,397 neonates (see Figure 1). Of these, 10,252 women (10,290 neonates) were in the nonwaterbirth group, 6521 women (6534 neonates) were in the waterbirth group, and 1570 women (1573 neonates) were in the intended waterbirth group. Demographics of the women in this sample are shown in Table 1. Briefly, the majority were white, married, and college educated. The mean age at conception was 29.9 years (standard deviation 5.3). Our sample does include larger proportions of both Amish/Mennonite (6.0%) and grand-multiparous women (8.5%), relative to the US population as a whole; as expected, there is a large overlap between these 2 groups. Additionally of note, 968 women had vaginal births after cesarean (VBACs), 134 gave birth to a neonate in breech presentation, and 54 women had twins. Because our sample was limited to those women who gave birth at home or in a birth center, all of these were vaginal births.

### Neonatal Outcomes

Neonates born underwater (waterbirths) fared better than their nonwaterbirth counterparts on all neonatal outcome measures, when controlling for primiparity (Table 2). The adjusted odds ratio (aOR) for neonatal transfer to the hospital, for waterbirth neonates compared to nonwaterbirth neonates, was 0.46 (95% confidence interval [CI], 0.32-0.68; $P < .001$). The aOR for NICU admission during the first 6 weeks was 0.59 (95% CI, 0.46-0.76; $P < .001$); the aOR for any hospital admission during the first 6 weeks was 0.75 (95% CI, 0.63-0.88; $P < .001$) (Table 2). There was no evidence of 5-minute Apgar scores below 7 being more common in the waterbirth group (aOR, 0.88; 95% CI, 0.65-1.19; $P = .42$).

By contrast, neonates whose mothers intended a waterbirth but did not have one (intended waterbirths) fared worse than neonates whose mothers had not planned to give birth in the water. Neonates in the intended waterbirth category had a 102% increase in the odds of a 5-minute Apgar score of less than 7 (aOR, 2.02; 95% CI,1.40-2.93; $P < 0.001$).

Although the number of events was too small for firm conclusions, we found no evidence of increased neonatal deaths (early or late) among neonates in the waterbirth group. There were 9 deaths (6 early, 3 late) in the nonwaterbirth comparison group; these were attributed to hypoxia, congenital anomalies, chorioamnionitis, cord accidents (3), and unknown causes (3). Among the waterbirth group, there were 3 neonatal deaths (2 early, one late), attributed to hypoxic ischemic encephalopathy, congestive heart failure, and unknown causes. In the intended waterbirth group, there were also 3 neonatal deaths (2 early, one late), attributed to placental abruption, shoulder dystocia with compressed cord, and hypoxia (Table 2).

### Maternal Outcomes

Women who completed the second stage while immersed in water (waterbirths) had a 35% reduction in odds of postpartum transfer (aOR, 0.65; 95% CI, 0.50-0.84; $P = .001$) and a 28% reduction in odds of maternal hospitalization in the first 6 weeks (aOR, 0.72; 95% CI, 0.59-0.87; $P < .001$) (Table 3). By contrast, women who had a waterbirth also had an 11% increase in odds of experiencing any genital tract trauma (aOR, 1.11; 95% CI, 1.04-1.18; $P = .002$). When categories based on trauma location and severity were assessed, however, there was no discernible pattern between the women in the 3 cohorts (Table 4). Women who planned a waterbirth but did not have one (intended waterbirths) experienced substantially increased odds of any genital tract trauma (aOR, 1.67; 95% CI, 1.49-1.87; $P < .001$) (Table 3).

## DISCUSSION

### Main Findings and Interpretation

This retrospective cohort study is the largest study on this topic to date and one of the first to focus on a US population. We found that waterbirth was not associated with an increased risk of 5-minute Apgar score of less than 7, immediate neonatal transfer of care to a hospital, any neonatal hospitalization in the first 6 weeks, or NICU admission in the first 6 weeks. For women, we found that waterbirth was associated with reduced risk of both immediate postpartum transfer of care to a hospital and any maternal hospitalization in the first 6 weeks. However, waterbirth was associated in our data with an increased risk of genital tract trauma. We found no evidence of an association between waterbirth and uterine, endometrial, or perineal infection.

