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Midwife-led care and obstetrician-led care for low-risk pregnancies: A cost comparison

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Abstract

Objective: Low-risk pregnant women cared for by midwives have similar birth outcomes to women cared for by physicians, although experiencing fewer medical procedures. However, limited research has assessed cost implications in the United States. Using national data, we assessed costs and resource use of midwife-led care vs obstetrician-led care for low-risk pregnancies using a decision-analytic approach.

Methods: We developed a decision-analytic model of costs (health plan payments to clinicians) and use of medical procedures during childbirth (epidural analgesia, labor induction, cesarean birth, episiotomy) and outcomes of care (birth at preterm gestation) that may differ with midwife-led vs obstetrician-led care. Model parameters for obstetric procedures were generated using Listening to Mothers III data, a national survey of women who gave birth in US hospitals in 2011-2012 and other published estimates. Cost estimates came from published or publicly available information on health insurance claims payments.

Results: The costs of childbirth for low-risk women with midwife-led care were, on average, $2262 less than births to low-risk women cared for by obstetricians. These cost differences derive from lower rates of preterm birth and episiotomy among women with midwife-led care, compared with obstetrician-led care. Across the population of US women with low-risk births each year (approximately 2.6 million), the model predicted substantially fewer preterm births (167 259 vs 219 427 for midwife-led vs obstetrician-led care) and fewer episiotomies (170 504 vs 415 686, for midwife-led vs obstetrician-led care).

Conclusions: A shift from obstetrician-led care to midwife-led care for low-risk pregnancies could be cost saving.

KEYWORDS
cost of care, decision analysis, maternity care, midwifery

1 | INTRODUCTION

Low-risk pregnant women who are cared for by midwives have birth outcomes similar to those of women cared for by physicians, including obstetricians, although experiencing fewer unnecessary procedures.[1] The proportion of midwife-attended births in the United States has increased since the 1980s,[2] but in 2016, midwives attended only 9% of the nearly 4 million US births.[3] The proportion of midwife-attended births varies across states,[4-6] but is much lower in the United

States than in the other developed nations such as Australia and the UK, where midwives attend more than 70% of births.[7] The potential for expanding midwifery care to improve access to and outcomes of maternity care is well-documented internationally,[8] but less researched in the US context.

The imperative for maternity care quality improvement is urgent in the United States. After improvements in perinatal health and health care in the early 20th century, maternal morbidity and mortality rates have risen over the last several decades.[9,10] The use of obstetric procedures also increased over this time period. According to birth certificate data, rates of labor induction more than doubled from 1990 to 2016, from 9.5% to 24.5% ,[3,11] a substantial fraction of which occur without a medical indication.[12] The cesarean rate increased from 5.5% in 1970 to a peak of 32.9% in 2009,[13,14] although it has leveled off and slowly decreased in the last few years.[3,15] Provisional data from 2018 report a cesarean rate of 31.9%.[16] Experts agree that this cesarean rate likely represents overuse of the procedure, and that maternal and infant health would be improved if fewer cesarean deliveries occurred.[17,18] Substantial hospital-level variation in cesarean birth rates, even among low-risk women, suggests that overuse of cesarean is partly driven by the differences in practice patterns.[19]

In addition to effects on patient safety and quality of care, overuse of medical procedures during childbirth influences costs of care. As such, midwifery-led care also holds promise as a high-value investment of health care resources, overall and in state Medicaid programs, which finance over 40% of US births.[1,20,21] Although many studies show the positive outcomes of midwifery-led maternity care,[1,22] limited prior studies have documented the potential cost savings of changes to the financing and organization of maternity care services to increase access to midwifery care in the United States.[23-26] Studies in other countries including the UK, Australia, and Canada have examined expenditures and cost-effectiveness of midwifery care, but these studies vary in terms of the midwifery care model being analyzed and the comparison group.[27-33] In addition, the health care financing and maternity care context in the United States is distinct, so the existing evidence is not easily applicable to health plan and policy discussions in the United States. Our objective was to compare the costs and outcomes of care for low-risk pregnancies with midwife-led care vs obstetrician-led care by using statistical models, built with existing published estimates and survey data.

2 | METHODS

This study used decision analysis, a quantitative approach that uses statistical modeling to provide a framework for decision making under uncertainty. Decision analysis has been widely applied in medicine and health policy to analyze complex problems (such as the ideal frequency of cervical cancer screening) by explicitly stating assumptions, and quantifying and evaluating trade-offs using a statistical model.[34,35] Decision analysis is widely used in cost-effectiveness analyses to synthesize information from different sources to quantify the costs and health outcomes of associated different alternatives.[36] This analysis employs decision trees, mathematically based representations that compare the expected outcomes of all the different competing strategies considered.

2.1 | Data and study population

Data for the decision tree parameters in this analysis were obtained from the Listening to Mothers III (LTM 3) survey, a nationally representative sample of women who gave birth to a singleton infant in a US hospital between July 1, 2011 and June 30, 2012 (N = 2400). The LTM 3 data include information on midwifery-led prenatal care, obstetric procedure use, and preterm birth. We supplemented the LTM 3 data with information from a Cochrane Collaboration review of evidence on the outcomes of midwifery care, using estimates from the meta-analysis to create parameter estimates and to measure uncertainty around these estimates.[1] There are limited other data sources available that include sufficient information on care during pregnancy and childbirth (such as midwife-led care vs physician-led care) and services use and costs. For example, many data sources with detail on care during childbirth, such as birth certificates and hospital discharge data, do not include cost information or include cost estimates derived from charge data.

