

# Cost-Effectiveness Analysis of Different Types of Labor for Singleton Pregnancy: Real Life Data

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## SUMMARY

**Introduction** Views on the conduct of labor have changed over time, and a significant difference exists in relation to obstetric centers.

**Objective** To assess cost, clinical outcomes and cost-effectiveness of different types of labor in singleton pregnancies.

**Methods** A decision model was used to compare vaginal labor, induced labor and planned cesarean section. All data were taken from the Book of Labor from the University Hospital for Gynecology and Obstetrics "Narodni Front", Belgrade, Serbia for labors conducted during one month period in 2011. Successful delivery (i.e. labor that began up to 42 gestation weeks, without maternal mortality and the newborn Apgar scores greater than or equal to seven in the fifth minute of life) was considered as the outcome of the cost effectiveness-analysis. To test the robustness of this definition probabilistic sensitivity analysis was performed.

**Results** From a total of 667 births, vaginal labor was conducted in 98 cases, induced vaginal in 442, while planned cesarean section was performed 127 times. Emergency cesarean section as a complication was much higher in the vaginal labor cohort compared to the induced vaginal cohort (OR=17.374; 95% CI: 8.522 to 35.418;  $p < 0.001$ ). The least costly type of labor was induced vaginal labor: average cost 461 euro, with an effectiveness of 98.17%. Both, vaginal and planned cesarean labor were dominated by the induced labor. The results were robust.

**Conclusion** Elective induction of labor was associated with the lowest cost compared to other types of labor, with favorable maternal and neonatal outcomes.

**Keywords:** cost-effectiveness; induction; labor

## INTRODUCTION

Type of labor is determined by several factors: the age and parity of mother, clinical status. Type of labor affects perinatal morbidity and mortality [1, 2]. The cost-effectiveness evaluation adds not only medical but also economic aspects to the labor.

The dominant type of labor during the 60's and 70's of the last century was a vaginal delivery. In the 1980's and especially in the 1990's of the previous century induced labor was on the rise [3, 4]. In the last decade there was an increase in the number of cesarean sections (including cesarean section required by the patient), especially in the developed countries [5]. In North America in 2010, almost one third of births (32.8%) were performed by cesarean section, compared to 20.7% in 1996 [6].

Most economic evaluations examine only the cost of different types of labor, without comparing outcomes of these types of labor. All of these studies found that spontaneous labor is the least costly intervention compared to both cesarean section and/or induced labor [7, 8, 9]. However, focusing only on the cost of labor is one-sided approach providing only partial evaluation for adequate decision making.

## OBJECTIVE

The aim of the study was to assess the cost, clinical outcomes and cost-effectiveness of different types of labor in singleton pregnancies using the data from the University Hospital for Gynecology and Obstetrics.

## METHODS

We conducted retrospective study at the University Hospital for Gynecology and Obstetrics "Narodni Front", Serbia. There are between 6,500 and 7,000 labors each year in the hospital, which is approximately 11% of all births in the country [10]. All labors conducted on low-risk obstetric population (i.e. no major fetal anomalies, no pregnancy complication) during a one-month period in 2011 were eligible for the study. During this period there were exactly 700 births. From the analysis we excluded women who had multiple pregnancies because of the greater likelihood that cesarean section would be conducted [11, 12]. In this way, 28 labors were excluded from further analysis. For the final analysis five more labors were excluded due to the lack of any data in the database. Thus, a

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total of 667 labors remained for final analysis. The study was performed anonymously for selected patients following the rules for non-interventional retrospective studies.

All information regarding the labor is recorded into the Book of Labors soon after the delivery. From the Book of Labors the following maternal data were collected: maternal age, parity, marital status, labor onset, duration of labor, delivery type, gestational week at delivery, type of induction (synthetic oxytocins and/or prostaglandins), application of epidural anesthesia, complications (hemorrhage, rupture of the cervix and/or rupture of the perineum) and whether the pregnancy was from the in-vitro fertilization program. Infant characteristics included gender, presentation, birth weight, length, head circumference and the Apgar score in the fifth minute of life. The study was planned according to the ethical guidelines following the Declaration of Helsinki. The Ethics Committee of the University Hospital approved study protocol.

