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Authors
Mei, Jenny Y
Mallampati, Divya
Pluym, Ilina D
et al.

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Complete List of Authors:	Mei, Jenny; University of California Los Angeles David Geffen School of Medicine, OB/GYN Mallampati, Divya; University of North Carolina at Chapel Hill, Obstetrics and Gynecology Pluym, Ilina; University of California Los Angeles, Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology Han, Christina; University of California Los Angeles David Geffen School of Medicine, Obstetrics and Gynecology; Center for Fetal Medicine & Women's Ultrasound, Center for Fetal Medicine Afshar, Yalda; University of California Los Angeles David Geffen School of Medicine, Obstetrics and Gynecology
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Twin Vaginal Deliveries in Labor Rooms: A Cost-Effectiveness Analysis

Jenny Y Mei, MD,[1] Divya Mallampati, MD,[2] Ilina D Pluym, MD,[1] Christina S Han, MD, [1,3]
Yalda Afshar, MD, PhD [1]

1. Division of Maternal Fetal Medicine, Department of Obstetrics and Gynecology, University of California, Los Angeles
2. Division of Maternal Fetal Medicine, Department of Obstetrics and Gynecology, University of North Carolina, Chapel Hill
3. Center for Fetal Medicine and Women's Ultrasound; Los Angeles, California

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***Corresponding Author**:

Yalda Afshar, MD, PhD

Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology

University of California, Los Angeles

200 Medical Plaza, Suite 430

Los Angeles, CA 90095-1740

Phone number: (310) 794-8492

Fax number: (310) 206-7186

E-mail: YAfshar@mednet.ucla.edu

ABSTRACT

Objective: Twin vaginal deliveries (VDs) are often performed in the operating room (OR) given the theoretical risk of conversion to cesarean delivery (CD) for the aftercoming twin. We aim to evaluate the cost-effectiveness of performing VDs for twin gestations in the labor and delivery room (LDR) versus the OR.

Study Design: We conducted a cost-effectiveness analysis using a decision-analysis model that compared the costs and effectiveness of two strategies of twin deliveries undergoing a trial of labor: 1) Intended delivery in the LDR and 2) Delivery in the OR. Sensitivity analyses were performed to assess model strength. The primary outcome was incremental cost effectiveness ratio (ICER) defined as cost needed to gain one quality adjusted life year (QALY).

Results: In the base case scenario, where 7% of deliveries resulted in conversion to CD for twin B, attempting to deliver twins in the LDR is the most cost-effective strategy. For every QALY gained by delivering in the OR, 243,335 USD would need to be spent (ICER). In univariate sensitivity analyses, the most cost-effective strategy shifted to delivering in the OR when the following was true: 1) probability of successful VD was less than 86%, 2) probability of neonatal morbidity after emergent CD exceeded 3.5%, 3) cost of VD in a LDR exceeded 10,500 USD, 4) cost of CD was less than 10,000 USD, or 5) probability of neonatal death from emergent CD exceeded 2.8%. Assuming a willingness-to-pay of 100,000 USD per neonatal QALY gained, attempted VD in the LDR was cost-effective in 51% of simulations in a Monte Carlo analysis.

Conclusion: Twin VDs in the LDR are cost-effective based on current neonatal outcome data. Further investigation is needed to elucidate the impact of cost and outcomes on optimal utilization of resources.

Keywords: twin vaginal deliveries, cost-effectiveness analysis

KEY POINTS

1. There is a propensity to perform twin vaginal deliveries (VD) in the operating room.
2. We assess cost-effectiveness of twin VDs in the labor and delivery room (LDR).
3. Twin VDs in the LDR are cost-effective based on current neonatal outcome data.