In this analysis, "costs" reflect the amount paid by a health insurance plan (public or private) for clinician fees and facility fees associated with childbirth and—for preterm birth—over the first year of life for the infant. Although comprehensive information on payment for childbirth-related expenses is not readily available, we compiled data from three publicly available and published sources on health plan expenditures:(a) a 2013 Truven Health Analytics report on the costs of childbirth, which used health insurance claims data on childbirth-related payments made to clinics, hospitals, and physicians by both Medicaid and private health plans for childbirth care generally and including some procedures[37]; (b) the Medicare Physician Fee Schedule, which a is complete listing of fees used by Medicare to pay clinicians on a fee-for-service basis[38]; (c) a March of Dimes report, which provides estimates on the costs of preterm birth over the first year of an infant's life based on an employer's health plan costs.[39] Cost parameters are shown in Table 1. The same cost values were used for both midwife-provided services and physician-provided services.

This analysis examined outcomes among low-risk women who could safely be cared for by a midwife, but who received prenatal care from either a midwife or an obstetrician. We created a sample of low-risk women from

TABLE 1 Model parameters

Parameter[a]	Value	Distribution	Source
Number of low-risk births in United States in 2016	2 588 178	-	1
Proportion of births with Medicaid coverage in the United States	0.45	-	**2**
RR of preterm birth with midwife-led care support *vs* obstetrician-led care support	0.76 [0.64, 0.91][b]	Log-normal	3

	Cost[c]			
Procedures	**Medicaid**	**Commercial**		**Source**
Preterm birth	26 870	53 741	-	4
Term birth	2371	4741	-	4
Vaginal birth	10 445	20 966	-	5
Cesarean	15 546	31 876	-	5
Epidural	189	1132	-	5
Labor induction	51	96	-	6
Episiotomy	169	319	-	6

1. Martin et al[3]
2. Martin et al[20]
3. Sandall et al[1]
4. Truven Health Analytics[39]
5. Truven Health Analytics[37]
6. Medicare Physician Fee Schedule Database (MPFS)[38]

[a]For data sources other than the Listening to Mothers III survey.
[b]Mean and 95% CI.
[c]Costs are shown in 2018 USD.

the LTM 3 data by excluding those with (a) gestational diabetes, (b) diabetes before pregnancy, (c) hypertension/high blood pressure medication use before pregnancy, (d) BMI > 35, or (e) fertility treatment. In the LTM 3 data, 68.9% of women met this definition of low risk. Applying this percentage to national birth data,[3] we estimate that there are approximately 2.6 million low-risk hospital births per year in the United States.

Midwife-led care was compared with obstetrician-led care among low-risk pregnancies. Midwife-led and obstetrician-led care was classified based on self-report of the type of clinician that led prenatal care, based on responses to an LTM 3 survey question. Women who reported other types of care practioners were excluded. Not all pregnancies that were categorized as "midwife-led care" had midwife-attended births, as complications that arose during labor may have necessitated an obstetrician as a birth attendant (eg, for a cesarean birth).

Among LTM 3 respondents with either an obstetrician or midwife providing care, 8.9% of low-risk pregnancies had midwife-led care and 91.1% had obstetrician-led care.

2.2 | Obstetric procedures and outcomes

Procedures used during childbirth included epidural analgesia, labor induction, cesarean birth, and episiotomy, and were measured based on women's self-report in LTM 3 data. These procedures are included because they carry an explicit cost associated with their use. Epidural, cesarean birth and episiotomy were coded based on responses to a single question for each procedure. Women were coded as having had a labor induction if they reported that a health care practioner had used a medical method to try to cause their labor to begin. We classified inductions as having occurred for a definitive medical reason or not for a definitive medical reason based on women's reported reasons for the induction, consistent with previously published studies (see Appendix S1 for full categorization).[40,41] Gestational lengths less than 37 completed weeks were categorized as preterm.

2.3 | Decision-analytic model

To estimate costs of midwife-led care compared with obstetrician-led care, we developed a decision-analytic model of the potential changes in health care costs and changes in the use of obstetric procedures associated with midwife-led vs obstetrician-led care. We constructed a decision tree comparing two different strategies of care for low-risk pregnancies: (a) obstetrician-led care and (b) midwife-led care. The endpoints were obstetric procedures during childbirth (epidural analgesia, labor induction, cesarean birth,

and episiotomy) with their corresponding costs (clinician and facility fees paid by public and private health plans).