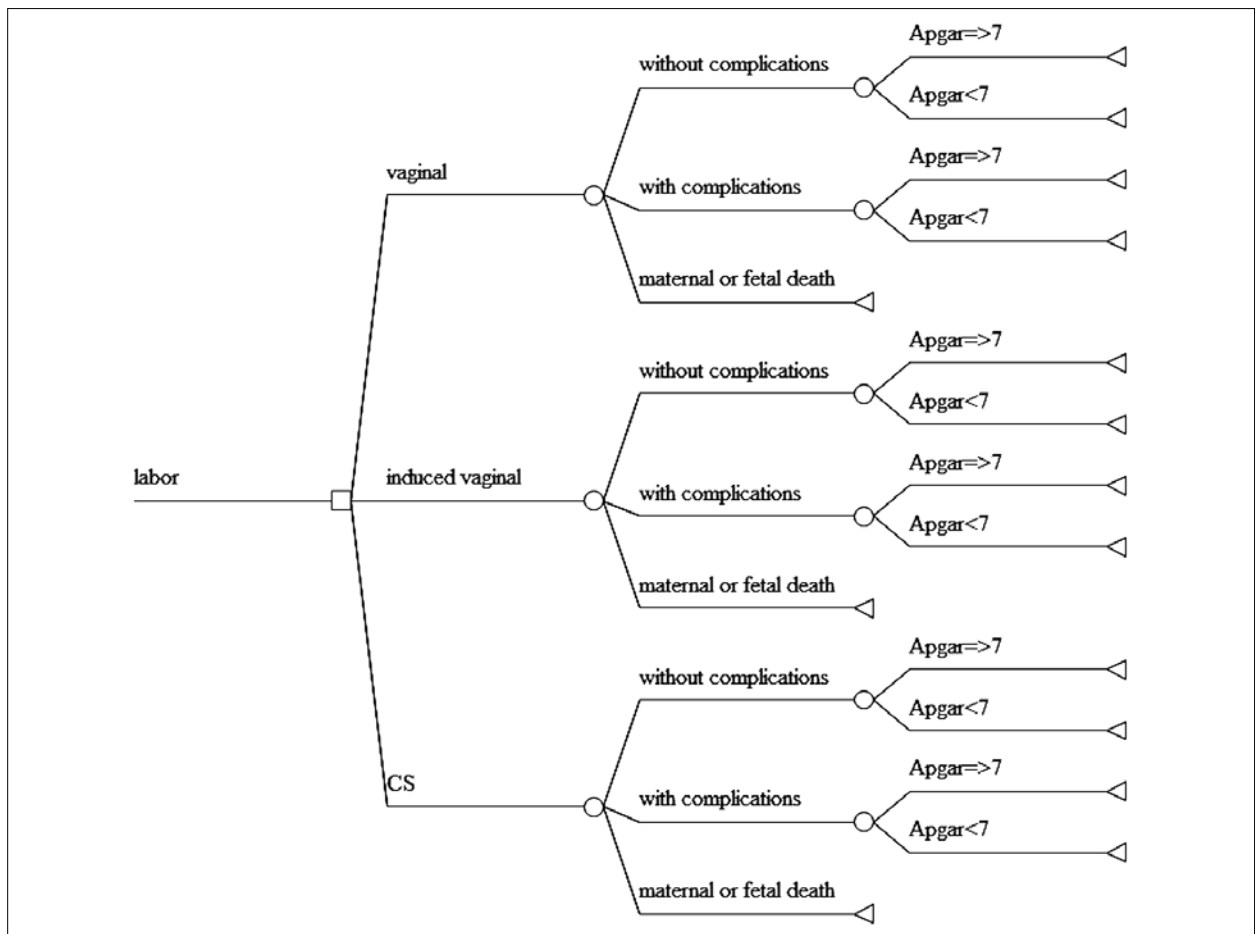
For the purposes of the study a decision analytic model was constructed using the TreeAge software version 1.5.2 Healthcare Module (TreeAge Software INC., Williamstown, Massachusetts, USA). The decision model was used to compare vaginal labor, induced labor and planned cesarean section. Schematic representation of the model is shown in Scheme 1.

All probabilities for individual events are calculated as the instantaneous probability of the data retrieved from

the database, using the formula  $p=n/N$ , where “p” is the probability, “n” is the number of events of interest, and “N” is the total number of exposed persons. Under the complications the following outcomes were observed: 1. occurrence of hemorrhage, 2. perineal lacerations (cervix and/or perineum), and 3. cesarean delivery in cases of vaginal labor (regardless of whether labor was induced or not). The Apgar score was observed as the newborn outcome, i.e. value of the Apgar score equal or greater than 7 in the fifth minute of life [13, 14].