INTRODUCTION

The incidence of twin pregnancies has increased over 65% since 1980 as a result of increasing maternal age and greater use of assisted reproductive technology.[1,2] By 2009, one in every 30 babies born in the United States was a twin, as compared with one in every 53 babies in 1980.[3] Twin deliveries are associated with both increased maternal and neonatal morbidity and mortality.[4,5] Both elective cesarean and vaginal-cesarean deliveries increased in the early 2000s, coinciding with a sentinel trial that found lower rates of perinatal and neonatal morbidity and mortality for planned caesarean section for breech presentation, compared to attempted vaginal delivery.[6,7] Combined vaginal-cesarean deliveries are associated with higher maternal morbidity than planned vaginal or cesarean deliveries (CD).[6]

The Twin Birth Study was a randomized-controlled trial of cephalic-presenting first twins and found no difference in composite maternal or neonatal morbidity between women undergoing vaginal or cesarean delivery.[2] Since that time, publications on neonatal safety data and consensus guidelines promote vaginal delivery (VD) of twin pregnancies. The American College of Obstetricians and Gynecologists (ACOG) and the Society for Maternal-Fetal Medicine (SMFM) made a joint recommendation encouraging VD in the setting of a cephalic-presenting first twin.[8]

There is no consensus on whether twin VDs should take place in the labor room (LDR) or the operating room (OR). The rate of conversion to CD for second twin has been low in previous studies, ranging from 4.5 to 10.4%, with no significant difference in neonatal outcome between VD and cesarean conversion.[9,10] The delivery location has not been addressed by bodies such as ACOG.[11] At many institutions, twin VDs are often performed in the OR for a theoretical need to convert to CD. We aim to evaluate the cost-effectiveness of performing VDs for twin gestations in the labor and delivery room (LDR) versus the OR using current neonatal outcome data.

MATERIALS AND METHODS

Data extracted from UCLA electronic medical record database was approved by the Institutional Review Board of the University of California, Los Angeles (IRB#18-000872). The majority of assumptions utilized existing data from published research or otherwise available in the public domain. We designed a decision-analysis model to compare the cost-effectiveness of two strategies of twin deliveries undergoing a trial of labor: 1) Intended delivery in the LDR and 2) Planned delivery in the OR. We assumed that all women in our model were candidates for a VD, that all pregnancies were either monochorionic-diamniotic or dichorionic-diamniotic twin pregnancies, and that there was no difference in the mode of delivery based upon chorionicity. For the base case analysis, we assumed a conversion to CD rate of 7% which is based upon a recent analysis at our institution and which has been corroborated in large scale prospective studies on twin VDs.[12]

The perspective of this study was societal. In each strategy, we derived the probabilities that women with twins would have spontaneous labor versus an induction of labor, would require a CD prior to the second stage of labor, and would necessitate an emergent delivery for the second twin from data from existing literature (Table 1).[13,14,15,16,17,18,19,20,21,22,23] We derived costs associated with delivery location, NICU admissions, and neonatal morbidities from various sources, including our own institutional database.[24] We estimated the probability of neonatal morbidity from literature on emergent CDs for singletons,[25] as well as available literature on neonatal outcomes with twin deliveries, including combined vaginal-cesarean deliveries.[10,26,27,28] Of note, morbid conditions were defined as the presence or development of hypoxic-ischemic encephalopathy, seizures, or cerebral palsy.

Data regarding the cost based on delivery location was taken from data from the Health Care Utilization Project (HCUP) and adjusted for January 2019 USD.[29] Because the health care costs of deliveries in a LDR, OR, and a combination of the two are both difficult to extrapolate from publicly available data and because these costs vary by institution and region, we estimated the costs of delivery location from HCUP data and from literature on the cost of using an OR. For our base case scenario, we estimated that the cost of a twin VD in an LDR and a CD was twice the cost of a singleton delivery in those respective locations. For twin deliveries in which there is a VD in an LDR and are converted to an emergent CD for Twin B, we added the cost for a singleton delivery in an LDR and a singleton delivery for a CD. For the cost of a VD done in an OR we added the cost of a VD done in an LDR with 120 minutes of OR time. Last, for VD in the OR that are converted to a CD for the second twin, we estimated this as the sum of the cost of a singleton VD, a singleton CD, and 60 minutes of OR time. A recent study has quoted each minute of OR time costing an average of $36 to $37, which we used for our analysis.[30] Neonatal costs of care were derived both from HCUP data and from the literature.[31,32] In sensitivity analyses, all costs were varied by half the base case estimate to double the base case estimate in order to account for a wide variation in facility-based and geographic health care costs in the United States.

