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Pelvic Floor Consequences of Cesarean Delivery on Maternal Request in Women with a Single Birth: A Cost-effectiveness Analysis

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Abstract

Background: The potential benefit in preventing pelvic floor disorders (PFDs) is a frequently cited reason for requesting or performing cesarean delivery on maternal request (CDMR). However, for primigravid women without medical/obstetric indications, the lifetime cost-effectiveness of CDMR remains unknown, particularly with regard to lifelong pelvic floor consequences. Our objective was to assess the cost-effectiveness of CDMR in comparison to trial of labor (TOL) for primigravid women without medical/obstetric indications with a single childbirth over their lifetime, while explicitly accounting for the management of PFD throughout the lifetime.
Methods: We used Monte Carlo simulation of a decision model containing 249 chance events and 101 parameters depicting lifelong maternal and neonatal outcomes in the following domains: actual mode of delivery, emergency hysterectomy, transient maternal morbidity and mortality, perinatal morbidity and mortality, and the lifelong management of PFDs. Parameter estimates were obtained from published literature. The analysis was conducted from a societal perspective. All costs and quality-adjusted life-years (QALYs) were discounted to the present value at childbirth.
Results: The estimated mean cost and QALYs were $14,259 (95% confidence interval [CI] $8,964-$24,002) and 58.21 (95% CI 57.43-58.67) for CDMR and $13,283 (95% CI $7,861-$23,829) and 57.87 (95% CI 56.97-58.46) for TOL over the combined lifetime of the mother and the child. Parameters related to PFDs play an important role in determining cost and quality of life.
Conclusions: When a woman without medical/obstetric indications has only one childbirth in her lifetime, cost-effectiveness analysis does not reveal a clearly preferable mode of delivery.

Introduction

Cesarean delivery is the most commonly performed operating room procedure in the United States.[1] In addition to being major abdominal surgery, cesarean delivery is associated with increased risk of neonatal respiratory morbidity and can cause complications in subsequent pregnancies, such as uterine rupture, placenta previa, and placenta accreta.[2] Cesarean delivery on maternal request (CDMR), defined as cesarean delivery for a singleton pregnancy on maternal request at term in the absence of any medical or obstetric indications,[3] has generated nationwide debate as the cesarean delivery rate reaches its highest level (31.1% of all births in 2006).[4] The widespread concern that some of this increase may be attributable to an increase in CDMR[5,6] provided impetus for the National Institutes of Health (NIH) 2006 State-of-the-Science Conference on CDMR.[3]

Patients and healthcare providers frequently report prevention of pelvic floor disorders (PFDs) as the primary reason for choosing cesarean delivery.[6,7] PFDs include several clinical conditions, such as urinary incontinence (UI), fecal incontinence (FI), and pelvic organ prolapse (POP). Among women 20 and older in the United States, the prevalences of UI, FI, and POP are 15.7%, 9.0%, and 2.9%, respectively.[8] These debilitating conditions significantly impact women's quality of life (QOL) and increase healthcare costs. Each year

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in the United States, UI costs $19.5 billion,[9] and over 200,000 women undergo inpatient surgery for POP.[10,11]

Although there is evidence supporting an association between vaginal birth and the development of PFDs,[3] only two cost-effectiveness studies[12,13] comparing modes of delivery have incorporated PFDs as a maternal outcome. One examined vaginal birth after a previous cesarean delivery,[12] and the other compared planned cesarean delivery with trial of labor (TOL) for primigravid women with macrosomic infants.[13] For primigravid women without medical or obstetric indications, however, the lifetime cost-effectiveness of CDMR vs. TOL remains unknown, particularly with regard to lifelong pelvic floor consequences. This subgroup of pregnant women is at the center of the CDMR debate.

The choice between CDMR and TOL is complex, involving both maternal and neonatal factors with short-term and long-term implications. Drawing on the advantage of decision analysis, which allows for multiple, often conflicting, factors to be analyzed in a single model, this study makes an important first step toward addressing this complex question by investigating the lifelong cost-effectiveness of CDMR vs. TOL for primigravid women without medical or obstetric indications having only one childbirth in their lifetime. A single birth model provides important insights for future studies of two or more childbirths.

Materials and Methods

Decision tree model

Cost-effectiveness analysis is a method designed to assess the comparative impacts (i.e., cost and effectiveness) of different health interventions.[14] It involves estimating the incremental costs and effects of an intervention compared with some alternatives.[14] The method has been widely applied to inform difficult clinical and public health decisions and has been used to assess the relative cost and benefit trade-offs of alternative healthcare interventions in gynecologic oncology, gynecologic surgery, maternal-fetal medicine, infertility treatment, and other subspecialties in the field of obstetrics and gynecology.[15–17]

A decision tree is a visual tool to illustrate how each compared intervention relates to the possible outcomes.[18] In this study, a decision tree model containing 249 chance events and 101 parameters was constructed mapping the sequence of most relevant clinical outcomes after each delivery management scheme (CDMR or TOL) throughout the mother and the newborn's lifetime (Fig. 1).

The patient in this analysis was defined as a 25-year-old (i.e., the mean age of American women at first childbirth[19]), primigravid woman with a term singleton birth without medical or obstetric indications (e.g., known fetal or maternal risk factors) favoring either management strategy. The woman has no history of PFD before delivery. We assumed that women who opt for CDMR undergo a cesarean delivery before onset of labor and that women undergoing TOL could not have a cesarean delivery without medical reasons. The analysis was conducted from a societal perspective, including all costs to the healthcare system and the patient.

Our analysis focused on women who actually have only one birth over their lifetime, who account for 21.6% of parous women in the United States.[20] We limited our analysis to a single birth because of lack of data on the differential risk of PFD consequences in women with different delivery modes at successive childbirths (e.g., an instrumental vaginal delivery followed by a CDMR vs. a CDMR followed by a spontaneous vaginal delivery). Single birth is also the scenario most favorable to CDMR and often is discussed as a specific situation in which it might be appropriate.

Our model incorporated the following PFDs: stress UI (SUI), FI, and POP. SUI is believed to be primarily a result of the childbirth experience, which can cause injury to muscles, connective tissues, and nerves.[16] In contrast, the etiology of urge UI, the other main type of UI in women, is less well characterized and, therefore, was not included in our model.[21] The definition of FI varies in the literature, with some studies including flatus incontinence whereas others consider involuntary loss of stool only.[22] Because prior studies show that flatal incontinence has less impact on QOL and there is confusion in women reporting voluntary vs. involuntary passing of flatus,[23] we defined FI as involuntary leakage of liquid/solid stool in our analysis. We did not include female sexual dysfunction (FSD)[5] because the published data on FSD do not provide sufficient detail to suit our analysis.

Our selection of other maternal and perinatal morbidities was guided by the 2006 Visco et al.[24] systematic review of research comparing outcomes of CDMR and TOL and supplemented by our review of more recent studies. Visco et al.[24] indicated moderate quality or some limited evidence for differential incidence of infection, hemorrhage/blood transfusion, and surgical complications between CDMR and TOL, as well as differences in the rate of neonatal respiratory morbidity. More recent studies also suggested evidence of differential rates of peripartum hysterectomy between CDMR and TOL.[25–27]

Data sources

Estimates of the base value and plausible ranges for the probability, cost, and utility parameters associated with each health state were obtained from the published literature (Tables 1, 2, 3, and 4). A utility value, ranging from 0 (death) to 1 (perfect health), quantifies an individual's perception and preference for a health state. All parameter estimates were reviewed by an expert panel, including two obstetricians and the two clinical authors with considerable clinical and research experience (D.F. and J.O.L.D). Because this study analyzed published data, it was not human subject research and, hence, did not require Institutional Review Board oversight.