A recent Cochrane review on waterbirth stated that: "Immersion during the 2nd stage of labour needs further investigation, but at present there is no clear evidence to support or not to support a woman's decision to give birth in water."[18] This review, as is the case for all Cochrane Collaboration

**Table 1. Sample Demographics and Pregnancy Characteristics for 18,343 Women (18,397 neonates) Who Gave Birth at Home or in a Birth Center with a Midwife[a]**

| | Total Sample N (%) | Nonwaterbirth n (%) | Waterbirth n (%) | Intended Waterbirth n (%) |
|---|---|---|---|---|
| **Race/ethnicity (categories are not mutually exclusive)[b]** | | | | |
| African or Caribbean | 386 (2.1) | 220 (2.1) | 122 (1.9) | 44 (2.8) |
| Asian | 820 (4.5) | 471 (4.6) | 274 (4.2) | 75 (4.8) |
| White | 16,785 (91.8) | 9336 (91.1) | 6027 (92.5) | 1422 (90.7) |
| Hispanic | 786 (4.3) | 448 (4.4) | 262 (4.0) | 76 (4.8) |
| Native American | 192 (1.0) | 117 (1.1) | 64 (1.0) | 11 (0.7) |
| Other | 373 (2.0) | 206 (2.0) | 129 (2.0) | 38 (2.4) |
| **Special groups (categories are not mutually exclusive)** | | | | |
| Amish/Mennonite/other Plain Church community | 1081 (5.9) | 963 (9.4) | 121 (1.9) | 23 (1.5) |
| Immigrant | 504 (2.7) | 298 (2.9) | 156 (2.4) | 50 (3.2) |
| **Education[c]** | | | | |
| Less than high school | 1338 (7.5) | 1094 (10.9) | 200 (3.1) | 44 (2.9) |
| Completed high school | 3126 (17.5) | 1756 (17.5) | 1134 (17.8) | 236 (15.4) |
| Completed 1-3 years of college | 4552 (25.4) | 2425 (24.2) | 1726 (27.1) | 401 (26.2) |
| Completed at least 4 years of college | 8885 (49.6) | 4739 (47.3) | 3297 (51.9) | 849 (55.5) |
| **Marital status[d]** | | | | |
| Married | 16,139 (88.0) | 9031 (88.1) | 5750 (88.2) | 1358 (86.5) |
| Partnered (although not married) | 1717 (9.4) | 950 (9.3) | 589 (9.0) | 178 (11.3) |
| Single (includes separated/divorced) | 420 (2.3) | 238 (2.3) | 153 (2.4) | 29 (1.9) |
| **Pregnancy characteristics** | | | | |
| Primiparous[e] | 4001 (21.8) | 2316 (22.5) | 1246 (19.1) | 439 (28.0) |
| Multiparous[f] | 13,184 (71.8) | 7121 (69.5) | 4984 (76.4) | 1079 (68.7) |
| Grand multiparous[g] | 1158 (6.3) | 815 (7.9) | 291 (4.5) | 52 (3.3) |
| History of cesarean[h] | 967 (5.3) | 535 (5.2) | 327 (5.0) | 105 (6.7) |
| Breech birth[i] (denominator is newborns) | 134 (0.7) | 85 (0.8) | 29 (0.4) | 20 (1.3) |
| Multiple birth | 54 (0.3) | 38 (0.4) | 13 (0.2) | 3 (0.2) |