The primary clinical outcome of our model was cumulative quality-adjusted life-years (QALY) of a neonate, focused on twin B in our analysis, over the course of an average life expectancy. We assumed that neonates born without morbidity (hypoxic-ischemic encephalopathy, cerebral palsy, or seizures) had a yearly QALY of 1 but varied the QALY at birth for neonates who were born with morbidity.[33,34] This outcome was discounted at a rate of 3% per year. The primary outcome of our cost-effectiveness model was incremental cost effectiveness ratio (ICER) defined as cost needed to gain one quality adjusted life year (QALY). Sensitivity analyses were

performed to assess model strength and the thresholds at which the most cost-effective strategy shifted. A tornado analysis was performed to identify potential key drivers of the model. Finally, a Monte-Carlo simulation was performed in order to vary all inputs simultaneously by converting all methods into distributions using the base case and range of each input, then running the analysis over a set number of trials. TreeAge Pro was used for analysis (Figure 1, TreeAge Software, Williamstown, MA).

RESULTS

Base-Case Analysis

In the base case scenario where 7% of deliveries resulted in conversion to CD for twin B, attempting to deliver twins in the LDR is the most cost-effective strategy. For every 1,000 women, it would cost $52,357,070 to deliver in the LDR versus $54,790,420 to deliver in the OR. We would gain 30,680 neonatal QALYs to deliver in the LDR versus 30,690 to deliver in the OR. We would expect 629 NICU admissions and 11 neonates with morbid conditions if twins were delivered in the LDR versus 620 NICU admissions and 10 neonates with morbid conditions if delivered in the OR. Overall, to deliver twins in the OR, a system would have to spend 243,335 USD to gain one QALY (ICER) (Table 2).

One-Way and Two-Way Sensitivity Analyses

In univariate sensitivity analyses, the most cost-effective strategy shifted to delivering in the OR when the following was true: 1) probability of successful VD was less than 86%, 2) probability of morbidity after emergent CD from the LDR exceeded 3.5%, 3) cost of VD in a LDR exceeded 10,500 USD, 4) cost of CD in the OR was less than 10,000 USD, or 5) probability of death from emergent CD exceeded 2.8%.

In bivariate analyses, the most cost-effective strategy was sensitive to cost of VD in the OR versus LDR (Figure 2a), probability of VD in the LDR compared to the cost of converting to a CD in the OR (Figure 2b), and, finally, the probability of morbidity after emergent CD compared to the lifetime costs of neonatal morbidity (Figure 2c).

Probabilistic Sensitivity Analysis

In a Monte Carlo analysis of 10,000 deliveries, attempted VD in the LDR was cost-effective in 51% of simulations, assuming a willingness-to-pay threshold of 100,000 USD per neonatal QALY gained.

DISCUSSION

This study assesses the cost-effectiveness of twin VD in the LDR from a societal perspective. Our results support that twin VDs in the LDR are cost-effective based on current neonatal outcome data.

