Current Epidemiology Reports (2023) 10:51–60
https://doi.org/10.1007/s40471-023-00321-3

REPRODUCTIVE AND PERINATAL EPIDEMIOLOGY (A M JUKIC, SECTION EDITOR)

We Do Not Know How People Have Babies: an Opportunity for Epidemiologists to Have Meaningful Impact on Population-Level Health and Wellbeing

Marit L. Bovbjerg[1] · Jennifer Brown[1] · Jonathan M. Snowden[2,3]

Accepted: 10 January 2023 / Published online: 9 February 2023

Abstract

Purpose of Review In this essay, we explore reasons why epidemiologists should study physiologic birth. We then discuss common pitfalls when attempting to study physiologic birth using epidemiologic methods, as well as possible solutions.

Recent Findings Epidemiology, as a field, has largely focused on scenarios wherein pregnancy and/or birth have gone wrong (e.g., preterm labor, birth defects). However, it is vital that we focus on "normal" births as well; lack of epidemiologic data on labor duration, for instance, has contributed to millions of unnecessary cesareans for dystocia (stalled labor).

Summary Surveillance requires an understanding of what is usual, so that unusual activity may be detected. There currently exists a dearth of epidemiologic research on birth without interventions, and this lack has led directly to maternal/child harm at the population level.

Keywords Parturition · Natural childbirth · Epidemiology

Approximately 383,000 babies are born each day, worldwide [1]; yet the mechanisms by which this happens remain largely a mystery [2]. Epidemiologists have done extensive work on the ways pregnancy and birth can go poorly (e.g., infertility, preeclampsia, exposure to environmental toxins), yet few in our field study how pregnancy and birth unfold when all physiologic processes work as they should, and medical intervention is unnecessary. This means not only is there a vast array of unanswered potential research questions, but more importantly, maternal and child health at the population level has suffered as a direct result of the dearth of epidemiologic evidence on physiologic birth. How can we validly characterize causes of pathological processes (let alone define pathology) if we lack foundational knowledge on what constitutes "normal"?

This article is part of the Topical Collection on *Reproductive and Perinatal Epidemiology*

✉ Marit L. Bovbjerg
marit.bovbjerg@oregonstate.edu

[1] Epidemiology Program, College of Public Health & Human Sciences, Oregon State University, Corvallis, OR, USA

[2] School of Public Health, Oregon Health & Science University – Portland State University, Portland, OR, USA

[3] Department of Obstetrics & Gynecology, Oregon Health & Science University, Portland, OR, USA

Labor Terminology

For those readers who do not have a background in pregnancy research, we begin with a description of labor. There is an initial period of *latent labor*, during which the cervix effaces (thins) and begins to dilate [3, 4]. This stage is not considered "labor" for the purpose of being admitted to a hospital to have the baby—one would be sent back home, with instructions to return when membranes rupture or contractions become more frequent and more intense [5]. Latent labor can last for several days [3, 4]. Latent labor is followed by *active labor*, during which contractions become more frequent and more intense, and cervical dilation accelerates [3, 4]. Active labor is thought to begin around 6 cm of dilation [6], and lasts several hours [7, 8]. Latent labor and active labor together comprise the *first stage* of labor. During the *second stage* of labor, which begins when the cervix is fully 10 cm dilated, the laboring person pushes, causing the fetus to descend through the bony structure of the pelvis and birth canal and eventually be born [3, 4]. The second stage

is much faster than the first, and is usually completed in less than 1 h, though the distribution is skewed with a long right tail [7, 8]. The *third stage* of labor is the period from birth of the neonate through birth of the placenta, and usually lasts less than half an hour [3, 4].

Defining Physiologic Birth and Its Benefits

In this essay, we are arguing specifically that epidemiologists should study physiologic birth. Physiologic births are those that occur without medical intervention: labor begins spontaneously, proceeds without pharmacologic or surgical assistance, and culminates with a spontaneous vaginal birth [9••]. Physiologic birth is the standard term for what is also sometimes called "normal birth" [9••]; both terms are used throughout the clinical literature and by government agencies [10] to mean "birth without intervention."

First, a caveat: clearly not all pregnant individuals should experience physiologic birth; obstetric intervention can and does save lives [11]. It is absolutely true that some laboring people need intervention, and some proportion of others will want intervention (e.g., epidural anesthesia).

However, for those individuals who are low-risk at the onset of labor, there are numerous benefits of physiologic birth for both parties [9••, 12–15]. Furthermore, current evidence suggests that many more people than previously assumed qualify as low *enough* risk for physiologic birth [16•].

Benefits of physiologic birth accrue largely because common obstetric interventions interfere with normal hormonal processes during labor and birth [4]. As one example, oxytocin is the hormone that causes uterine contractions once labor has started. This occurs at least partly via Ferguson's reflex, wherein pressure of the fetal head on the cervix causes pulsatile releases of oxytocin from the pituitary gland [17]. Epidural anesthesia numbs the person's lower pelvis, which interferes with Ferguson's reflex because sensation in the cervix is dulled [17]. Thus, labor slows down, because the mother is not producing as much endogenous oxytocin as she would be without the epidural [17]. She then "needs" synthetic oxytocin (brand name Pitocin in the USA) to speed up her labor [18]. Synthetic oxytocin does not cross the blood–brain barrier (endogenous oxytocin does), and the laboring individual as a result has less oxytocin in their brain at the end of labor [17]. Because oxytocin, in addition to causing uterine contractions, is also the "love hormone," lower level of oxytocin in the brain at the time of birth interferes with mother/infant bonding [17]. It also interferes with breastfeeding initiation, because the next hormone in the signal cascade for beginning milk production is not triggered without sufficient endogenous oxytocin [17]. Evidence is also beginning to accumulate that synthetic oxytocin during the first stage of labor increases a woman's risk of requiring anti-hemorrhagic drugs in the third stage [19].

