Original Review

Waterbirth: An Integrative Analysis of Peer-Reviewed Literature

CEU

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Introduction: Despite a growing body of evidence for waterbirth safety, a myriad of political and cultural issues result in limited use in US hospitals compared to other developed nations. The purpose of this article is to critically analyze the evidence on maternal and neonatal outcomes of waterbirth to help inform evidence-based clinical practice in the United States.

Methods: A literature search was performed using electronic databases CINAHL, Ovid MEDLINE, PubMed, EMBASE, and PsycINFO. Thirty-eight studies, including 2 randomized controlled trials and 36 observational studies, were reviewed. Studies were conducted in 11 countries, mostly outside the United States. More than 31,000 waterbirths were described.

Results: Aggregate results suggest that waterbirth is associated with high levels of maternal satisfaction with pain relief and the experience of childbirth, and may increase the likelihood of an intact perineum. Waterbirth is associated with decreased incidence of episiotomy and severe perineal lacerations, and may contribute to reduced postpartum hemorrhage. Data indicate no difference in maternal or neonatal infection rates or nursery admissions after waterbirth. Neonatal mortality rates are low and similar after waterbirth and uncomplicated conventional birth. The calculated cord avulsion rate is 2.4 per 1000 waterbirths; it is unknown how this compares to conventional birth due to a lack of data that permits direct comparison.

Discussion: The majority of waterbirth research to date is observational and descriptive; thus, reported outcomes do not demonstrate causal associations. However, existing evidence is reassuring. Case-controlled studies have included thousands of women who gave birth underwater without an apparent increase in maternal or neonatal morbidity or mortality. Potential risks associated with waterbirth for women and neonates appear minimal, and outcomes are comparable to those expected in any healthy childbearing population.
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Keywords: hydrotherapy, water immersion, labor, birth, waterbirth, natural childbirth, integrative review

A related patient education handout can be found at the end of this issue and at www.sharewithwomen.org

INTRODUCTION

The study of waterbirth is complicated by the nature of the modality because some women labor and birth in water and others labor in water before giving birth conventionally. Therefore, critical evaluation of the literature requires a clear distinction of the mode and place of birth. Waterbirth is defined as fetal emergence underwater and is distinct from immersion hydrotherapy used during labor but not during the actual moment of birth. The safety and benefits of laboring in water have been well established.[1] Evidence about the safety and benefit of waterbirth remains less clear because most prior reviews of waterbirth literature have been restricted to scant data from a few randomized controlled trials conducted to date.[1,2]

Waterbirth is limited in US hospitals compared to other developed nations, despite a growing body of evidence regarding its safety and increasing international use. In 2009 only, 229 US hospitals offered waterbirth.[3] In contrast, most hospitals in the United Kingdom and more than one-quarter of European hospitals in German-speaking regions provide waterbirth to healthy women.[4,5] Table 1 presents common barriers identified in research studies that provide insight into why waterbirth may not be common practice in the United States. Professional organizations' statements against the routine use of waterbirth,[6,7] along with a lack of evidence-based national guidelines supporting waterbirth, may also limit the widespread practice of waterbirth in the United States. Current recommendations from professional organizations regarding waterbirth are presented in Table 2.

The purpose of this article is to critically analyze peer-reviewed research on maternal and neonatal outcomes of waterbirth. The goals of this integrative synthesis are to help identify gaps in knowledge and to inform policy statements and evidence-based clinical practice in the United States.

METHODS

Search Strategy

A literature search was performed using electronic databases CINAHL, Ovid MEDLINE, PubMed, EMBASE, and PsycINFO. Key words included: alternative birth method, bath, childbirth, hydrotherapy, Leboyer, natural childbirth, nonpharmacologic, parturition, labor, labor-second stage, tub, pool, waterbirth, and water immersion.

The following definitions were used: 1) *water labor*—use of immersion during some portion of labor, with birth into

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Quick Points

- The majority of published waterbirth research consists of simple descriptive or case-control observational studies performed outside of the United States.
- Current evidence supports that outcomes of waterbirth are likely equivalent, if not improved, among healthy women with low-risk pregnancies, compared to conventional birth.
- There is no evidence that waterbirth is associated with increased aggregate risk of maternal or neonatal morbidity or mortality.
- Waterbirth literature demonstrates a rate of cord avulsion of approximately 2.4 per 1000 births. There are no data to compare this rate with that observed following conventional birth. If cord avulsion occurs, long-term sequelae can be prevented with appropriate management.

air; 2) *waterbirth*—birth of neonate entirely underwater, regardless of placental delivery location; and 3) *conventional birth*—birth occurring without immersion during any stage of labor. Delineation of these terms is essential given evidence that benefits and potential risks differ between labor and birth in water.

Criteria for Inclusion and Exclusion

All descriptive, observational, and randomized trial studies of waterbirth published in peer-reviewed journals were included; case reports and qualitative studies were excluded. Studies were also excluded if researchers solely examined outcomes of water labor. Articles were limited to English publications, and no time frame was imposed. Bibliographies were hand-searched for additional relevant references. A total of 1121 articles were found; 187 duplicates were removed. After abstracts were reviewed, 844 articles were eliminated due to inclusion and exclusion criteria and 90 articles were read entirely. Of these, 38 met criteria and were included in this review. Studies that met review criteria were analyzed by the first 2 authors, who uniformly agreed on study characteristics and findings. Their conclusions are detailed in Table 3.

The matrix method was used to create a detailed literature matrix, which organized the articles thematically, facilitated analysis of waterbirth data, and provided a mechanism for synthesizing perinatal outcomes.[8] Level of evidence was determined according to Melnyk and Fineout-Overholt's criteria.[9]

RESULTS

Characteristics of Studies Reviewed

Two randomized controlled trials (RCTs) and 36 observational studies were included in this review. Studies included waterbirths in 34 hospitals and 3 birth centers; one additional article examined hospital, birth center, and home waterbirths. Studies were conducted in 11 countries: 16 in the United Kingdom; 5 in Italy; 5 in Switzerland; 2 in Austria; 2 in Australia; 2 in Iran; 2 in Turkey; and one each in France, Germany, South Africa, and the United States. Study designs ranged from RCTs to case-control studies, descriptive studies without control groups, and clinical audits. Sample sizes ranged from 10 to 5192 waterbirths. Maternal outcomes were measured in 35 studies, and neonatal outcomes were measured in 33. After excluding women described in multiple publications, a total of 31,453 unique waterbirths were identified.

Early literature on waterbirth included simple descriptive reports of maternal and neonatal outcomes. These studies revealed excellent maternal and neonatal outcomes among healthy women who birthed in water. However, significant study limitations must be considered, including the lack of clearly defined inclusion or exclusion criteria or clinical guidelines, and failure to differentiate between water labor and waterbirth. This review includes 15 descriptive research articles.[4,10–23] Melnyk and Fineout-Overholt classify single descriptive studies with no control group as level VI evidence in their 7-level hierarchy of evidence for intervention/treatment.[9] This indicates weak evidence but more instructive than case reports, personal experience, or the opinion of authorities and/or reports of an expert committee.

Over time, waterbirth research evolved from simple descriptions to comparative observational studies that primarily used bivariate approaches to analyze outcomes. Researchers increasingly differentiated participants based on birth location and described inclusion and exclusion criteria, protocol standards, and measurement tools, thus allowing more confidence in the data. These studies significantly expanded the understanding of waterbirth practice and the maternal and fetal–neonatal outcomes expected in healthy study populations. This review includes 21 case-control observational studies,[5,24–43] which Melnyk and Fineout-Overholt classify as level IV evidence.[9] These studies represent significant advancement in the quality of supportive evidence for waterbirth practice despite significant limitations, including the lack of ability to establish causality.

Two RCTs of waterbirth have been published in peer-reviewed journals.[44,45] Although Melnyk and Fineout-Overholt classify RCTs as level II evidence, indicating that these trials are critical in the evaluation of waterbirth despite limitations related to design and methodology,[9] both of these trials had a number of limitations.

In 2004, Woodward and Kelly conducted a pilot RCT with a preference arm aimed to assess waterbirth versus conventional birth outcomes, the feasibility of a multicenter study of waterbirth, and whether women would be willing to participate in a waterbirth RCT.[45] The randomized arm

Table 1. Cited Barriers to Waterbirth Practice

Financial consideration (eg, tub installation, maintenance costs)[38,50,51]
Staffing concerns[38,51]
Lack of medical staff support including obstetricians, nurses, and pediatricians[38,51]
Lack of hospital administrator's support[50]
Lack of patient information facilitating evidence-based information on waterbirth[50]
Limited tub availability[51]
Concern about maintaining water temperature[52]
Provider concern about the physical stress on the provider of supporting waterbirth (eg, back problems)[51,52]
Inability to view the perineum[52]
Limited access/availability to training to learn new skills to support waterbirth[51,52]

Sources: Pagano[38]; Houston[50]; Garland[51]; Meyer.[52]

consisted of 60 women (40 assigned to waterbirth; 20 assigned to conventional maternity care without hydrotherapy). The pilot study had limitations, including insufficient sample size; inadequate methodology to address recruitment, allocations, and treatment administration; and frequent crossover among study arms. These complicated data analysis and interpretation. Despite limitations, the authors concluded that "randomization did not affect women's satisfaction with their birth experience and most women responded positively when asked whether they would participate in a similar trial," indicating that future RCTs of waterbirth may be feasible.[45]

Chaichian and colleagues conducted the second RCT and compared outcomes of 53 conventional births and 53 waterbirths. They concluded that women in the waterbirth group were more likely to give birth "naturally" than were women in the comparison group.[44] However, the results from this RCT are difficult to interpret due to the poor reporting of methods and results.

Although these RCTs represent the most rigorous analyses of waterbirth outcomes to date, they are limited by multiple problems with design, as noted. Both were grossly underpowered to detect differences in potentially harmful effects or reported benefits of waterbirth. Thus, this review provides a synthesis of all peer-reviewed waterbirth research, observational as well as experimental, to facilitate an accurate understanding of the state of waterbirth science and to assist clinicians to conduct informed consent discussions with families who are interested in the practice.

Maternal Outcomes

Perineal Outcomes

Research demonstrates that waterbirth is associated with the decreased use of episiotomy compared with conventional birth.[5,16,26,27,29,30,33,35–37,41–44] Results of multiple descriptive studies also show an association between waterbirth and a

Table 2. Statements of Professional Organizations on Waterbirth

Professional Organization Date of Publication	Statement
American Congress of Obstetricians and Gynecologists & American Academy of Pediatrics, 2014[6]	"The safety and efficacy of immersion in water during the second stage of labor have not been established, and immersion in water during the second stage of labor has not been associated with maternal or fetal benefit. Given these facts and case reports of rare but serious adverse effects in the newborn, the practice of immersion in the second stage of labor (underwater delivery) should be considered an experimental procedure that only should be performed within the context of an appropriately designed clinical trial with informed consent"
American College of Nurse-Midwives 2014[7]	"Researchers indicate that women who experience uncomplicated pregnancies and labors with limited risk factors and evidence-based management have comparable maternal and neonatal outcomes whether or not they give birth in water. Professional lability carriers, hospital administrators, health care insures, and regulatory entities should not prevent or disallow maternity care providers or facilities with maternity services from providing immersion hydrotherapy for labor and birth with trained attendants who follow evidence-based guidelines"
United Kingdom Royal College of Obstetricians and Gynaecologists Royal College of Midwives, 2006[49]	A joint statement concluded that waterbirth data are reassuring despite potentially rare but serious neonatal complications, and advocates for full disclosure while supporting women's choice of underwater birth with experienced providers.

Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
Aird et al[24] 1997 Austria Level IV	Case-control of 100 waterbirths compared to a control group of the first 100 conventional births in the birth log; matched for age, parity, and obstetric history	Medical records	**No analgesia:** primiparous waterbirth, n = 6; primiparous conventional birth, n = 1 ($P = .12$); multiparous waterbirth, n = 14; multiparous conventional birth, n = 5 ($P = .04$) **Intact perineum**: primiparous waterbirth 8.7% vs primiparous conventional birth 13.3% ($P = .05$)	**Apgar scores > 6 at 1 minute:** 96% WB vs CB 88% ($P = .068$) **NICU admission:** n = 0 **Infective morbidity:** n = 0	Maternity providers completed questionnaires. Quality of providers' records unknown, and potential for bias.
Alderdice et al[4] 1995 United Kingdom Level VI	Retrospective description of 4494 waterbirths provided by 219 heads of maternity services representing 227 NHS facilities, 5 non-NHS hospitals, 76 self-employed midwives	Postal questionnaires sent to medical providers asking them to retrieve data from medical records, or good estimates from incomplete records; follow-up phone interviews if clarity needed	**Maternal complications:** described as PPH and severe perineal trauma, n = 33 **Interested in WB RCT:** n = 168	**Morbidity:** described as respiratory problems and infections, n = 51 **Mortality:** n = 12 after waterbirth or water labor with conventional birth (none directly related to water)	Data based on good estimates derived from incomplete records
Baxter[25] 2006 Austria Level IV/VI	Part I: Case-control 229 waterbirths compared to 102 water labors with conventional birth	Medical records and patient satisfaction survey	**No analgesia:** WB 8% vs WL 5% **Intact perineum:** WB 38% vs WL 14%	**Apgar scores > 7 at 5 minutes:** WB 98% vs WL 84%	WL and WB were clearly defined; data utility limited by lack of scientific method

Continued.

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Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
			1st-degree/labial laceration: WB 32% vs WL 21% **2nd-degree laceration:** WL 32% vs WB 29% **3rd-degree laceration:** WB n = 1 vs WL n = 1 **Episiotomy:** WB n = 0 vs WL n = 30 **EBL > 500 mL:** WB 7% vs WL 11%	**Apgar scores > 9 at 10 minutes:** WB 100% vs WL 97% **NICU admission:** WB n = 1 after shoulder dystocia with meconium aspiration	
	Part II: Case-control 229 waterbirths compared to 102 water labors with conventional birth	Postal patient survey	**Perception of relaxation:** used 0–10 VAS (1 = poor; 10 = best) 93% WL/WB scored ≥ 7 **Pain relief perception:** used 0–10 VAS (1 = poor; 10 = best) 80% WL/WB scored ≥ 7 **WB without intention to give birth in water or undecided at time of admission:** 28% **Main themes:** relaxed, pain relief, comfortable, self-control, effective	Not reported	WL and WB were clearly defined; qualitative data in a mixed-methods study

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Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
Bodner et al[26] 2002 United Kingdom Level IV	Case-control 140 waterbirths compared to 140 conventional births controls selected from birth database as the next parity; matched for normal spontaneous vaginal birth	Review of medical records	**Analgesia:** WB 93.6% vs CB 69.3% ($P = .0001$) **Perineal lacerations:** no statistically significant difference observed between the 2 groups ($P > .05$) **Episiotomy:** WB 1.4% vs CB 32.9% ($P = .0001$) **PPH > 500 mL:** WB 1.4% vs CB 10.0% ($P = .002$) **Postpartum hemoglobin:** WB 11.2g/dL vs CB 11.1g/dL ($P > .05$) **Manual placenta removal:** WB 1.4% vs CB 7.1% ($P = .017$) **Maternal infection:** requiring antibiotics WB n = 2 vs CB n = 8 ($P = .03$)	**Apgar scores at 1 min < 7:** WB 1.4% vs CB 4.3% ($P > 0.05$) **Apgar scores at 5 min < 7:** WB 0.7% vs CB 0.7% ($P > .05$) cord pH < 7.1: WB 2.1% vs CB 2.9% ($P > .05$) **requiring antibiotics:** WB n = 0 vs CB n = 2 ($P > 0.05$)	Groups matched by parity; parameters well-defined, a priori
Brown[10] 1998 United Kingdom Level VI	Clinical audit of 343 waterbirths	Chart audit by senior midwife; ear and umbilical swabs from the neonate; high vaginal swabs following the 3rd stage of labor	**Intact perineum:** primiparous waterbirth n = 66 vs multiparous waterbirth n = 91	**Apgar scores > 7 at 1 minute:** 94% **Apgar scores > 7 at 5 minutes:** 99.7%	Parity data reported; no comparison group; descriptions of WB practice at this facility were provided; maternal intention to use tub versus actual use was described; data utility limited by lack of scientific method

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Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
			1st-degree lacerations: primiparous waterbirth n = 21 vs multiparous waterbirth n = 32 **2nd-degree lacerations:** primiparous waterbirth n = 37 vs multiparous waterbirth n = 46 **3rd-degree lacerations:** primiparous waterbirth n = 2 vs multiparous waterbirth n = 0 **Episiotomy:** Primiparous waterbirth n = 5 vs multiparous waterbirth n = 2 **Hemorrhage:** n = 2 **Manual removal of placenta:** n = 2 **Infection treated with antibiotics:** n = 1	**NICU admission:** n = 2 **Mortality:** n = 1 intracranial hemorrhage **Morbidity:** n = 0 **Infection:** n = 5 (ear swab pseudomonas n = 2, MRSA ear swab required antibiotics n = 1, sticky eye requiring eye drops required n = 2) **Shoulder dystocia:** n = 5	
Burke et al[27] 1995 United Kingdom Level IV/VI	Part I: Case-control 50 waterbirths selected using a random selection table from the pool register; a control group of 50 conventional births was selected from the birth register; matched for age and parity as the next spontaneous vaginal birth	Medical records			

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Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
			No analgesia: multiparous waterbirth 21%, multiparous conventional birth 4%, primiparous waterbirth 0%, primiparous conventional birth 15% **Episiotomy:** WB n = 0, multiparous conventional birth 8%, primiparous conventional birth 27% **Intact perineum:** multiparous waterbirth 75%, multiparous conventional birth 66%, primiparous waterbirth 19%, primiparous conventional birth 15% **1st-degree laceration:** multiparous waterbirth 17%, multiparous conventional birth 13%, primiparous waterbirth 31%, primiparous conventional birth 27% **2nd-degree laceration:** multiparous waterbirth 8%, multiparous conventional birth 13%, primiparous waterbirth 50%, primiparous conventional birth 31%	**Apgar score:** mean scores at 1 minute were the same for birth groups; range scores at 1 minute, WB 6–10 vs CB 3–9	Limited to descriptive statistics; controlled for parity unlike many other studies

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Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
	Part II: Survey 100 waterbirths compared to 100 conventional births	Postal questionnaire	**Multiparous ease of birth compared to prior birth:** WB 98% easier vs CB 89% easier **Positive birth experience:** WB 96% vs CB 81% **Consider another WB:** 90% yes, 6% unsure, 2% no **Perineal comfort postpartum:** **"painful":** WB 0% vs CB 7% **"comfortable":** WB 33% vs CB 26% **"uncomfortable":** WB 15% vs CB 9%	Not reported	Examined maternal experience and satisfaction; limited response rates similar among groups (WB 56%, CB 53%); 56% CB group considered WB with 30% desiring WB at birth which could confound examination of satisfaction
Burns et al[11] 2012 United Kingdom Level VI	Prospective description of 8924 births that occurred in hospitals, alongside birth center, free-standing birth centers, or homes; 5192 were waterbirths	Information recorded by birth midwife on standardized data sheet. Midwife at each center collated and checked data forms for completeness and entered into database	**Intact perineum:** 1/3 WB (n = 2,754) **Episiotomy:** WB/WL 9% **3rd-degree laceration:** WB/WL 2% **Physiologic 3rd stage:** WB 86.1% **3rd stage in water:** 55.8% **PPH**: WB 0.9% **Retained placenta:** WB 2% **Cord avulsion:** WB: n = 18/N = 5,192 vs WL n = 2/N = 3,732	**NICU admission:** WB/WL 1.6% (all discharged without additional problems) **Suspected infection:** WB/WL 0.39 **Stillborn:** n = 2 **Neonatal deaths:** n = 2 **Resuscitation:** 1.2% **Respiratory difficulty:** 0.73%; (Note all of the above are WL/WB combined)	Confounding variables (some data was reported with WB and WL together); power analysis performed to enable observation of rare events; prospectively recorded data with piloted process prior to data collection; large WB sample

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Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
Burns[28] 2001 United Kingdom Level IV	Case-control 1372 waterbirths compared to 1372 conventional births; matched for parity and risk factors	Information recorded by midwife on data sheet	**Intact perineum:** higher incidence WB **Episiotomy:** higher incidence CB **Hemorrhage:** WB 3.3% vs CB 3.6% **Water effectiveness:** reported by women and midwives was more helpful than less helpful	**NICU admission:** WB 1.2% vs CB 2.5% (n = 13: grunting, Apgar score < 10 at 5 minutes, low blood gas, low temp, jaundice, tachypnea, poor feeding, bilious vomiting, congenital abnormality) **Mortality:** WB n = 1 (versa previa) **Cord avulsion:** n = 2; no transfusions required	Groups matched by parity; prevalence and incidence reported for some but not all data
Burns et al[29] 1993 United Kingdom Level IV	Case-control all women who used the pool resulting in 171 waterbirths with a control group of 131 women who did not use pool selected by the next woman in birth register; matched for parity	Medical records	**No analgesia:** primiparous waterbirth 50%, primiparous conventional birth 24%, multiparous water birth 75%, multiparous conventional birth 51% **Vaginal wall laceration:** primiparous waterbirth 16%, primiparous conventional birth 11%, multiparous water birth 10%, multiparous conventional birth 2% **Labial lacerations:** primiparous waterbirth 6%, primiparous conventional birth 2%, multiparous water birth 0%, multiparous conventional birth 1% **2nd-degree laceration:** primiparous waterbirth 43%, primiparous conventional birth 43%, multiparous	Not reported	WB and WL data reported together; percentages were reported but are difficult to evaluate for significance; data reported by parity