There has been a significant push for increased twin VDs in recent years by the SMFM and ACOG after multiple studies, including a randomized controlled trial,[2] showed no increased morbidity with twin VDs. Prior studies quoted rates of conversion ranging from 4.5% to 10.4%.[35,36,37] A recent sub-analysis of the Twin Birth Study had a conversion rate of 7%, similar to that of our institution, which we used in our base case scenario.[12]

Very few cost effectiveness analyses have been performed on twin VDs, especially analyzing delivery in the LDR versus OR. One prior study from Mauldin et al in 1998 analyzed delivery management of a nonvertex second twin and found that breech extraction of the second twin was more cost effective than external cephalic version or primary CD.[38]

Using a value of $100,000 per quality-adjusted life year threshold, our findings suggest that based on our current neonatal outcome data, delivering in an LDR is the most cost-effective

strategy. The threshold of $100,000 per QALY was used based on modern recommendations suggesting that the historical $50,000 per QALY threshold was too low.[39] More recently, the World Health Organization has suggested that thresholds of $110,00 to $160,000 per QALY are more appropriate in light of global assumptions about values, attitudes towards risk, and per capita annual income.[40] In our analysis, even when liberalizing the thresholds to $160,000 per QALY, twin VD in the LDR still holds true as the most cost-effective strategy.

Univariate analyses, however, demonstrate that the most cost-effective strategy is highly sensitive to cost, the probability of neonatal morbidity, and the chances of success of a VD. Moreover, our Monte Carlo simulation demonstrates that delivery in an LDR is cost-effective in approximately half of simulations. While this analysis provides insight into the economic implications of delivery location, robust data on neonatal outcomes and health care costs are needed to provide a more definitive answer.

Multifetal gestations have been shown to require significantly higher health care resources and cost as compared to singleton pregnancies.[41,42] With the consistent rise of twin pregnancies in recent years, one must consider the costs associated with twin deliveries. In an online survey completed by anesthesiologists in California, responders reported that 64% of twin VDs take place in the OR, and 55% have an anesthesiologist present, with an average time of 60 minutes per delivery.[43]

While there are many contributing factors to the cost of twin deliveries, time and resources spent in the OR should be taken into consideration. While some may point out the advantage of having certain medications and equipment immediately available in the OR or having the ability to quickly convert to general anesthesia if needed, 75% of conversions in our study avoided requiring general anesthesia. Carvalho et al. found that only 27% of deliveries required anesthesia

intervention during the second stage, and of those, 68% were epidural top-ups, which do not require an OR.[44]

Our sensitivity analyses suggest that determination of cost effectiveness of twin VD in the LDR depends on individualized assessments of the clinical scenario. Based on our findings, these assessments will have to consider not only institutional costs, but also probability of neonatal morbidity and chance of successful vaginal delivery. Our model can provide a loose framework to help assess which clinical scenarios are more likely to result in a cost-effective outcome.

Limitations to our study include the fact that there are few probabilities and health state utilities that have been examined in the perinatal patient population, thus some values were extrapolated and varied over wide ranges in sensitivity analyses to generate a meaningful model. This may have contributed to the high sensitivity of our cost-effective strategy to variables including cost and probability of both neonatal morbidity and a successful vaginal delivery. Cost data in general is not transparent in the United States, and thus many of our assumptions regarding different delivery locations particularly in the setting of conversion to CD for second twin may overestimate the true costs. This limitation should be considered in light of the fact that our model is sensitive to costs of VD in the LDR versus OR, and the cost of CD in the OR at a given institution.

A noteworthy limitation is that due to practice culture, current neonatal outcome data is largely based on conversions to CD that took place with the first twin having delivered vaginally in the OR. Thus, we are assuming neonatal outcome data to be equivalent with delivery of first twin in the LDR with subsequent conversion to CD of second twin, though this may not be the case if carried out in actuality.

While we only compared two strategies (delivery in the LDR versus OR), there are other operative strategies in twin VDs that are worth modeling in terms of cost-effectiveness of twin

VDs, namely active management of second twin, including internal podalic version, breech extraction, and forceps use. We did not undertake analyses of these latter nature due to our intent on analyzing cost-effectiveness across all-comers, however these strategies are worth investigating in future studies. Furthermore, as noted by the sensitivity nature of this model, the availability of providers trained in breech extractions, need for multidisciplinary coverage with anesthesiologists and neonatologists, and regional medicolegal implications may further limit the generalizability of this conclusions to all institutions.