For each strategy of care for low-risk pregnancies, we divided births based on preterm gestation. Data from LTM 3 were not used for this parameter owing to the limited sample size of respondents with midwife-led care and preterm births, but were used to estimate all other study outcomes. Based on a recent meta-analysis,[1] we estimated that the risk of preterm birth with midwife-led care was lower compared with obstetrician-led care support (Table 1; relative risk [RR] 0.76 [95% confidence interval (CI) 0.64-0.91]). A graphical representation of the first level of the decision tree for the two models of care is shown in Figure 1. A proportion of all births occur by means of planned cesarean. For all other births, labor could be either induced or spontaneous. Labor induction may occur because of medical necessity or without a definitive medical reason. Among women with inductions and those without, women could receive regional anesthesia (either epidural or spinal) or not. Birth mode after labor could include unplanned cesarean or vaginal birth, with vaginal births occurring either spontaneously or with assistance (vacuum or forceps). For both types of vaginal births, there is a chance for an episiotomy at the time of birth. A graphical representation of the decision tree of possible events during childbirth at preterm gestations is shown in Figure 2. The identical possibilities are also modeled for childbirth at gestations >37 weeks, but these are separated in the decision model, owing to cost differences based on gestational age. The potential events in Figure 2 are the same for both obstetrician-led and midwife-led care and term births; however, the differences in the outcomes between models is accounted by the probability of the occurrences of the different events in the decision tree using either adjusted odds ratios (AOR) or relative risk reductions (RRR), as shown in Table 2. Odds ratios (AOR) associated with midwife-led care vs obstetrician-led care were transformed to changes in probability. All parameters from the OB branch of the model are available in Appendix S2. The midwife branch parameters were derived by applying the AORs, RRs, and RRRs reported in Tables 1 and 2.

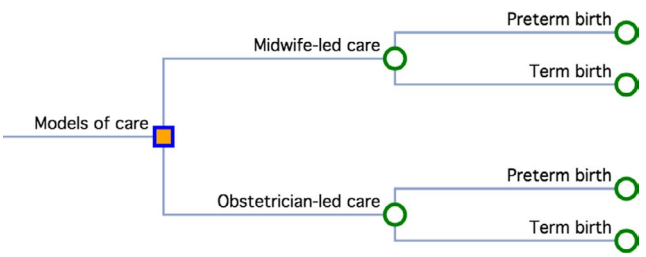

FIGURE 1 First level of decision tree for midwife-led and obstetrician-led care

2.4 | Statistical analysis

To incorporate the difference in the probability of the occurrences of the different events between midwife-led and obstetrician-led models of care, we modeled such events using logistic regression, with midwife-led care as the main predictor and controlling for race/ethnicity and marital status (Table 2). We selected these covariates because these factors were found to be independently associated with the use of midwifery care in a previous analysis using LTM 3 data.[42]

2.5 | Sensitivity analyses

To test the sensitivity of the model's results to specific parameters' uncertainty, we conducted a probabilistic sensitivity analysis, mathematically simulating the full range of potential results 10 000 different times by varying all parameters simultaneously. The parameters and probability distributions are shown in Table 2.

We constructed the decision tree using OpenTree[43] and conducted all decision analyses in R.[44]

3 | RESULTS

Decision-analytic models were based on measured associations between midwife-led care and obstetric procedure use in LTM 3 data, shown in Table 2. Midwife-led care was associated with 60% lower odds of episiotomy (adjusted odds ratio [AOR] 0.40 (95% confidence interval [CI] 0.18-0.88)], compared with obstetrician-led care, after controlling for maternal race/ethnicity and marital status. The adjusted odds of planned cesarean birth and epidural associated with midwife-led care were lower than obstetrician-led care, but differences were not statistically significant.

The 10 000 simulated scenarios comparing midwife-led care to obstetrician-led care indicated lower costs for midwife-led care. The average difference in costs for births to low-risk women with midwife-led care was $2421 less than the cost of births to low-risk women cared for by obstetricians (Table 3). These cost differences derive mostly from lower measured rates of preterm birth and episiotomy among women with midwife-led care, compared with obstetrician-led care. The majority of these cost savings (92%) are attributable to lower rates of preterm births under midwife-led care compared with obstetrician-led care.

Across the population of US women with low-risk births each year (approximately 2.6 million), the model predicted substantially fewer preterm births under midwife-led care (167 259) compared with obstetrician-led care (219 427), as shown in Table 3. Based on this model, if all low-risk women had midwife-led rather than obstetrician-led care, this would avert, on average, 51 550 (95% prediction interval