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Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
			water birth 43%, multiparous conventional birth 34% **3rd-degree laceration:** primiparous waterbirth n = 1, primiparous conventional birth n = 1, multiparous WB/CB n = 0 **Episiotomy:** Primiparous waterbirth 3%, primiparous conventional birth 23%, multiparous water birth 1%, multiparous conventional birth 11%		
Chaichian et al[44] 2009 Iran Level II	RCT 53 waterbirths compared to 53 conventional births; participants initially screened by questionnaire then randomly assigned	Questionnaire of outcomes measures	**Analgesic use:** WB 3.8% vs CB 100% ($P = .001$) **Episiotomy:** 23% > for CB **Laceration rate:** 12% > for WB (most were minimal)	**Apgar score:** NSS	Study lacks detail; risk of measurement bias (eg, parity not reported); WB vs CB clearly defined
Cortes et al[30] 2011 United Kingdom Level IV	Part I: Case-control maternal outcomes of 160 waterbirths compared to 623 conventional births	Outcome data from an electronic NHS database	**Intact perineum:** WB 34% vs CB 36% **1st-degree laceration:** WB 19% vs CB 9% **2nd-degree laceration:** WB 37% vs CB 40% **3rd-degree laceration:** WB 2.5% vs CB 1.2% ($P > .05$, RR: 1.9) **Episiotomy:** CB 5% vs WB 0%	Not reported	WB vs CB clearly defined

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Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
	Part II: Case-control evaluating women's pelvic floor outcomes 1 year postpartum in 94 waterbirths compared to 60 conventional births	Postal questionnaire with 2 validated questionnaires on pelvic floor performance: ICIQ-VS and ICIQ-KH Long	**No vaginal symptoms:** WB 27% vs 28% **Mild vaginal symptoms:** WB 73% vs CB 72% **No urinary symptoms:** WB 5% vs CB 0% **Mild urinary symptoms:** WB 94% vs CB 100% **Stress incontinence:** WB 66% vs CB 68% (*P* = .78, RR:0.96, 95% CI: 0.75-1.23) **Urge incontinence:** WB 52% vs CB 39% (*P* = .14, RR:1.33, 95% CI: 0.90-1.99)	Not reported	Secondary data; questionnaires validated; WB vs CB clearly defined; participants with prior pelvic floor dysfunction excluded
Dahlen et al[12] 2013 Australia Level VI	Retrospective description of 819 waterbirths compared to 5325 conventional births	Handwritten medical records	**3rd-/4th-degree lacerations:** WB < stool adjusted OR 1.40 (CI 1.12–1.75) **PPH (> 500 mL):** WB < stool adjusted OR 2.04 (CI 1.44–2.90)	**Apgar score < 7 at 5 minutes:** > risk in semirecumbent position with CB vs WB; adjusted OR 4.61 (CI 1.29–15.52)	Confounding variables (eg, some data reported WB/CB together); adjusted ORs provided; covariates such as birth weight and parity were controlled
Demirel et al[13] 2013 Turkey Level VI	Clinical audit of 191 newborns born in water during the study period	Medical records	**Primiparous:** 25% **Multiparous:** 74%	**NICU admission:** 3.1% (respiratory problems n = 4, polycythemia n = 1; pneumonia n = 1; myelocele n = 1) **Antibiotic use:** n = 1 **Brachial nerve paralysis:** n = 1 **Cord avulsion:** n = 1 **Cephal hematoma:** n = 1	No comparison group; 220 WB occurred, but data for just 191 newborns retrieved for evaluation

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Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
Eberhard et al[14] 2005 Switzerland Level VI	Prospective observation of 3327 waterbirths, 2763 bed births, and 1049 birthing stool births	Midwives prospectively documented on a questionnaire for all births, VAS used 0-100mm left side indicated "no pain" and right side indicated "intolerable strong pain"	**No analgesia:** primiparous waterbirth 55.1% vs primiparous conventional birth 27.5 %, multiparous waterbirth 74.5% vs multiparous conventional birth 56.6% **Narcotic use:** primiparous waterbirth 34.7% vs primiparous conventional birth 64.5%, multiparous waterbirth 14.7% vs multiparous conventional birth 32.4% **Pain perception while pushing:** primiparous waterbirth 73.17 vs primiparous conventional birth 69.82 ($P = .001$), multiparous waterbirth 76.77 vs multiparous conventional birth 73.98 ($P = .000$) **Postpartum pain perception:** primiparous waterbirth 68.54, primiparous conventional birth 71.89 ($P = .000$), multiparous waterbirth 66.04 vs multiparous conventional birth 67.94 ($P = .034$)	Not reported	Parity reported; risk related to cofounding variables and measurement bias with use of VAS

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Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
Fehervary et al[31] 2004 Germany Level IV	Part I: Case-control 34 neonates born in water, 26 neonates born after WL with CB, and 36 neonates born via WB without WL	Bacterial cultures results after swabbing participants' ears and palates	Not reported	**No bacteria cultured:** WB n = 18, CB n = 23, WL n = 23 **Most frequently cultured bacteria:** Staph epidermis, E. Coli, enterococci **Only cultured in WB:** Group B strep, Citrobacter spp.	Culture results differentiated by WB, WL, and CB
	Part II: Case-control 100 neonates born in water compared to 100 neonates born conventionally	Medical records and questionnaire sent to mothers regarding infection after discharge	**Most frequently cultured bacteria:** Staph epidermis, E. Coli, enterococci **Only cultured in WB:** B strep, Citrobacter spp. **No bacteria cultured:** WB n = 18, CB n = 23, WL n = 23 **6 months postpartum maternal infection:** WB n = 0, CB n = 3	**Apgar scores:** all were 9 after 1 minute, and 10 at 5 minutes **Nursery transfer:** WB 6% vs CB 7% **Cord pH:** WB 7.25 vs CB 7.23 **Neonatal bacterial infection:** WB n = 3, CB n = 2 **Hyperbilirubinemia:** WB n = 2, CB n = 1 **Reported neonatal infection 6 months postpartum:** WB 31% vs CB 28%	Objective markers for neonatal infection used; long-term follow-up (6 months) was performed, which is rare in WB research; potential bias related to differences in questionnaire return rates: WB 60% vs CB 47%
Forde et al[15] 1999 United Kingdom Level VI	Part I: Observational study of 49 waterbirths	Information recorded by midwife on data sheet; microbial results	**Vaginal swabs grew:** Candida n = 5, GBS n = 1	**Apgar score:** all above 8 at 5 minutes **NICU admission:** n = 1 jaundice and polycythemia **Infection:** n = 0 **Hypothermic:** n = 2 **Transient tachypnea or tachycardia:** n = 6 **Mild asphyxia responded to basic resuscitation:** n = 2 **Cord pH moderate to severe asphyxia:** n = 0	No comparison group; excellent review of birth management and neonatal observation after WB; strong a priori; missing neonatal data from some participants

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Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
	Part II: Patient satisfaction survey 49 women who gave birth in water	Postal questionnaire	**Satisfaction with birth experience:** described their experience as "excellent" 81%, "good" 16%, "disappointing" 0.03% **Would use the pool again in another birth:** 86% **Hesitation about being part of a research project:** "no" 43%	Not reported	Response rate was 76%
Garland[16] 2000 United Kingdom Level VI	Clinical audit of waterbirths from 4 NHS units and one private practice; 1:1 waterbirth to conventional birth comparison; matched for parity, trail of scar, age, ethnicity for each of the units	Data collected from medical records and entered into each unit's computer file; all data then aggregated	**Demerol:** WB 3% vs CB 60% **Intact perineum:** primiparous waterbirth 57%, primiparous conventional birth 51%, multiparous waterbirth 57%, multiparous conventional birth 36% **1st-/2nd-degree lacerations:** primiparous waterbirth 57%, primiparous conventional birth 51%, multiparous waterbirth 42%, multiparous conventional birth 52% **Episiotomy:** limited to higher risk CB only **EBL > 500 mL:** very small numbers too small for meaningful analysis	**Apgar score:** small proportion of neonates in both groups had low Apgar scores; all scores at 5 minutes were satisfactory	Total number of WB not reported; groups matched by parity, ethnicity, and mother's age; WL excluded; lacks scientific method making it difficult to evaluate for significance

Continued.

Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
Garland[17] 2002 United Kingdom Level VI	Clinical audit 680 waterbirths from 9 NHS units and one private practice; 1:1 waterbirth to conventional birth comparison; matched for parity, trail of scar, age, ethnicity for each of the units (participants reported in prior study[16])	Data collected from medical records and entered into each unit's computer file; all data then aggregated	**Intact perineum:** primiparous waterbirth 32% vs multiparous waterbirth 46% **3rd-degree laceration:** primiparous waterbirth/primiparous conventional birth 0.8%, multiparous waterbirth 0.2%, multiparous conventional birth 0.6% **PPH $>$ 500 mL:** primiparous waterbirth 5%, primiparous conventional birth 3.7%, multiparous waterbirth 4%, multiparous conventional birth 4%	**Apgar score $<$ 7 at 5 minutes:** primiparous waterbirth 3.3%; primiparous conventional birth 5%, multiparous waterbirth 3.1%, multiparous conventional birth 3.1%	WL excluded; parameters not defined; well-defined a priori; aggregate and unit specific data provided; all units had established WB service with clinical guidelines.
Garland[18] 2006 United Kingdom Level VI	Clinical audit 1993 waterbirths from 9 NHS units and one private practice; 1:1 waterbirth to conventional birth comparison; matched for parity, trail of scar, age, ethnicity for each of the units (participants reported in prior studies[16,17])	Data collected from medical records and entered into each unit's computer file; all data then aggregated	**Intact perineum:** primiparous waterbirth 33.8%; primiparous conventional birth 18.2%, multiparous waterbirth 41.7%, multiparous conventional birth 33.6%) **3rd-degree lacerations:** waterbirth 1.7% vs conventional birth 2%	**Apgar scores $<$ 7 at 5 minutes:** primiparous waterbirth 0.1%, primiparous conventional birth 0.7%, multiparous waterbirth 0.1%, multiparous conventional birth 0.52%	WL excluded; parameters not defined a priori; aggregate data provided while preserving the integrity of evidence from each unit; incidence reported with reference to parity.

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Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
			PPH: primiparous waterbirth 3%, primiparous conventional birth 6.6%, multiparous waterbirth/multiparous conventional birth 4% **Combined risk PPH:** WB 3.6 % vs CB 4.8%		
Geissbühler et al[32] 2000 Switzerland Level IV	Case-control 2014 waterbirths compared to 2362 bed births, and 1108 birthing stool births	Data recorded by midwife and physician on standardized questionnaire	**No Analgesia:** WB 70.6% vs bed 54.1%; 66.1% stool, significantly less analgesia used in WB ($P < .0001$) **Intact perineum:** WB 27.6% vs CB 24.9%, ($P < .05$) **Labial lacerations:** WB 21.4% vs bed 12.9% ($P < .001$) **1st-/2nd-degree lacerations:** WB 51.2%, CB 34.8% ($P < .0001$) **3rd-/4th-degree laceration:** WB 2.7% vs bed 4.1% ($P < .05$) **Episiotomy:** WB 12.8%, bed 25.4%, stool 27.7% ($P < .001$) **EBL based on mean hemoglobin:** significantly less EBL WB (WB −4.1 vs CB −6.6) ($P < .0001$) **WB-rated birth:** satisfying and closer to wonderful than dreadful on VA S (0–100) ($P = .0001$)	**Apgar score at 5 minutes:** WB 9.8 vs CB 9.6 ($P < .0001$) **Apgar score at 10 minutes:** ($P = < .0001$) **Mean average arterial cord pH:** WB 7.30 vs CB 7.26 ($P < .0001$) **Infection:** WB n = 12 vs CB n = 25 **Ocular infection:** WB n = 10 vs CB n = 5 **Shoulder dystocia:** WB 0.29%, CB 0.46%	Well-defined measurement variables; contamination risk of WL; water temperature was self-regulated and not reported (potential confounder).