We accounted for the major cost items during and after childbirth over the course of the woman's and newborn's lifetimes, including delivery, maternal and neonatal mortality and morbidity, management and treatment of PFDs, and productivity loss (Table 3). Hospital facility costs and physicians' professional fees associated with the delivery were estimated using the Medicare fee schedules,[98] which are developed to measure the costs of providing medical services to Medicare patients and widely used in economic evaluations to represent the societal cost of healthcare.[109] Because the medically recommended period of recovery for cesarean delivery is usually 2 weeks longer than that for vaginal delivery, we incorporated a 2-week difference in productivity loss between these delivery modes.[123,124] (A sensitivity analysis was conducted varying the difference in this recovery period between vaginal and cesarean delivery. There was no

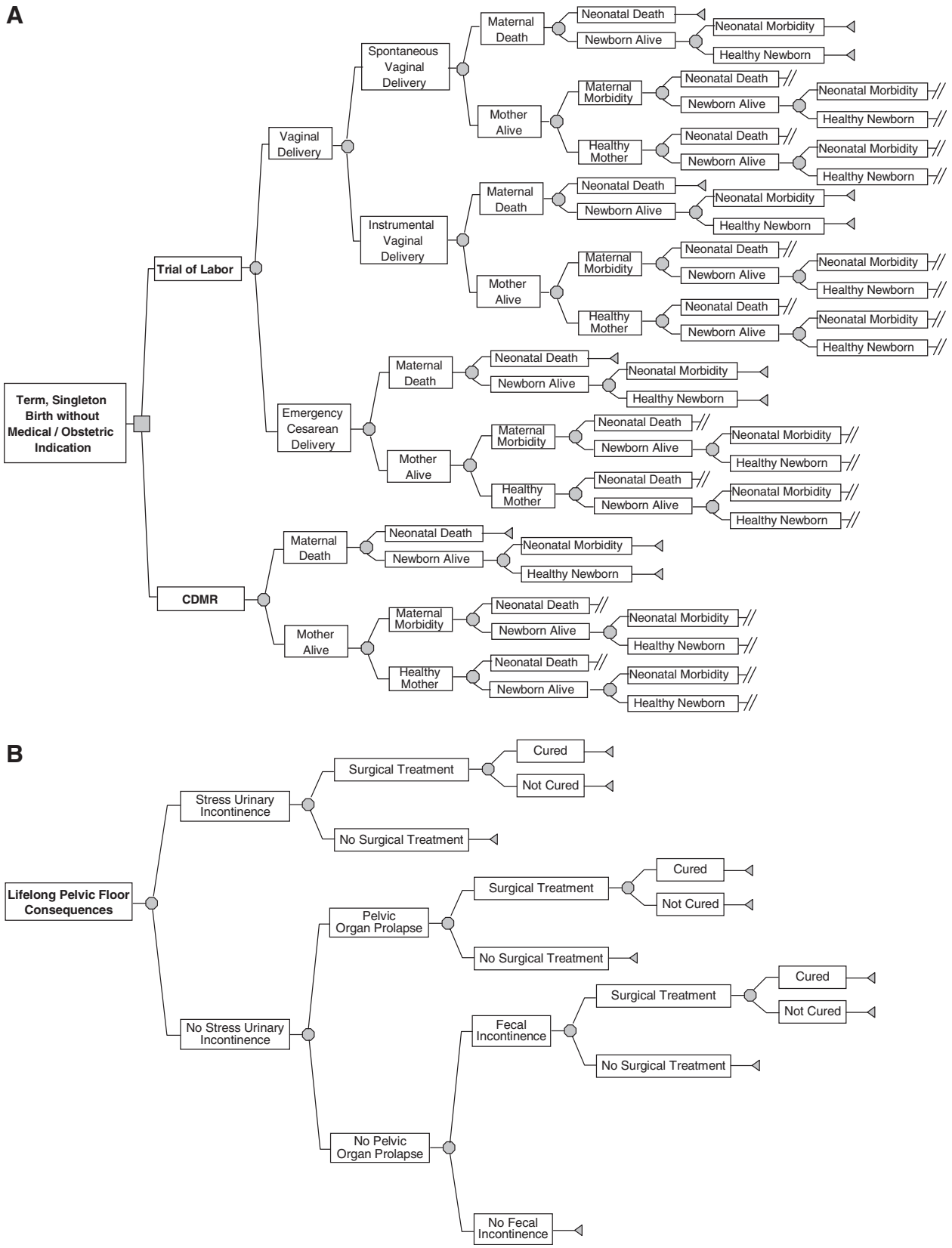

FIG. 1. Decision tree model for one term singleton birth without medical or obstetric indications. Part A of the figure illustrates the portion of the decision tree related to short-term maternal and neonatal outcomes. Part B of the figure depicts the portion of the decision tree related to the long-term pelvic floor consequences. Square, decision node; circle, chance node; triangle, end node; double slash, branch continues with the Lifelong Pelvic Floor Consequences subtree.

Table 1. Estimates of Probability Parameters in Model

Parameter	*Base value*	*Range*[a]	*References*
Trial of labor			
Probability of having a vaginal delivery	90%	84.4%–97.0%	25, 28–30
If vaginal delivery			
Probability of spontaneous vaginal delivery	90%	85.0%–95.0%	25, 31, 32
If spontaneous vaginal delivery			
Probability of maternal death	0.0%	0.0%–0.0020%	33, 34[b]
Probability of neonatal death	0.02%	0.018%–0.063%	35–38
If spontaneous vaginal delivery and mother alive			
Probability of composite maternal morbidity[c]	1.22%	0.94%–1.35%	31, 39–44
Probability of having stress urinary incontinence (SUI)	19.90%	14.93%–40.80%	45–49
Probability of having pelvic organ prolapse (POP)	8.9%	7%–9.79%	47, 50
Probability of having fecal incontinence (FI)	2.65%	2.13%–6.9%	47, 48, 51–53
If spontaneous vaginal delivery and baby alive			
Probability of neonatal morbidity[d]	1.0%	0.75%–1.25%	54
If instrumental vaginal delivery			
Probability of maternal death	0.0028%	0.0024%–0.0028%	29, 33, 34[b]
Probability of neonatal death	0.0352%	0.030%–0.063%	35–38
If instrumental vaginal delivery and mother alive			
Probability of composite maternal morbidity[c]	3.81%	2.58%–4.19%	29, 31, 39–44
Probability of having SUI	21.80%	16.35%–43.50%	45–47, 49
Probability of having POP	12.0%	7%–13.2%	47, 50
Probability of having FI	8.0%	3.9%–18.8%	47, 51–53, 55, 56
If instrumental vaginal delivery and baby alive			
Probability of neonatal morbidity[d]	0.9%	0.68%–1.13%	54
If emergency cesarean delivery			
Probability of maternal death	0.0097%	0.0097%–0.0250%	25, 33, 34, 57
Probability of neonatal death	0.08%	0.06%–0.169%	36, 38
If emergency cesarean delivery and mother alive			
Probability of composite maternal morbidity[c]	13.69%	10.04%–17.01%	31, 39–42, 44, 58–61
Probability of having SUI	11.50%	7.00%–33.00%	45, 47, 49, 50, 62
Probability of having POP	7%	0.00%–11.0%	47, 50
Probability of having FI	5%	4.0%–8.47%	47, 52, 55, 56, 63
If emergency cesarean delivery and baby alive			
Probability of neonatal morbidity[d]	4.5%	3.55%–4.95%	64, 65
Cesarean delivery on maternal request (CDMR)			
Probability of maternal death	0.0059%	0.0%–0.0148%	26, 33, 34, 57
Probability of neonatal death	0.047%	0.0%–0.173%	36, 38, 66–69
If CDMR and mother alive			
Probability of composite maternal morbidity[c]	5.01%	2.47%–9.39%	25, 26, 31, 39–44, 59, 61, 70
Probability of having SUI	10.00%	0.0%–33.00%	45–47, 49, 50, 62
Probability of having POP	1%	0.0%–6%	47, 50
Probability of having FI	1.78%	0.0%–7.7%	47, 52, 55, 56, 63, 71
If CDMR and baby alive:			
Probability of neonatal morbidity[d]	3.3%	2.9%–3.63%	54, 64, 65, 72
Treatment of pelvic floor disorders SUI			
Proportion of SUI symptomatic women seeking healthcare for SUI	61%	45.75%–76.25%	73

(*Continued*)

Table 1. (Continued)

Parameter	*Base value*	*Range*[a]	*References*
Proportion of women seeking healthcare for SUI who receive surgical treatment	29.8%	22.35%–37.25%	74
Success rate of SUI surgeries	81.3%	63%–93%	75–82
POP			
Proportion of POP symptomatic women seeking healthcare for POP	73%	54.75%–91.25%	73
Proportion of women seeking healthcare for POP who receive surgical treatment	75%	56.25%–93.75%	Authors' assumption
Success rate of surgical treatment for POP	71%	58%–100%	83–89
FI			
Proportion of FI symptomatic women seeking healthcare for FI	33.8%	20.5%–43%	73, 90, 91
Proportion of women seeking healthcare for FI who receive surgical treatment	17.46%	13.10%–34.50%	92[e]
Success rate of FI surgeries	25%	10%–54%	93–97

[a]Plausible ranges of the parameters were determined based on data from the literature or ±25% of the base value if no range was available from the literature.
[b]Supplemented by authors' analysis of the 2004 National Hospital Discharge Survey data.
[c]Including any blood transfusion, wound infection and endometritis, peripartum hysterectomy, and surgical injury of the uterine, bladder, or bowel (see Table 2 for more details).
[d]Including respiratory distress syndrome (RDS) and transient tachypnea (TTN).
[e]Supplemented by unpublished research data from the Michigan Bowel Control Program.