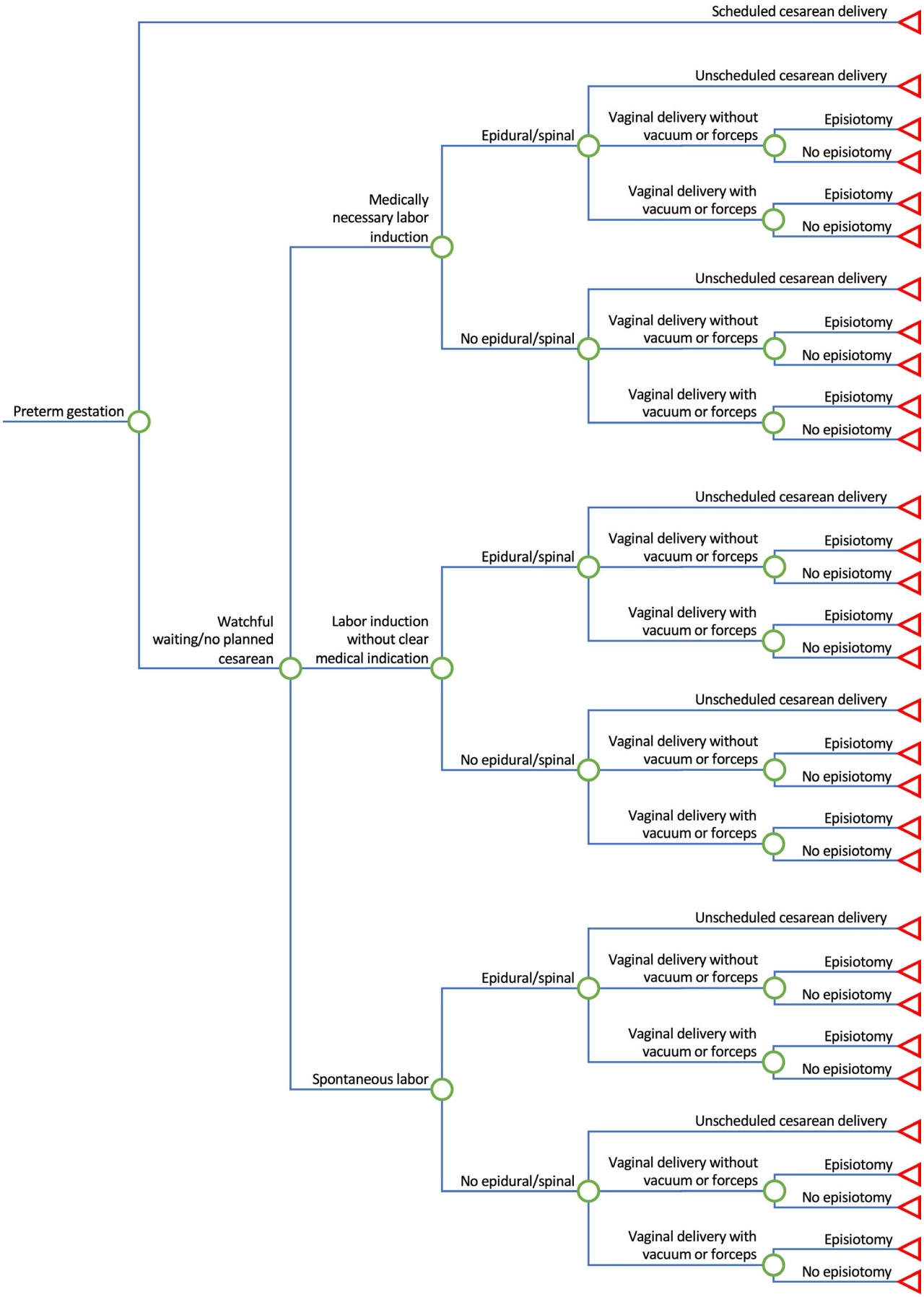

FIGURE 2 Decision tree of possible events following labor at preterm gestation

TABLE 2 Study population and model parameters using estimates from LTM survey, United States, 2012

Parameter	Mean [95% CI]	Distribution
Proportion of births under midwife-led care	0.09 [0.08-0.11]	Beta
AOR of planned cesarean with midwife-led care vs obstetrician-led care	0.49 [0.20-1.21]	Log-normal
RRR of induction with definitive medical reason (vs no induction) with midwife-led care vs obstetrician-led care	1.87 [0.91-3.87]	Log-normal
RRR of induction without definitive medical reason (vs no induction) with midwife-led care vs obstetrician-led care	0.71 [0.38-1.35]	Log-normal
AOR of epidural with midwife-led care vs obstetrician-led care	0.68 [0.40-1.14]	Log-normal
AOR of episiotomy with midwife-led care vs obstetrician-led care	0.40 [0.18-0.88]	Log-normal
RRR of spontaneous vaginal birth (vs cesarean) with midwife-led care vs obstetrician-led care	1.54 [0.82-2.91]	Log-normal
RRR of assisted vaginal birth (vs cesarean) with midwife-led care vs obstetrician-led care	0.38 [0.05-3.00]	Log-normal

[PI] 17 566-81 217) preterm births each year. The model also predicted fewer planned cesareans (257 014 vs 436 975, for midwife-led vs obstetrician-led care), epidurals (1 607 355 vs 1 838 755, for midwife-led vs obstetrician-led care), and episiotomies (195 795 vs 415 665, for midwife-led vs obstetrician-led care).

To estimate potential cost savings across these scenarios, we compared potential changes in expenditures for childbirth based on an increase in the proportion of low-risk pregnancies cared for by midwives at a national level. A ten-percentage-point increase in the proportion of low-risk pregnancies with midwife-led care (ie, from 8.9% to 18.9%) would generate $627 million in cost savings in the United States, annually, by means of lower rates of preterm birth and episiotomy (Table 3). An increase to 40% of pregnancies with midwife-led care would generate $1949 million in cost savings annually.

4 | DISCUSSION

This study used a decision-analytic modeling approach to compare costs of childbirth care and the use of medical procedures for low-risk pregnancies with midwife-led care to those with obstetrician-led care. We combined costs, procedure use, and outcomes that may differ with midwife-led vs obstetrician-led care under the same analytical framework to understand the potential population-level effects of shifting a greater proportion of low-risk pregnancies to midwife-led care. Owing to data limitations, the results of this analysis likely represent a lower-bound or conservative estimate of the potential cost differences between midwife-led and obstetrician-led prenatal care; yet, it provides the best, current, nationwide estimates of this difference to help inform policy discussions on improving US maternity care.