As another example of common interventions interfering with evolutionary benefits of physiologic birth, passing through the vagina has at least two advantages for the fetus, compared to being born via cesarean. First, this passage colonizes the fetus/neonate with beneficial flora; infant microbiomes are very different for those born vaginally vs. by cesarean [20]. Second, the birth canal is very elastic. As it stretches to accommodate the passing of a human fetus (stretching orders of magnitude larger than the vagina's normal state), these elastic tissues exert mechanical pressure on the fetal lungs. This expunges the amniotic fluid found in all fetal lungs while still in utero [4], and eases the respiratory transition to breathing air [20]. Babies born by cesarean have much higher incidence of neonatal respiratory distress syndrome, because their lungs are not mechanically cleared of fluid by the birth process [20–22].

These and other potentially beneficial processes associated with physiologic birth are sorely under-studied by epidemiologists. Thus, clinicians and policy makers are left with a weak evidence base from which to design and implement policies and provide optimal care.

Intervention Overuse Is a Driver of Maternal/Child Morbidity and Mortality

Unnecessary obstetric interventions cause harm beyond interference with physiologic processes, because all procedures have risks [6, 9••, 17, 20, 23–32]. A cesarean birth, for instance, is major abdominal surgery, and carries all the risks inherent in such a procedure, e.g., risks related to anesthesia and infection. Over the past few decades, once maternal and neonatal death rates were brought down to modern levels, the health of the childbearing population throughout middle- and high-income countries has been driven largely by the unnecessary, over-use of obstetric interventions like cesarean birth [6, 9••, 20, 25, 33, 34]. While the ideal rate of cesarean is not zero [35], nor should it be 32%, as has been true in the USA since 2007 [36, 37]. Indeed, the World Health Organization (WHO) recommends no more than 10–15%, depending on patient population [26, 38]—above these levels, the risks of cesarean outweigh any possible benefits [20]. Likewise, labor induction and augmentation carry risks, as do epidural anesthesia and continuous electronic fetal monitoring—all common procedures [17, 19, 28–32, 39–41]. These interventions are certainly necessary in some circumstances. However, in current practice, they are overused for various reasons, and at a population level, the risks are outweighing benefits [9••, 42].

It is, of course, impossible to determine whether any given procedure is or was "unnecessary"; such determinations

would require access to counterfactual scenarios. However, because (i) obstetric procedures have known risks, (ii) population maternal/child health metrics have not continued to improve despite increased reliance on such procedures in the last three decades, and (iii) there is excessive variability (up to tenfold) in intervention usage rates between hospitals [43, 44], maternity care providers and national health authorities generally agree with the WHO's determination that obstetric interventions are used too often [6, 45]. That is, while in any given scenario, not everyone will agree whether *one particular* intervention is necessary or not, everyone does agree that *some proportion* of interventions are unnecessary. This is not to say individual obstetricians or midwives deliberately use interventions unnecessarily; almost certainly, most clinicians practice with the best interests of their patients in mind. Unfortunately, the climate in which they are currently practicing dictates that they *do things* [46, 47], and women as a group are left assuming risk without receiving benefit [11].

There is an extensive literature documenting intervention overuse in hospitals, and the resulting maternal morbidity and mortality [20, 32, 48–51]. For instance, white women in the USA die from pregnancy-related causes 2–3 times as often as those in Europe (18/100,000 live births vs. 2 to 7/100,000), and Black women in the USA die 6–7 times as often (55/100,000) [52]. The USA is also the only high-income country in the world in which maternal mortality is increasing over time [52, 53], and this is not because pregnant individuals here are less healthy than they are anywhere else [54, 55]. All of this is within a context wherein obstetric interventions are ubiquitous in modern US hospitals (32% cesareans, 41% labor inductions, 74% epidural or other anesthesia) [56, 57]; clearly *doing more things* is not helping.

Lack of Descriptive Epidemiology Data Causes Harm

Which brings us to why epidemiologists should study physiologic birth. Epidemiologists routinely conduct surveillance activities, so that we know what is usual. This, of course, allows identification of what is unusual, at the population level. But how can we know what is abnormal for pregnancy and birth, if we do not first understand what normal looks like? This lack of epidemiologic baseline data has caused harm to maternal and child health because currently the lines between "part of the biologically expected distribution" and "abnormal, requiring intervention" are blurred, if not outright unknown. Thus, interventions, which always carry risks, are regularly used without knowing whether the patient is truly experiencing *abnormal* labor and birth.

As one example, for several decades, labor progress was measured using Friedman's curve (like a growth curve, but for cervical dilation—also called a "partogram") [58, 59]. Friedman's papers proposing his partogram were published in 1955–1956, and through processes a medical historian might find fascinating, quickly became part of standard practice [2, 16•, 19]. The subsequent decades saw millions of women globally being subjected to labor augmentation (usually synthetic oxytocin) if they did not dilate at the Friedman's curve suggested rate of 1 cm per hour [9••, 60, 61]. Many in turn eventually had cesareans for "failure to progress" or "labor dystocia"; these are leading causes of cesarean in the USA [6, 62, 63]. Over decades, this affected tens of millions of women globally [6, 62, 64], with corresponding poorer outcomes for both women and neonates secondary to risks associated with these interventions. Given near-universal use of Friedman's partogram [18–21], with documented real-world consequences, one might assume that Friedman based his labor progress recommendations on high-quality, epidemiologic surveillance data. One would be wrong.

Rather, Friedman made his labor progress generalizations based on a mere 1000 women, 500 primiparas [58] and 500 multiparas [59], laboring in a single hospital in New York. Not only was the sample lacking in diversity and statistical power to assess subgroups, but the data were collected from a sample that included a high rate of interventions to hasten birth (e.g., 55% forceps deliveries). Also included were numerous labors in which the fetus was known to be stillborn—arguably incorrectly, if the goal was to document normal, healthy labors [58, 59]. Other clinical and research methods used by Friedman also do not conform to modern best practices (e.g., cervical dilation was commonly assessed through rectal rather than vaginal examinations) [65]. Yet the Friedman partogram was nonetheless ubiquitous in practice, for decades.

It was not until 2010 that the first large-scale paper was published refuting Friedman's data (turns out, labor can progress much more slowly, and it is usually fine) [7]. The American College of Obstetricians & Gynecologists (ACOG) [6] and the WHO [64] have since withdrawn support of Friedman's curve, and evidence continues to be published suggesting that slower labors can have good outcomes [8, 66, 67]. Interestingly, although Friedman's curve supposedly depicted an "average" labor, we are unaware of any interventions developed to slow labors that progressed faster than Friedman suggested. Medical philosophers take note.