Continued.

Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
Geissbühler et al[33] 2004 Switzerland Level IV	Case-control 3617 waterbirths compared to 5401 conventional births (participants reported in prior studies[32])	Data recorded by midwife and physician on standardized questionnaire	**No analgesia:** WB 69.6% vs CB 58.0% ($P < .05$) **Intact perineum:** WB 34.2% vs CB 29.2% ($P = .000$) **1st-/2nd-degree laceration:** WB 50.1% vs CB 41.1% ($P = .000$) **3rd-/4th-degree laceration:** WB 2.3% vs CB 3.6% ($P = .000$) **Episiotomy:** WB 8.3% vs CB 25.7% **EBL hemoglobin drop:** WB 5.25g/L vs CB 8.08 g/L ($P = .00$) **Infection:** NSS **Antibiotic use:** WB 5.2% vs CB 8.9%	**Apgar score < 7 at 5 minutes:** WB 0.11% vs CB 0.32% **Apgar score < 9 at 10 minutes:** WB 0.27% vs CB 0.76% **Injury-associated complications:** WB 1.3% vs CB 2.8% ($P = .000$) **NICU admission delivery room:** WB 0.2% vs CB 0.6% ($P = .000$) **NICU admission postpartum unit:** WB 0.6% vs CB 0.6% ($P = .684$) **Ocular infection:** WB n = 14 vs CB n = 45 ($P = .022$) **Overall infection:** CB n = 60 vs WB n = 20 ($P = .015$) **Shoulder dystocia:** WB 0.2% vs CB 0.3% ($P = .382$) **Arterial cord pH:** WB 7.29 vs CB 7.27 ($P = .000$)	Parameters well-defined, a priori; large sample size; WB had fewer OB risk factors that were not controlled for in analysis; risk related to cofounding variables as WL utilized by 782 women of which 647 had vaginal births and were included in CB group
Gilbert et al[19] 1999 United Kingdom Level VI	Surveillance survey 4032 neonates born in water or conventionally after water labor	1500 pediatricians were surveyed each month via postal questioners; findings were verified with the regional notification scheme and regional coordinators were contacted to verify if any deaths after WB had occurred in addition to those reported	Not reported	**Therapeutic antibiotics required:** WB 3.1% vs CB 4.7% ($P = .003$) **NICU admission:** WB n = 34/4030 (0.0084%; Risk per 1000 live births: 8.4 (95% CI 5.8-11.8) vs Low risk CB n = 878/19,360 (0.045%) **WB perinatal mortality:** 1.2/1000 live births	Conventional birth comparison data based on "low risk" conventional deliveries in the region in published and unpublished reports. Validation only of fetal death; contamination bias due to unmatched groups of WL vs WB; possibility of confounding variables

Continued.

Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
				Mortality: deaths directly attributable to WB n = 0 **Risk of complication CB:** 0.8/1000 to 4.6/1000 live births **Relative risk for perinatal mortality WB:** 0.9/1000 **Hypoxic ischemic encephalopathy grade 2/3:** CB 2/1000 live births (95% CI 1.6-2.9) vs WB 1.2/1000 (95% CI 0.4-2.9) **Perinatal death:** WB n = 5 (1 stillborn, 1 stillborn born unattended at home, 1 neonatal herpes infection, 1 intracranial hemorrhage after precipitous delivery, 1 hypoplastic lung) vs WL n = 6 **Respiratory support:** n = 13 **Lower respiratory tract issues:** n = 15 **Pneumonia:** n = 2 **Hypernatremia:** n = 1 **Hypoxic ischemia encephalopathy :** n = 5 **Cord Avulsion:** n = 5	related morbidity or mortality
Menakaya et al[35] 2013 Australia Level IV	Case-control matched cohort of 219 waterbirths compared to 219 conventional births	Medical records	**Intact perineum:** WB n = 88 vs CB n = 68 (P = .122) **3rd-/4th-degree lacerations:** WB n = 1 vs CB n = 4 **Episiotomy:** WB n = 0 vs CB n = 33 (P < .001) **Hemorrhage > 500 mL:** primiparous waterbirth n = 4, primiparous conventional birth	**Apgar score < 7 at 1 minute:** primiparous waterbirth n = 7, primiparous conventional birth n = 3 (P = .18); multiparous waterbirth n = 18, multiparous conventional birth n = 5 (P < .01) **Apgar scores < 7 at 5 minutes:** primiparous waterbirth n = 1, primiparous conventional birth	Groups matched by risk, parity, and gestational age; WL clearly excluded; women excluded from CB group if pharmacologic pain relief method used

Continued.

Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
			n = 5 ($P = .49$); multiparous waterbirth n = 6, multiparous conventional birth n = 6 ($P = .38$)	n = 0 ($P = .49$); multiparous waterbirth n = 2, multiparous conventional birth n = 1 ($P = .49$) **NICU admission:** primiparous waterbirth n = 3, primiparous conventional birth n = 1 ($P = .38$); multiparous waterbirth n = 5, multiparous conventional birth n = 0 ($P = < .03$) **NICU admission reason:** feeding difficulties n = 3 WB, apnea n = 1 WB, low Apgar score n = 2 WB, shoulder dystocia n = 1 WB, meconium aspiration n = 1 WB, respiratory distress n = 1 CB	
Mistrangelo et al[34] 2007 Italy Level IV	Case-control 25 waterbirths compared to 27 conventional births	Ultrasound and testing of pelvic floor strength and function	**Intact perineum:** WB n = 8 vs CB n = 3 ($P = .279$) **1st-degree lacerations:** WB n = 7 vs CB n = 10 ($P = .639$) **2nd-degree lacerations:** WB n = 9 vs CB n = 12 ($P = .721$) **Episiotomy:** WB n = 1 vs CB n = 2 ($P = .265$) **Urethral mobility during valsalva:** WB 34.9° vs CB 29.5° ($P = .098$)	Not reported	Low risk of measurement bias due to well-defined ultrasound criteria with 2nd observer for increased interobserver reliability; unknown if groups were similar in terms of potential confounding variables (eg, episiotomy)

Continued.

Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
			Excursion of pubo-rectal sling angle: WB 8.7° vs CB 11.0° ($P = .120$) **Experienced or reported urinary incontinence, urge incontinence, or fecal incontinences at 6 months postpartum:** n = 0		
Mollamhmutoglu et al[36] 2012 Turkey Level IV	Case-control 207 waterbirths compared to 2 control groups: 191 conventional births with epidural analgesia and 204 conventional births without epidural analgesia	Information recorded by provider on data sheet and by VAS	**Perineal lacerations:** WB 20.8%, epidural conventional birth 6.8%, unmedicated conventional birth 1.5% (P=.0001) **Episiotomy:** WB 27.1%, epidural conventional birth 69.1%, unmedicated conventional birth 89.2% ($P = .0001$) **VAS pain perception:** WB 4.7, epidural conventional birth 5.8, unmedicated conventional birth 5.6 ($P = .0001$) **Hemoglobin drop:** NSS	**Apgar score > 7 at 1 minute:** WB 87.4%, epidural conventional birth100%, unmedicated conventional birth 98.5% **Apgar score > 7 at 5 minutes:** each group 100% **NICU admission:** WB 2.4%, epidural conventional birth 3.7%, unmedicated conventional birth 1% (NSS) **Infection:** n = 0 **Morbidity or mortality:** n = 0	Stratified sample based on parity; laceration data reported in aggregate; low risk of contamination as each study group was well-defined, and differentiated by treatment; parameters well-defined, a priori within robust study protocol
Otigbah et al[37] 2000 United Kingdom Level IV	Case-control 301 waterbirths compared to 301 conventional births; cases matched with next	Case notes and hospital computerized data system	**Analgesia:** primiparous waterbirth 32% vs primiparous conventional birth 5% ($P = .0001$);	**Apgar score at 1 minute:** (NSS) primiparous waterbirth 8.37 vs primiparous conventional birth 8.47,	Groups matched by parity, risk, age, and induction method; large sample but still underpowered to assess some key variables

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Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
	conventional birth in birth register not requiring Pitocin (oxytocin)		multiparous waterbirth 43% vs multiparous conventional birth 11% ($P = .0001$) **Intact perineum:** primiparous waterbirth 41% vs primiparous conventional birth 29% ($P < .05$); multiparous waterbirth 43.5% vs CB 42% (NSS) **1st-degree lacerations:** primiparous waterbirth 17% vs primiparous conventional birth 6%, multiparous waterbirth 27.3% vs multiparous conventional birth 18.5% **2nd-degree lacerations:** primiparous waterbirth 28 vs primiparous conventional birth 15%, multiparous waterbirth 28% vs multiparous conventional birth 21.5% **3rd-degree laceration:** primiparous waterbirth n = 3 vs primiparous conventional birth n = 1, multiparous waterbirth n = 0 vs multiparous conventional birth n = 4	waterbirth 8.43 vs multiparous conventional birth 8.55 **Apgar score at 5 minutes:** (NSS) primiparous waterbirth 9.54 vs primiparous conventional birth 9.56, multiparous waterbirth 9.59 vs multiparous conventional birth 9.60 **NICU admission:** WB n = 2 vs CB n = 4 **Shoulder dystocia:** WB n = 5 vs CB n = 4 **Infection/neonatal deaths:** n = 0	

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Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
			Episiotomy: primiparous waterbirth 10% vs primiparous conventional birth 39%, multiparous waterbirth 1.2% vs multiparous waterbirth 15% **PPH:** WB n = 4 vs CB n = 8 **Infection:** multiparous waterbirth n = 1 (pyrexia treated with antibiotics, negative cultures)		
Odent[20] 1983 France Level VI	Clinical audit of 100 waterbirths	Hospital birth registry	**1st-degree lacerations:** n=29 **Episiotomy:** n = 0 **Infection:** n = 0 **Manual removal placenta:** n=2	**NICU admission:** n = 1 **Perinatal deaths:** n = 0 **Positive pressure ventilation:** n= 2	Exclusion and inclusion criteria not reported; risk of investigator bias
Pagano et al[38] 2010 Italy Level IV	Case-control 110 nulliparous waterbirths compared to a control group of 110 nulliparous conventional births; matched for risk	Hospital birth registry; cost was estimated by valuing all the supplied activities through local tariffs	**Perineal laceration:** WB 52.7% vs CB 72.7% **Episiotomy:** WB 1% vs CB 25% **Mean birth cost:** WB € 967 vs CB € 688 **Incremental health care cost per avoided perineal tear owed to WB:** € 1395.7 (95% CI)	**Apgar score at 1 minute:** WB 9.48 vs CB 9.28 **Apgar score at 5 minutes:** WB 9.95 vs CB 9.84	Groups matched by risk; only reviewed article to address economics of waterbirth; an incremental cost effectiveness ratio was calculated; cost of pool installation was not considered
Richmond[21] 2003 United Kingdom Level VI	Retrospective description of a random sample of 240 waterbirths taken from 482 women who	Questionnaires; pilot study had questionnaire and recorded interviews that were transcribed and analyzed	**WB as "very pleasurable and fulfilling":** 20.9% **WB as "quite pleasurable":** 33.5%	**NICU admission:** n = 3 **Behavior differences between WB neonates and CB neonates:** (n = 129	Validated questionnaire; response rate was 78.85%; neonates with agar score < 7 at 1 minute were excluded;