In the decision-analytic model constructed for this study, we found that—across a population of low-risk women—lower odds of preterm birth and episiotomy among women with midwife-led care could result in an average cost savings of approximately $2000 per birth when shifted from obstetrician-led to midwife-led care. When aggregated up to a societal level, if the number of women receiving midwife-led prenatal care increased from 8.9% to 18.9%, this would generate $618 million in cost savings nationally each year. Indeed, a national shift in the workforce and care model for low-risk pregnancy could potentially improve value in maternity care for both public and private payers. State Medicaid programs play a crucial role as a funder for maternity services.[45,46] Greater use of midwifery care may help extend each Medicaid dollar to ensure continued access to care in a time of heightened fiscal limitations. Increases in the proportion of low-risk pregnancies cared for by midwives would also move United States toward greater alignment with many European countries.[7]

Greater use of midwife-led care for low-risk pregnancies in the United States would better align the maternity care workforce with the risk level of pregnant patients (most pregnancies are low risk),[1,8] and could also alleviate projected shortages of OB/GYNs.[47] This analysis showed that a shift from obstetrician-led care to midwife-led care for low-risk pregnancies could be cost saving, both for employers who finance private health plans and taxpayers who finance Medicaid programs. For example, among Medicaid beneficiaries, a small increase in the proportion of midwife-led care (ie, from 8.9% to 10%) would yield annual cost savings of $19 million, and an increase from 8.9% to 40% would yield annual cost savings of $539 million. Among privately insured pregnancies, a shift from 8.9% to 10% in the proportion cared for by midwives would yield cost savings of $48 million, and a shift from 8.9% to 40% would yield cost savings of $1.35 billion.

The clinical practice of midwifery has long emphasized physiologic and low intervention birth.[48] This analysis indicates that the benefits of this model of care include lower cost and fewer obstetric procedures. Facilitating such a shift for low-risk pregnancies could include a role for health plans, who could encourage midwifery care through policies such

TABLE 3 Mean and 95% prediction interval (PI) in parentheses of the national cost per birth and number of medical procedures during childbirth for obstetrician-led and midwife-led care for low-risk pregnancies

	Obstetrician-led care	Midwife-led care
Cost per birth ($)[a]	29 659	27 238
	(28 457-30 936)	(25 426-29 108)
	Medical procedures during childbirth at a national level	
Preterm births	219 434	167 885
	(181 672-259 473)	(129 409-214 502)
Planned cesarean	436 975	257 014
	(386 199-493 331)	(103 204-529 369)
Epidural	1 838 755	1 607 355
	(1 767 262-1 913 231)	(1 287 747-1 899 061)
Episiotomy	415 665	195 795
	(354 446-480 324)	(82 553-381 967)
		Cost savings (Million $)
Ten-percentage-point increase in the proportion of births cared by midwives (8.9%-18.9%)		626.5
		(237.7-1073.5)
Increase from 8.9% to 40.0% in the proportion of births cared by midwives		1948.5
		(739.1-3338.6)

[a]Costs in 2018 USD.

as "stepped" pregnancy care, initiating all low-risk pregnancies in midwifery care as a default, with referral for those with complications that require more specialized care.[49,50] Expansion of midwifery care could also have positive effects on overall hospital maternity unit performance beyond patients who are cared for by midwives, as studies have found that women who give birth in hospitals where midwives work are less likely to experience some types of obstetric procedures.[51-53]

The cost estimates generated by this study are similar to recent findings from the Center for Medicare and Medicaid Innovation's Strong Start for Mother and Newborns Initiative evaluation, which documented cost savings of $2010 per birth for Medicaid beneficiaries receiving midwife-led, birth center-based maternity care, compared with Medicaid beneficiaries receiving typical care.[54] However, Strong Start only focused on Medicaid beneficiaries and studied the cost outcomes of midwifery-led care in the birth center setting, which is distinct from hospital-based care. Currently, over 98% of the US births take place in hospitals.[20] Increasing the availability of midwifery care in community settings in the United States (ie, birth center and home birth) could be considered alongside increases in access to hospital-based midwifery care. Future research modeling cost savings associated with moving some births from the hospital to community settings would be informative.

State regulatory and policy contexts also affect the practice of midwifery and access to midwifery care during pregnancy. Certified nurse-midwife scope of practice differs depending on state, and generally states that more autonomous midwifery scope of practice would result in more midwife-attended births.[2,4,5,55] There is also variation in how midwifery practice is integrated into hospitals, which may impact the extent to which hospital-based midwives are delivering lower intervention care.[6] State policy that supports midwives practicing at their full clinical capacity, without physician oversight or supervision, may support greater access to midwifery care.[4,55]

State and federal policy efforts have catalyzed innovation in payment models for maternity care alongside ongoing efforts in other clinical areas.[56,57] For example, the recent Blueprint for Advancing High-Value Maternity Care Through Physiologic Childbearing has an entire section devoted to payment reform and innovation in maternity care, highlighting the promise of bundled payments, shared savings, and episode-based care.[58] As a clearly defined and time-limited health condition, pregnancy and childbirth care may be particularly well-suited for bundled payment models, which associate a global fee with provision of a set of services.[59] Given this study's findings about the potential cost savings associated with a shift toward midwife-led care, the inclusion of midwives as key members of clinical care teams in settings using bundled payments may improve the prospects for this type of payment innovation, which has already shown promise in health systems such as Geisinger.[60]