[a]Data come from the Midwives Alliance of North America Statistics Project, birth years 2004 to 2009.
[b]Fourteen women were missing data on race.
[c]Three hundred ninety-six women were missing data on education.
[d]Eight women were missing data on partner status.
[e]One woman was missing data on parity.
[f]Includes women with 2-4 previous births only; primiparous, grand multiparous, and multiparous are mutually exclusive groups.
[g]Grand multiparous is defined as at least 5 previous births (live births or stillbirths after 20 weeks' gestation).
[h]Eight women were missing data on history of cesarean.
[i]Sixty-one newborns were missing data on presentation.

publications, focused exclusively on results of randomized controlled trials (RCTs), of which there are only a few comparing waterbirth to nonwaterbirth[43,44]—and these were small and underpowered. Another problem inherent in these studies, as well as in any large, future, hypothetical RCTs, is that women in the waterbirth group whose labors become complicated are often directed to discontinue immersion,[45,46] but women randomized to nonwaterbirth would not suddenly be asked to get in the water. This one-way noncompliance with the assigned intervention group could introduce differential misclassification bias, making interpretation of intention-to-treat results problematic. This bias is also apparent in observational studies: women who develop complications get out of the tub, but rarely do women who never intended a waterbirth suddenly decide to get in. To our knowledge, we are the first to address this issue by reporting separately on the intended waterbirth group.

These methodologic issues, taken together, led the Cochrane review's authors to state unprecedentedly (the Cochrane Group is well known for their randomized trial preference) that: "Large audits and cohort studies should be undertaken in units which provide a pool facility to provide evidence for practice."[18] In this article, we have presented results from just such a large cohort study: 18,397 neonates, 35% (n = 6534) of who were born underwater. Furthermore, this is the first waterbirth study to report results for a US population.

We found that neonates born underwater were not at increased risk of adverse outcomes; on the contrary, they fared better than their nonwaterbirth counterparts on all outcomes. Rather than being a true benefit of waterbirth, however, this finding is likely secondary to the misclassification bias described above: outcomes in the intended waterbirth group were uniformly worse than those observed in the (planned) nonwaterbirth group. Taken together, these findings suggest

**Table 2.** Comparison of Newborn Outcomes in Newborns Born Underwater (Waterbirth), Newborns Not Born Underwater (Nonwaterbirth), and Newborns Whose Mothers Intended a Waterbirth But Did Not Have One (Intended Waterbirth)[a]

| | Frequencies | | | Adjusted Results | | | | |
|---|---|---|---|---|---|---|---|---|
| | Nonwaterbirth | Waterbirth | Intended Waterbirth | | Waterbirth | | Intended Waterbirth | |
| | n = 10,290 | n = 6534 | n = 1573 | Nonwaterbirth | aOR (95% CI) | *P* Value | aOR (95% CI) | *P* Value |
| **5-minute Apgar score <7,[b] n (%)** | | | | | | | | |
| No | 10,125 (98.8) | 6451 (99.0) | 1526 (97.6) | – | | | | |
| Yes | 120 (1.2) | 66 (1.0) | 38 (2.4) | 1.0 | 0.88 (0.65, 1.19) | .42 | 2.02 (1.40, 2.93) | < .001 |
| **Transfer to the hospital during the postpartum period for a neonatal indication,[c] n (%)** | | | | | | | | |
| No | 10,094 (98.8) | 6463 (99.5) | 1532 (98.4) | – | | | | |
| Yes | 118 (1.2) | 34 (0.5) | 25 (1.6) | 1.0 | 0.46 (0.32, 0.68) | < .001 | 1.33 (0.86, 2.06) | .20 |
| **Infant hospitalization, first 6 weeks,[d] n (%)** | | | | | | | | |
| No | 9809 (95.5) | 6301 (96.6) | 1484 (94.5) | – | | | | |
| Yes | 465 (4.5) | 220 (3.4) | 87 (5.5) | 1.0 | 0.75 (0.63, 0.88) | < .001 | 1.21 (0.95, 1.53) | .12 |
| **NICU admission, first 6 weeks,[e] n (%)** | | | | | | | | |
| No | 10,013 (97.6) | 6426 (98.6) | 1521 (97.1) | – | | | | |
| Yes | 242 (2.4) | 90 (1.4) | 45 (2.9) | 1.0 | 0.59 (0.46, 0.76) | < .001 | 1.18 (0.85, 1.63) | .32 |
| | n (rate/1000) | n (rate/1000) | N (rate/1000) | | | | | |
| **Early neonatal death (7 completed days)[f]** | | | | | | | | |
| No, n | 10,280 | 6532 | 1569 | | | | | |
| Yes, n (rate/1000) | 6[g] (0.58/1000) | 2[h] (0.31/1000) | 2[i] (1.27/1000) | [k] | [k] | | [k] | |
| **Late neonatal death (at least 7, but not yet 28, completed days)[m]** | | | | | | | | |
| No, n | 10,276 | 6529 | 1568 | | | | | |
| Yes, n (rate/1000) | 3[n] (0.29/1000) | 1[p] (0.15/1000) | 1[q] (0.64/1000) | [k] | [k] | | [k] | |

