

AN OVERVIEW OF THE HEALTH ECONOMIC IMPLICATIONS OF ELECTIVE CAESAREAN SECTION

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Abstract

The caesarean section rate has continued to increase in most industrialised countries, which raises a number of economic concerns. This paper provides an overview of the health economic implications of elective caesarean section. It provides a succinct summary of the health consequences associated with elective caesarean section for both the infant and the mother over the perinatal period and beyond. It highlights factors that complicate our understanding of the health consequences of elective caesarean section, including inconsistencies in definitions and coding of the procedure, the failure to adopt an intention to treat principle when drawing comparisons, and the widespread reliance on observational data. The paper then summarises the economic costs associated with elective caesarean section. Evidence is presented to suggest that planned caesarean section may be less costly than planned vaginal birth in some clinical contexts, for example where the singleton fetus lies in a breech position at term. In contrast, elective caesarean section (or caesarean section as a whole) appears to be more costly than vaginal delivery (either spontaneous or instrumented) in low risk or unselected populations. The paper proceeds with an overview of economic evaluations associated with elective caesarean section. All are currently based on decision-analytic models. Evidence is presented to suggest that planned trial of labour (attempted vaginal birth) following a previous caesarean section appears to be a more cost-effective option than elective caesarean section, although its cost-effectiveness is dependent upon the probability of successful vaginal delivery. There is conflicting evidence on the cost-effectiveness of maternal request caesareans when compared to trial of labour. The paucity of evidence on the value pregnant women, clinicians and other groups in society place on the option of elective caesarean section is highlighted. Techniques that might be used to elicit

preferences for elective caesarean section and its attributes are outlined. The paper concludes with directions for future research in this area.

Key points for decision makers

- Evidence is presented to suggest that planned caesarean section may be less costly than planned vaginal birth in some clinical contexts. In contrast, elective caesarean section (or caesarean section as a whole) appears to be more costly than vaginal delivery (either spontaneous or instrumented) in low risk or unselected populations.
- Planned trial of labour (attempted vaginal birth) following a previous caesarean section appears to be a more cost-effective option than elective caesarean section, although its cost-effectiveness is dependent upon the probability of successful vaginal delivery. There is conflicting evidence on the cost-effectiveness of maternal request caesareans when compared to trial of labour.

1. Introduction

The term 'caesarean section' refers to the surgical procedure in which incisions are made in the mother's abdominal wall and uterus to deliver one or more babies, or, more rarely, to remove a dead fetus. Caesarean section has traditionally been divided into either elective or emergency procedures. Elective caesarean sections are planned and performed prior to labour; in contrast, emergency caesarean sections are unplanned and performed during labour, often in response to fetal compromise, failure to progress, antepartum haemorrhage or pregnancy-induced hypertension. The delineation of elective caesarean sections can be problematic with wide variations in what may be considered elective by both parturients and their health care providers. Clinical consensus is generally lacking on the medical and obstetric indications for elective caesarean sections,^[1] although recent guidelines from the National Institute of Health and Care Excellence (NICE) in England and Wales do provide evidence from systematic reviews or meta-analyses of randomised controlled trials to support elective caesarean sections for some indications, for example, singleton breech presentation at term where external cephalic version is contraindicated or has been unsuccessful.^[2] Similarly, the role of maternal request in determining whether an elective caesarean section is performed is often nebulous, and may be prompted by the suggestion of the physician or by a combination of decision-makers. Further, in several jurisdictions maternal request caesareans are often coded with other indications because of insurance coverage and liability concerns.^[3]

The rate of caesarean section deliveries has increased markedly across the industrialised world in recent years. In the United States, for example, the percentage of all births that are caesarean deliveries increased substantially from 20.7% in 1996 to an all-time high of 32.9% in 2009,^[4] with more than 1.3 million caesareans now performed annually.^[5] This has been accompanied by a simultaneous decrease in assisted vaginal birth rates. In England, the

percentage of all births that are caesarean deliveries increased substantially from 9.0% in 1980 to an all-time high of 24.8% in 2009.^[2] Table 1 summarises recent caesarean section rates for member countries of the Organisation of Economic Co-operation and Development (OECD). A similar pattern has been observed in non-OECD member countries. Surveys of maternal and perinatal health funded by the World Health Organisation revealed a median rate of caesarean delivery of 33% across eight randomly selected countries in Latin America, with 55% performed in private hospitals.^[6] Further, primary caesarean rates have increased markedly; women who have a primary caesarean section have a greater than 90% chance of having a repeat caesarean section, further increasing overall caesarean rates in the future.^[7] National estimates of the elective primary caesarean delivery rate have generally shown rising trends across jurisdictions.^[1, 4]