The perspective of analysis was the Republic Health Insurance Fund (RHIF) of Serbia. Since the perspective of the study was the RHIF only direct medical costs have been considered. The following types of costs were taken into account: hospital days, prenatal and postnatal care of the newborn, all labor interventions, health technologies applied during and after birth, as well as the costs of healthcare workers. From the final analysis we excluded costs charged on private or supplemental health insurance (e.g. accommodation in apartment, arrival of the obstetric doctor outside the working hours), as well as personal contributions by non-residents or any costs charged to foreign health funds.

According to the legislation, the cost of epidural anesthesia is not covered by the compulsory health insurance, i.e. it is a non-standard service. All medicines and service for induction are included for the cost of 124.56



**Scheme 1.** Representation of the decision analytical model

CS – cesarean section

euro. This cost represents out of pocket expenses per patient. We included this cost into the analysis even when it is not reimbursed, because we wanted the cost to be as realistic as possible from a third party payer view. The pharmacoeconomic evaluation was observed only for the period of stay in hospital, up to the point of discharge of mother and newborn.

All costs are presented in euro (the average exchange rate in 2011 was 1 EUR=102.04 RSD).

## Outcome

Successful delivery was considered as the outcome of the cost effectiveness analysis. The term successful delivery considered labor that began up to 42 gestation weeks, without maternal mortality and the Apgar scores of the newborn greater than or equal to 7 in the fifth minute of life [13, 14, 15]. In this way, under a single outcome, both maternal and neonatal outcome, were included.

## Analysis

All calculations were performed using Microsoft Excel, EduStat 2.01 versions (2005, Alpha Omnia, Belgrade, Serbia). Relationship between the occurrence of complications and types of labor, were evaluated using the odds ratio (OR). OR is defined as the ratio between the probability of success relative to the probability of failure; in the case of this analysis failure is defined as the likelihood of complications depending on the delivery type.

For cost-effectiveness analysis the TreeAge module Healthcare version 1.5.2 software was used. Sensitivity analyses were conducted for factors that could possibly restrict the generalization of the study results [16]. To test the robustness we performed a probabilistic sensitivity analysis using the Monte Carlo simulation, simultaneously sampling parameter from an appropriate distribution. For probability we selected a Dirichlet/beta distribution, while for cost the gamma distribution was applied [17].

## RESULTS

General demographic data of mothers and infants, regardless of the type of labor, are given in Table 1. The average age of mother was 30.5 years, and only 9.6% had preterm labor. More than half of all women (54.8%) were nullipara. No maternal death was recorded.

Of 667 deliveries, there were five prenatal or neonatal deaths. Of the remaining 662 newborns 50.6% were female. Most newborns were in vertex presentation (94.8%), while other presentations were less frequent (breech only 1.2%). Characteristics of mother and newborn by the type of labor are presented in Table 2. There was a statistically significant difference ( $p < 0.05$ ) among all variables depending on the type of labor except for the variable "parity".

From a total of 667 births, vaginal labor was conducted in 98 cases, induced vaginal 442, while the planned cesarean section was performed 127 times. In the cohort of vaginal delivery: rupture of the cervix (10.2%), rupture of the perineum (8.2%) and cesarean section (32.6%) were recorded as complication. In the cohort of induced vaginal labor the

**Table 1.** Demographic characteristics of mothers and newborns

Characteristics		Values		
		Mean±SD	Minimum	Maximum
Mother/labor	Age (years)	30.55±5.53	14	47
	Gestation (weeks)	38.73±2.24	23	42
	Duration of labor (minutes)	245.39±162.74	10	990
	Delivery of the placenta (minutes)	4.646±3.436	0 (during)	25
Newborn	Weight (g)	3337.69±569.20	750	5200
	Length (cm)	51.21±2.95	33	59
	Head circumference (cm)	34.57±1.76	25	54
	Apgar score at fifth minute	9.69±0.82	2	10