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Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
	experienced waterbirth from 5 birth centers; also a pilot study of 9 women with waterbirth was also performed	and used to improve the questionnaire	**WB as "not particularly pleasurable": 7.1%** **Placenta delivered in water: 12.8%** **Reasons for choosing WB:** 78% seemed natural, 78% thought would be less painful, 72.6% gentle birth of baby	multiparas); 48% no difference; 52% reported WB neonates to be more alert, more peaceful, calmer, more content, placid, less stressed, and suckled better at the breast	random selection not described
Ros[39] 2009 South Africa Level IV	Case-control 24 neonates born in water compared to 27 neonates born conventionally	Medical records and telephonic interview 14 days after birth	Not reported	**Apgar score at 1 minute:** WB 8.4 vs CB 8.15 **Apgar score at 5 minutes:** WB 8.93 vs CB 8.81 **Apgar score < 7:** WB 0% vs CB 14% **NICU admission:** $n = 0$ **Cord pH:** WB/WC average 7.26 **Hypothermia:** WB 15% vs CB 41% **Hyperthermia:** WB 4% vs CB 0% **Suction required mouth and nose:** WB $n = 5$ vs CB $n = 6$ **Free flow oxygen required:** WB $n = 3$ vs CB $n = 4$ **Positive pressure ventilation:** WB $n = 0$ vs CB $n = 1$	Strong priori criteria; WB vs CB clearly defined; same data collection tool utilized for each group; descriptive data only
Rosenthal[22] 1991 United States Level VI	Retrospective description of 679 waterbirths	Information recorded by provider on data sheet	**No repair required:** 33% **Episiotomy:** $n = 5$ **Infection:** $n = 1$ (endometritis)	**Apgar score < 5 at 1 minute or < 7 at 5 minutes:** $n = 0$ **NICU transfer rate:** $n = 8$ **Cord avulsion:** $n = 4$	Described sample clinical protocols; minimal data reported

Continued.

Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
Thöeni et al[40] 2005 Italy Level IV	Case-control 737 primiparous waterbirths compared to 407 primiparous conventional births and 142 primiparous women who gave birth on a birthing stool	Medical records	**Intact perineum:** WB 57%, CB 48%, stool 36% **1st-degree lacerations:** (NSS) WB 23.7%, CB 22.3%, stool 23% **2nd-degree lacerations:** (NSS) WB 11.4%, CB 11%, stool 13% **3rd-degree lacerations:** (NSS) WB 0.95%, CB 0.9%, stool 2.1% **Episiotomy:** WB 0.68%, CB 23.3%, stool 8.4% ($P < .01$) **Hemoglobin change g/dL:** (NSS) WB 10.9, CB 10.1, stool 10.23	**Infection signs (skin color change or tachypnea):** WB 1.22% vs CB and stool 2.63% **C-reactive protein:** WB 1.5 vs CB & stool 2.82 ($P < .05$) **Cord pH:** WB 7.27, CB 7.26, stool 7.24 **Cord base excess:** −5.35 WB, −6.09 CB, −6.82 stool **Shoulder dystocia:** n = 3 all resolved in water	Rigorous methodology within limits of design; objective measures with C-reactive protein and cultures; complicated study to describe in single article; unclear if WL was excluded
Thöni et al[23] 2004 Italy Level VI	Clinical audit of 1355 waterbirths	Medical records	**Intact perineum:** 57% primiparous waterbirth; compared to 36% and 48% in the other 2 groups **3rd-degree laceration:** 0.53% **Episiotomy:** 0.44% (n = 6)	**Treated with antibiotics:** 1.34% WB (10/741) vs 3.4% CB (15/440) **C-reactive protein values:** WB 1.5 vs 2.82 CB **Infectious signs:** (tachypnea, skin color changes) WB 1.34% vs CB 3.4% **Shoulder dystocia:** n = 3 (all resolved with birth of posterior arm in water) **Broken clavicle after shoulder dystocia:** n = 1	Report lacks detail of methods (some outcomes report a comparison group while others do not); no prior criteria described; complicated study to describe in single article
Torkamani et al[41] 2010 Iran Level IV	Case-control 50 waterbirths compared to 50 conventional births	Questionnaire filled out by colleagues of the project; pain score estimated with a VAS form 0–10	**No analgesic:** WB 85.7% vs CB 41.2% ($P < .05$) **Episiotomy:** WB 38.8% vs CB 64.4% ($P < .010$)	**Apgar scores < 8 at 5 minutes:** WB 0% vs CB 14.6 % **NICU admission:** CB n = 1	Groups matched by parity, age, and gestational age; good priori criteria

Continued.

Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
			VAS 0-10 Pain score: WB 3.53 vs CB 6.96 ($P < .001$) **Satisfaction:** 72.3% would choose WB again, 8.7% CB would choose CB again		
Torrisi et al[42] 2010 Italy Level IV	Case-control 70 waterbirths compared to 453 conventional births	ICIQ SF questionnaires at 3 and 12 months, and Wexner's continence grading scale	**Intact perineum:** (NSS) WB 25.7% vs CB 22% **1st-/2nd-degree lacerations:** WB 71%, CB 50% ($P < .05$) **Episiotomy:** WB 2.8%, CB 28% ($P < .05$) **Urinary incontinence 12 months postpartum:** WB 17.1% vs CB 10.6% **Stress urinary incontinence:** WB 100% vs CB 65% (CB also reported urge, mixed, enuresis, dribbling, and other; while WB reported none listed above) **Gas incontinence 12 months postpartum:** WB 2.8% vs CB 8% (CB reported liquid incontinence 2% and solid incontinence 0.3%) **Poor sexual behavior 12 months postpartum:** WB 9% vs CB 21%	Not reported	Strong priori parameters; validated questionnaires; only study reviewed that reported postpartum incontinence and sexual behavior
Woodward et al[45] 2004 United Kingdom Level II	RCT pilot study (n = 80) with a randomized arm (n = 60: 40 waterbirths, 20 conventional births), and a preference arm	Medical records and a questionnaire mailed to participants to assess maternal satisfaction	**No analgesia:** randomized arm WB n = 4 vs CB n = 1 ($P = .18$), preference arm WB n = 0 vs CB n = 1 ($P = .78$)	**Apgar score < 8 at 5 minutes:** randomized arm WB n = 1 vs randomized arm CB n = 0, preference arm both n = 0	RCT with preference arm; analysis of the randomized arm was by intention to treat; longitudinal 6-week postpartum follow-up;

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Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
	(n = 20: 10 waterbirths, 10 conventional births); 10 waterbirths occurred in the randomized arm and 5 waterbirths in the preference arm. Randomization arm performed via sequentially numbered opaque envelopes		**Intact perineum:** randomized arm WB n = 9 vs CB n = 6 (P = .54), preference arm WB n = 5 vs CB n = 3 (P = .39) **1st-degree laceration:** randomized arm WB 18%, randomized arm CB 10%, preference arm WB 0%, preference arm CB 20% **2nd-degree laceration:** randomized arm WB 20%, randomized arm CB 15%, preference arm WB 10%, preference arm CB 40% **3rd-degree laceration:** randomized arm WB n = 1, randomized arm CB n = 0, preference arm WB/CB n = 0 **Maternal satisfaction (0-6 scale; 0 = not at all satisfied, 6 = extremely satisfied):** randomized arm WB 4.32 vs randomized arm CB 4.29 (P = .94); preference arm WB 4.50 vs preference arm CB 3.78 (P = .58)	**Time to first breath:** randomized arm WB 6.10 seconds vs CB 4.5 seconds (P = .60), preference arm WB 21 seconds vs CB 2.5 seconds (P = .097) **NICU admission:** randomized arm WB n = 3 vs CB n = 1 (P = .71), vs WB n = 0 vs CB n = 1 **Length of hospital stay:** randomized arm WB 28.0 hours vs 30.5 hours (P = .70), preference arm WB 19.5 hours vs CB 20.5 hours (P = .366) **Antibiotics use:** preference arm WB n = 3 vs CB n = 1 (P = .71), WB n = 0 vs CB n = 1 **Arterial cord pH:** preference arm WB 7.23 vs CB 7.18 (P = .15), randomized arm WB 7.24 vs CB 7.20 (P = .336) **Venous cord pH:** preference arm WB 7.32 vs CB 7.33 (P = .59), randomized arm WB 7.28 vs CB 7.33 (P = .727)	power analysis not described; underpowered as pilot study; cross-contamination between study arms, many data points to report in one study

Continued.

Table 3. Summary of Research on Waterbirth Published in Peer-Reviewed Journals

Author, Year of Publication, Country, Level of Evidence[a]	Study Design Sample	Source of Data	Maternal Outcomes	Neonatal Outcomes	Critique: Strengths and Limitations
				Arterial PCO2: randomized arm WB 6.26 vs CB 7.76 ($P = .003$), preference arm WB 6.14 vs CB 6.74 ($P = .009$)	
Zanetti-Dällenbach et al[5,43] 2006, 2007 Switzerland Level IV	Case-control 89 waterbirths compared to 133 water labors with conventional birth and 146 conventional births without water labor; 2006 study reported the same data presented in 2007 study with an addition of a 3rd control group of 145 operative births	Information recorded by midwife and physician on data sheet in the medical record	**Analgesia:** WB 40.4% vs WL 72.9% ($P = .001$), CB 48% vs WB (NSS) **Intact perineum:** WB 9%, WL 9%, CB 20.5% ($P = .001$) **1st-/2nd-degree lacerations:** WB 53.9%, WL 21.8%, CB 26.0% **3rd-/4th-degree lacerations:** WB 0%, WL 2.3%, CB 0.7% **Episiotomy:** WB 5.6%, WL 48.9%, CB 37.0 ($P = .001$) **Infection:** WB/WL each one upper respiratory tract infection, urinary tract infections, CB n = 2, endometritis n = 1 **Retained placenta:** (NSS) WB n = 1, WL n = 3, CB n = 3 **Mean hemoglobin change from birth to 2 days postpartum:** (NSS) WB 1.2, WL 1.3, CB 1.4	**Apgar score 1 minute:** (NSS) WB 8.7, WL 8.5, CB 8.7 **NICU admission:** (NSS) WB 0%, WL 1.5%, CB 3.4% **Clinical signs of infection:** (NSS) WB 5.6%, WL 3%, CB 1.4% **Fever > 38°C:** (NSS) WB n = 1, WL n = 2, CB n = 0 **Conjunctivitis:** WB n = 5, WL n = 3 **Arterial cord pH:** (NSS) WB 7.26, WL 7.23, CB 7.25 **Venous cord pH:** WB 7.38 vs CB 7.35 ($P = .05$), WL 7.34 vs WB ($P = .002$)	Well defined priori; failure to follow "failed" WB with intention to treat analyses that could have masked complications; univariate analyses

Abbreviations: CB, conventional birth; CI, confidence interval; EBL, estimated blood loss; GBS, group B streptococcus; ICIQ-KH, International Consultation on Incontinence Questionnaire King's Health; ICIQ-SF. International Consultation on Incontinence Questionnaire-Short Form; ICIQ-VS, International Consultation on Incontinence Questionnaire for Vaginal Symptoms; MRSA, Methicillin-resistant Staphylococcus aureus; NICU, neonatal intensive care unit; NHS, National Health Service; NSS, not statistically significant; OB, obstetric; OR, odds ratio; PPH, postpartum hemorrhage; RCT, randomized controlled trail; VAS, Visual Analogue Scale; WB, waterbirth; WL, water labor with conventional birth.