Our analysis provides economic information that supports twin VDs in the LDRs, the feasibility and local cost, as well as potential medico-legal ramifications of adopting this strategy will need to be determined by individual institutions. Further research including randomized controlled trials or prospective studies with larger cohorts is needed to elucidate the current state of twin VDs and the optimal location, namely labor room or the OR.

Our cost effectiveness analysis showed that twin VDs in the LDR are cost-effective based on current neonatal outcome data. We intend that this analysis catalyzes further investigations into the appropriateness of planned vaginal twin deliveries in labor rooms and to optimize costs and resource utilization in the future.

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Table 1: Parameter Values for Base-Case and Sensitivity Analyses

Input	Base-Case (%)	Range (%)	References
Labor Probabilities			
Induction of labor	48	20-50	13, 14, 15
CD prior to second stage in an induction of labor	25	12-61	16, 17

CD prior to second stage in spontaneous labor	10	9-24	16, 17
VD of both twins	93	75-99	12
Neonatal Outcome Probabilities			
NICU admission	62	17-78	26, 27
NICU admission if delivered by emergent cesarean delivery	77	55-82	25, 27
Neonatal morbidity for a vaginal delivery or a converted cesarean delivery	1	0-1.7	28
Neonatal morbidity if delivered by emergent cesarean	2	1-6	18, 19, 20
Fetal/neonatal death	1.7	0.8-3.4	15, 28
QALY for neonate with severe morbidity*	0.75	0.6-0.96	33, 34

Average life expectancy	79	76-81	21, 22
Discount rate	0.03	0-0.06	--
Cost (USD)			
Cesarean delivery	12897	6448-25794	29
Vaginal delivery in an LDR	7937	3968-15874	29
VD in LDR and emergent CD in OR	10417	5208-20834	29
VD in OR	12521	6260-25042	29
VD and CD in OR	12709	6354-25418	29
NICU admission	43254	21627-25418	29
Nursery care	1234	617-2468	29
Lifetime cost of severe neonatal morbidity	1490745	750000-3000000	21, 31

Key: CD – cesarean delivery; VD – vaginal delivery; QALY – quality adjusted life years; LDR – labor and delivery room; OR – operating room; NICU – neonatal intensive care unit

Severe neonatal morbidity is defined as the presence or development of hypoxic-ischemic encephalopathy, seizures, or cerebral palsy

Table 2: Cost-Effectiveness Outcomes Based on Strategy (per 1000 women) for Base Case

	Delivery in the LDR	Delivery in the OR
Total Cost (USD)	$52,357,070	$54,790,420
Total neonatal QALYs	30,680	30,690
Incremental cost per QALY	--	$243,335
NICU admissions	629	620
Neonates with morbid conditions*	11	10

ICER, incremental cost effectiveness ratio

**Morbid conditions were defined as the presence or development of hypoxic-ischemic encephalopathy, seizures, or cerebral palsy*

QALY = Quality adjusted life year; NICU = neonatal ICU; LDR = Labor and delivery room; OR = operating room

Figure 1. **Decision-analysis model on Tree Age Pro**

A decision-analysis model was designed to compare the cost-effectiveness of two strategies of twin deliveries undergoing a trial of labor: 1) Intended delivery in the LDR and 2) Planned delivery in the OR. Cases were then compared based on undergoing induction of labor versus spontaneous labor, second stage of labor reached versus undergoing CD prior to second stage, and lastly, mode and location of delivery. For the base case analysis, we assumed a conversion to CD rate of 7%

which is based upon a recent analysis at our institution and which has been corroborated in large scale prospective studies on twin VDs.