**Table 2.** Characteristics of mothers, newborns and labor, depending on the type of labor

Variable		Type of labor			p value
		Vaginal (n=98)	Induced vaginal (n=442)	Cesarean section (n=127)	
Mother/labor	Age (years)	29.8±5.7	29.8±5.1	33.7±5.4	<0.001*
	Parity (n)	1.8±1.1	1.6±0.9	1.6±0.7	0.143, NS
	Gestation (weeks)	38.3±2.7	39.1±1.6	38.3±2.2	<0.001*
	Duration of labor (minutes)	275.56±166.86	304.26±118.40	10.08±0.50	<0.001*
	Delivery of the placenta (minutes)	4.28±3.56	6.10±2.61	0.04±0.46	<0.001*
Newborn	Weight (g)	3170.4±627.6	3417.6±452.7	3299.7±698.3	<0.001*
	Length (cm)	50.4±3.4	51.6±2.3	50.8±3.8	0.003*
	Head circumference (cm)	34.0±2.0	34.7±1.6	34.7±2.0	0.002*
	Apgar score at fifth minute	9.49±1.18	9.84±0.49	9.46±0.93	<0.001*

Variables are presented as mean ± standard deviation and compared by ANOVA test.

\*  $p < 0.05$ ; NS – not significant

**Table 3.** The costs and number of hospital days, depending of the type of labor

Variable		Type of labor			p value
		Vaginal	Induced vaginal	Cesarean section	
Mother	Cost (EUR)	336.66±296.63	342.57±115.82	546.06±166.63	<0.001*
	Hospital days (n)	5.49±3.27	4.64±3.02	7.67±4.40	<0.001*
Newborn	Cost (EUR)	146.73±141.18	116.62±116.99	156.92±198.57	0.007*
	Hospital days (n)	4.49±2.53	3.76±2.17	5.16±2.68	<0.001*

Variables are presented as mean ±standard deviation and compared by ANOVA test.

\* p<0.05

n – number

**Table 4.** The total costs for the different type of labor and outcomes

Type of labor	Complications	Apgar score	Total costs in EUR (mean±SD)
Vaginal	Without	<7	673.51±218.26
		≥7	370.45±382.43
	With	<7	714.54±102.46
		≥7	552.77±275.26
Prenatal or neonatal death			3181.04
Induced vaginal	Without	<7	850.31±255.12
		≥7	449.17±184.22
	With	<7	1409.14±484.08
		≥7	457.74±178.02
Prenatal or neonatal death			279.63
Elective Cesarean section	Without	<7	1205.98±657.95
		≥7	656.90±207.34
	With	<7	–
		≥7	1617.40
Prenatal or neonatal death			686.58±209.22

following complications were recorded: rupture of the cervix (28.5%), rupture of the perineum (9.3%), rupture of the cervix and perineum (0.7%) and cesarean section (2.7%). In the case of cesarean section hemorrhage as a complication was recorded only in one case (0.8%). In the case of the vaginal labor the probability for complication (emergency cesarean section, rupture of the perineum and/or cervix) was 49% higher compared to the induced vaginal labor (OR=1.488; 95% CI 0.959-2.308; p=0.048). However occurrence of emergency cesarean section as a complication was much higher in the vaginal labor cohort compared to the induced vaginal cohort (OR=17.374; 95% CI 8.522-35.418; p<0.001).

## Costs

Table 3 shows the costs for the mother and child and the corresponding number of hospital days according to the type of labor. There was a statistically significant difference in these variables between the various types of labor. As

**Table 5.** The cost-effectiveness results (base-case results)

Type of labor	Cost (EUR)	Δ Cost (EUR)	Effectiveness (% of successful delivery*)	Δ Effectiveness (% of successful delivery)	C/E (EUR/ successful delivery)	ICER (EUR/ successful delivery)
Induced vaginal	461.24		0.9817		469.86	
Vaginal	510.90	49.65	0.9184	- 0.0633	556.29	Dominated
Cesarean section	700.36	239.10	0.9124	- 0.0693	767.60	Dominated

\* Successful delivery – labor that began up to 42 gestation weeks, without maternal mortality and Apgar scores of the newborn greater than or equal to 7 in the fifth minute of life.

Dominated – strategy that has higher cost and lower effectiveness than comparator.

might be expected, planned cesarean section was the most costly type of labor for mother and newborn: 546 euro and 157 euro respectively. Interestingly, induced vaginal labor was the least costly procedure: 343 euro for mother and 117 euro for the newborn. The difference in costs is evident through the number of hospital days too. Women who had planned cesarean section remained in the hospital on average seven days, compared to women who had induced vaginal delivery with only four days.