A nice, large, descriptive epidemiology paper on this topic, back in the 1960s, could have utterly changed the trajectory of midwifery and obstetrics, and improved maternal and child health for millions. Indeed, the cesarean rate in the USA might well be closer to the WHO's 10–15% ideal, had we not gone down the erroneous 1 cm per hour path. The cesarean epidemic is not the only example of iatrogenic harm done by the lack of epidemiologic baseline knowledge on labor and birth. There are numerous other examples of

common obstetric interventions that evidence now suggests do more harm than good: episiotomies [24], continuous electronic fetal monitoring for low-risk labors [31, 32], and indiscriminately using misoprostol for the not-FDA-approved application of inducing labor [28, 29, 68], to name just a few. Many of these are still in common use; indeed many hospitals have policies *requiring* continuous electronic fetal monitoring, even though this practice is known to cause harm via increasing unnecessary cesareans without conveying any benefit whatsoever [31, 32, 56, 57, 69–71].

Although this opportunity for descriptive epidemiology was missed by more than half a century and the harm done to maternal and child health cannot be taken back, the good news is that there is still an opportunity (and a need) for descriptive epidemiologic research to fill physiologic birth-related evidence gaps. The bad news is that if our field does not conduct this research now that its necessity is appreciated, we will not be able to claim ignorance if maternal and child health is harmed through more decades of unnecessary intervention. The best time to conduct epidemiologic research on physiologic birth was 70 years ago, but the second-best time to conduct this research is now.

Epidemiologic Study of Physiologic Birth: Challenges and Solutions

Having argued above that epidemiologists *should* study physiologic birth, we now turn to our ideas on *how* to study it. It is, paradoxically, currently extremely difficult to study normal, physiologic birth in most middle- and high-income countries, because so few people experience it. We do know that the approach of "doing more medical stuff" has, to-date, utterly failed to yield better or more equitable birth outcomes, so an impetus for studying physiologic birth is clear. However, abundant challenges remain. Below we offer specific insights for our fellow epidemiologists wishing to tackle this topic.

Collaborate to Improve the Epidemiologic Methods Used in Clinical Research

Other groups of professionals, most notably midwifery researchers, have studied physiologic birth (also known as normal birth) for many years. Indeed, the midwife-led International Normal Labour and Birth Research Conference held its first meeting 20 years ago [72]. Midwifery researchers deserve quite a bit of credit for bringing our collective attention to the dearth of evidence about physiologic birth, even though this is a phenomenon that plays out tens of thousands of times, every day, around the world [1].

However, we must also acknowledge the limited epidemiology training and experience the average clinician-researcher has. The clinical literature includes widespread inaccurate classification of epidemiologic study designs [73–75] and inappropriate statistical methods [58, 59, 76, 77]. Secondary to the preeminence of the randomized trial design in medical schools' limited epidemiology curricula, we also see prominent physicians on social media completely discounting observational work, and insisting on randomized trials for everything [78–80]. The medical literature would thus benefit from both correcting previous inaccurate and/or misapplied epidemiologic methods, *as well as* more nuanced and advanced epidemiologic insights going forward. Collaborations among epidemiologists and our clinical colleagues are, in our opinion, necessary to advance this field. An increased level of epidemiologic rigor in the clinical obstetric and midwifery literatures could, in turn, lead to improved maternity care policy and better health outcomes. We epidemiologists must be willing to collaborate with midwives and obstetricians.

Collaborate to Improve the Clinical and Policy Knowledge of Epidemiologists

Perinatal epidemiology as a whole has a peculiar set of biases and methods [81•], and all of these apply when studying physiologic birth. Given the hospital context in which labor and birth usually occur, it behooves the intrepid epidemiologist tackling the topic of physiologic birth to also have a healthy awareness of the nuances of biases and methods pertinent to healthcare epidemiology (e.g., informed presence bias in medical records [82]), or to collaborate with someone who does. But beyond just understanding the strengths and limitations of electronic health records (EHRs) for research purposes, there exists a whole array of other considerations when studying birth in particular, without knowledge of which one may well draw erroneous conclusions from data analyses. For example, midwives do not perform cesareans. When a pregnant or laboring person under a midwife's care requires this intervention, the midwife transfers care to the on-call obstetrician. At first glance, then, it might seem that a midwifery service at a particular hospital has a cesarean rate of 0%. This is incorrect, of course; it is merely an artifact of the fact that midwives do not actually perform cesareans themselves. These sorts of issues apply universally (midwives are not surgeons), and are somewhat easy to overcome by collaborating with a clinical colleague or health service researcher familiar with pregnancy and birth.

However, there also exists a set of potential data oddities that will vary by geography. Each country (and each state within the USA) has its own scope of practice for each type of clinician. For example, midwives in Oregon can attend vaginal birth of twins but midwives in Washington cannot [83]. Medicaid (health insurance for low-income Americans)

will pay for prenatal genetic testing in some states but not others, leading to a variety of possible biases in data. Community (home or birth center) birth midwives in Colorado, until very recently, were not allowed to use anti-hemorrhagic drugs; even minor postpartum hemorrhages thus required swift transfer to a hospital, where such drugs are available [33]. Interpreting data without awareness of these nuances can easily lead to erroneous conclusions. Close collaboration with people who do have this expertise (often midwifery researchers), for each geographic area in which you will work, is a must.

Address Persistent Selection Bias

This challenge is one familiar to all perinatal epidemiology researchers [27]: namely, persistent and extensive selection bias. With nearly all women experiencing at least one obstetric intervention during labor in the USA [56, 57, 70, 71], finding a sample of people who experienced physiologic birth becomes quite challenging. (Arguably, it was challenging in Friedman's day, too—see 55% forceps deliveries [58].) Within the current high-intervention environment, people who do *not* receive any interventions tend to be much lower risk, and probably they also differ on important psychosocial characteristics (better self-advocates, able to afford a doula, etc.).