LDR, labor and delivery room; OR, operating room; CD, cesarean delivery; VD, vaginal delivery

Figure 2a. Two-way sensitivity analysis of cost of vaginal delivery in the OR versus LDR

Figure 2b. Two-way sensitivity analysis of probability of VD in the LDR compared to the cost of converting to a CD in the OR

Figure 2c. Two-way sensitivity analysis of probability of morbidity after emergent CD and the lifetime costs of neonatal morbidity

Two-way sensitivity analysis of cost of VD in the OR versus LDR (Figure 2a), probability of VD in the LDR compared to the cost of converting to a CD in the OR (Figure 2b), and probability of morbidity after emergent CD and the lifetime costs of neonatal morbidity (Figure 2c). The blue area depicts the combinations of these variables in which delivery in the LDR is cost effective, and the red area shows the values at which delivery in the OR is cost effective. The base case estimate is represented in the bottom right.

VD, vaginal delivery; LDR, labor and delivery room; OR, operating room

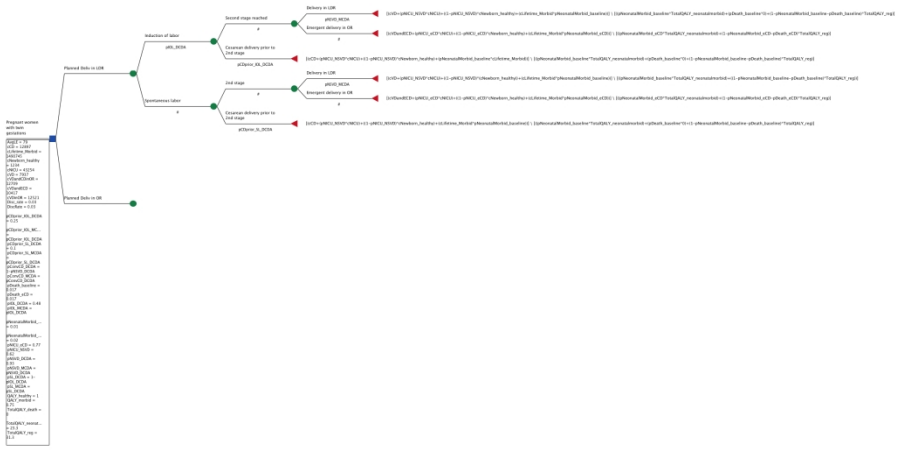

Figure 1. Decision-analysis model on Tree Age Pro. A decision-analysis model was designed to compare the cost-effectiveness of two strategies of twin deliveries undergoing a trial of labor: 1) Intended delivery in the LDR and 2) Planned delivery in the OR. Cases were then compared based on undergoing induction of labor versus spontaneous labor, second stage of labor reached versus undergoing CD prior to second stage, and lastly, mode and location of delivery. For the base case analysis, we assumed a conversion to CD rate of 7% which is based upon a recent analysis at our institution and which has been corroborated in large scale prospective studies on twin VDs.
LDR, labor and delivery room; OR, operating room; CD, cesarean delivery; VD, vaginal delivery

234x105mm (300 x 300 DPI)