Table 2. Probability Parameters Associated with Composite Maternal Morbidity

Parameter	*Base value*	*Range*[a]	*References*
Trial of labor			
Spontaneous vaginal delivery			
Maternal: Any blood transfusion	0.3%	0.11%–0.33%	31, 39, 40, 44
Maternal: Infection (including wound infection and endometritis)	0.8%	0.72%–0.88%	39–41
Maternal: Peripartum hysterectomy	0.023%	0.0207%–0.03%	27, 42, 43
Maternal: Surgical injury (including uterine, bladder, or bowel injuries)	0.1%	0.09%–0.11%	39, 40
Instrumental vaginal delivery			
Maternal: Any blood transfusion	1.0%	0.12%–1.1%	31, 39, 40, 44
Maternal: Infection (including wound infection and endometritis)	2.6%	2.34%–2.86%	39–41
Maternal: Peripartum hysterectomy	0.05%	0.03%–0.055%	29, 42, 43
Maternal: Surgical injury (including uterine, bladder, or bowel injuries)	0.2%	0.1%–0.22%	39, 40
Emergency cesarean delivery			
Maternal: Any blood transfusion	0.6%	0.37%–1.1%	31, 39, 40, 44, 58, 59
Maternal: Infection (including wound infection and endometritis)	11.2%	9.45%–13.14%	39–41, 58, 61
Maternal: Peripartum hysterectomy	0.12%	0.108%–0.38%	42, 58, 59
Maternal: Surgical injury (including uterine, bladder, or bowel injuries)	2.1%	0.17%–3.02%	39, 40, 58, 60
Cesarean delivery on maternal request			
Maternal: Any blood transfusion	0.3%	0.07%–4.455%	26, 31, 39, 40, 44, 59, 70
Maternal: Infection (including wound infection and endometritis)	4.53%	2.3%–8.261%	26, 39–41, 61
Maternal: Peripartum hysterectomy	0.06%	0.0%–0.715%	25–27, 39, 42, 43, 59
Maternal: Surgical injury (including uterine, bladder, or bowel injuries)	0.14%	0.1%–0.17%	26, 39, 40

[a]Plausible ranges of the parameters were determined based on data from the literature or ±25% of the base value if no range was available from the literature.

Table 3. Estimates of Cost-related Parameters, in 2007 U.S. Dollars

Parameter	*Base value*	*Range*[a]	*References*
Obstetric care (including delivery and postpartum care)			
Spontaneous vaginal delivery	$3,520	$2,640–$4,400	98–100
Instrumental vaginal delivery	$3,569	$2,677–$4,461	98–101
Emergency cesarean delivery	$6,513	$4,885–$8,141	98–100, 102
Cesarean delivery on maternal request	$4,735	$3,666–$6,110	30, 98, 102
Maternal outcomes			
Composite maternal morbidity after spontaneous vaginal delivery[b]	$1,308	$981–$1,635	12
Composite maternal morbidity after instrumental vaginal delivery[b]	$1,283	$962–$1,604	12
Composite maternal morbidity after emergency cesarean delivery[b]	$313	$235–$391	12
Composite maternal morbidity after planned cesarean delivery[b]	$219	$164–$274	12
Maternal death	$2,589	$1,942–$3,236	12
Neonatal outcomes			
Neonatal morbidity (postbirth respiratory problem)	$62,843	$24,082–$180,611	12
Neonatal death	$48,662	$24,082–$72,245	12
National mean age of women at first childbirth	25.2 years	–	19
Additional productivity loss of cesarean delivery compared with vaginal delivery	2 weeks	–	Authors' assumption
National median wage rate/week for women aged ≥25	$654	$491–$818	103
National median wage rate/week for workers (regardless of gender and age)	$695	$521–$869	103
Female life expectancy at age of first childbirth (i.e., 25.2 years of age)	56 years	–	104
Life expectancy at birth (regardless of gender)	77.5 years	–	104
Pelvic floor disorders (PFDs)			
Time of PFD onset (measured as number of years after delivery)	10 years	0–20 years	Authors' assumption
Stress urinary incontinence (SUI)			
Annual cost of routine care for SUI (for community dwelling adult, mainly absorbent materials and cleaning)	$595	$129–$2,185	105, 106
Annual productivity loss associated with SUI when age <65 years	104 hours	52–192.4 hours	9
Age at which women undergo SUI surgeries	54 years	49–59 years	107, 108
Cost of diagnosis evaluation of SUI	$239	$120–$479	105
Cost of SUI surgery	$9,849	$5,396–$19,296	105
Pelvic organ prolapse (POP)			
Annual cost of routine care for POP	$0	–	Authors' assumption
Annual productivity loss associated with POP when age <65 years	0 hours	–	Authors' assumption
Age at which women undergo POP surgeries	59 years	49–60 years	108–110
Cost of diagnosis evaluation of POP	$230	$173–$288	98
Cost of POP surgery	$5,787	$4,340–$7,234	109
Fecal incontinence (FI)			
Annual cost of routine care (primarily absorbent materials and cleaning)	$241	$24–$1,009	111, 112
Annual productivity loss associated with FI when age <65 years	37.44 hours	28.08–46.8 hours	113
Age at which women undergo FI surgeries	55 years	49–62 years	114, 115
Cost of diagnosis evaluation of FI	$659	$494–$824	111
Cost of FI surgery	$7,868	$5,901–$9,835	116

[a]Plausible ranges of the parameters were determined based on data from the literature or ±25% of the base value if no range was available from the literature.

[b]The cost of the composite maternal morbidity was derived based on the following cost estimates (adjusted to 2007 U.S. dollars) from Chung et al.[12] weighted by the distribution of the probability of each individual morbidity subsequent to different modes of delivery: peripartum hysterectomy after vaginal delivery ($5,710), infection after vaginal delivery ($1,562), blood transfusion after vaginal delivery ($395), surgical injury ($997), emergency hysterectomy after cesarean delivery ($1,547), infection after cesarean delivery ($171), and blood transfusion after cesarean delivery ($321).

Table 4. Estimates of Utility-Related Parameters

Parameter	*Base value*	*Range*[a]	*References*
Obstetric events			
Spontaneous vaginal delivery	0.92	0.69–1.00	117, 118
Instrumental vaginal delivery	0.76	0.57–0.95	117, 118
Emergency cesarean delivery	0.59	0.44–0.74	117, 118
Cesarean delivery on maternal request	0.91	0.50–0.99	117, 118
Maternal outcomes			
Peripartum hysterectomy[b] (regardless of mode of delivery)	0.605	0.3–0.81	13, 119
Infection[c] (regardless of mode of delivery) (first year after delivery)	0.995	0.972–0.999	12
Blood transfusion[c] (regardless of mode of delivery) (first year after delivery)	0.995	0.972–0.999	12
Surgical injury after cesarean delivery[c] (first year after delivery)	0.972	0.945–0.995	12
Maternal death	0	–	Authors' assumption
Neonatal outcomes			
Postbirth respiratory problem[d]	0.99	0.70–0.99	120
Neonatal death	0.01	0–0.02	117, 120
Pelvic floor disorders[e]			
Stress urinary incontinence (SUI)	0.81	0.60–1	106
After successful surgical treatment for SUI	0.870	0.689–1	121
Pelvic organ prolapse (POP)	0.7067	0.4677–0.9457	122
After successful surgical treatment for POP	0.949	0.782–1	121
Fecal incontinence (FI)	0.50	0.40–0.65	13
After successful surgical treatment for FI	0.943	0.821–1	121

[a]Plausible ranges of the parameters were determined based on data from the literature or ±25% of the base value if no range was available from the literature.
[b]We assumed that the disutility of hysterectomy lasts for the woman's entire lifetime.
[c]Chung et al.[12] estimated the per diem disutility of infection to be 0.48 and a duration of disutility for 4 days. We assumed the same per diem disutility value (i.e., 0.48) for infection, blood transfusion, and surgical injury. For infection and blood transfusion, we varied the event duration from 1 to 21 days and use 4 days as base case. For surgical injury, we varied the duration of disutility from 4 to 42 days and use 21 days as base case.
[d]We used the disutility of admission to neonatal nursery as a proxy measure for the disutility associated with postbirth respiratory problem.
[e]When data on the Pelvic Floor Impact Questionnaire (PFIQ) were used, we assumed linear relationship between the FPIQ score and utility score.

statistically meaningful difference in our findings.) Lost productivity in the event of maternal and neonatal death was estimated based on a work life from age 25 to 65 and 18 to 65 for the mother and the child, respectively. For PFDs, we only modeled the routine care cost, diagnostic evaluation and surgery costs, and productivity loss for the subset of women who actively seek healthcare for the condition (used as an indicator for having bothersome symptoms) because some women may not have symptoms bothersome enough to entail such costs. Behavioral and pharmacological therapies of PFDs were not included in the model because of their relatively lower cost compared with surgical treatment and the limited availability of such data for FI and POP. Moreover, costs associated with reoperations for PFDs were not considered because of a lack of quality data on the timing of such reoperations. All cost estimates were adjusted to 2007 U.S. dollars.[125] Future costs were discounted to the time at childbirth using a 3% discount rate.