[a]Based on Melnyk & Fineout-Overholt's Rating System for the Hierarchy of Evidence[9]: level I = systematic reviewed or meta-analysis RCTs; level II = RCTs; level III = controlled trails without randomization; level IV = case-control and cohort; level V = systematic reviews of descriptive and qualitative studies; level VI = single descriptive or qualitative; level VII = opinion of authorities or expert committees.

[b]Many studies reported on both labor and birth outcomes. For the purposes of this review, only outcomes pertinent to birth in water are included in this table.

reduced incidence and severity of perineal laceration, although episiotomy has not been consistently controlled for in analyses.[5,26,32,33,37,43]

Results from 13 reviewed studies indicate a higher incidence of intact perineums among women who birthed in water compared with women who birthed conventionally.[16,18,24,25,27,28,32,33,35,37,38,40,42] Evidence suggests that when lacerations do occur, waterbirth may be associated with an increased likelihood of first-degree[5,27,32,33,37,43] and second-degree lacerations rather than severe lacerations, as compared to conventional birth.[5,32,33,37,42,43]

A case-control study by Baxter was the only reviewed study that reported an association between waterbirth and decreased incidence of second-degree lacerations compared to conventional birth.[25] However, only 5 studies controlled for parity, a significant factor in perineal outcomes.[12,16,27,29,35] Burke and Kilfoyle reported that multiparous women who birthed conventionally were at an increased risk of second-degree lacerations (13%) compared to women who birthed in water (8%).[27] In contrast, Burns and Greenish found a higher incidence of second-degree lacerations in both primiparous and multiparous women who birthed in water compared with women who birthed conventionally.[29] Menakaya et al and Garland reported comparable rates of first- and second-degree lacerations among women who birthed conventionally and women who chose waterbirth.[16,35] As such, the relationship between waterbirth and the likelihood of first- or second-degree perineal laceration remains unclear.

The relationship between waterbirth and severe perineal laceration is similarly unclear. Waterbirth was associated with decreased likelihood of third- and fourth-degree perineal lacerations compared to conventional birth in 6 studies,[12,32,33,35,37,43] but no relationship to laceration was observed in 3 other studies.[18,25,29] Cortes and colleagues were the only researchers to report an increased incidence of third-degree lacerations with waterbirth (2.5% in waterbirth compared to 1.2% in conventional birth; $P > .005$); however, variables associated with severe lacerations, such as episiotomy and neonatal weight, were not controlled for in this study.[30] Garland was the only author to control for parity when assessing severe perineal laceration.[17] Garland did not report P values, but found that primiparous women were equally likely to experience a third-degree laceration whether they gave birth in water or not (0.8%), whereas multiparous mothers who birthed in water experienced fewer third-degree lacerations (0.2%) compared to their counterparts who birthed conventionally (0.6%). In summary, despite the limitations of available data, it appears that waterbirth is likely associated with a decreased likelihood of severe lacerations and a higher incidence of intact perineums.

Infection and Antibiotic Administration

Five studies indicated no difference in rates of maternal infection among women after waterbirth or conventional birth.[25,26,32,37,43] Zanetti-Dallenbach et al assessed maternal leucocytes and C-reactive protein upon admission and 2 days postpartum and found no difference in these markers after conventional birth and waterbirth.[43] Bodner et al were the only authors to report a lower risk of maternal infection among women after waterbirth (1.4%) compared to conventional birth (5.7%), but operational definitions of infection were unclear ($P = .03$).[26] Otigbah et al reported one case of maternal pyrexia after 301 waterbirths; the woman was treated with antibiotics and subsequent cultures were negative.[37] Geissbühler et al reported that maternal prophylactic (4.2%) and therapeutic (4.7%) antibiotic use occurred more frequently with conventional birth compared to waterbirth (2.1% and 3.1%, respectively; $P \leq .003$ for both analyses), but self-selection bias and failure to control for confounders make data difficult to interpret.[33] Although reviewed studies are reassuring that waterbirth is not associated with an excessive infection risk, it is important to note that most failed to define how infection was assessed and measured, and/or failed to account for potential differences in demographic and clinical characteristics among study groups, which significantly limits interpretation and generalization of results.

Hemorrhage and Blood Loss

Few studies have examined blood loss beyond subjective estimations. However, some studies examined postpartum hemorrhage using additional and objective measures such as manual placental removal rates and serum hemoglobin or hematocrit, with actual or calculated change values. Measurements and findings are inconsistent among studies, and interpretation is complicated by treatment inconsistency and failure to control for confounders such as physiologic versus active management of third-stage labor.[45] Keeping these limitations in mind, research generally supports an association between waterbirth and the equivalent[5] or decreased[26,32,33,37] postpartum blood loss compared to conventional birth.

Geissbühler et al reported a clinically significant drop in hemoglobin levels after conventional birth versus waterbirth (decline of −1.48 g/L vs –1.15 g/L respectively; $P < .0001$).[32,33] Zanetti-Dallenbach et al compared maternal hemoglobin 2 days postpartum with admission values; women who birthed conventionally had a greater change and lower levels compared to women following waterbirth ($P = .045$).[43] However, 2 comparative case-control studies reported no difference in postpartum hemoglobin levels in women who birthed in water or conventionally.[36,40] In summary, available research demonstrates that women who birth in water experience either less total blood loss or no difference in blood loss compared to women who birthed conventionally.

Pain Relief

Reviewed research suggests that women who birth in water use less analgesia than women who birth conventionally. However, water labor and waterbirth overlap in most studies,[23,24,27,29,32,33,37,40] making it difficult to interpret the impact of hydrotherapy on pain relief strictly at the time of birth (water labor has been demonstrated to provide pain relief in many RCTs).[1] Eight studies found a significant association between waterbirth and no analgesia use compared to conventional birth.[23,24,27,29,32,33,37,40] Aird et al were the only authors to report differences by parity: Multiparous women were more likely not to use analgesia during waterbirth versus conventional birth, whereas primiparous women demonstrated no differences.[24] Comparative observational studies depict the increased use of pharmacologic pain relief methods (epidurals, opioids, spasmolytics) in association with conventional birth versus waterbirth.[5,16,24,28,36,41,44] In contrast, 2 studies reported no difference in analgesia use among women who birthed in water or air.[43,45]

Maternal pain perception was reported in 2 studies. Eberhard et al found that women who birthed in water perceived more pain during the second stage of labor than did women who birthed conventionally; however, the conventional group had the option of epidural analgesia.[14] Mollamahmutoğlu et al's study assessed maternal pain in 3 treatment groups: 1) waterbirth, 2) conventional birth with epidural analgesia, and 3) conventional birth without epidural analgesia (there was no indication if this group used other forms of analgesia).[36] Using a visual analogue scale to measure pain perception, they observed that women who birthed in water had lower scores (4.7) compared with women who gave birth conventionally with (5.8) or without (5.6) epidural analgesia ($P = .0001$); however, the timing of assessment was not addressed. In summary, the examination of pain and relief methods used during waterbirth is complicated by the fact that most women do use immersion hydrotherapy strictly at the time of birth, and the pain-relieving effects of labor in water have been previously well established. However, most studies of waterbirth indicate that the modality is associated with a reduced use of pharmacologic pain relief methods; and one study found an association between lower self-reported pain following waterbirth compared to conventional birth with or without epidural analgesia.[36]

Satisfaction

Burke and Kilfoyle compared maternal satisfaction with pain relief methods among women who birthed conventionally and women who birthed in water.[27] The waterbirth group used hydrotherapy or hydrotherapy plus a nitrous oxide mix (Entonox), while mothers who birthed conventionally were given the option of the nitrous oxide mix or meperidine (Demerol). More women were satisfied with pain relief after waterbirth (89%) compared with conventional birth (77%), but *P* values were not calculated. Four authors evaluated satisfaction with childbirth, and all reported that women had higher satisfaction levels after waterbirth compared to women who birthed conventionally.[15,21,32,41] In summary, aggregate data indicate that waterbirth is associated with high levels of maternal satisfaction with pain relief and childbirth, but self-selection bias was likely. Confounding variables were not adequately controlled in most studies, and limitations related to study design and methodology were present.

Neonatal Outcomes

Apgar Scores

Apgar scores were the most commonly measured neonatal outcome in reviewed studies; 22 reported data on scores at one minute, 5 minutes, 10 minutes, or a combination of multiple scores. Two studies did not specify the time at which scores were measured, which is critical for interpretation given that one-minute scores have no long-term clinical significance in the absence of other findings.[27,39] Overall, results suggest there is no difference in Apgar scores after waterbirth versus conventional birth.[24,26,27,31,33,35,37,44] However, some disparate findings were observed for scores at one minute: 8 studies reported no difference,[5,24,26,31,37,43,44] 2 studies found significantly higher scores after waterbirth,[25,35] and one study found lower scores after waterbirth.[36] Results of 10 studies measuring 5-minute Apgar scores reported no differences after underwater or conventional births,[5,18,24,31,33,35,37,43–45] whereas 4 studies reported significantly higher scores among neonates born in water.[12,32,38,41] Four studies measured 10-minute Apgar scores, and all reported no differences regardless of birth place.[11,31,33,43] In summary, available evidence suggests there is no difference in one- and 10-minute Apgar scores after waterbirth versus conventional birth; and 5-minute scores may be similar or higher after waterbirth in healthy study populations.