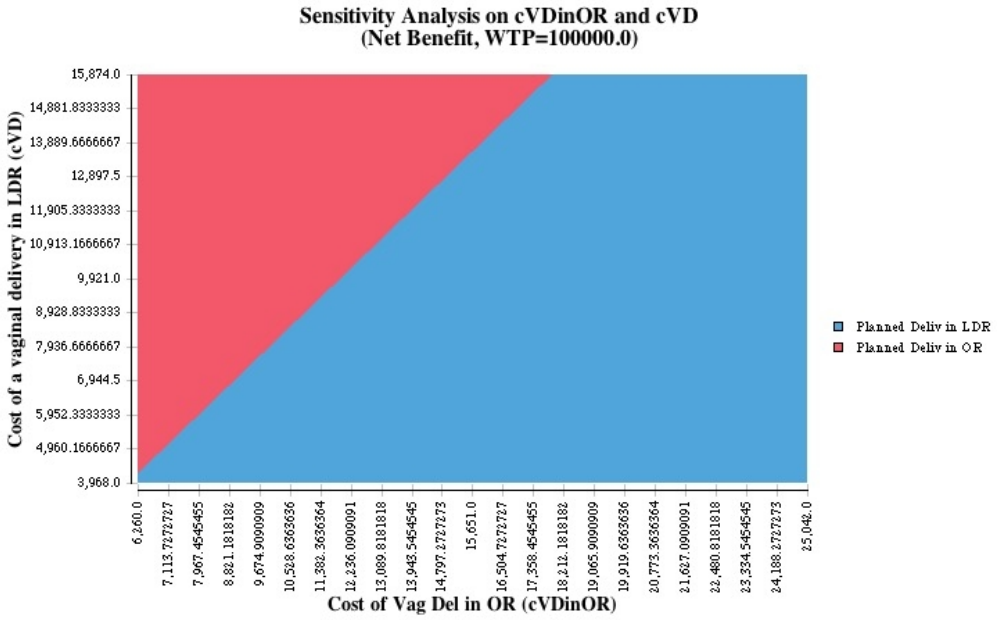

Figure 2a. Two-way sensitivity analysis of cost of vaginal delivery in the OR versus LDRFigure 2b. Two-way sensitivity analysis of probability of VD in the LDR compared to the cost of converting to a CD in the OR Figure 2c. Two-way sensitivity analysis of probability of morbidity after emergent CD and the lifetime costs of neonatal morbidity Two-way sensitivity analysis of cost of VD in the OR versus LDR (Figure 2a), probability of VD in the LDR compared to the cost of converting to a CD in the OR (Figure 2b), and probability of morbidity after emergent CD and the lifetime costs of neonatal morbidity (Figure 2c). The blue area depicts the combinations of these variables in which delivery in the LDR is cost effective, and the red area shows the values at which delivery in the OR is cost effective. The base case estimate is represented in the bottom right. VD, vaginal delivery; LDR, labor and delivery room; OR, operating room

254x158mm (72 x 72 DPI)