A possible solution to this issue is to limit samples, and acknowledge the selection biases. This was demonstrated in two recent labor duration papers mentioned above: Zhang et al. used a large, multi-center hospital dataset, but excluded much of the sample because of intervention use [7]; Tilden et al. used a large dataset from midwife-attended community home or birth center births, wherein obstetric interventions are unavailable [8]. Both have extensive selection biases. However, by understanding how long "normal labor" is in these highly selected samples, we can begin to guess more accurately how long it might be for all pregnant persons. Ideally, as data become available for selected samples, guidelines and practices change, leading in turn to *less* difficulty obtaining an intervention-free sample. The WHO and ACOG, for instance, in the last decade issued their new, anti-Friedman labor duration guidelines [6, 64] based, by necessity, solely on evidence from these and other recent, highly selected samples.

Identify Diverse Data Resources

The next challenge is where to obtain data on pregnancy, labor, and postpartum processes and outcomes. Electronic health records are an obvious choice—but it is worth remembering that medical records contain data about *care*, and often billable care only (or that which might be necessary for litigation, at least in the USA) [84–87]. EHRs also tend to contain data points that were easily measured, rather than those that would be most useful to researchers. For instance, birthweight is universally recorded in labor and delivery medical records with near-perfect accuracy, but provides epidemiologists with little value [28]. Apgar scores are similar—they are always recorded, yet are not particularly useful for epidemiologic work [29]. On the flip side, medical records almost never contain data on other variables of potential interest to epidemiologists, such as whether a doula was present, whether the pregnancy was intended, or various social determinants of health. Each of these could potentially be important in terms of health and wellness outcomes, both short- and long-term, but because they are not directly relevant to the care being provided, they would not appear in medical records. Also important might be the extent of mistreatment experienced by the woman during labor—things like being yelled at, scolded, or threatened by staff, loss of autonomy, having invasive procedures done without consent (e.g., episiotomy; this is assault), not being believed about pain levels, and/or having potentially concerning symptoms ignored. Sadly, we are learning, this is often quite extensive: 1 in 6 women overall in the USA; nearly 1/3 for low-income women of color [49, 88, 89]. Undoubtedly important in terms of health and wellness outcomes for the childbearing person, nonetheless this mistreatment would never be included in a medical record.

Despite these drawbacks, physiologic birth studies with EHRs are certainly possible, and indeed we ourselves have conducted dozens. However, as with any other pre-existing data source, one must guard against forcing the research question to fit the data, rather than finding data appropriate for a given research question. Another issue with medical records is that prenatal and postpartum care are outpatient, but birth usually occurs in an inpatient setting. This could mean different EHR systems for the same person's data, which would need to be manually merged. Indeed, multicenter studies can be challenging because different hospitals use different EHR systems. This issue of different EHR systems applies almost exclusively in the USA; countries with universal health care usually have a single EHR system used throughout [31]. Solutions here are obvious: find yourself some international colleagues who have data, use data collected and merged by others, or creatively consider alternative data sources that may exist (e.g., data from community births or pre-existing maternal self-reported data).

Finally, it is important to consider primary data collection, despite challenges in terms of research costs, administrative burden, and event counts/statistical power. If we continue to limit ourselves to data that were collected within existing health care systems, then we will necessarily have our research questions constrained by the care that is both available and consistently documented in those settings. In

other words, we cannot hope to study the impact of *doing less* to birthing people if we only study those who birth in settings wherein too much is routinely done [11].

Reject a Pathology Framework, and Collect Data Accordingly

As noted above, within the US health care system, the primary purpose of clinical data collection is to support the practice of medicine (e.g., diagnosing and treating pathology), with ancillary functions including insurance billing and protection against liability [84–87]. However, childbirth is fundamentally not a pathology. This causes a mismatch between the data that are collected within US health care, and the data that are most needed to study physiologic birth. But this data mismatch goes deeper than mere data collection: epidemiologic research on childbirth will be stymied and stuck until we assign equal value and give equal considerations to experiences, processes, and beneficial outcomes [49, 90]. Consider this: perhaps the most fundamental element of physiologic childbirth — labor — is itself not a complication, nor a procedure that is performed, and thus cannot be billed for. As such, it is not recorded in population-level administrative databases in the USA (i.e., birth certificates, health care claims). As a result, there is a robust and extensive body of research that seeks to identify the *mere presence of labor* from administrative data [91, 92]. This would be important if, for instance, one wished to study outcomes among people laboring after previous cesarean, while excluding those who chose elective repeat cesarean [93].

Epidemiologic research on childbirth will not advance as rapidly or productively as we need if we rely on an incorrect medical (pathology) framework for our research. Instead, we must draw on the definition of epidemiology, as the study of disease and *health-related states* in populations, and push the boundaries of what is considered important and worthwhile. Specifically, we must emphasize *processes* (e.g., labor, postpartum recovery, meeting breastfeeding goals), *beneficial outcomes* (e.g., a spontaneous vaginal birth, avoiding postpartum depression), and people's *values and experiences* as much as (or more than) pathology—all while acknowledging that pathology does sometimes occur and intervention becomes necessary.

It is not just perinatal epidemiology; all fields of medicine and public health over-rely on pathology frameworks [94, 95]. However, unlike other fields of health research, perinatal epidemiologists concern ourselves primarily with a body system and events that are explicitly non-pathological. Pregnancy is an expected part of the life cycle for female mammals; it is not "wrong" the way a tumor is. Perinatal epidemiologists thus stand to gain the most from adjusting their approach away from pathology, and the costs of neglecting this approach are in turn highest.

Cultivate New Sources of Funding

If we are being honest, funding is another challenge one will face when studying physiologic birth. At least in the USA, federal agencies tend to be siloed based on diseases. As we said above, childbirth in general is not a "disease," and physiologic birth certainly is not—thus, this line of research inquiry does not neatly fit into the disease framework expected by funders. Furthermore, descriptive epidemiology work is always a challenge to sell to funding agencies, even though it is, for many topics including physiologic birth, both innovative and potentially very high impact. Perhaps this will change, with the recent push by those within our own field to return to descriptive epidemiology more generally [96, 97].

In the meantime, foundation funding is a possibility, and luckily, much important work on physiologic birth can be done relatively cheaply with secondary data, albeit with caveats as described above. Over time, as more and more work in this area gets published, and policies get changed as a result, we are hopeful that the value of physiologic birth descriptive epidemiology and its potential impact on both maternal and child health will become apparent to funders. Grant proposals often casually declare the proposed work to be "paradigm shifting"—epidemiologic research on physiologic birth truly has this potential.