Effectiveness was measured by quality-adjusted life-years (QALYs) over the combined lifetime of the mother and the newborn. QALYs were computed by multiplying the number of expected life-years in each health state by the utility associated with that health state. Our model assumed the utility for maternal outcomes was independent from the utility for neonatal outcomes and the QALYs were additive. For example, we assumed the utility of maternal death and the utility of a healthy neonate after cesarean delivery were independent, such that each future year in the woman's and the newborn's life was counted as 0 and 1 QALY, respectively, with the overall QALYs being the sum of the numbers. For concurrent maternal outcomes (e.g., maternal infection and surgical injury), we assumed the utilities were independent and multiplicative. Only women actively seeking healthcare for a PFD condition were assumed to incur disutility. QALY estimates later in life were discounted to the time at childbirth using a 3% discount rate.

Data analysis

We used Monte Carlo simulation ($n = 5000$ iterations) to determine the expected cost and expected QALY throughout the lifetime of the woman and newborn for CDMR and TOL, respectively. Monte Carlo simulation is a method of using repeated random sampling to compute the results. Possible values of each input parameter were defined by a prespecified distribution. In each iteration, a random set of values for all input parameters was drawn from such prespecified distributions, entered in the model, and used to calculate the outcome measures. By doing so, the simulation accounted for the variability of parameter values and identified important factors influencing the cost-effectiveness outcome.

We simultaneously varied the value of 79 parameters from five domains: actual mode of delivery, transient maternal morbidity and mortality, paripartum hysterectomy,

perinatal morbidity and mortality, and the lifelong management of PFDs (i.e., all parameters with a specified range in Tables 1, 2, 3, and 4). We assumed a RiskPert distribution for the probability and utility parameters (a special form of beta distribution).[126] The base value identified for each parameter (Tables 1 and 4) corresponded to the mode of the RiskPert distribution. We also assumed that the lower and upper bounds of the parameters covered 95% of the values for the underlying distribution. For cost parameters, we drew on the desirable property of lognormal distributions (e.g., skewed distribution, positive and unbounded range).[127] The parameter base value (Table 3) corresponded to the mode of the lognormal distribution, and the natural logs of the lower and upper bounds of the parameter were assumed to cover 95% of the values for the underlying normal distribution. We applied truncated lognormal distributions to age parameters in a similar manner except they were subject to certain minimum and maximum values, such as minimum age of 25 (i.e., age at delivery) and maximum age of 81 (i.e., 25 plus the life expectancy of American women at age 25) for onset of PFDs.

With 5000 iterations of data, the mean and 95% confidence intervals (CIs) for the expected cost and QALY associated with CDMR and TOL, respectively, were calculated. We also estimated the mean and 95% CIs for the expected incremental cost (i.e., CDMR cost − TOL cost), incremental QALY (i.e., CDMR QALY − TOL QALY), the average cost-effectiveness ratios (i.e., CDMR cost/CDMR QALY, TOL cost/TOL QALY), and the incremental cost-effectiveness ratio (ICER) (i.e., incremental cost divided by incremental QALY). An incremental cost-effectiveness plane and cost-effectiveness acceptability curve also were constructed to assess the probability distribution of the ICER. Because cost and ICER measures are typically not normally distributed and our results also suggested skewed distribution of QALY data, we estimated the 95% CIs based on a nonparametric method using the 2.5th and 97.5th percentiles.[128] DecisionTools Suite® software (Palisade Corporation, Ithaca, NY) and SAS 9.1 (SAS Institute Inc., Cary, NC) were used for data analysis.

Results

For a primigravid woman without medical or obstetric indications having only one childbirth in her lifetime, Monte Carlo simulation suggested that, on average, CDMR would cost $14,259 (95% CI $8,964-$24,002) over the combined lifetime of the mother and newborn, whereas TOL would cost $13,283 (95% CI $7,861-$23,829) (Table 5). The estimated mean incremental cost of CDMR (compared with TOL) was $976 (95% CI −$7,863-$7,935). In terms of QALY, undergoing CDMR would result in 58.21 QALYs (95% CI 57.43-58.67) over the lifetime of the mother and the newborn, and TOL was expected to generate 57.87 QALYs (95% CI 56.97-58.46). The estimated mean incremental QALY of CDMR (compared with TOL) was 0.35 (95% CI −0.24-1.10). Because the confidence intervals of both the estimated mean incremental cost and incremental QALY contain zero, there was no statistically significant difference in the expected cost or expected QALY between CDMR and TOL at the 0.05 level.

Figure 2 shows the incremental cost-effectiveness plane, which plots the joint distribution of the incremental cost and incremental QALY. Each dot on the plane corresponds to one incremental cost and QALY pair resulting from one iteration of the simulation. The incremental cost and QALY pairs were largely distributed across each quadrant of the incremental cost-effectiveness plane, primarily in the first,

Table 5. Summary of Results from Monte Carlo Simulation

Monte Carlo simulation	*Trial of labor*	*Cesarean delivery on maternal request (CDMR)*[a]
Cost, mean (95% CI[a])	$13,283 ($7,861-$23,829)	$14,259 ($8,964-$24,002)
Quality-adjusted life-years (QALY), mean (95% CI)	57.87 (56.97-58.46)	58.21 (57.43-58.67)
Average cost-effectiveness ratio, mean (95% CI)	$230/QALY ($135/QALY-$414/QALY)	$245/QALY ($153/QALY-$417/QALY)
ΔCost,[b] mean (95% CI)	$976 (−$7,863-$7,935)	
ΔQALY,[c] mean (95% CI)	0.35 (−0.24-1.10)	

Most significant parameters[d]	*Effect of 1 SD*[e] *increase in parameter on ΔCost*[b]	*Effect of 1 SD*[e] *increase in parameter on ΔQALY*[c]
Probability of stress urinary incontinence (SUI) after CDMR (SD[e] = 0.09)	$2,509	−0.17
Probability of SUI after spontaneous vaginal delivery (SD[e] = 0.07)	−$1,711	0.10
Cost of neonatal morbidity (SD[e] = 47,589)	$924	n/a
Cost of CDMR (SD[e] = 625)	$625	n/a
Annual routine care cost for SUI (SD[e] = 1,009)	−$1,080	n/a
Age of pelvic floor disorder onset (SD[e] = 5.20)	$817	−0.11
Utility of CDMR (SD[e] = 0.13)	n/a	0.13
Utility of pelvic organ prolapse (SD[e] = 0.13)	n/a	−0.09
Utility of SUI (SD[e] = 0.10)	n/a	−0.10

[a]CI, confidence interval.
[b]ΔCost, cost of CDMR − cost of trial of labor.
[c]ΔQALY, QALY of CDMR − QALY of trial of labor.
[d]All these parameters are statistically significant at 0.05 level.
[e]SD, standard deviation. These are estimated SDs of the parameters based on the simulation ($n = 5000$ iterations).

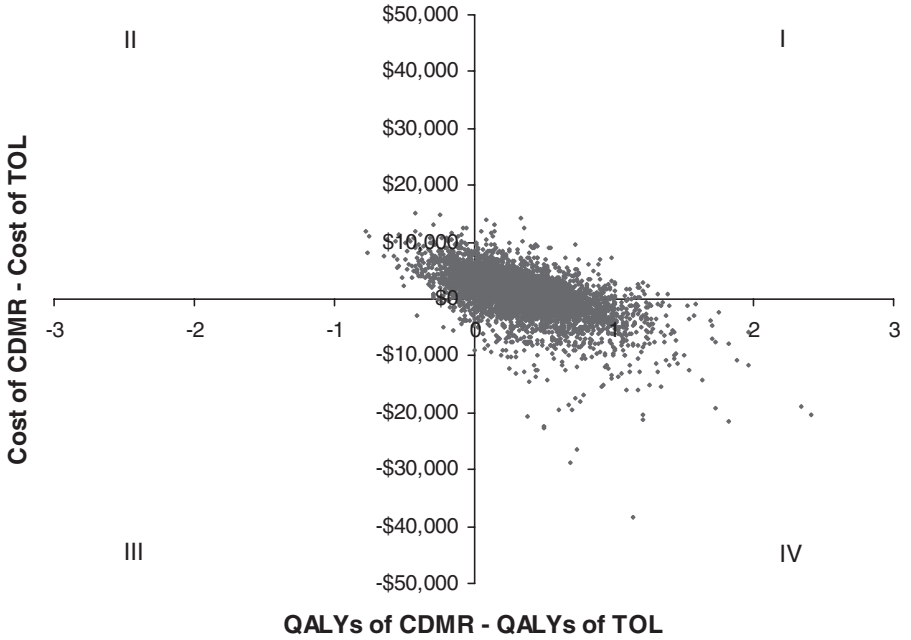

FIG. 2. Incremental cost-effectiveness plane. The horizontal axis represents the difference in quality-adjusted life-years (QALYs) between cesarean delivery on maternal request (CDMR) and trial of labor (TOL) (i.e., incremental QALY). The vertical axis represents the difference in the costs between CDMR and TOL (i.e., incremental cost). Each dot in the figure corresponds to one incremental cost and incremental QALY pair resulting from one iteration of the Monte Carlo simulation.