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; NICU, neonatal intensive care unit.
[a]Raw data as well as adjusted odds ratios (aOR) and 95% confidence intervals (95% CI) are presented; the nonwaterbirth group serves as the reference category. Analyses adjust for primiparity.
[b]Seventy-one neonates were missing data on 5-minute Apgar score.
[c]Across all 3 groups, the most common reasons for transfer were respiratory distress and/or low Apgar score. One hundred thirty-one neonates were missing data on neonatal transfer.
[d]Thirty-one neonates were missing data on hospitalizations in the first 6 weeks.
[e]Sixty neonates were missing data on NICU admissions in the first 6 weeks.
[f]There are no missing data for the death variables. The 4 nonwaterbirth and 2 intended waterbirth neonates not accounted for here died of autopsy-confirmed congenital anomalies that are incompatible with life and were removed from analysis, as is customary when examining fetal/neonatal death as an outcome.
[g]Causes of death: 1) hypoxia (neonate never attempted to breathe; life support removed after 2 days; no autopsy); 2) patent ductus arteriosis was official cause but no autopsy; 3) prelabor brain damage (tight nuchal cord; neonate never attempted to breathe; life support removed after 2 days; no autopsy but brain damage was receiving obstetrician's diagnosis); 4) acute chorioamnionitis (autopsy-confirmed); 5) cord rupture/hemorrhage (autopsy-confirmed); and 6) unknown (no autopsy; official cause was cardiac failure).
[h]Causes of death: 1) hypoxic ischemic encephalopathy (confirmed with magnetic resonance imaging on day 4; life support subsequently removed); and 2) congestive heart failure (autopsy-confirmed).
[i]Causes of death: 1) placental abruption (placenta came out with neonate; no autopsy); and 2) shoulder dystocia with cord compression (autopsy-confirmed).
[k]Cell counts too low to produce reliable effect estimates.
[m]There are no missing data for the death variables. The one nonwaterbirth and 2 waterbirth neonates not accounted for here died of autopsy-confirmed congenital anomalies that are incompatible with life and were removed from analysis, as is customary when examining fetal/neonatal death as an outcome. Also not included here are neonates who died during the early neonatal period; the denominator for late neonatal death rates has been limited to those infants still at risk of the outcome.
[n]Causes of death: 1) cord prolapse (no autopsy); 2) unknown (neonate never attempted to breathe and did not respond to resuscitation; no autopsy; this woman had a subsequent neonate with the same issue); and 3) unknown (no autopsy).
[p]Cause of death: unknown (no autopsy).
[q]Cause of death: official cause was hypoxia, but there was no autopsy.