Conclusions

Because birth, unlike so many other topics of study by epidemiologists, is *fundamentally not a disease*, our field will require theoretical and methodological advancements to accommodate the research agenda we have outlined above. Physiologic birth requires a mindset shift for the researcher. Rather than trying to figure out how to fix what is wrong, instead we are trying to understand an extremely common biological process as it unfolds naturally.

Medical interventions in pregnancy and birth are used more often than they should be. Not only does this excessive use fail to improve outcomes, it often outright causes harm, by pathologizing something that was not a disease in the first place. However, we must also acknowledge that physiologic birth, as it has evolved in humans, sometimes leads to major morbidity and mortality. Obstetric intervention is absolutely necessary in many cases. There is thus a challenge for researchers and clinicians in this field: we do not know enough about the natural process to predict who will have complications requiring intervention, but without that thorough understanding of the "natural" process, it remains difficult to make the evidence-based case against routine use of interventions. This is one of the many paradoxes of epidemiologic research on physiologic childbirth: the almost

complete absence of normal cases in the current healthcare climate prevents studying what promotes normal and good outcomes.

The serious harm done to maternal/child populations by the absence of strong research on physiologic birth to-date nonetheless presents a large and exciting opportunity for epidemiologists: the breadth and potential impact of research questions are virtually limitless. We have outlined several challenges and practical realities to consider when conducting epidemiologic research on physiologic birth. Despite these challenges, we hope that more epidemiologists will take this opportunity. Pregnant and birthing people in this country deserve a strong and valid evidence base for their decisions and their care, and they should not have to wait another 70 years for it.

Compliance with Ethical Standards

Conflict of Interest The authors declare no competing interests.

References

Papers of particular interest, published recently, have been highlighted as:
• Of importance
•• Of major importance

1. World death and birth rate 2021 - StatisticsTimes.com. Accessed August 8, 2022. https://statisticstimes.com/demographics/world-death-and-birth-rate.php.
2. Butler K. 4 million babies are born every year, so why do we still know so little about childbirth? Mother Jones. Accessed August 31, 2022. https://www.motherjones.com/politics/2018/11/4-million-babies-are-born-every-year-so-why-do-we-still-know-so-little-about-childbirth/.
3. Oxorn H. Human labor & birth. 5th ed. McGraw-Hill; 1986.
4. Blackburn ST. Maternal, fetal, & neonatal physiology: a clinical perspective, 2nd edn. Saunders; 2003.
5. Beake R MA, Research Associate, Sarah, Chang B MPhil, PhD, Lecturer, Yan Shing, Cheyne R RGN, MSc, PhD, Professor of Midwifery, Helen, Spiby Mp RN, RM, Professor of Midwifery, Helen, Sandall. RM Ms PhD, Professor of Social Science and Women's Health, Jane, Bick D. Experiences of early labour management from perspectives of women, labour companions and health professionals: a systematic review of qualitative evidence. Midwifery. 2018;57:69–84. https://doi.org/10.1016/j.midw.2017.11.002.
6. American College of Obstetricians and Gynecologists, Society for Maternal-Fetal Medicine. Obstetric care consensus number 1: safe prevention of the primary cesarean delivery. Published online 2014. https://www.acog.org/Clinical-Guidance-and-Publications/Obstetric-Care-Consensus-Series/Safe-Prevention-of-the-Primary-Cesarean-Delivery?IsMobileSet=false.
7. Zhang J, Landy HJ, Branch DW, et al. Contemporary patterns of spontaneous labor with normal neonatal outcomes. Obstet Gynecol. 2010;116(6):1281–7. https://doi.org/10.1097/AOG.0b013e3181fdef6e.
8. Tilden EL, Snowden JM, Bovbjerg ML, et al. The duration of spontaneous active and pushing phases of labour among 75,243 US women when intervention is minimal: a prospective, observational cohort study. EClinMed. 2022;48:101447. https://doi.org/10.1016/j.eclinm.2022.101447.
9.•• Downe S, Byrom S. Squaring the circle: normal birth research, theory and practice in a technological age. 1st Edition. Pinter & Martin Ltd; 2019. **This book covers, from a midwifery research perspective, what we know about physiologic birth, why it's important, and how one might study it.**
10. Downe S. Reducing routine interventions during labour and birth: first, do no harm. Cad Saude Publica. 2014;30(Suppl 1):S21-22. https://doi.org/10.1590/0102-311xco04s114.
11. Miller S, Abalos E, Chamillard M, et al. Beyond too little, too late and too much, too soon: a pathway towards evidence-based, respectful maternity care worldwide. The Lancet. 2016;388(10056):2176–92. https://doi.org/10.1016/S0140-6736(16)31472-6.
12. Betrán AP, Temmerman M, Kingdon C, et al. Interventions to reduce unnecessary caesarean sections in healthy women and babies. Lancet Lond Engl. 2018;392(10155):1358–68. https://doi.org/10.1016/S0140-6736(18)31927-5.
13. ten Hoope-Bender P, de Bernis L, Campbell J, et al. Improvement of maternal and newborn health through midwifery. Lancet Lond Engl. 2014;384(9949):1226–35. https://doi.org/10.1016/S0140-6736(14)60930-2.
14. Coxon K, Homer C, Bisits A, Sandall J, Bick D. Reconceptualising risk in childbirth. Midwifery. 2016;38:1–5. https://doi.org/10.1016/j.midw.2016.05.012.
15. Sandall J. Normal birth: a public health issue. Pract Midwife. 2004;7(1):4–5.
16.• Bovbjerg ML, Cheyney M, Brown J, Cox KJ, Leeman L. Perspectives on risk: assessment of risk profiles and outcomes among women planning community birth in the United States. Birth. 2017;44(3):209–21. https://doi.org/10.1111/birt.12288. **This research suggests many of the traditional markers of "high risk" pregnancy do not, in fact, confer much additional risk in terms of maternal and neonatal birth outcomes. For instance, prior cesarean is not really an issue if the birthing person has also had a prior vaginal birth.**
17. Buckley S, Moberg KU. Nature and consequences of oxytocin and other neurohormones during the perinatal period. In: Squaring the Circle: Normal Birth Research, Theory, and Practice in a Technological Age. Pinter & Martin Ltd.; 2019.
18. Petersen A, Poetter U, Michelsen C, Gross MM. The sequence of intrapartum interventions: a descriptive approach to the cascade of interventions. Arch Gynecol Obstet. 2013;288(2):245–54. https://doi.org/10.1007/s00404-013-2737-8.
19. Erickson EN, Lee CS, Emeis CL. Role of prophylactic oxytocin in the third stage of labor: physiologic versus pharmacologically influenced labor and birth. J Midwifery Womens Health. 2017;62(4):418–24. https://doi.org/10.1111/jmwh.12620.
20. Sandall J, Tribe RM, Avery L, et al. Short-term and long-term effects of caesarean section on the health of women and children. Lancet Lond Engl. 2018;392(10155):1349–57. https://doi.org/10.1016/S0140-6736(18)31930-5.
21. Benterud T, Sandvik L, Lindemann R. Cesarean section is associated with more frequent pneumothorax and respiratory problems in the neonate. Acta Obstet Gynecol Scand. 2009;88(3):359–61. https://doi.org/10.1080/00016340802668899.
22. Gilbert SA, Grobman WA, Landon MB, et al. Elective repeat cesarean delivery compared with spontaneous trial of labor