4.1 | Limitations

This study provides a rigorous cost comparison analysis of hospital-based midwife-led vs obstetrician-led care for low-risk pregnancies in the United States using parameters derived from a national sample. However, the data and the methods carry important limitations. There are no clinical records or diagnoses included in the LTM 3 data, and our ability to identify low-risk pregnancies was limited by available data. Information on use of procedures in LTM data is self-reported, but these data have been widely used in maternity care research and self-reporting of obstetric procedures such as cesarean birth is very accurate.[61] In the LTM 3 survey, there was a relatively small sample size for midwife-attended births (N = 126), and we were not able to stratify by parity or other potentially relevant factors. The use of the Cochrane review[1] as the data source for the impact of midwife-led care on preterm birth is also a limitation, given the lack of US studies in the analysis. Findings from the Strong Start assessment of birth center-based midwifery care offer

some reassurance, given that Medicaid beneficiaries receiving this model of care were less likely to give birth preterm than were those receiving typical obstetric care.[54] Although primary collection of cost data would be optimal, we did not have access to a primary source of cost data. Cost data also reflect the current reimbursement structure—which pays substantially more for cesarean (vs vaginal) birth but does not always have a similar pay differential for other obstetric procedures (such as forceps/vacuum or induction). As such, the estimated cost savings associated with midwife-led vs obstetrician-led care are likely an underestimate. In addition, we used the Medicare fee schedule as a source of costs for some of the procedures, but Medicare covers few births. However, this was the best available data source in this context. Decision-analytic modeling is based on the statistical assessments of associational, not causal relationships between midwife-led care and the outcomes. This analysis focuses on the prenatal care practioner, rather than the intrapartum care practioner, and cannot identify comanagement by both a midwife and an obstetrician. Finally, there may be unmeasured differences between women who had midwifery-led care and those who did not.

4.2 | Conclusions

This analysis shows that a shift from obstetrician-led care to midwife-led care for low-risk pregnancies could be cost saving and potentially support broad efforts to improve quality and value in the US maternity care.

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REFERENCES

1. Sandall J, Soltani H, Gates S, Shennan A, Devane D. Midwife-led continuity models versus other models of care for childbearing women. *Cochrane Database Syst Rev*. 2016;(8). https://doi.org/10.1002/14651858.CD004667.pub3.Copyright
2. Declercq E. Midwife-attended births in the United States, 1990–2012: Results from revised birth certificate data. *J Midwifery Women's Heal*. 2015;60(1):10-15.
3. Martin JA, Hamilton BE, Osterman MJK, Driscoll AK, Drake P. Births: final data for 2016. *Natl Vital Stat Rep*. 2018;67(1):1-104.
4. Yang TY, Attanasio LB, Kozhimannil KB. State scope of practice laws, nurse-midwifery workforce, and childbirth procedures and outcomes. *Women's Heal Issues*. 2016;26(3):262-267.
5. Declercq ER, Paine LL, Simmes DR, Dejoseph JF. State regulation, payment policies, and nurse-midwife services. *Health Aff*. 1998;17(2):190-200.
6. 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):1-20.
7. Malott AM, Davis BM, McDonald H, Hutton E. Midwifery care in eight industrialized countries: how does Canadian midwifery compare? *J Obstet Gynaecol Can*. 2009;31(10):974-979.
8. Ten Hoope-Bender P, De Bernis L, Campbell J, et al. Improvement of maternal and newborn health through midwifery. *Lancet*. 2014;384(9949):1226-1235.
9. Callaghan WM. Overview of maternal mortality in the United States. *Semin Perinatol*. 2012;36(1):2-6.
10. Kuklina EV, Meikle SF, Jamieson DJ, et al. Severe obstetric morbidity in the United States: 1998–2005. *Obstet Gynecol*. 2009;113(2 Pt 1):293-299.
11. Martin JA, Hamilton BE, Ventura SJ, Osterman M, Wilson EC, Mathews TJ. Births: final data for 2010. *Natl Vital Stat Rep*. 2012;61(1):1990-2010.
12. Dublin S, Johnson KE, Walker RL, et al. Trends in elective labor induction for six Unites States Health Plans, 2001–2007. *J Women's Heal*. 2014;23(11):904-911.
13. Martin JA, Hamilton BE, Ph D, et al. Births: final data for 2009. *Natl Vital Stat Rep*. 2011;60(1):1-70.
14. Declercq E, Young R, Cabral H, Ecker J. Is a rising cesarean delivery rate inevitable? Trends in industrialized countries, 1987 to 2007. *Birth*. 2011;38(2):99-104.
15. Hamilton BE, Martin JA, Osterman MJK, Driscoll AK, Rossen LM. Births: Provisional data for 2017. Vital Statistics Rapid Release; no 4. Hyattsville, MD: National Center for Health Statistics. 2018. Available from: https://www.cdc.gov/nchs/data/vsrr/report004.pdf
16. Hamilton BE, Martin JA, Osterman M, Driscoll AK, Rossen LM. Births: Provisional Data for 2018; 2019. https://www.cdc.gov/nchs/products/index.htm.%0Ahttps://www.cdc.gov/nchs/data/vsrr/report002.pdf. Accessed August 29, 2019.
17. American College of Obstetricians and Gynecologists. Safe prevention of the primary cesarean delivery. Obstet Care Consensus No. 1. *Obstet Gynecol*. 2014;123:693-711.
18. WHO Statement on Caesarean Section Rates, 2015. https://doi.org/10.1016/j.rhm.2015.07.007
19. Kozhimannil KB, Law MR, Virnig BA. Cesarean delivery rates vary tenfold among US hospitals; reducing variation may address quality and cost issues. *Health Aff (Millwood)*. 2013;32(3):527-535.
20. Martin JA, Hamilton BE, Osterman M, Driscoll AK, Drake P. *Births: Final Data for 2017*; Vol. 67.; 2018. https://www.cdc.gov/nchs/data_access/Vitalstatsonline.htm. Accessed January 7, 2019.
21. Erratum to Medicaid Covered Births, 2008 through 2010, in the context of the implementation of health reform [Women's Health, 23, 5, (2013), e273–e280]. *Women's Heal Issues*. 2013;23(6):3867.
22. Renfrew MJ, Mcfadden A, Bastos MH, et al. Midwifery and quality care: findings from a new evidence-informed framework for maternal and newborn care. *Lancet*. 2014;384(9948):1129-1145.
23. Altman MR, Murphy SM, Fitzgerald CE, Andersen HF, Daratha KB. The cost of nurse-midwifery care: use of interventions, resources, and associated costs in the hospital setting. *Women's Heal Issues*. 2017;27(4):434-440.
24. Carr CA. Charges for maternity services: associations with provider type and payer source in university teaching hospital. *J Midwifery Women's Heal*. 2000;45(5):378-383.