second, and fourth quadrants. In 12.14% of the iterations, CDMR was dominated by TOL (i.e., CDMR was more costly and less effective than TOL), whereas in 33.32% of the iterations, CDMR was the dominant strategy, with higher QALY and lower cost. In the other 54.54% of the iterations, one delivery scheme was less costly and the other generated higher QALY, with significant variability in the magnitude of the ICER (95% CI $352/QALY-$220,496/QALY).

Figure 3 illustrates the probability that CDMR is cost-effective compared with TOL for a given cutoff cost-effectiveness ratio that a society is willing to pay. For example, if a society is willing to pay $50,000 for one QALY, there is an 82% chance that undergoing CDMR is cost-effective compared with TOL (i.e., there is an 82% chance that the additional cost of CDMR is $<$ $50,000 for each additional QALY gained). The null hypothesis that there is no net benefit of CDMR is rejected only when the cost-effectiveness

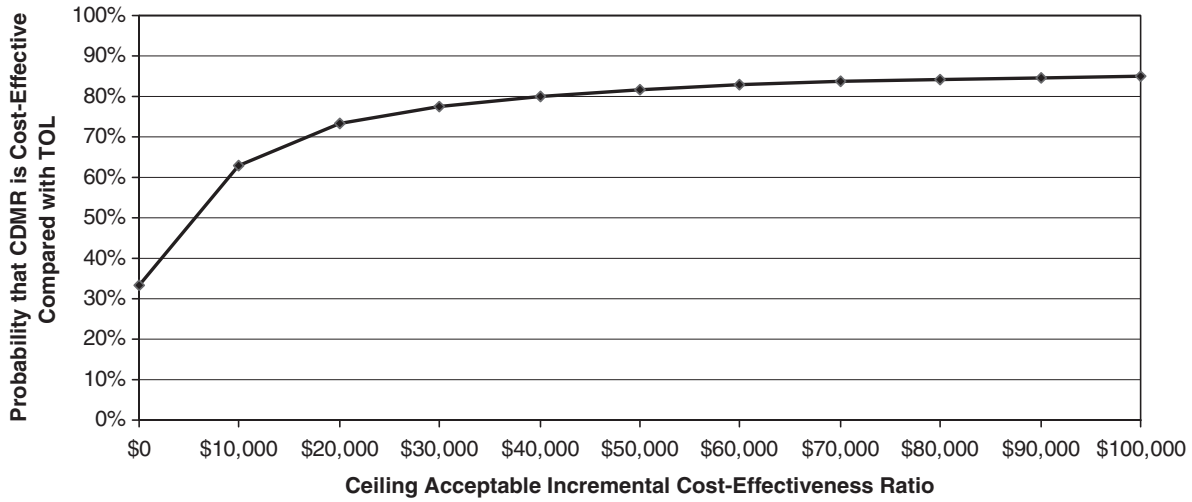

FIG. 3. Cost-effectiveness acceptability curve. This figure illustrates the probability that cesarean delivery on maternal request (CDMR) is cost-effective compared with trial of labor (TOL) for a given cutoff cost-effectiveness ratio that a society is willing to pay. For example, if a society is willing to pay $50,000 for one QALY, there is an 82% chance that undergoing CDMR is cost-effective (i.e., there is an 82% chance that the additional cost of CDMR is $<$ $50,000 for each additional QALY gained).

acceptability curve is above 95%.[129] In our simulation, the probability of CDMR being cost-effective never exceeded 88% for any cutoff cost-effectiveness ratio. Therefore, we could not reject the null hypothesis that there was no net benefit of CDMR in comparison to TOL.

Table 5 reports the factors identified as most influential in the simulation and their estimated effects on the incremental cost and QALY. The cost of CDMR and neonatal morbidity significantly affected the incremental cost between CDMR and TOL. PFD-related parameters also were found important. For example, based on the simulation data, a 1 standard deviation (SD) increase in the probability of developing SUI after CDMR was associated with a $2,509 increase in the incremental cost and a 0.17 reduction in incremental QALY. In contrast, a 1 SD increase in the probability of developing SUI after spontaneous vaginal delivery resulted in a $1,711 reduction in the incremental cost and a 0.10 increase in incremental QALY. In addition, the age of PFD onset, women's perceived quality of life when having POP or SUI, and the annual routine care cost for SUI all influenced the expected incremental cost and QALY between CDMR and TOL.

Discussion

There has been a growing debate surrounding the appropriateness of CDMR, especially in view of the recent substantial increase in cesarean delivery rate in the United States. Using currently available evidence, we assessed the lifetime cost-effectiveness of CDMR compared with TOL from a societal perspective. Our results showed that for primigravid women without medical or obstetric indications and with only one childbirth over their lifetime, CDMR and TOL are associated with comparable costs and QALYs. Moreover, PFD-related parameters were found to be important factors in the cost-effectiveness assessment.

By modeling the impact of delivery mode on lifelong PFD outcomes, this study provides a more comprehensive view of the long-term cost and quality of life consequences of CDMR among primigravid women who have no medical or obstetric indications and do not go on to have future deliveries. The model structure developed in this analysis can be used as a basis for future cost-effectiveness analyses of CDMR that include multiple deliveries.

Although prevention of PFDs is a frequently cited reason for requesting or performing CDMR, our analyses suggest that even after considering the long-term pelvic floor consequences, CDMR is not superior to TOL in terms of lifelong cost and quality of life for a primigravid woman without medical or obstetric indications having only one childbirth over her lifetime. However, our findings also imply that CDMR is not worse than TOL in this subpopulation of women. This is consistent with the NIH State-of-the-Science statement that there are "relatively similar degrees of risk from both pathways in women intending to limit their childbearing to one or two children."[3]

Our finding, however, should not be generalized to women with multiple childbirths. Women with a primary cesarean delivery face increased risk for complications in subsequent pregnancies.[2] This could substantially increase the cost while reducing QOL for women undergoing CDMR. Similarly, women with more than one vaginal delivery are at higher risk for PFDs, which could increase the lifetime cost while reducing the QALY for TOL patients. The overall impact of additional childbirths on the cost-effectiveness of CDMR will require further investigation as more data become available about maternal and neonatal outcomes associated with different modes of delivery at successive childbirths. Further, the cost-effectiveness of CDMR will likely differ for women with medical indications or in certain high-risk situations. For example, a planned cesarean delivery may prove beneficial for preterm or postterm births by preventing serious morbidity and mortality during labor. Further research analyzing this issue for subsets of women with certain indications would inform whether there are specific subpopulations who may benefit from CDMR.

The framework of cost-effectiveness analysis offers a unique opportunity to identify gaps in the current literature about CDMR and its relationship with PFDs. For example, we located only two studies examining women's utility related to their delivery experience and outcomes.[117,118] This makes it difficult to evaluate the implications of CDMR for women's quality of life. In addition, the PFD-related parameters were found to be significant factors in our model; yet there is a fair amount of uncertainty surrounding these parameters. Future research providing better estimates of these parameters would facilitate more elaborated comparisons between CDMR and TOL.

Several additional factors must be kept in mind when interpreting our findings. First, to streamline the analytical model, we did not consider coexisting PFDs. Consequently, we might have overestimated the cost related to the care of PFDs, biasing our results in favor of CDMR. This could also cause underestimation of disutility associated with PFDs, however, biasing the QALY estimates in favor of TOL. Second, although there is evidence that forceps delivery may be more likely than vacuum delivery to cause PFDs,[130] our analysis could not stratify on these two types of instrumental vaginal delivery because of a lack of detailed data.