after a prior cesarean delivery: a propensity score analysis. Am J Obstet Gynecol. 2012;206(4):311.e1-9. https://doi.org/10.1016/j.ajog.2012.02.002.
23 Adams-Chapman I. Long-term neurologic outcome of infants born by cesarean section. Clin Perinatol. 2008;35(2):437-454,viii. https://doi.org/10.1016/j.clp.2008.03.001.
24. Hartmann K, Viswanathan M, Palmieri R, Gartlehner G, Thorp J, Lohr KN. Outcomes of routine episiotomy: a systematic review. JAMA J Am Med Assoc. 2005;293(17):2141–8. https://doi.org/10.1001/jama.293.17.2141.
25. Seijmonsbergen-Schermers AE, Peters LL, Goodarzi B, et al. Which level of risk justifies routine induction of labor for healthy women? Sex Reprod Healthc Off J Swed Assoc Midwives. 2020;23:100479. https://doi.org/10.1016/j.srhc.2019.100479.
26. World Health Organization & Human Reproduction Programme. WHO statement on caesarean section rates. WHO. Published 2015. Accessed October 12, 2018. http://www.who.int/reproductivehealth/publications/maternal_perinatal_health/cs-statement/en/.
27. Souza J, Gülmezoglu A, Lumbiganon P, et al. Caesarean section without medical indications is associated with an increased risk of adverse short-term maternal outcomes: the 2004–2008 WHO Global Survey on Maternal and Perinatal Health. BMC Med. 8:71–71. https://doi.org/10.1186/1741-7015-8-71.
28. Chatsis V, Frey N. Misoprostol for cervical ripening and induction of labour: a review of clinical effectiveness, cost-effectiveness and guidelines. Canadian Agency for Drugs and Technologies in Health; 2018. Accessed August 25, 2020. http://www.ncbi.nlm.nih.gov/books/NBK538944/.
29. Wagner M. From caution to certainty: hazards in the formation of evidence-based practice — a case study on evidence for an association between the use of uterine stimulant drugs and amniotic fluid embolism. Paediatr Perinat Epidemiol. 2005;19(2):173–6. https://doi.org/10.1111/j.1365-3016.2005.00630.x.
30. Jansen L, Gibson M, Bowles BC, Leach J. First do no harm: interventions during childbirth. J Perinat Educ. 2013;22(2):83–92. https://doi.org/10.1891/1058-1243.22.2.83.
31. Sartwelle TP, Johnston JC. Continuous electronic fetal monitoring during labor: a critique and a reply to contemporary proponents. Surg J N Y N. 2018;4(1):e23–8. https://doi.org/10.1055/s-0038-1632404.
32 Alfirevic Z, Devane D, Gyte GM, Cuthbert A. Continuous cardiotocography (CTG) as a form of electronic fetal monitoring (EFM) for fetal assessment during labour. Cochrane Database Syst Rev. 2017;2:CD006066. https://doi.org/10.1002/14651858.CD006066.pub3.
33. Fox B, Worts D. Revisiting the critique of medicalized childbirth: a contribution to the sociology of birth. Gend Soc. 1999;13(3):326–46. https://doi.org/10.1177/089124399013003004.
34. Bogdan-Lovis E, de Vries RG. Ethics and the architecture of choice for home and hospital birth. J Clin Ethics. 2013;24(3):192–7. https://doi.org/10.1086/JCE201324303.
35. Betran AP, Ye J, Moller AB, Souza JP, Zhang J. Trends and projections of caesarean section rates: global and regional estimates. BMJ Glob Health. 2021;6(6):e005671. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(18)31927-5/fulltext.
36. Menacker F, Hamilton BE. Recent trends in cesarean delivery in the United States. NCHS Data Brief. 2010;35:1–8.
37. Centers for Disease Control and Prevention. Births—method of delivery. NCHS Fast Stats. Published May 16, 2022. Accessed August 23, 2022. https://www.cdc.gov/nchs/fastats/delivery.htm.
38. Appropriate technology for birth. Lancet. 1985;2(8452):436–7.
39. Page K, McCool WF, Guidera M. Examination of the pharmacology of oxytocin and clinical guidelines for use in labor. J Midwifery Womens Health. 2017;62(4):425–33. https://doi.org/10.1111/jmwh.12610.
40 Simpson KR, Knox GE. Oxytocin as a high-alert medication: implications for perinatal patient safety. MCN Am J Matern Child Nurs. 2009;34(1):8–15. https://doi.org/10.1097/01.NMC.0000343859.62828.ee. (quiz 16-17).
41. Cleveland Clinic. Epidural: what it is, procedure, risks & side effects. Cleveland Clinic. Published 2021. Accessed August 23, 2022. https://my.clevelandclinic.org/health/treatments/21896-epidural.
42. Shearer EL. Cesarean section: medical benefits and costs. Soc Sci Med 1982. 1993;37(10):1223–31.
43. Kozhimannil KB, Law MR, Virnig BA. Cesarean delivery rates vary tenfold among US hospitals; reducing variation may address quality and cost issues. Health Aff Proj Hope. 2013;32(3):527–35. https://doi.org/10.1377/hlthaff.2012.1030.
44. Parliamentary Office of Science and Technology. Caesarean Sections.; 2002. Accessed October 27, 2022. https://www.parliament.uk/globalassets/documents/post/pn184.pdf.
45. US Department of Health and Human Services. Pregnancy and childbirth — healthy people 2030 | health.gov. Accessed January 14, 2022. https://health.gov/healthypeople/objectives-and-data/browse-objectives/pregnancy-and-childbirth.
46. World Health Organization. Health System Financing. WHO; 2010.
47. Jordan TJ. The nature of medical reasoning and the limits of medical information. In: Understanding Medical Information:A User's Guide to Informatics and Decision Making. McGraw-Hill; 2002.
48. Plough AC, Galvin G, Li Z, et al. Relationship between labor and delivery unit management practices and maternal outcomes. Obstet Gynecol. 2017;130(2):358–65. https://doi.org/10.1097/AOG.0000000000002128.
49. Vedam S, Stoll K, Taiwo TK, et al. The Giving Voice to Mothers study: inequity and mistreatment during pregnancy and childbirth in the United States. Reprod Health. 2019;16(1):77. https://doi.org/10.1186/s12978-019-0729-2.
50. Gijsen R, Hukkelhoven CWPM, Schipper CMA, Ogbu UC, de Bruin-Kooistra M, Westert GP. Effects of hospital delivery during off-hours on perinatal outcome in several subgroups: a retrospective cohort study. BMC Pregnancy Childbirth. 2012;12:92. https://doi.org/10.1186/1471-2393-12-92.
51. Brown J, McIntyre A, Gasparotto R, McGee TM. Birth outcomes, intervention frequency, and the disappearing midwife—potential hazards of central fetal monitoring: a single center review. Birth Berkeley Calif. 2016;43(2):100–7. https://doi.org/10.1111/birt.12222.
52. Elflein J. Maternal mortality rates by country worldwide 2019. Statista. Accessed October 28, 2022. https://www.statista.com/statistics/1240400/maternal-mortality-rates-worldwide-by-country/.
53. Centers for Disease Control and Prevention. Maternal mortality. Published October 27, 2021. Accessed January 13, 2022. https://www.cdc.gov/reproductivehealth/maternal-mortality/index.html.
54. Declercq E, Menacker F, Macdorman M. Maternal risk profiles and the primary cesarean rate in the United States, 1991–2002. Am J Public Health. 2006;96(5):867–72. https://doi.org/10.2105/AJPH.2004.052381.
55. Bailit JL, Love TE, Mercer B. Rising cesarean rates: are patients sicker? Am J Obstet Gynecol. 2004;191(3):800–3. https://doi.org/10.1016/j.ajog.2004.01.051.
56. Declercq E, Sakala C, Corry M, Applebaum S. Listening to Mothers II: Report of the Second National US Survey of Women's Childbearing Experiences. Accessed April 6, 2009. www.childbirthconnection.com.