A number of factors have contributed to the increasing rates of caesarean delivery. These include improved surgical and anaesthetic techniques, reduced risk of post-operative complications, demographic and nutritional factors, providers' and patients' perception of the safety of the procedure, and changes in health systems (with a gradual move away from out-of-hospital settings and low technology midwifery and obstetrics in many jurisdictions).^[4, 6] The contribution of maternal requests for non-medical reasons to increasing rates of elective caesarean delivery is difficult to quantify. The popular notion of significant numbers of women being "too posh to push" is generally not borne out by the empirical evidence. A recent critical review of the literature found that the phenomenon of true maternal request caesareans remains relatively rare.^[8] Quantifying the contribution of economic incentives to increasing rates of caesarean delivery is also far from straightforward. A small number of econometric studies have suggested that physicians' financial incentives and concerns about bearing the personal risk of malpractice may play some role.^[9, 10]

The economic consequences of increasing caesarean delivery rates are potentially of great relevance to decision-makers. Drawing upon evidence identified through searches of PubMed, EMBASE, CINAHL, the Cochrane Library, Web of Knowledge and Google Scholar, and studies published since 2000 (search strategy presented in Appendix 1), this article provides an overview of economic issues surrounding elective caesarean section. It highlights gaps in our current knowledge of the topic and identifies requirements for further research in this area. We begin with a brief overview of the evidence on the health consequences of elective caesarean section.

2. Health Consequences Associated with Elective Caesarean Section

Assessments of the health consequences of elective caesarean section are complicated by several factors. First, published studies have not defined elective caesarean section in a consistent way, and often use indirect evidence from proxies, such as planned caesareans (which may or may not include women or foetuses with defined medical indications), ‘unlaboured’ caesareans, or caesareans performed without a defined medical indication. Second, the majority of studies published to date have compared health consequences by actual mode of delivery, not planned mode of delivery. Comparisons should ideally be based on the intention to treat principle and compare planned modes of delivery among women with a defined risk profile. Third, existing studies are not always based on ideal clinical practices for alternative modes of delivery, so the balance of risks and benefits may alter in an improved practice environment, or at least one with an alternative configuration of trained medical and nursing staff that adheres to evidence-based clinical protocols. Fourth, and perhaps most importantly, the evidence is largely drawn from observational sources and, therefore, prone to the selection biases common to non-randomised studies more broadly.

One large multi-centre randomised controlled trial of planned caesarean section versus planned vaginal birth for breech presentation revealed that rates of perinatal mortality, neonatal mortality, and serious neonatal morbidity were significantly lower in the planned caesarean group.^[11] However, this trial is of questionable relevance to elective caesarean section as some trial participants were in labour before presentation. Furthermore, the results of trials comparing planned caesarean section performed for medical indications with alternative planned modes of delivery are not applicable to contexts without medical indications, because caesarean mortality and morbidity is confounded by pre-existing obstetric or general medical conditions.^[12]

Despite these caveats, a number of studies have examined the risks and benefits of elective caesarean section versus vaginal delivery for the infant. A recent review article concluded that elective caesarean section is associated with increased risk for neonatal respiratory morbidity and fetal laceration and potentially decreased risk for brachial plexus injury, neonatal sepsis, intracranial haemorrhage, intrapartum asphyxia, and neonatal encephalopathy, compared with vaginal delivery.^[13] A recent population-based study from the United States that used linked birth and death certificates to analyse data for women without medical indications revealed an odds ratio for neonatal mortality for primary caesarean delivery of 2.02 (95% CI: 1.60–2.55) compared with vaginal delivery.^[14] However, some investigators have noted that this may be counterbalanced by preventive benefits in terms of antepartum stillbirths, particularly at 39 weeks gestation and beyond.^[15, 16]