Conclusions

This study makes an important first step toward addressing a complicated question: Is cesarean delivery on maternal request more cost-effective than trial of labor when lifelong pelvic floor consequences are considered? Our results suggest that in the absence of medical and obstetric indications, CDMR and TOL are not significantly different from each other in terms of lifelong cost and QALY for primigravid women having only one childbirth over their lifetime. Women's QOL related to delivery experience and the PFD-related factors should be studied more closely and incorporated in future decision analyses. This will help advance the understanding of the complex relationship between childbirth and long-term maternal outcomes and allow for more informed clinical and policy recommendations.

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Disclosure Statement

The authors have no conflicts of interest to report.

References

1. Sakala C, Corry MP. Evidence-based maternity care: What it is and what it can achieve. New York: Childbirth Connection, Reforming States Group, Milbank Memorial Fund, 2008. Available at www.childbirthconnection.org/pdf.asp?PDFDownload=evidence-based-maternity-care Accessed November 5, 2008.
2. ACOG Committee Opinion No. 386: Cesarean delivery on maternal request. Obstet Gynecol 2007;110:1209–1212.
3. The National Institutes of Health. National Institutes of Health State-of-the-Science Conference statement: Cesarean delivery on maternal request March 27–29, 2006. Obstet Gynecol 2006;107:1386–1397.
4. Hamilton BE, Martin JA, Ventura SJ. Births: Preliminary data for 2006. National Vital Statistics Reports, vol 56, No. 7. Hyattsville, MD: National Center for Health Statistics, 2007.
5. Buhling KJ, Schmidt S, Robinson JN, Klapp C, Siebert G, Dudenhausen JW. Rate of dyspareunia after delivery in primiparae according to mode of delivery. Eur J Obstet Gynecol Reprod Biol 2006;124:42–46.
6. Wax JR, Cartin A, Pinette MG, Blackstone J. Patient choice cesarean: An evidence-based review. Obstet Gynecol Surv 2004;59:601–616.
7. Penna L, Arulkumaran S. Cesarean section for non-medical reasons. Int J Gynaecol Obstet 2003;82:399–409.
8. Nygaard I, Barber MD, Burgio KL, et al. Prevalence of symptomatic pelvic floor disorders in U.S. women. JAMA 2008;300:1311–1316.
9. Hu TW, Wagner TH, Bentkover JD, Leblanc K, Zhou SZ, Hunt T. Costs of urinary incontinence and overactive bladder in the United States: A comparative study. Urology 2004;63:461–465.
10. Brown JS, Waetjen LE, Subak LL, Thom DH, Van den Eeden S, Vittinghoff E. Pelvic organ prolapse surgery in the United States, 1997. Am J Obstet Gynecol 2002;186:712–716.
11. Boyles SH, Weber AM, Meyn L. Procedures for pelvic organ prolapse in the United States, 1979–1997. Am J Obstet Gynecol 2003;188:108–115.
12. Chung A, Macario A, El-Sayed YY, Riley ET, Duncan B, Druzin ML. Cost-effectiveness of a trial of labor after previous cesarean. Obstet Gynecol 2001;97:932–941.
13. Culligan PJ, Myers JA, Goldberg RP, Blackwell L, Gohmann SF, Abell TD. Elective cesarean section to prevent anal incontinence and brachial plexus injuries associated with macrosomia—A decision analysis. Int Urogynecol J Pelvic Floor Dysfunct 2005;16:19–28.
14. Gold MR, Siegel JE, Russell LB, Weinstein MC. Cost-effectiveness in health and medicine. New York: Oxford University Press, 1996.
15. Manuel MR, Chen LM, Caughey AB, et al. Cost-effectiveness analyses in gynecologic oncology: Methodological quality and trends. Gynecol Oncol 2004;93:1–8.
16. Van Voorhis BJ. Evaluating economic studies in reproductive medicine. Semin Reprod Med 2003;21:85–93.
17. Grobman WA. Decision analysis in obstetrics and gynecology. Obstet Gynecol Surv 2006;61:602–607.
18. Haddix AC, Teutsch SM, Corso PS. Prevention effectiveness: A guide to decision analysis and economic evaluation. New York: Oxford University Press, 2003.
19. Martin J, Hamilton B, Sutton P, Ventura SJ, Menacker F, Munson ML. Births: Final data for 2003. National Vital Statistics Reports, vol 54 No. 2. Hyattsville, MD: National Center for Health Statistics, 2005.
20. Dye J. Fertility of American women (data from the June 2004 Supplement of the CPS). Washington, DC: U.S. Census Bureau. 2005. Available at www.census.gov/prod/2005pubs/p20-555.pdf
21. Norton P, Brubaker L. Urinary incontinence in women. Lancet 2006;367:57–67.
22. Landefeld CS, Bowers BJ, Feld AD, et al. National Institutes of Health state-of-the-science conference statement: Prevention of fecal and urinary incontinence in adults. Ann Intern Med 2008;148:449–458.
23. Boreham MK, Richter HE, Kenton KS, et al. Anal incontinence in women presenting for gynecologic care: Prevalence, risk factors, and impact upon quality of life. Am J Obstet Gynecol 2005;192:1637–1642.
24. Visco AG, Viswanathan M, Lohr KN, et al. Cesarean delivery on maternal request: Maternal and neonatal outcomes. Obstet Gynecol 2006;108:1517–1529.
25. Liu S, Liston RM, Joseph KS, Heaman M, Sauve R, Kramer MS. Maternal mortality and severe morbidity associated with low-risk planned cesarean delivery versus planned vaginal delivery at term. Can Med Assoc J 2007;176:455–460.
26. Silver RM, Landon MB, Rouse DJ, et al. Maternal morbidity associated with multiple repeat cesarean deliveries. Obstet Gynecol 2006;107:1226–1232.
27. Whiteman MK, Kuklina E, Hillis SD, et al. Incidence and determinants of peripartum hysterectomy. Obstet Gynecol 2006;108:1486–1492.
28. Menacker F, Declercq E, Macdorman MF. Cesarean delivery: Background, trends, and epidemiology. Semin Perinatol 2006;30:235–241.
29. Smith GC, Pell JP, Cameron AD, et al. Risk of perinatal death associated with labor after previous cesarean delivery in uncomplicated term pregnancies. JAMA 2002;287:2684–2690.
30. Declercq E, Barger M, Cabral HJ, et al. Maternal outcomes associated with planned primary cesarean births compared with planned vaginal births. Obstet Gynecol 2007;109:669–677.
31. Koroukian SM. Relative risk of postpartum complications in the Ohio Medicaid population: Vaginal versus cesarean delivery. Med Care Res Rev 2004;61:203–224.
32. Kozak LJ, Weeks JD. U.S. trends in obstetric procedures, 1990–2000. Birth 2002;29:157–161.
33. Hall MH. Variation in caesarean section rate. Maternal mortality higher after caesarean section. BMJ 1994;308:654–655.
34. Hall MH, Bewley S. Maternal mortality and mode of delivery. Lancet 1999;354:776.
35. Demissie K, Rhoads GG, Smulian JC, et al. Operative vaginal delivery and neonatal and infant adverse outcomes: Population-based retrospective analysis. BMJ 2004;329:24–29.