The total costs for the different types of labor and outcomes are summarized in Table 4. There was a statistically significant difference in costs within each subtype of delivery (in subgroup of vaginal delivery: F=3.349; p=0.002; in subgroup of induced vaginal delivery: F=25.571; p<0.001 and in the subgroup cesarean section: F=15.708; p<0.001).

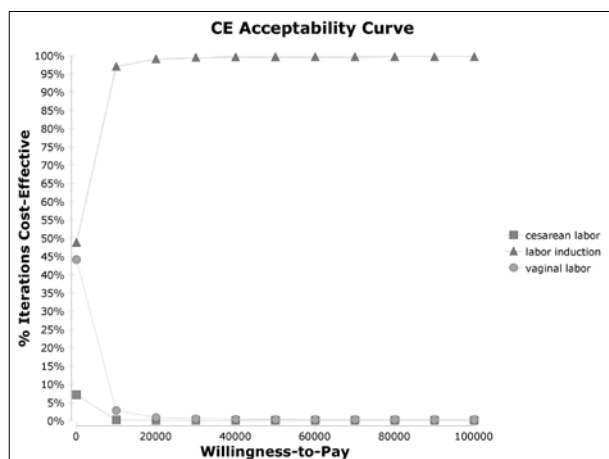
## Cost-effectiveness

The results of cost-effectiveness analysis are presented in Table 5. The least costly type of labor was induced vaginal labor, 461 euro with an effectiveness of 98.17% (i.e. percent of labors marked as successful meaning no maternal death and Apgar score higher than 7). The cost of cesarean section was the highest with the least probability for preferred outcome (91.24%).

Sensitivity analysis indicated that results were robust. Cost-effectiveness acceptability curve that indicates the probability (% of iterations) in which each labor type is cost-effective at different willingness-to-pay threshold is represented in Graph 1. Induction of labor is cost-effective at a willingness to pay of 20,000 euro, which is usually observed as threshold for numerous European countries and also North America.

## DISCUSSION

Results of our study suggests that induced labor was the least costly type of labor, and at the same time the most



**Graph 1.** Cost-effectiveness acceptability curve

efficient type of labor, with the cost-effectiveness ratio of just below 470 euro per one successful labor. The other two types of labor, vaginal and planned cesarean section, were less effective compared to induced labor, with higher cost. Such a discrepancy in the cost between vaginal and induced labor can be explained by the fact that the number of complications (especially emergency cesarean delivery) was significantly lower among induced women. Very similar results have been demonstrated in other studies [18, 19, 20]. Also, possible explanation could be lower gestation week in the cohort of vaginal labor (Table 2).

There was a statistically significant difference in the number of maternal and newborn hospital days between different types of labor (Table 3). On average women who were delivered by cesarean section left the hospital after eight days, compared to only five days for women who were delivered by induction. This can also explain the large difference in labor cost.

The cost-effectiveness analysis conducted by Kaimal et al. showed that the induction of labor has a positive effect on maternal and neonatal clinical outcomes. The authors showed that induction has a positive impact on the quality of life of women who were induced at 41 weeks compared to expectant management until 42 weeks. As the result, the induction of labor was a cost-effective strategy with an incremental cost-effectiveness ratio of US\$ 10945 per one quality adjusted life year [21]. Very similar results were presented in the previous study [18] where the induction of labor was cost-effective at US\$ 10789 per quality adjusted life year at 41 weeks of gestation or US\$ 9932 per quality adjusted life year at 40 weeks gestation.

Unlike these two studies, the results of another study dealing with the evaluation of economic and health outcomes of elective induction [22] showed that induction of labor leads to significantly higher costs and greater number of cesarean deliveries, which is highly dependent on the gestational age, parity and the Bishop score. In the nulliparous women, regardless of the Bishop score, induction incurs a significant marginal cost. However the difference in results between this study and our study may be explained by the different decision models used and different outcome value. We looked at the maternal or

neonatal death and the Apgar score, while Kaufman et al. [22] looked at cesarean delivery and fetal death. Finally, and perhaps most importantly, all probability for this study are real-life data (i.e. clinical practice from the University clinic), whereas in Kaufman's study, he and colleagues estimated probability from a number of different studies.