The risks and benefits of elective caesarean section for the mother have been summarised in a number of review articles.^[3, 17, 18] Limited observational evidence suggests no difference in maternal mortality between planned caesarean delivery and planned vaginal delivery.^[3] One systematic review, which also graded the quality of evidence, revealed that planned caesarean delivery is associated with a lower risk of haemorrhage and blood transfusion, no

difference in emergency hysterectomy, postpartum pain, postpartum depression, and duration of breastfeeding, and weak evidence of a higher risk of anaesthetic complications and maternal infection, in comparison with planned vaginal delivery.^[3] The same review revealed that planned caesarean delivery is associated with a lower risk of maternal infection and surgical complications, in comparison with unplanned ‘emergency’ or ‘laboured’ caesarean deliveries.^[3]

The consequences of elective caesarean for maternal health have also been measured over the longer term. Of particular note is evidence from a large body of literature to suggest that rates of stress urinary incontinence following elective caesarean section are either lower or no different to those following vaginal delivery.^[3] Weak evidence suggests a lower risk of anal incontinence following elective caesarean section in comparison to either instrumental vaginal deliveries or unplanned ‘emergency’ or ‘laboured’ caesarean deliveries.^[3] Although one study estimated an increased risk of subsequent stillbirth associated with all caesarean deliveries, it did not control for medical indications.^[19] Consequently, the consequences of elective caesarean section for subsequent reproductive health remain relatively unexplored.

3. Economic Costs Associated with Elective Caesarean Section

In this section, we focus on evidence on the economic costs associated with elective caesarean section, drawing largely from 15 studies identified by the literature searches and published since 2000.^[20-34] The summary methods of each of these studies are reported in Table 2. This includes an overall assessment of study quality based on 12 relevant reporting items included in the recently published Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement.^[35] The results of each of these studies are summarised in Appendix 2.

The studies varied in their comparison groups. Five studies compared elective caesarean section (or, where this was not available, caesarean section as a whole) with alternative modes of delivery in selected clinical populations, either following a previous caesarean section^[23, 26, 29] or following a singleton breech presentation.^[28, 32] Overall mean cost estimates were higher for the mother, infant and mother-infant dyad when planned elective caesarean section was compared with planned trial of labour (attempted vaginal birth) following a previous caesarean section. However, there is evidence to suggest that failed vaginal birth after caesarean accounts for the most expensive total birth experience in this clinical context, largely driven by the recourse to operative delivery and increased rates of infant admissions to neonatal units and subsequent oxygen requirements.^[26, 29] Evidence from the Term Breech trial suggests that planned caesarean is less costly, on average, than planned vaginal birth for the singleton fetus in a breech presentation at term (Can\$7,165 versus \$8,042; 2002 prices).^[32] Although the planned caesarean group incurred higher costs, on average, for pre-labour caesareans, which included procedure fees as well as the costs associated with time in the operating room, the postnatal ward and the normal nursery, women in the planned vaginal birth group spent more time, on average, in the labour and delivery suite, and their infants required more care in neonatal intensive and intermediate care units.

The remaining ten studies compared elective caesarean section (or caesarean section as a whole) with alternative modes of delivery in low risk pregnancies^[20, 21, 25, 27] or unselected populations.^[22, 24, 30, 31, 33, 34] Here, a consistent pattern emerged with all studies reporting higher mean costs of initial hospital stay for elective caesarean section (or caesarean section as a whole) compared to vaginal delivery (either spontaneous or instrumented). Methodological differences between studies restrict the value of pooling costs across health systems, jurisdictions and time periods. Nevertheless, the mean cost of the initial hospital stay

following elective caesarean section (or caesarean section as a whole) varied between 1.1 and 4.1 times that following vaginal delivery (either spontaneous or instrumented) (Appendix 2).^[20, 31] Previous reviews have highlighted the importance of differences in medical and nursing staff costs, equipment and consumables, and labour and delivery suite and operating theatre overheads between elective caesarean section and vaginal delivery.^[36] Another factor driving the difference in mean cost of the initial hospitalisation is the length of postnatal stay. Declercq and colleagues analysed routine data extracted from birth certificates and birth-related hospital discharge records from Massachusetts, United States, and estimated a mean postnatal stay of 4.3 days for planned primary caesarean births compared to 2.4 days for planned vaginal births.^[25] Similarly, Petrou and Glazener analysed data from a random sample of 1242 women receiving postnatal care in the Grampian Region of Scotland during the period June 1990 to May 1991. They estimated a mean postnatal stay of 7.1 days for caesarean births as a whole compared to 4.4 days for vaginal births.^[33]