36. Towner D, Castro MA, Eby-Wilkens E, Gilbert WM. Effect of mode of delivery in nulliparous women on neonatal intracranial injury. N Engl J Med 1999;341:1709–1714.
37. Wen SW, Liu S, Kramer MS, et al. Comparison of maternal and infant outcomes between vacuum extraction and forceps deliveries. Am J Epidemiol 2001;153:103–107.
38. MacDorman MF, Declercq E, Menacker F, Malloy MH. Neonatal mortality for primary cesarean and vaginal births to low-risk women: Application of an "intention-to-treat" model. Birth 2008;35:3–8.
39. Allen V, O'Connell C, Baskett T. Maternal morbidity associated with cesarean delivery without labor compared with induction of labor at term. Obstet Gynecol 2006;108:286–294.
40. Allen VM, O'Connell CM, Liston RM, Baskett TF. Maternal morbidity associated with cesarean delivery without labor compared with spontaneous onset of labor at term. Obstet Gynecol 2003;102:477–482.
41. Burrows LJ, Meyn LA, Weber AM. Maternal morbidity associated with vaginal versus cesarean delivery. Obstet Gynecol 2004;103:907–912.
42. Forna F, Miles AM, Jamieson DJ. Emergency peripartum hysterectomy: A comparison of cesarean and postpartum hysterectomy. Am J Obstet Gynecol 2004;190:1440–1444.
43. Simoes E, Kunz S, Bosing-Schwenkglenks M, Schmahl FM. Association between method of delivery, puerperal complication rate and postpartum hysterectomy. Arch Gynecol Obstet 2005;272:43–47.
44. Lydon-Rochelle M, Holt VL, Martin DP, Easterling TR. Association between method of delivery and maternal rehospitalization. JAMA 2000;283:2411–2416.
45. Farrell SA, Allen VM, Baskett TF. Parturition and urinary incontinence in primiparas. Obstet Gynecol 2001;97:350–356.
46. Fritel X, Fauconnier A, Levet C, Benifla JL. Stress urinary incontinence 4 years after the first delivery: A retrospective cohort survey. Acta Obstet Gynecol Scand 2004;83:941–945.
47. MacLennan AH, Taylor AW, Wilson DH, Wilson D. The prevalence of pelvic floor disorders and their relationship to gender, age, parity and mode of delivery. Br J Obstet Gynaecol 2000;107:1460–1470.
48. Peschers UM, Sultan AH, Jundt K, Mayer A, Drinovac V, Dimpfl T. Urinary and anal incontinence after vacuum delivery. Eur J Obstet Gynecol Reprod Biol 2003;110:39–42.
49. Schytt E, Lindmark G, Waldenstrom U. Symptoms of stress incontinence 1 year after childbirth: Prevalence and predictors in a national Swedish sample. Acta Obstet Gynecol Scand 2004;83:928–936.
50. Lukacz ES, Lawrence JM, Contreras R, Nager CW, Luber KM. Parity, mode of delivery, and pelvic floor disorders. Obstet Gynecol 2006;107:1253–1260.
51. Faltin DL, Sangalli MR, Roche B, Floris L, Boulvain M, Weil A. Does a second delivery increase the risk of anal incontinence? Br J Obstet Gynaecol 2001;108:684–688.
52. MacArthur C, Bick DE, Keighley MR. Faecal incontinence after childbirth. Br J Obstet Gynaecol 1997;104:46–50.
53. Sultan AH, Kamm MA, Bartram CI, Hudson CN. Anal sphincter trauma during instrumental delivery. Int J Gynaecol Obstet 1993;43:263–270.
54. Dani C, Reali MF, Bertini G, et al. Risk factors for the development of respiratory distress syndrome and transient tachypnoea in newborn infants. Italian Group of Neonatal Pneumology. Eur Respir J 1999;14:155–159.
55. Abramov Y, Sand PK, Botros SM, et al. Risk factors for female anal incontinence: New insight through the Evanston-Northwestern twin sisters study. Obstet Gynecol 2005;106:726–732.
56. Bahl R, Strachan B, Murphy DJ. Pelvic floor morbidity at 3 years after instrumental delivery and cesarean delivery in the second stage of labor and the impact of a subsequent delivery. Am J Obstet Gynecol 2005;192:789–794.
57. Lydon-Rochelle M, Holt VL, Easterling TR, Martin DP. Cesarean delivery and postpartum mortality among primiparas in Washington State, 1987–1996(1). Obstet Gynecol 2001;97:169–174.
58. Allen VM, O'Connell CM, Baskett TF. Maternal and perinatal morbidity of caesarean delivery at full cervical dilatation compared with caesarean delivery in the first stage of labour. Br J Obstet Gynaecol 2005;112:986–990.
59. Bergholt T, Stenderup JK, Vedsted-Jakobsen A, Helm P, Lenstrup C. Intraoperative surgical complication during cesarean section: An observational study of the incidence and risk factors. Acta Obstet Gynecol Scand 2003;82:251–256.
60. Gregory KD, Henry OA, Ramicone E, Chan LS, Platt LD. Maternal and infant complications in high and normal weight infants by method of delivery. Obstet Gynecol 1998;92:507–513.
61. van Ham MA, van Dongen PW, Mulder J. Maternal consequences of caesarean section. A retrospective study of intra-operative and postoperative maternal complications of caesarean section during a 10-year period. Eur J Obstet Gynecol Reprod Biol 1997;74:1–6.
62. Rortveit G, Daltveit AK, Hannestad YS, Hunskaar S. Urinary incontinence after vaginal delivery or cesarean section. N Engl J Med 2003;348:900–907.
63. Lal M, Mann CH, Callender R, Radley S. Does cesarean delivery prevent anal incontinence? Obstet Gynecol 2003;101:305–312.
64. Levine EM, Ghai V, Barton JJ, Strom CM. Mode of delivery and risk of respiratory diseases in newborns. Obstet Gynecol 2001;97:439–442.
65. Morrison JJ, Rennie JM, Milton PJ. Neonatal respiratory morbidity and mode of delivery at term: Influence of timing of elective caesarean section. Br J Obstet Gynaecol 1995;102:101–106.
66. Foley ME, Alarab M, Daly L, Keane D, Rath A, O'Herlihy C. The continuing effectiveness of active management of first labor, despite a doubling in overall nulliparous cesarean delivery. Am J Obstet Gynecol 2004;191:891–895.
67. Gilbert WM, Hicks SM, Boe NM, Danielsen B. Vaginal versus cesarean delivery for breech presentation in California: A population-based study. Obstet Gynecol 2003;102:911–917.
68. Gould JB, Danielsen B, Korst LM, et al. Cesarean delivery rates and neonatal morbidity in a low-risk population. Obstet Gynecol 2004;104:11–19.
69. MacDorman MF, Declercq E, Menacker F, Malloy MH. Infant and neonatal mortality for primary cesarean and vaginal births to women with "no indicated risk," United States, 1998–2001 Birth Cohorts. Birth 2006;33:175–182.
70. Allen VM, O'Connell CM, Farrell SA, Baskett TF. Economic implications of method of delivery. Am J Obstet Gynecol 2005;193:192–197.
71. McKinnie V, Swift SE, Wang W, et al. The effect of pregnancy and mode of delivery on the prevalence of urinary and fecal incontinence. Am J Obstet Gynecol 2005;193:512–517.
72. Zanardo V, Simbi AK, Franzoi M, Solda G, Salvadori A, Trevisanuto D. Neonatal respiratory morbidity risk and