Cord pH

Newborn blood gases were analyzed in 10 studies.[5,15,26,31–33,39,40,43,45] Four studies found no difference in cord pH after conventional birth or waterbirth. One study reported no difference in arterial cord pH but significantly increased venous cord pH after waterbirth compared to a comparison group.[43] Arterial cord pH was significantly higher among water-born neonates in 2 additional observational studies, although methodological issues limit the validity of study conclusions.[32,33] Additionally, the partial pressure of carbon dioxide was significantly higher in neonates born conventionally versus those born underwater in a pilot RCT.[45] Overall, research indicates that waterbirth is associated with equivalent or improved umbilical cord gases compared to conventional birth. Findings cannot be explained due to limitations of study designs and may be a result of differences in clinical practice or populations choosing waterbirth, and/or other factors not yet explicated.

Cord Avulsion

Five studies reported cord avulsion incidence.[11,13,19,28,45] Woodward and Kelly's pilot RCT was the only study to report an absence of avulsion in either the experimental or control group (N = 80).[45] Among studies without comparison groups, Demirel et al reported one avulsion in 191 waterbirths,[13] while Gilbert and Tookey reported 5 avulsions among 4032 waterbirths.[19] Burns' clinical audit reported 2 avulsions amid 1372 waterbirths but did not indicate the avulsion incidence among 20,779 conventional births, given the focus on the reason for neonatal intensive care unit (NICU) admission after waterbirth.[28] Burns et al[11] reported 18 avulsions among 5192 waterbirths (0.35%), compared with 2 avulsions among 2723 conventional births (0.07%); the reported analyses did not generate a *P* value or crude odds ratio. Using data reported by Burns et al, a crude odds ratio can be calculated as 4.28 but is difficult to interpret due to study limitations and sample differences including size.[11] In total, reviewed studies reported an incidence of cord avulsion rate of 2.4 per 1000 waterbirths (26 among 10,797 waterbirths). However, it is not known if this rate reflects a difference in risk associated with waterbirth; lack of data hinders a direct comparison to the incidence of cord avulsion during conventional birth in comparable healthy populations.

Infection and Antibiotic Administration

Infection is a common concern regarding the neonatal safety of waterbirth. In the reviewed studies, infection was most commonly operationalized as a fever greater than 38°C. Authors of 13 studies compared neonatal infection rates and antibiotic administration after waterbirth versus conventional birth.[5,11,24,26,31–33,36,37,39,40,43,45] Three studies without a comparison group reported a low incidence of infection and antibiotic administration in water-born neonates.[10,15,19] In 11 studies with comparisons of groups differentiated by type of birth, no differences were reported in neonatal infection rates.[5,11,24,26,31,32,36,37,40,43,45]

Authors of 4 additional studies reported various neonatal outcomes that help to provide clarity on what (if any) relationship exists between waterbirth, neonatal infection, and related symptomatology.[33,39,40,43] Geissbüehler et al reported that neonates born underwater were less likely to experience infection (eg, pulmonary, urogenital, ocular, other) than those born conventionally ($P = .015$).[33] Zanetti-Dallenbach et al reported more conjunctivitis in neonates born underwater (5 cases among 89 waterbirths; a rate of 56/1000) versus in comparison groups. There were 3 cases among 133 neonates born conventionally after immersion during labor—combined with 0 cases among 279 born conventionally without immersion at any point in labor (a rate of 7.2/1000)—without statistically significant differences in neonatal fever or other clinical signs of infection.[43] Thoeni et al reported decreased C-reactive protein in neonates born underwater versus conventional birth, without differences in infection diagnoses ($P < .05$).[40] Ros reported that neonates had lower axillary temperatures (< 36.2°C) after conventional birth (41%) compared to neonates born underwater (15%).[39]

Newborn microbial colonization was measured in 3 studies.[31,46,47] Zanetti-Dallenbach et al initially reported no difference in group B streptococcus (GBS) colonization among neonates born in water or conventionally, but their subsequent study revealed a lower GBS colonization rate among neonates born underwater,[46] leading to speculation that there may be a "wash-out effect" associated with waterbirth.[47] Fehervary et al examined the general colonization of neonates born underwater compared with neonates after water labor and neonates whose mothers labored and birthed without immersion.[31] They reported no difference in colonization or infection rates among study groups and noted less colonization when culturing the palate versus ear in all 3 study groups, suggesting little to no oral intake of pool water by neonates. This finding is reassuring regarding minimal risk of water aspiration previously reported in case studies.[48]

Three clinical audits reported a low incidence of neonatal infection and antibiotic use in neonates born underwater; however, these audits had no comparison groups. Brown reported 2 cases of conjunctivitis (0.5%) and 2 neonates who required antibiotics (0.5%) following waterbirth.[10] Forde reported 2 positive ear cultures (4%) following waterbirth, but neither neonate required antibiotic treatment.[15] Gilbert and Tookey reported 2 cases of pneumonia (0.05%) among 4032 neonates born underwater.[19] In summary, the risk of neonatal infection following waterbirth appears to be low, and data are reassuring despite methodological issues that prevent definitive conclusions. However, several of the studies that reported no difference in neonatal infection rates were underpowered; a sample of at least 1000 participants per group would be needed to observe at least 2 rare events with a 95% probability.[11]

Neonatal Intensive Care Unit Admissions

Eighteen studies reported NICU admission rates[5,10,11,13,15,19,24,25,28,31,33,35–37,39,41,43,45]; of those, 4 were clinical audits that reported data from water-born neonates without a comparison group.[10,13,15,19] Aggregate results from 10 studies suggest there are no differences in NICU admission rates following waterbirth or conventional birth.[5,11,24,28,31,36,37,39,43,45] Geissbüehler et al reported more complications requiring transfer from the delivery room to the NICU in neonates born conventionally (37 cases among 5901 births; rate of 6.27/1000), compared to neonates born in water (6 cases among 3617 waterbirths; rate of 1.66/1000), but demographic and clinical differences among groups were poorly controlled.[33] Menakaya et al were the only authors to report more frequent NICU admissions among 219 neonates born underwater compared to 219 conventionally born neonates (3.5% vs 0.5%, respectively; $P = .023$).[35] They found that 8 neonates were admitted for special care after waterbirth and did not require long-term follow-up after discharge (2 after resuscitation; one for an apneic event; one after shoulder dystocia; one with respiratory distress and meconium aspiration; and 3 for feeding difficulties), whereas one conventionally born neonate was admitted for respiratory distress syndrome.[35] Among clinical audits, most NICU admission rates after waterbirth were low: 0.5%,[10] < 1%,[25] 2%,[15] and 3.1%.[13] Authors of one surveillance study reported a NICU admission rate for neonates born under water as 8.4%,[19] yet reports for neonates born conventionally to low-risk women in the same region at that time ranged from 9.2% to 64%.[19]

Neonatal Injury and Death

Neonatal injury and death is uncommon after waterbirth. Geissbühler and colleagues reported more injury-associated complications in neonates born conventionally (163 of 5901; rate of 27.6/1000) versus underwater (46 of 3617; rate of 12.7/1000), which may be attributable to differences among study groups rather than treatment effects ($P < .001$).[33] Similar study limitations were present when Burns et al reported 2 neonatal deaths after conventional births and 0 neonatal deaths following waterbirths ($N = 8942$),[11] and when Torkamani et al reported zero deaths following waterbirth compared to one death among 50 conventional births ($N = 100$).[41] The most robust data were published by Gilbert and Tookey, who calculated a low neonatal mortality rate of 1.2 per 1000 (relative risk 0.9) for waterbirth based on 4032 cases, which is comparable or favorable compared to low-risk populations following conventional birth.[19]

DISCUSSION AND CLINICAL IMPLICATIONS

This review critically examined the literature on birth in water and found that the vast majority of waterbirth evidence is observational in nature with small sample sizes; most studies were underpowered to detect many potential differences in maternal or neonatal morbidity and mortality among study groups. As such, the outcomes reported merely demonstrate associations or lack thereof in a given sample. However, as Alfirevic and Gould indicated in their position statement on behalf of the United Kingdom's Royal Colleges of Obstetricians and Midwives, "one could argue that the evidence is reassuring, given thousands of women have given birth under water in the last few decades,"[49] and this was also borne out in the reassuring, albeit limited, research reviewed.

Existing waterbirth research has significant limitations related to study design and methodology that warrant discussion and should be kept in mind when reviewing this synthesis of research findings. Design flaws common to existing research may have resulted in a diminished ability to observe significant effects of waterbirth or inappropriate assumptions that observed differences are related to treatment effect rather than other factors. As previously noted, several authors failed to differentiate between water labor and waterbirth, or they compared waterbirth to conventional birth without accounting for water labor and other key confounding factors.[14,33,40] These limitations, combined with the failure to analyze waterbirth outcomes by the intention to treat, risk masking complications and limit the ability to interpret study findings. Analysis of negative or positive treatment effect(s) of immersion were frequently further limited by failures to describe—much less control for—differences in clinical characteristics or demographics among study groups, the timing and duration of immersion hydrotherapy, water temperature, and percentage of body surface area covered during immersion related to tub size and water volume.

One of the most significant limitations of research reviewed was the inability to control for factors inherent to the model of care in which hydrotherapy was provided. The option of waterbirth is generally offered as one aspect of a holistic approach to maternity care that values the promotion of physiologic childbirth and/or nonintervention in the absence of complications. Other elements of this care model that could impact maternal and neonatal outcomes were not controlled in analyses, including but not limited to a therapeutic environment, labor support, skin-to-skin contact between mother and newborn, and delayed cord clamping in the immediate postpartum period.

Nonetheless, this review indicates that most perinatal outcomes are acceptable and likely equivalent (if not improved) in women and neonates following waterbirth when compared to conventional birth. The possibility of rare adverse outcomes, such as neonatal water aspiration, cord rupture, and waterborne infections,[48] have been cited as reasons why waterbirth should not be endorsed, yet available evidence suggests that these risks are minimal.[6] Isolated case studies often cited as evidence that waterbirth is dangerous for the neonate lack denominators and controlled comparisons; they are considered the lowest level of evidence for intervention/treatment.[9]

Many authors have expressed concerns over the observational nature of existing waterbirth research and called for examination within RCTs,[2] whereas others have wondered whether randomizing women to waterbirth is ethical or feasible.[1,16,21,32,45] However, most authors believe that RCTs are both possible and necessary. Future RCTs with clear distinctions between water labor, waterbirth, and conventional birth, as well as control of confounding variables may help establish further evidence of both optimal and nonoptimal outcomes associated with the practice.

This review did not reveal an association between waterbirth and excessive risk for either mother or child. However, Burns et al's study suggested an association between waterbirth and a 4-fold increase in the risk of cord avulsion, although methodological weaknesses limit the interpretation and significance of these findings.[11] The number and proportion of waterbirths with cord avulsion in reviewed studies were small (26 among 10,797 waterbirths), and there were no reported long-term sequelae. Nonetheless, providers should take precautions when guiding water-born neonates to the surface to avoid undue cord traction and to quickly clamp the cord if unusual blood loss is visualized—unless another source of bleeding can be immediately identified.