that, when potential complications arose during labor, the attending midwife recommended that the woman discontinue water immersion, perhaps to allow for closer monitoring of fetal heart tones or to visualize fetal scalp color, etc. Thus, the intended waterbirth category reflects a cohort of women who were experiencing more complicated labors or births. It is not surprising that the outcomes for women and neonates in the intended waterbirth category were worse. Following, it is also not surprising that the neonates of women who remained in the tub or pool (the waterbirth group) had better outcomes: all of the nonstraightforward (ie, potentially elevated risk) mother–newborn dyads had been asked to get out of the tub. The substantially improved outcomes observed among neonates who were born underwater is almost certainly an artifact of this unavoidable but appropriate clinical management. The nonwaterbirth comparison (reference) group consists of women who never wanted (or who did not have access to) waterbirth. It seems likely that some of these women would have developed complications during labor that would have led to discontinuing immersion, had they been laboring in

**Table 3. Maternal Outcomes of Women Who Had a Waterbirth, Nonwaterbirth, or Intended Waterbirth But Gave Birth Outside of the Planned Water Immersion[a]**

| | Frequencies | | | Adjusted Results | | | | |
|---|---|---|---|---|---|---|---|---|
| | Nonwaterbirth n = 10,252 | Waterbirth n = 6521 | Intended Waterbirth n = 1570 | | Waterbirth | | Intended Waterbirth | |
| | n (%) | n (%) | n (%) | Nonwaterbirth | aOR (95% CI) | *P Value* | aOR (95% CI) | *P Value* |
| **Maternal genital tract trauma (any)[b]** | | | | | | | | |
| No | 5162 (50.7) | 3186 (49.3) | 581 (37.4) | – | | | | |
| Yes | 5018 (49.3) | 3272 (50.7) | 973 (62.6) | 1.0 | 1.11 (1.04-1.18) | .002 | 1.67 (1.49-1.87) | < .001 |
| **Postpartum transfer[c]** | | | | | | | | |
| No | 9990 (98.0) | 6415 (98.8) | 1514 (97.2) | – | | | | |
| Yes | 199 (2.0) | 80 (1.2) | 43 (2.8) | 1.0 | 0.65 (0.50, 0.84) | .001 | 1.36 (0.97, 1.90) | .07 |
| **Maternal hospitalization, first 6 weeks[d]** | | | | | | | | |
| No | 9890 (96.6) | 6354 (97.6) | 1502 (95.9) | – | | | | |
| Yes | 343 (3.4) | 154 (2.4) | 65 (4.1) | 1.0 | 0.72 (0.59, 0.87) | < .001 | 1.17 (0.89, 1.54) | .21 |
| **Maternal postpartum reproductive tract infection[e]** | | | | | | | | |
| No | 10,002 (97.8) | 6389 (98.2) | 1525 (97.6) | – | | | | |
| Yes | 221 (2.2) | 119 (1.8) | 38 (2.4) | 1.0 | 0.87 (0.69, 1.09) | .23 | 1.08 (0.78, 1.52) | .69 |

Abbreviations: aOR, adjusted odds ratios; CI, confidence interval.
[a]Raw data as well as aOR and 95% CIs (95% CI) are presented; all analyses adjust for primiparity.
[b]One hundred fifty-one women were missing data on genital tract trauma.
[c]One hundred and two women were missing data on postpartum transfer.
[d]Thirty-five women were missing data on hospitalization in the first 6 weeks postpartum.
[e]Forty-nine women were missing data on postpartum reproductive tract infection (includes endometrial, perineal, or uterine infection in the first 6 weeks postpartum).

water. Therefore, the nonwaterbirth reference group contains both women who could have had waterbirths and those whose labors were more complicated, and who therefore would have been asked to get out of the tub; for women who plan waterbirths, these 2 exposure groups have been separated into waterbirth and intended waterbirth.