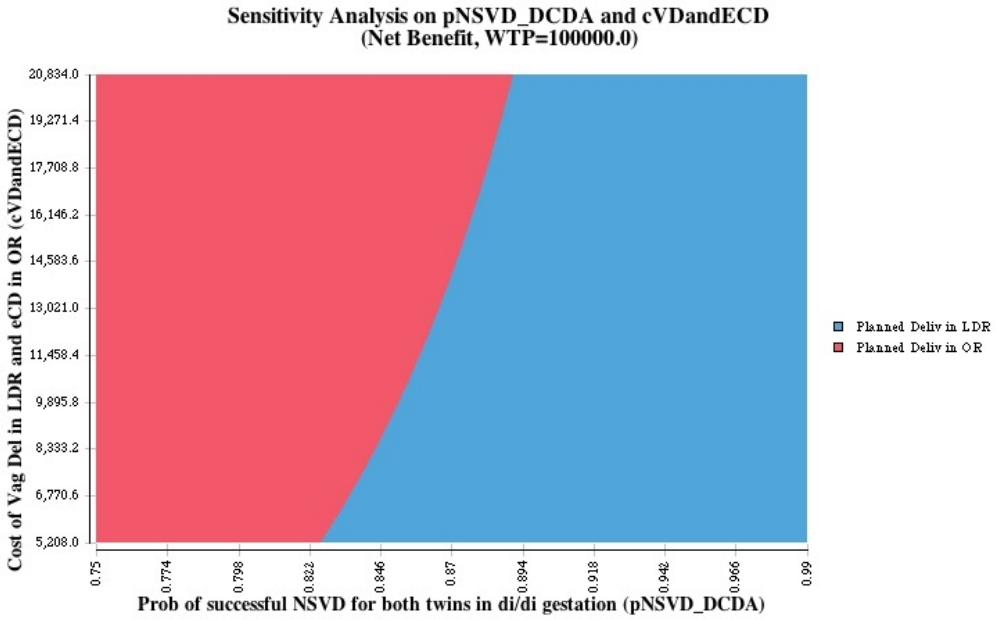

Figure 2a. Two-way sensitivity analysis of cost of vaginal delivery in the OR versus LDR
Figure 2b. Two-way sensitivity analysis of probability of VD in the LDR compared to the cost of converting to a CD in the OR
Figure 2c. Two-way sensitivity analysis of probability of morbidity after emergent CD and the lifetime costs of neonatal morbidity
Two-way sensitivity analysis of cost of VD in the OR versus LDR (Figure 2a), probability of VD in the LDR compared to the cost of converting to a CD in the OR (Figure 2b), and probability of morbidity after emergent CD and the lifetime costs of neonatal morbidity (Figure 2c). The blue area depicts the combinations of these variables in which delivery in the LDR is cost effective, and the red area shows the values at which delivery in the OR is cost effective. The base case estimate is represented in the bottom right.
VD, vaginal delivery; LDR, labor and delivery room; OR, operating room

254x158mm (72 x 72 DPI)

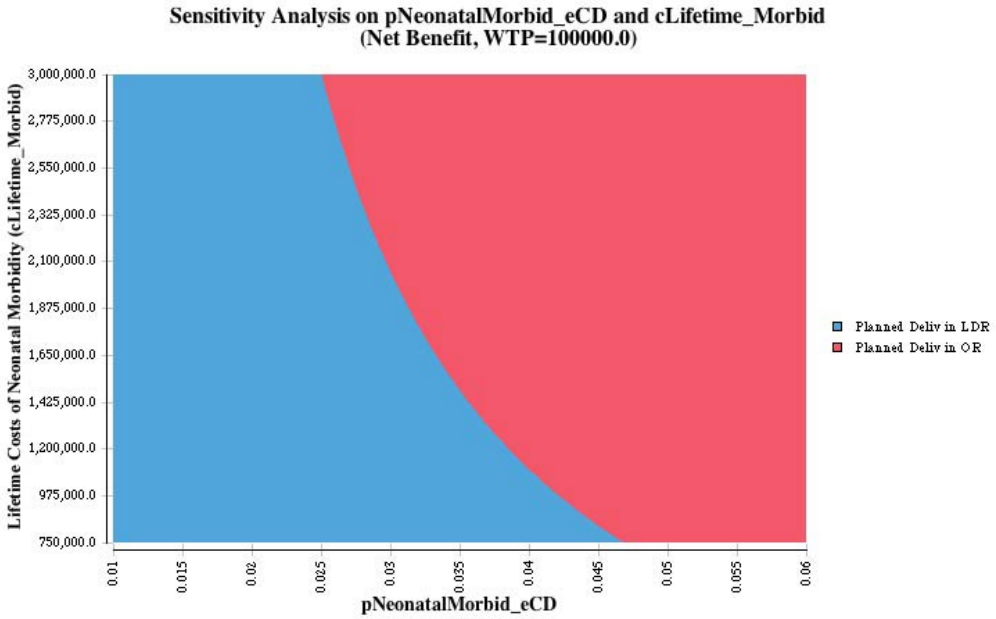

Figure 2a. Two-way sensitivity analysis of cost of vaginal delivery in the OR versus LDRFigure 2b. Two-way sensitivity analysis of probability of VD in the LDR compared to the cost of converting to a CD in the OR Figure 2c. Two-way sensitivity analysis of probability of morbidity after emergent CD and the lifetime costs of neonatal morbidity Two-way sensitivity analysis of cost of VD in the OR versus LDR (Figure 2a), probability of VD in the LDR compared to the cost of converting to a CD in the OR (Figure 2b), and probability of morbidity after emergent CD and the lifetime costs of neonatal morbidity (Figure 2c). The blue area depicts the combinations of these variables in which delivery in the LDR is cost effective, and the red area shows the values at which delivery in the OR is cost effective. The base case estimate is represented in the bottom right. VD, vaginal delivery; LDR, labor and delivery room; OR, operating room

254x158mm (72 x 72 DPI)