25. Oakley D, Murtiand T, Mayes F, et al. Processes of care: comparisons of certified nurse-midwives and obsetetricians. *J Nurse Midwifery*. 1995;40(5):399-409.
26. Rosenblatt RA, Dobie SA, Hart LG, et al. Interspecialty differences in the obstetric care of low-risk women. *Am J Public Health*. 1997;87(3):344-351.
27. Janssen PA, Mitton C, Aghajanian J. Costs of planned home vs. Hospital birth in British Columbia attended by registered midwives and physicians. *PLoS One*. 2015;10(7):1-11.
28. Homer CS, Matha DV, Jordan LG, Wills J, Davis GK. Community-based continuity of midwifery care versus standard hospital care: a cost analysis. *Aust Heal Rev*. 2001;24(1):85-93.
29. Reinharz D, Blais R, Fraser WD, Contandriopoulos A-P. Cost-effectiveness of midwifery services vs. medical services in Quebec. *Can J Public Heal*. 2000;91:I12–I15.
30. Ryan P, Revill P, Devane D, Normand C. An assessment of the cost-effectiveness of midwife-led care in the United Kingdom. *Midwifery*. 2013;29(4):368-376.
31. Toohill J, Turkstra E, Gamble J, Scuffham PA. A non-randomised trial investigating the cost-effectiveness of Midwifery Group Practice compared with standard maternity care arrangements in one Australian hospital. *Midwifery*. 2012;28(6):e874-e879.
32. Walters D, Gupta A, Nam AE, Lake J, Martino F, Coyte PC. A cost-effectiveness analysis of low-risk deliveries: a comparison of midwives, family physicians and obstetricians. *Healthc Policy*. 2015;11(1):61-75.
33. Schroeder E, Petrou S, Patel N, et al. Cost effectiveness of alternative planned places of birth in woman at low risk of complications: evidence from the Birthplace in England national prospective cohort study. *BMJ*. 2012;344(7854):1-13.
34. Kuntz K, Russell L, Owens D, GD S, Trikalinos T, Salomon J. .Decision models in cost-effectiveness analysis. In: Neumann P, Sanders G, Russell L, Siegel J, Ganiats T eds. *Cost-Effectiveness in Health and Medicine*, 2nd edn. New York, NY: Oxford University Press; 2017:105–136.
35. Thao V, Enns EA, Patrick SW, Levy R, Kozhimannil KB. Decision science can help policymakers to identify and evaluate policies to treat opioid use disorder among pregnant women. *Women's Heal Issues*. 2018;28(1):2-5.
36. Neumann P, Sanders G, Russell L, Siegel J, Ganiats T, eds. *Cost-Effectiveness in Health and Medicine*. New York, NY: Oxford University Press; 2017.
37. Truven Health Analytics. *The Cost of Having a Baby in the United States*. Ann Arbor, MI; Truven Health Analytics; 2013.
38. Medicare Physician Fee Schedule Database (MPFS). https://www.cms.gov/apps/physician-fee-schedule/search/search-criteria.aspx. Published 2018. Accessed August 25, 2019.
39. Truven Health Analytics. Premature Birth: The Financial Impact on Business; 2013. https://www.marchofdimes.org/materials/premature-birth-the-financial-impact-on-business.pdf. Accessed June 13, 2018.
40. Kozhimannil KB, Attanasio LB, Johnson PJ, Gjerdingen DK, McGovern PM. Employment during pregnancy and obstetric intervention without medical indication: labor induction and cesarean delivery. *Women's Heal Issues*. 2014;24(5):469-476.
41. Jou J, Kozhimannil KB, Johson PJ, Sakala C. Patient-perceived pressure from clinicians for labor induction and cesarean delivery: a population-based survey of U.S. women. *Health Serv Res*. 2015;50(4):961-981.
42. Weisband YL, Gallo MF, Klebanoff MA, Shoben AB, Norris AH. Progression of care among women who use a midwife for prenatal care: Who remains in midwife care? *Birth*. 2018;45:28–36.
43. Jalal H, Cross A, Alarid-Escudero F, Myriam HM. PS 1-58 DTREE: An Open Source Tool for Building Decision Trees and Cost-effectiveness Analysis. In: *38th Annual North American Meeting of the Society for Medical Decision Making*; 2016:E57.
44. Jalal H, Pechlivanoglou P, Krijkamp E, Alarid-Escudero F, Enns E, Myriam Hunink MG. An overview of R in health decision sciences. *Med Decis Mak*. 2017;37(7):735-746.