Nonetheless, the neonates in the waterbirth group were born underwater, and we found no evidence of any subsequent increased risk for any adverse neonatal outcome. Safety of waterbirth (as opposed to merely laboring in water) is currently the issue under heaviest scrutiny in the recent ACOG/AAP guidelines,[3] as well as the evidence gap identified by the authors of the Cochrane Review.[18] Based on the strength of evidence presented here, we cannot conclude that waterbirth is beneficial; however, based on our results, waterbirth certainly is not harmful to the neonate. Our findings also suggest that US midwives attending home and birth center births on the whole are appropriately managing women as they labor and birth in water.

Our newborn morbidity results are consistent not only with those in the Cochrane review[18] but also with those of most other published observational studies, which almost universally report no adverse outcomes for waterbirth neonates.[26–35,46,47] By contrast, Carpenter et al[48] reported an increase in respiratory distress symptoms among waterbirth neonates; however, the sample size was small (N = 38), and the authors reflect that ascertainment bias may have played a prominent role. Hawkins,[49] in a small (N = 32), nonrandomized cohort study, reported more neonatal infections (and therefore greater morbidity) in the waterbirth group, although during the study period a lack of adherence to tub-cleaning protocols required intervention by the hospital's infection control team, likely affecting the study's results. All other published reports of increased neonatal morbidity following waterbirth are case reports or case series without control groups.[1,14,21–24,45,50–57]

We lacked sufficient power to calculate reliable adjusted odds ratios for early and late neonatal deaths. Nonetheless, there was no evidence of elevated mortality among the waterbirth group, a finding that is consistent with our morbidity results as well as with those published by others.[26,58] Furthermore, of the 3 neonatal deaths in the waterbirth group, none were attributed to causes that might stem from the waterbirth (ie, no drowning, no cord avulsion, no respiratory distress).

Women in our sample who gave birth while immersed in water had no increased risk of adverse outcomes except for genital tract trauma: they experienced an 11% increase in odds of genital tract trauma, although without a discernible pattern as to trauma location and severity. Cortes et al[59] also reported an increased risk of perineal trauma for women who gave birth while immersed in water. The Cortes study, however, contradicts the bulk of the literature, which has reported reduced risk of genital tract trauma, or no change in risk, among women who had a waterbirth.[26–28,32–34,44,46,47,60] Because ours is the first large cohort study to report results in a US population, and the largest cohort study to date, our finding of increased risk of maternal genital tract trauma requires further investigation. In the meantime, clinicians should discuss the possible risk of genital tract trauma as part of shared decision making and the informed consent process around waterbirth.

Other studies have also reported no increased risk of infection among women who have waterbirths,[26,29,32,61]

**Table 4.** Comparison of Location and Severity of Maternal Birth Canal Trauma by Whether or Not the Birth Was a Waterbirth, a Nonwaterbirth, or an Intended Waterbirth[a]

| | Frequencies | | | Adjusted Results | | | | |
|---|---|---|---|---|---|---|---|---|
| | Nonwaterbirth n = 10,252 | Waterbirth n = 6521 | Intended Waterbirth n = 1570 | | Waterbirth | | Intended Waterbirth | |
| | n (%) | n (%) | n (%) | Non-waterbirth | aOR (95% CI) | *P* Value | aOR (95% CI) | *P* Value |
| None | 5162 (50.6) | 3186 (48.9) | 581 (37.3) | – | | | | |
| Episiotomy only | 21 (0.2) | 1 (0.02) | 11 (0.7) | [b] | [b] | | [b] | |
| 1st- or 2nd-degree perineal only | 3,140 (30.8) | 1980 (30.4) | 547 (35.1) | 1.0 | 1.06 (0.98, 1.14) | .13 | 1.52 (1.34, 1.73) | < .001 |
| 3rd- or 4th-degree perineal only | 63 (0.6) | 27 (0.4) | 13 (0.8) | 1.0 | 0.79 (0.50, 1.24) | .30 | 1.73 (0.94, 3.18) | .07 |
| Mild labial only | 551 (5.4) | 487 (7.5) | 101 (6.5) | 1.0 | 1.50 (1.32, 1.71) | < .001 | 1.74 (1.39, 2.17) | < .001 |
| More severe: labial only | 142 (1.4) | 87 (1.3) | 27 (1.7) | 1.0 | 1.10 (0.84, 1.45) | .50 | 1.61 (1.06, 2.46) | .028 |
| Other trauma requiring repair | 21 (0.2) | 6 (0.09) | 2 (0.1) | [b] | [b] | | [b] | |
| Trauma at multiple sites | 1080 (10.6) | 684 (10.5) | 263 (16.9) | 1.0 | 1.10 (0.99, 1.23) | .085 | 2.09 (1.77, 2.47) | < .001 |
| Trauma NOS | 63 (0.6) | 61 (0.9) | 14 (0.9) | 1.0 | 1.60 (1.12, 2.28) | .01 | 1.96 (1.09, 3.52) | .025 |