57. Declercq ER, Sakala C, Corry MP, Applebaun S, Herrlich A. Listening to mothers III: pregnancy and birth. Childbirth Connection; 2013. Accessed July 5, 2018. http://transform.childbirthconnection.org/reports/listeningtomothers/.
58. Friedman EA. Primigravid labor; a graphicostatistical analysis. Obstet Gynecol. 1955;6(6):567–89. https://doi.org/10.1097/00006250-195512000-00001.
59. Friedman EA. Labor in multiparas; a graphicostatistical analysis. Obstet Gynecol. 1956;8(6):691–703.
60. Akoury HA, MacDonald FJ, Brodie G, Caddick R, Chaudhry NM, Frize M. Oxytocin augmentation of labor and perinatal outcome in nulliparas. Obstet Gynecol. 1991;78(2):227–30.
61 Hinshaw K, Simpson S, Cummings S, Hildreth A, Thornton J. A randomised controlled trial of early versus delayed oxytocin augmentation to treat primary dysfunctional labour in nulliparous women. BJOG Int J Obstet Gynaecol. 2008;115(10):1289–95. https://doi.org/10.1111/j.1471-0528.2008.01819.x. (discussion 1295-1296).
62. Boerma T, Ronsmans C, Melesse DY, et al. Global epidemiology of use of and disparities in caesarean sections. Lancet Lond Engl. 2018;392(10155):1341–8. https://doi.org/10.1016/S0140-6736(18)31928-7.
63. Perez-Botella M, van Lessen L, Morano S, de Jonge A. What works to promote physiological labour and birth for healthy women and babies? In: Squaring the Circle: Normal Birth Research, Theory, and Practice in a Technological Age. Soo Downe and Sheena Byrom, eds. Pinter & Martin Ltd; 2019.
64. WHO labour care guide: user's manual. Accessed August 24, 2022. https://www.who.int/publications-detail-redirect/9789240017566.
65. Zhang J, Troendle J, Mikolajczyk R, Sundaram R, Beaver J, Fraser W. The natural history of the normal first stage of labor. Obstet Gynecol. 2010;115(4):705–10. https://doi.org/10.1097/AOG.0b013e3181d55925.
66. Bonet M, Oladapo OT, Souza JP, Gülmezoglu AM. Diagnostic accuracy of the partograph alert and action lines to predict adverse birth outcomes: a systematic review. BJOG Int J Obstet Gynaecol. 2019;126(13):1524–33. https://doi.org/10.1111/1471-0528.15884.
67. Oladapo OT, Diaz V, Bonet M, et al. Cervical dilation patterns of "low-risk" women with spontaneous labour and normal perinatal outcomes: a systematic review. BJOG Int J Obstet Gynaecol. 2018;125(8):944–54. https://doi.org/10.1111/1471-0528.14930.
68. Induction of Labor: The Misoprostol Controversy. Medscape. Accessed August 25, 2020. http://www.medscape.com/viewarticle/458959.
69. Bovbjerg ML. Opposition to waterbirth is not evidence based. J Womens Health 2002. Published online October 2, 2020.https://doi.org/10.1089/jwh.2020.8790.
70. Heelan L. Fetal monitoring: creating a culture of safety with informed choice. J Perinat Educ. 2013;22(3):156–65. https://doi.org/10.1891/1058-1243.22.3.156.
71. Cypher RL. Electronic fetal monitoring documentation. J Perinat Neonatal Nurs. 2018;32(1):24–33.
72. Normal Labour and Birth Research Conference: History. Normal Labour & Birth Research Conference. Published June 16, 2016. Accessed August 30, 2022. https://normalbirthconference.com/history/.
73. Klebanoff MA, Snowden JM. Historical (retrospective) cohort studies and other epidemiologic study designs in perinatal research. Am J Obstet Gynecol. 2018;219(5):447–50. https://doi.org/10.1016/j.ajog.2018.08.044.
74. Snowden JM, Klebanoff MA. Accurate identification of cohort study designs in perinatal research: a practical guide. Am J Obstet Gynecol. 2022;227(2):231-235.e1. https://doi.org/10.1016/j.ajog.2022.03.014.
75. Bovbjerg M. Waterbirth: an integrative analysis of peer-reviewed literature. J Midwifery Womens Health. 2015;60(6):787. https://doi.org/10.1111/jmwh.12399.
76. Snapp C, Stapleton SR, Wright J, Niemczyk NA, Jolles D. The experience of land and water birth within the American Association of Birth Centers Perinatal Data Registry, 2012–2017. J Perinat Neonatal Nurs. 2020;34(1):16–26. https://doi.org/10.1097/JPN.0000000000000450.
77. Schorn MN, McAllister JL, Blanco JD. Water immersion and the effect on labor. J Nurse Midwifery. 1993;38(6):336–42.
78. Prasad V. Published October 31, 2022. Accessed November 8, 2022. https://twitter.com/VPrasadMDMPH/status/1587211156640317441.
79. Prasad V. Published November 2, 2022. Accessed November 8, 2022. https://twitter.com/VPrasadMDMPH/status/1587988443035889664.
80. Prasad V. Published November 7, 2022. Accessed November 8, 2022. https://twitter.com/VPrasadMDMPH/status/1589770445825642497.
81.• Wilcox, Allen J. Fertility and pregnancy: an epidemiologic perspective. Oxford University Press; 2010. **This book is an extremely well-written treatise explaining all of the potential pitfalls an epidemiologist must consider when studying pregnancy and birth.**
82. Goldstein BA, Bhavsar NA, Phelan M, Pencina MJ. Controlling for informed presence bias due to the number of health encounters in an electronic health record. Am J Epidemiol. 2016;184(11):847–55. https://doi.org/10.1093/aje/kww112.
83. Vedam S, Stoll K, MacDorman M, et al. Mapping integration of midwives across the United States: impact on access, equity, and outcomes. PLOS ONE. 2018;13(2):e0192523. https://doi.org/10.1371/journal.pone.0192523.
84. Edmondson ME, Reimer AP. Challenges frequently encountered in the secondary use of electronic medical record data for research. Comput Inform Nurs CIN. 2020;38(7):338–48. https://doi.org/10.1097/CIN.0000000000000609.
85. Farmer R, Mathur R, Bhaskaran K, Eastwood SV, Chaturvedi N, Smeeth L. Promises and pitfalls of electronic health record analysis. Diabetologia. 2018;61(6):1241–8. https://doi.org/10.1007/s00125-017-4518-6.
86. Jetley G, Zhang H. Electronic health records in IS research: quality issues, essential thresholds and remedial actions. Decis Support Syst. 2019;126:113137. https://doi.org/10.1016/j.dss.2019.113137.
87. Beesley LJ, Mukherjee B. Bias reduction and inference for electronic health record data under selection and phenotype misclassification: three case studies. Published online December 23, 2020:2020.12.21.20248644. https://doi.org/10.1101/2020.12.21.20248644.
88. Declercq E, Sakala C, Belanoff C. Women's experience of agency and respect in maternity care by type of insurance in California. PloS One. 2020;15(7):e0235262. https://doi.org/10.1371/journal.pone.0235262.
89. Portee A. Serena Williams on her near-death experience after giving birth: "no one was really listening." TODAY.com. Accessed November 1, 2022. https://www.today.com/health/womens-health/serena-williamss-essay-black-pregnancy-rcna23328.
90. Snowden JM, Guise JM, Kozhimannil KB. Promoting inclusive and person-centered care: starting with birth. Birth Berkeley Calif. 2018;45(3):232–5. https://doi.org/10.1111/birt.12351.
91. Gregory KD, Korst LM, Gornbein JA, Platt LD. Using administrative data to identify indications for elective primary cesarean delivery. Health Serv Res. 2002;37(5):1387–401. https://doi.org/10.1111/1475-6773.10762.