Partial economic evaluation of different methods of delivery in Canada showed that deliveries after the induction of labor had the highest cost compared to women with spontaneous onset of labor or cesarean delivery with no labor [9]. Our findings may be explained by the different population of pregnant women. Specifically, in the Canadian study, the average age of mothers was significantly lower than in Serbia (for spontaneous onset of labor 26.4 years compared to 29.8 years respectively; cesarean delivery without labor 28.5 years compared to 33.7 years, respectively). Also there was a difference in mean gestational age, as well as differences in the neonatal characteristics. At the same time, even the authors of the study indicated that the cost of cesarean delivery may be underestimated given that the fee for healthcare workers, (especially obstetrician-gynecologist) is exactly the same for all types of delivery.

For a long time in the scientific literature debate has existed regarding the benefits and risks of induced labor. In fact, earlier studies have shown that elective induction increases the risk of emergency cesarean section, especially in women who were nullipara [22-25]. On the other hand, Gülmezoglu et al. [26] prepared the review for the Cochrane database based on the evidence from 22 studies, in order to evaluate the benefits and harms of a labor induction at term or post-term compared to spontaneous labor or later induction of labor. In this review, authors concluded that policy of labor induction compared with expectant management was associated with fewer prenatal deaths and fewer cesarean sections. Our findings are in line with the results of Gülmezoglu's review. Both Gülmezoglu and this study showed that significantly fewer cesarean sections in labor were performed in case of induction compared with expectant management.

Inevitably, this study has several limitations. We looked only at short term outcomes for different types of labor. Several studies have demonstrated that cesarean delivery can affect long-term maternal reproductive health or even child future health [27-30]. Also, we did not express outcomes as quality adjusted life years because of the paucity of the published quality of life data on maternal preferences and complications. The published cost-effectiveness studies that used quality adjusted life years, generalized utilities from literature regarding the maternal preferences toward pregnancy loss [21]. Furthermore, our analysis and data came from the University hospital, so that results cannot be generalized to different clinical practice.

Our study provides more evidence about the different types of delivery not only from a medical but also from an economic point of view. We recognize that the medical point of view in terms of successful delivery is the leading one, but economic considerations are also important to discuss with families and physicians to aid informed decisions.



## CONCLUSION

This study does not attempt to advocate such a high rate of induction in hospitals, although our study showed favorable results on avoidance of cesarean deliveries after the induction of labor. Elective induction of labor was associated with the lowest cost compared to other types of labor, with the decrease in the risk of cesarean delivery and the normal Apgar score for the newborn.

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## Анализа трошковне исплативости различитих врста порођаја код једноплодних трудноћа – подаци из праксе

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### КРАТАК САДРЖАЈ

**Увод** Начин порођаја се током година мењао, а значајна разлика постоји у погледу клиничког центра у којем се порођај обавља.

**Циљ рада** Циљ рада је био да се процене трошкови, клинички исходи и трошкова исплативост различитих врста порођаја код једноплодних трудноћа.

**Методе рада** За потребе рада конструисано је „дрво“ одлучивања, ради поређења спонтаног вагиналног, индукованог вагиналног порођаја и планираног царског реза. Из књиге порођаја ГАК „Народни фронт“ узети су подаци о свим порођајима обављеним у једномесечном периоду 2011. године. Као исход анализе трошковне исплативости посматран је успешан порођај, дефинисан као порођај који је почео до навршене 42. недеље гестације, без смртност мајке и са Апгар скором новорођенчета већим или једнаким 7 у петом

минуто по рођењу. Применом пробабилистичке анализе осетљивости испитана је поузданост резултата.

**Резултати** Од укупно 667 порођаја, вагинални порођај је урађен у 98 случајева, индуковани у 442 случаја, а планирани царски рез 127 пута. Хитни царски рез, као компликација, био је знатно чешћи код жена са спонтаним вагиналним порођајем него код жена које су порођене применом индукције ( $OR=17,374$ ;  $95\%CI: 8,522-35,418$ ;  $p<0,001$ ). Индуковани вагинални порођај је имао најмање трошкове (461 евро), с ефикасношћу од 98,17%. Спонтани вагинални и планирани царски рез су биле скупље стратегије с мањом ефикасношћу (доминиране стратегије). Резултати су били поуздани.

**Закључак** Елективан индуковани порођај је имао најниже трошкове у односу на друге врсте порођаја, са жељеним исходима по мајку и дете.

**Кључне речи:** трошкова исплативост; индукција; порођај

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