45. Markus AR, Andres E, West KD, Garro N, Pellegrini C. Medicaid covered births, 2008 through 2010, in the context of the implementation of health reform. *Womens Health Issues*. 2013;23(5):e273-e280.
46. Markus AR, Rosenbaum S. The role of Medicaid in promoting access to high-quality, high-value maternity care. *Women's Heal Issues*. 2010;20(1):S67-S78.
47. Rayburn WF. *The Obstetrician-Gynecologist Workforce in the United States: Facts, Figures and Implications*. Washington, DC; 2017. https://www.acog.org/Clinical-Guidance-and-Publications/The-Ob-Gyn-Workforce/The-Obstetrician-Gynecologist-Workforce-in-the-United-States. Accessed April 17, 2018.
48. American College of Nurse-Midwives, Midwives Alliance of North America, National Association of Certified Professional Midwives. *Supporting Healthy and Normal Physiologic Childbirth: A Consensus Statement by ACNM, MANA, and NACPM*. Silver Spring, MD; American College of Nurse-Midwives, Midwives Alliance of North America, National Association of Certified Professional Midwives; 2012.
49. Geerts CC, van Dillen J, Klomp T, Lagro-Janssen A, de Jonge A. Satisfaction with caregivers during labour among low risk women in the Netherlands: the association with planned place of birth and transfer of care during labour. *BMC Pregnancy Childbirth*. 2017;17(1):1-10.
50. Hendry C. The New Zealand maternity system: A midwifery renaissance. In: Davis-Floyd RE, Barclay L, Daviss B-A, Tritten J, eds. *Birth Models That Work*. Berkeley: University of California Press; 2009.
51. Carlson NS, Neal JL, Tilden EL, et al. Influence of midwifery presence in United States centers on labor care and outcomes of low-risk parous women: a Consortium on Safe Labor study. *Birth*. 2019;46:487–499.
52. Neal JL, Lamp JM, Buck JS, Lowe NK, Gillespie SL, Ryan SL. Outcomes of nulliparous women with spontaneous labor onset admitted to hospitals in preactive versus active labor. *J Midwifery Women's Heal*. 2014;59(1):28-34.
53. Attanasio LB, Kozhimannil KB. Relationship between hospital-level percentage of midwife-attended births and obstetric procedure utilization. *J Midwifery Womens Health*. 2018;63(1):14-22.
54. Hill I, Dubay L, Courtot B, et al. Strong Start for Mothers and Newborns Evaluation: Year 5 Project Synthesis. Vol 1: Cross-C.; 2018.
55. Markowitz S, Adams EK, Lewitt MJ, Dunlop AL. Competitive effects of scope of practice restrictions: public health or public harm? *J Health Econ*. 2017;55:201-218.
56. Cutler DM, Ghosh K. The potential for cost savings through bundled episode payments. *N Engl J Med*. 2012;366(12):1075-1077.
57. Angood PB, Armstrong EM, Ashton D, et al. Blueprint for action: steps toward a high-quality, high-value maternity care system. *Women's Heal Issues*. 2010;20(1S):S18-S49.

58. Avery MD, Bell AD, Bingham D, et al. *Blueprint for Advancing High-Value Maternity Care Through Physiologic Childbearing*. Washington, DC; 2018. http://www.nationalpartnership.org/research-library/maternal-health/blueprint-for-advancing-high-value-maternity-care.pdf. Accessed July 19, 2018.
59. The Clinical Episode Payment (CEP) Work Group. Accelerating and Aligning Clinical Episode Payment Models: Maternity Care; 2016. http://hcp-lan.org/workproducts/cep-whitepaper-final.pdf. Accessed August 25, 2019.
60. Berry SA, Laam LA, Wary AA, et al. ProvenCare perinatal: a model for delivering evidence/guideline-based care for perinatal populations. *Jt Comm J Qual Patient Saf*. 2011;37(5):229-239.
61. Attanasio LB, Kozhimannil KB, Srinivas SK, Kjerulff KH. Concordance between women's self-reported reasons for cesarean delivery and hospital discharge records. *Women's Heal Issues*. 2017;27(3):329-335.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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