CONCLUSION

Waterbirth is a practice consistent with the midwifery model of care that may support the midwifery–client relationship while maximizing physiologic childbirth. However, scant patient and provider knowledge about the care practice may limit routine support for waterbirth in the United States, particularly in hospital settings. Similarly, the drive for quantifiable research outcomes to inform clinical practice frequently results in skepticism, or criticism of practices such as waterbirth, for which level I evidence is lacking. Currently, nonexperimental waterbirth research provides the best available data on outcome and safety, despite appropriate critique of the limitations of this evidence. This review provides a shared foundation for childbearing women and their providers to discuss the waterbirth data and potential associated benefits and risks.

There is an important distinction to be made between health professionals introducing an intervention with an unproven benefit and lack of data versus clinicians offering a care practice that lacks level I evidence but has a body of supportive research literature, particularly when doing so in response to consumer demand and in the context of historical use. Waterbirth research currently demonstrates that risks associated with waterbirth for women and neonates are minimal, and outcomes are comparable to those expected in healthy populations.[11,49] As such, existing data support trained professionals in offering the practice to healthy women using evidence-based practice guidelines.

In summary, in order to provide quality health care, providers must consider evidence from multiple sources, synthesize the best available evidence with clinical expertise, and consider patient preferences and values. The potential risks and benefits of waterbirth according to existing data must be discussed with women interested in the practice, along with the potential risks and benefits of other pain management options and maternity care practices in order to ensure informed choice.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to disclose.

REFERENCES

1. Cluett ER, Burns E. Immersion in water in labour and birth. *The Cochrane Database Syst Rev*. 2009;(2):CD000111. DOI: 10.1002/14651858.CD000111.pub3.
2. Simpson KR. Underwater birth. *J Obstet Gynaecol Neonatal Nurs*. 2013;42(5):588-594.
3. Harper B. The real scoop on hospital waterbirth. Paper presented at: Association of Women's Health, Obstetric and Neonatal Nurses. 2009; San Diego, CA.
4. Alderdice F, Marchant S, Ashurst H, Hughes P, Berriidge G, et al. Labour and birth in water in England and Whales: Survey report. *Br J Midwifery*. 1995;3(7):375-382.
5. Zanetti-Dällenbach R, Lapaire O, Maertens A, Holzgreve W, Hösli I. Water birth, more than a trendy alternative: A prospective, observational study. *Arch Gynecol Obstet*. 2006;274(6):355-365.
6. American College of Obstetricians and Gynecologists. Immersion in water during labor and delivery. Committee Opinion No. 594. *Obstet Gynecol* 2014;123:912-915.
7. American College of Nurse-Midwives. *Position Statement: Hydrotherapy during labor and birth*. http://www.midwife.org/acnm/files/ccLibraryFiles/Filename/000000004048/Hydrotherapy-During-Labor-and-Birth-April-2014.pdf. Published April 2014. Accessed April 7, 2014.
8. Garrard J. *Health Sciences Literature Review Made Easy: The Matrix Method*. 3rd ed. Burlington, MA: Jones & Bartlett Publishers; 2010.
9. Melnyk BM, Fineout-Overholt E. *Evidence-Based Practice in Nursing & Healthcare: A Guide to Best Practice*. 2nd edition, Philadelphia, PA: Lippincott Williams & Wilkins; 2010.
10. Brown L. The tide has turned: Audit of water birth. *Br J Midwifery*. 1998;6(4):236-243.
11. Burns EE, Boulton MG, Cluett E, Cornelius VR, Smith LA. Characteristics, interventions, and outcomes of women who used a birthing pool: A prospective observational study. *Birth*. 2012;39(3):192-202.
12. Dahlen HG, Dowling H, Tracy M, Schmied V, Tracy S. Maternal and perinatal outcomes amongst low risk women giving birth in water compared to six birth positions on land. A descriptive cross sectional study in a birth centre over 12 years. *Midwifery*. 2012;29(7):759-764.
13. Demirel G, Moraloğlu O, Celik IH, et al. The effects of water birth on neonatal outcomes: A five-year result of a referral tertiary centre. *Eur Rev Med Pharmacol Sci*. 2013;17(10):1395-1398.
14. Eberhard J, Stein S, Geissbuehler V. Experience of pain and analgesia with water and land births. *J Psychosom Obstet Gynaecol*. 2005;26(2):127-133.
15. Forde C, Creighton S, Batty A, Hawdon J, Summers-Ma S. Labour and delivery in the birthing pool. *Br J Midwifery*. 1999;7(3):165-171.
16. Garland D, Jones KC. Waterbirth, supporting practice with clinical audit. *MIDIRS Midwifery Digest*. 2000;10:333-336.
17. Garland D. Collaborative waterbirth audit-supporting practice with audit. *MIDIRS Midwifery Digest*. 2002;12(4):508-511.
18. Garland D. On the crest of a wave: Completion of a collaborative audit. *MIDIRS Midwifery Digest*. 2006;16(1):81-85.
19. Gilbert RE, Tookey PA. Perinatal mortality and morbidity among babies delivered in water: Surveillance study and postal survey. *BMJ*. 1999;319(7208):483-487.
20. Odent M. Birth under water. *Lancet*. 1983;2(8365-66):1476-1477.
21. Richmond H. Women's experience of waterbirth. *Pract Midwife*. 2003;6(3):26-31.
22. Rosenthal M. Warm-water immersion in labor and birth. *The Female Patient*. 1991;16:35-47.
23. Thöni A, Moroder L. Waterbirth: A safe and natural delivery method. Experience after 1355 waterbirths in Italy. *Midwifery Today Int Midwife*. 2004(70):44-48.
24. Aird IA, Luckas MJ, Buckett WM, Bousfield P. Effects of intrapartum hydrotherapy on labour related parameters. *Aust NZ J Obstet Gynaecol*. 1997;37(2):137-142.
25. Baxter L. What a difference a pool makes: Making choice a reality. *Br J Midwifery*. 2006;14(6):368-372.
26. Bodner K, Bodner-Adler B, Wierrani F, et al. Effects of water birth on maternal and neonatal outcomes. *Wien Klin Wochenschr*. 2002;114(10-11):391-395.
27. Burke E, Kilfoyle A. A comparative study waterbirth and bedbirth. *Midwives*. 1995;108(1284):3-7.
28. Burns E. Waterbirth. *MIDIRS Midwifery Digest*. 2001;(suppl 2):S10-S13.
29. Burns E, Greenish K. Water birth. Pooling information. *Nurs Times*. 1993;89(8):47-49.
30. Cortes E, Basra R, Kelleher CJ. Waterbirth and pelvic floor injury: A retrospective study and postal survey using ICIQ modular long form questionnaires. *Eur J Obstet Gynecol Reprod Biol*. 2011;155(1):27-30.
31. Fehervary P, Lauinger-Lörsch E, Hof H, Melchert F, Bauer L, Zieger W. Water birth: Microbiological colonisation of the newborn, neonatal and maternal infection rate in comparison to conventional bed deliveries. *Arch Gynecol Obstet*. 2004;270(1):6-9.
32. Geissbühler V, Eberhard J. Waterbirths: A comparative study. A prospective study on more than 2,000 waterbirths. *Fetal Diagn Ther*. 2000;15(5):291-300.
33. Geissbühler V, Stein S, Eberhard J. Waterbirths compared with landbirths: An observational study of nine years. *J Perinat Med*. 2004;32(4):308-314.
34. Mistrangelo E, Gaggero CR, Nadalini C, et al. Does water delivery affect pelvic floor? Ultrasound evaluation of perineal function. *Arch Gynecol Obstet*. 2007;276(2):133-138.
35. Menakaya U, Albayati S, Vella E, Fenwick J, Angstetra D. A retrospective comparison of water birth and conventional vaginal birth among women deemed to be low risk in a secondary level hospital in Australia. *Women Birth*. 2013;26(2):114-118.
36. Mollamahmutoğl L, Moraloğlu O, Özyer S, et al. The effects of immersion in water on labor, birth and newborn and comparison with epidural analgesia and conventional vaginal delivery. *J Turkish-German Gynecol Assoc*. 2012;13:45-49.
37. Otigbah CM, Dhanjal MK, Harmsworth G, Chard T. A retrospective comparison of water births and conventional vaginal deliveries. *Eur J Obstet Gynecol Reprod Biol*. 2000;91(1):15-20.
38. Pagano E, De Rota B, Ferrando A, Petrinco M, Merletti F, Gregori D. An economic evaluation of water birth: the

cost-effectiveness of mother well-being. *J Eval Clin Pract*. 2010;16(5):916-919.
39. Ros H. Effects of waterbirths and traditional bedbirths on outcomes for neonates. *Curationis*. 2009;32(2):46-52.
40. Thoeni A, Zech N, Moroder L, Ploner F. Review of 1600 water births. Does water increase the risk of neonatal infection? *J Matern Fetal Neonatal Med*. 2005;17(5):357-361.
41. Torkamani S, Kangani F, Janani F. The effects of delivery in water on duration of delivery and pain compared with normal delivery. *Pak J Med Sci*. 2010;26(3):551-555.
42. Torrisi G, Giuseppe E, Fonti I, Ferraro S, D'Urso E, Guardabasso V. Water birth and perineal dysfunctions: Prospective study. *Neurourol Urodyn*. 2010;29(S2):89-91.
43. Zanetti-Daellenbach RA, Tschudin S, Zhong XY, Holzgreve W, Lapaire O, Hösli I. Maternal and neonatal infections and obstetrical outcome in water birth. *Eur J Obstet Gynecol Reprod Biol*. 2007;134(1):37-43.
44. Chaichian S, Akhlaghi A, Rousta F, Safavi M. Experience of water birth delivery in Iran. *Arch Iran Med*. 2009;12(5):468-471.
45. Woodward J, Kelly SM. A pilot study for a randomised controlled trial of waterbirth versus land birth. *BJOG*. 2004;111(6): 537-545.
46. Zanetti-Dallenbach R, Lapaire O, Maertens A, Frei R, Holzgreve W, Hosli I. Water birth: Is the water an additional reservoir for group B streptococcus? *Arch Gynecol Obstet*. 2006;273(4):236-238.
47. Zanetti-Dallenbach RA, Holzgreve W, Hosli I. Neonatal group B streptococcus colonization in water births. *Int J Gynaecol Obstet*. 2007;98(1):54-55.
48. Pinette MG, Wax J, Wilson E. The risks of underwater birth. *Am J Obstet Gynecol*. 2004;190(5):1211-1215.
49. Alfirevic Z, Gould RM. *Immersion in Water During Labour and Birth (RCOG/Royal College of Midwives Joint Statement No. 1)*. Sussex Place, London, UK: Royal College of Obstetricians and Gynaecologists and the Royal College of Midwives; 2006. 50.
50. Houston J. Promoting a policy for use of water in labour and for birth in the United States. *MIDRIS Midwifery Digest*. 2010;20(4):471-475.
51. Garland D. Exploring carers' views and attitudes towards the use of water during labor and birth. *MIDRIS Midwifery Digest*. 2011;21(2):193-196.
52. Meyer S, Weible C, Woever K. Perceptions and practice of waterbirth: A survey of Georgia midwives. *J Midwifery Womens Health*. 2010;55(1): 55-58.

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