92. Muoto I, Darney BG, Lau B, et al. Shifting patterns in cesarean delivery scheduling and timing in Oregon before and after a statewide hard stop policy. Health Serv Res. 2018;53(Suppl 1):2839–57. https://doi.org/10.1111/1475-6773.12797.
93. Dissanayake MV, Bovbjerg ML, Tilden EL, Snowden JM. The association between hospital frequency of labor after cesarean and outcomes in California. Womens Health Issues Off Publ Jacobs Inst Womens Health. 2020;30(6):453–61. https://doi.org/10.1016/j.whi.2020.07.005.
94. Poteat TC, Logie CH. A case for strengths-based approaches to addressing intersectional stigma in HIV research. Am J Public Health. 2022;112(S4):S347–9. https://doi.org/10.2105/AJPH.2021.306659.
95. Banyard V, Hamby S. Strengths-based prevention: reducing violence and other public health problems. American Psychological Association; 2021. Accessed August 31, 2022. https://www.apa.org/pubs/books/strengths-based-prevention.
96. Fox MP, Murray EJ, Lesko CR, Sealy-Jefferson S. On the need to revitalize descriptive epidemiology. Am J Epidemiol. 2022;191(7):1174–9. https://doi.org/10.1093/aje/kwac056.
97. Lesko CR, Fox MP, Edwards JK. A framework for descriptive epidemiology. Am J Epidemiol. Published online July 1, 2022:kwac115. doi:https://doi.org/10.1093/aje/kwac115