Abbreviations: aOR, adjusted odds ratio; CI, confident interval; NOS, not otherwise specified.
[a]Raw data as well as aOR and 95% CIs (95% CI) are presented. The multinomial logistic regression model controlled for primiparity.
[b]Cell counts too low to produce reliable effect estimates.

although one study found an elevated risk.[35] In our study, we found no association between waterbirth and maternal perineal, uterine, or endometrial infection.

Women in the intended waterbirth category had increased odds of all adverse outcomes, although only genital tract trauma was statistically significant. As discussed above, this finding could be an artifact of the misclassification bias wherein women experiencing complicated labors were asked to discontinue water immersion. Alternatively, perhaps midwives attempted to speed the second stage in cases of fetal distress by cutting an episiotomy or allowing/encouraging tearing by verbally coaching a woman to continue to push, or push harder, in the final moments of birth. Alternatively, some underlying condition or risk factor (eg, smoking or poor nutrition) that predisposes to fetal complications could also place the woman at risk for reduced tissue integrity.[62]

### Strengths and Limitations

This research uses data from the MANA Stats Project, birth years 2004 to 2009. Although this dataset has many strengths, including evidence of reliability and validity, data collection procedures that preclude a midwife from entering data only from births with good outcomes, a large sample size, extremely high participation by women, and large numbers of covariables,[36] it does have limitations. Chief among these is the fact that data are collected by a voluntary sample of midwives. We previously estimated that approximately 30% of midwives attending home or birth center births in the United States contribute data,[36] and it is certainly possible that contributing midwives are not representative of all midwives attending US home and birth center births. We cannot predict how this would affect our results on waterbirth.

Additionally, our results are based on women who gave birth at home or in a birth center. These women likely are not representative of the US childbearing population as a whole. Additionally, they by definition gave birth with minimal medical intervention, which also is not the norm for US women, for whom the majority of births occur in the hospital under biomedical management.[63,64] However, because the few US hospitals that do offer birth tubs typically prohibit their use by higher risk women and by women who utilize epidural analgesia or other ongoing interventions,[28] and because even in hospitals the vast majority of laboring women are low-risk at the onset of labor, it seems reasonable that our results could be applied in US hospital settings where waterbirth is offered.

## CONCLUSION

This study is the largest cohort study to date on waterbirth, the first large study from the United States, and the first to report separately on outcomes for mother–newborn dyads who did not complete a planned waterbirth because of risk factors that arose in the intrapartum period. Our results indicate that waterbirth does not confer an increased risk of morbidity or mortality for the newborn, but women completing the second stage immersed in water may experience more genital tract trauma. Our results are congruent with findings from studies in other settings, and contrary to the recently published ACOG/AAP clinical guidelines, suggest that waterbirth is a reasonably safe option for use in low-risk, low-intervention births—especially when the risks associated with other forms of pharmacologic pain management are considered.

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## CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

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