mode of delivery at term: Influence of timing of elective caesarean delivery. Acta Paediatr 2004;93:643–647.
73. Morrill M, Lukacz ES, Lawrence JM, Nager CW, Contreras R, Luber KM. Seeking healthcare for pelvic floor disorders: A population-based study. Am J Obstet Gynecol 2007;197: 86.e1–86.e6.
74. Kinchen KS, Long S, Orsini L, Crown W, Bump RC. Healthcare utilization among women who undergo surgery for stress urinary incontinence. Int Urogynecol J Pelvic Floor Dysfunct 2004;15:154–159.
75. Chene G, Amblard J, Tardieu AS, et al. Long-term results of tension-free vaginal tape (TVT) for the treatment of female urinary stress incontinence. Eur J Obstet Gynecol Reprod Biol 2007;134:87–94.
76. Mammen C, Chilaka V, Cust MP. Urological surgical techniques. Best Pract Res Clin Obstet Gynaecol 2006;20: 139–156.
77. Ministry of Health and Long-term Care. Tension-free vaginal tape for stress urinary incontinence. Health technology literature review. Available at www.health.gov.on.ca/english/providers/program/mas/tech/reviews/sum_tvt_020104.html#2. Accessed May 25, 2006.
78. Nilsson CG, Kuuva N, Falconer C, Rezapour M, Ulmsten U. Long-term results of the tension-free vaginal tape (TVT) procedure for surgical treatment of female stress urinary incontinence. Int Urogynecol J Pelvic Floor Dysfunct 2001;12 (Suppl 2):S5–8.
79. Schraffordt Koops SE, Bisseling TM, Heintz AP, Vervest HA. The effectiveness of tension-free vaginal tape (TVT) and quality of life measured in women with previous urogynecologic surgery: Analysis from The Netherlands TVT database. Am J Obstet Gynecol 2006;195:439–444.
80. Ulmsten U, Henriksson L, Johnson P, Varhos G. An ambulatory surgical procedure under local anesthesia for treatment of female urinary incontinence. Int Urogynecol J Pelvic Floor Dysfunct 1996;7:81–85.
81. Valpas A, Kivela A, Penttinen J, et al. Tension-free vaginal tape and laparoscopic mesh colposuspension in the treatment of stress urinary incontinence: Immediate outcome and complications—A randomized clinical trial. Acta Obstet Gynecol Scand 2003;82:665–671.
82. Ward KL, Hilton P. A prospective multicenter randomized trial of tension-free vaginal tape and colposuspension for primary urodynamic stress incontinence: two-year follow-up. Am J Obstet Gynecol 2004;190:324–331.
83. Carey MP, Slack MC. Transvaginal sacrospinous colpopexy for vault and marked uterovaginal prolapse. Br J Obstet Gynaecol 1994;101:536–540.
84. Hefni MA, El-Toukhy TA. Long-term outcome of vaginal sacrospinous colpopexy for marked uterovaginal and vault prolapse. Eur J Obstet Gynecol Reprod Biol 2006;127: 257–263.
85. Juma S. Anterior vaginal suspension for vaginal vault prolapse. Tech Urol 1995;1:150–156.
86. Lovatsis D, Drutz HP. Safety and efficacy of sacrospinous vault suspension. Int Urogynecol J Pelvic Floor Dysfunct 2002;13:308–313.
87. Maher CF, Cary MP, Slack MC, Murray CJ, Milligan M, Schluter P. Uterine preservation or hysterectomy at sacrospinous colpopexy for uterovaginal prolapse? Int Urogynecol J Pelvic Floor Dysfunct 2001;12:381–384.
88. Nygaard IE, McCreery R, Brubaker L, et al. Abdominal sacrocolpopexy: A comprehensive review. Obstet Gynecol 2004;104:805–823.
89. Olsen AL, Smith VJ, Bergstrom JO, Colling JC, Clark AL. Epidemiology of surgically managed pelvic organ prolapse and urinary incontinence. Obstet Gynecol 1997;89: 501–506.
90. Johanson JF, Lafferty J. Epidemiology of fecal incontinence: The silent affliction. Am J Gastroenterol 1996;91:33–36.
91. Bliss DZ, Fischer LR, Savik K. Managing fecal incontinence: Self-care practices of older adults. J Gerontol Nurs 2005;31: 35–44.
92. Demirci S, Gallas S, Bertot-Sassigneux P, Michot F, Denis P, Leroi AM. Anal incontinence: The role of medical management. Gastroenterol Clin Biol 2006;30:954–960.
93. Bravo Gutierrez A, Madoff RD, Lowry AC, Parker SC, Buie WD, Baxter NN. Long-term results of anterior sphincteroplasty. Dis Colon Rectum 2004;47:727–731.
94. Halverson AL, Hull TL. Long-term outcome of overlapping anal sphincter repair. Dis Colon Rectum 2002;45: 345–348.
95. Karoui S, Leroi AM, Koning E, Menard JF, Michot F, Denis P. Results of sphincteroplasty in 86 patients with anal incontinence. Dis Colon Rectum 2000;43:813–820.
96. Malouf AJ, Norton CS, Engel AF, Nicholls RJ, Kamm MA. Long-term results of overlapping anterior anal-sphincter repair for obstetric trauma. Lancet 2000;355:260–265.
97. Trowbridge ER, Morgan D, Trowbridge MJ, DeLancey JO, Fenner DE. Sexual function, quality of life, and severity of anal incontinence after anal sphincteroplasty. Am J Obstet Gynecol 2006;195:1753–1757.
98. Centers for Medicare and Medicaid Services. 2007 Medicare payment schedule. Available at www.cms.hhs.gov/home/medicare.asp Accessed May 30, 2007.
99. Vahratian A, Zhang J, Hasling J, Troendle JF, Klebanoff MA, Thorp JM Jr. The effect of early epidural versus early intravenous analgesia use on labor progression: A natural experiment. Am J Obstet Gynecol 2004;191:259–265.
100. Vahratian A, Zhang J, Troendle JF, Sciscione AC, Hoffman MK. Labor progression and risk of cesarean delivery in electively induced nulliparas. Obstet Gynecol 2005;105: 698–704.
101. Guillemette J, Fraser WD. Differences between obstetricians in caesarean section rates and the management of labour. Br J Obstet Gynaecol 1992;99:105–108.
102. Riley ET, Cohen SE, Macario A, Desai JB, Ratner EF. Spinal versus epidural anesthesia for cesarean section: A comparison of time efficiency, costs, charges, and complications. Anesth Analg 1995;80:709–712.
103. Bureau of Labor Statistics. Weekly and hourly earnings data from the Current Population Survey. Available at www.bls.gov/data/ Accessed May 29, 2007.
104. Arias E. United States life tables, 2003. National Vital Statistics Reports, vol 54, No. 14. Hyattsville, MD: National Center for Health Statistics, 2006.
105. Wilson L, Brown JS, Shin GP, Luc KO, Subak LL. Annual direct cost of urinary incontinence. Obstet Gynecol 2001;98: 398–406.
106. Subak LL, Brown J, Kraus S, et al. The "cost" of urinary incontinence for women. Obstet Gynecol 2006;107:908–916.
107. Waetjen LE, Subak LL, Shen H, et al. Stress urinary incontinence surgery in the United States. Obstet Gynecol 2003;101:671–676.
108. Fialkow MF, Newton KM, Lentz GM, Weiss NS. Lifetime risk of surgical management for pelvic organ prolapse or urinary incontinence. Int Urogynecol J Pelvic Floor Dysfunct 2008;19:437–440.

109. Subak LL, Waetjen LE, van den Eeden S, Thom DH, Vittinghoff E, Brown JS. Cost of pelvic organ prolapse surgery in the United States. Obstet Gynecol 2001;98:646–651.
110. Uma R, Libby G, Murphy DJ. Obstetric management of a woman's first delivery and the implications for pelvic floor surgery in later life. Br J Obstet Gynaecol 2005;112:1043–1046.
111. Mellgren A, Jensen LL, Zetterstrom JP, Wong WD, Hofmeister JH, Lowry AC. Long-term cost of fecal incontinence secondary to obstetric injuries. Dis Colon Rectum 1999;42:857–865.
112. Adang EM, Engel GL, Rutten FF, Geerdes BP, Baeten CG. Cost-effectiveness of dynamic graciloplasty in patients with fecal incontinence. Dis Colon Rectum 1998;41:725–733.
113. Deutekom M, Dobben AC, Dijkgraaf MG, Terra MP, Stoker J, Bossuyt PM. Costs of outpatients with fecal incontinence. Scand J Gastroenterol 2005;40:552–558.
114. Halverson AL, Hull TL, Paraiso MF, Floruta C. Outcome of sphincteroplasty combined with surgery for urinary incontinence and pelvic organ prolapse. Dis Colon Rectum 2001;44:1421–1426.
115. Deutekom M, Terra MP, Dobben AC, et al. Selecting an outcome measure for evaluating treatment in fecal incontinence. Dis Colon Rectum 2005;48:2294–2301.
116. Sung VW, Rogers ML, Myers DL, Akbari HM, Clark MA. National trends and costs of surgical treatment for female fecal incontinence. Am J Obstet Gynecol 2007;197:652.e1–5.
117. Vandenbussche FP, De Jong-Potjer LC, Stiggelbout AM, et al. Differences in the valuation of birth outcomes among pregnant women, mothers, and obstetricians. Birth 1999;26:178–183.
118. Turner CE, Young JM, Solomon MJ, et al. Vaginal delivery compared with elective caesarean section: The views of pregnant women and clinicians. Br J Obstet Gynaecol 2008;115:1494–1502.
119. Mankuta DD, Leshno MM, Menasche MM, Brezis MM. Vaginal birth after cesarean section: Trial of labor or repeat cesarean section? A decision analysis. Am J Obstet Gynecol 2003;189:714–719.
120. Pham CT, Crowther CA. Birth outcomes: Utility values that postnatal women, midwives and medical staff express. Br J Obstet Gynaecol 2003;110:121–127.
121. Barber MD, Walters MD, Bump RC. Short forms of two condition-specific quality-of-life questionnaires for women with pelvic floor disorders (PFDI-20 and PFIQ-7). Am J Obstet Gynecol 2005;193:103–113.
122. Wren PA, Janz NK, Brubaker L, et al. Reliability of health-related quality-of-life measures 1 year after surgical procedures for pelvic floor disorders. Am J Obstet Gynecol 2005;192:780–788.
123. Sale JS, Kollenberg K. The working parents handbook. New York: Simon and Schuster, 1996.
124. The U.S. Equal Employment Opportunity Commission. Pregnancy discrimination Available at www.eeoc.gov/types/pregnancy.html Accessed May 20, 2009.
125. Bureau of Labor Statistics. Consumer price index—All urban consumers. Available at www.bls.gov/data/home.htm Accessed December 31, 2007.
126. Palisade Corporation. Guide to using @RISK: Risk analysis and simulation add-in for Microsoft Excel. Ithaca, NY: Microsoft, 2008.
127. Doubilet P, Begg CB, Weinstein MC, et al. Probabilistic sensitivity analysis using Monte Carlo simulation. A practical approach. Med Decis Making 1985;5:157–177.
128. Lord J, Asante MA. Estimating uncertainty ranges for costs by the bootstrap procedure combined with probabilistic sensitivity analysis. Health Econ 1999;8:323–333.
129. Lothgren M, Zethraeus N. Definition, interpretation and calculation of cost-effectiveness acceptability curves. Health Econ 2000;9:623–630.
130. Kearney R, Miller JM, Ashton-Miller JA, et al. Obstetric factors associated with levator ani muscle injury after vaginal birth. Obstet Gynecol 2006;107:144–149.

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