Three further points are worthy of note. First, the limited time horizon of all reviewed studies is likely to underestimate the economic costs associated with each mode of delivery and, potentially, the cost differences between elective caesarean section and alternative modes of delivery. The Grampian study by Petrou and Glazener revealed that hospital readmission costs during the first two months postpartum were significantly higher following a caesarean section (UK£3200 versus £1698 following a spontaneous vaginal delivery; 1999-2000 prices).^[33] Furthermore, a Taiwanese population-based study revealed that hospital outpatient costs were significantly higher following elective caesarean section, compared to vaginal delivery, during the first six months postpartum.^[37] Second, and related, almost all reviewed studies are underpowered to detect rare adverse sequelae. There is a suggestion of increased occurrence of asthma, food allergy and obesity extending into adulthood, following caesarean section.^[38] The life-long costs associated with these health

sequelae might be considerable and may outweigh short-term concerns. Third, all reviewed studies ignore direct non-medical costs and indirect costs associated with alternative modes of delivery. There may be an assumption that women are economically unproductive for a period following childbirth, thus wider economic costs are likely to be the same whatever the mode of delivery. This narrow viewpoint ignores additional care and support of women at home often provided by relatives and friends during the postnatal period. This may constitute both direct costs, for example, in terms of travel, and indirect costs if they take additional time off work.

4. Economic Evaluations Associated with Elective Caesarean Section

In this section, we focus on evidence on economic evaluations associated with elective caesarean section, drawing largely from 12 studies identified by the literature searches and published since 2000.^[2, 39-49] The summary methods of each of these studies are reported in Table 3. This includes an overall assessment of study quality based on all reporting items included in the recently published Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement.^[35] The results of each of these studies are summarised in Appendix 3.

The most common comparator for elective caesarean section was planned trial of labour (attempted vaginal birth) following a previous caesarean section.^[40, 42, 43] A consistent pattern is reported with trial of labour clearly emerging as the most cost-effective planned mode of delivery following a previous caesarean section. Nevertheless, its cost-effectiveness is dependent upon the probability of successful vaginal delivery. Chung and colleagues concluded that a success rate of at least 74% was required for trial of labour to achieve cost-

effectiveness,^[40] whilst Fawsitt and colleagues found that trial of labour remained cost-effective with success rates as low as 67%.^[42]

Two studies evaluated the cost-effectiveness of maternal request caesareans.^[2, 49] Xu and colleagues used a Monte Carlo simulation decision model to compare the cost-effectiveness of maternal request caesareans with trial of labour in primigravid women without a medical or obstetric indication for caesarean section in the United States.^[49] The authors report a probability of cost-effectiveness of 82% for maternal request caesareans at a societal cost-effectiveness threshold of US\$50,000 for an additional quality-adjusted life year (QALY). This contrasts with the results of a cost-effectiveness model developed on behalf of NICE in England and Wales,^[2] which found that trial of labour dominated maternal request caesareans with a probability of cost-effectiveness of 100% across cost-effectiveness thresholds. The divergent findings are likely to be explained, at least in part, by two factors. First, although the decision-analytic model developed by Xu and colleagues was informed by the published literature, the evidence was not clearly reviewed and extracted in a systematic manner. Second, and perhaps more pertinently, much of the evidence used to populate their model was not based on planned mode of delivery.

Other economic evaluations have demonstrated that elective caesarean section represents a cost-effective mode of delivery in selected clinical contexts. This includes in HIV infected women where there is an interest in the prevention of mother-to-child transmission of the virus.^[39, 44, 46] Recent evidence suggests that the risk of HIV transmission is the same for a caesarean section and a vaginal birth in women on highly active anti-retroviral therapy with a viral load of less than 400 copies per ml or any anti-retroviral therapy with a viral load of less than 50 copies per ml, and consequently that elective caesareans should not be offered to these subgroups.^[2] In the context of women who are infected with the hepatitis C virus, the cost-effectiveness of elective caesarean section remains highly dependent upon the mother-

to-child transmission rate.^[47] Limited observational evidence suggests that there is no difference in risk of vertical transmission by mode of delivery.^[2] Therefore, policy makers understandably remain reluctant to recommend elective caesareans for these women. However, in the subgroup of women co-infected with HIV, clinical and cost-effectiveness evidence both support the offer of elective caesareans, driven by reduction in mother-to-child transmission of both the hepatitis C virus and HIV.^[2, 48]

5. Preferences for Elective Caesarean Section

Regardless of the evidence surrounding the economic cost and cost-effectiveness of elective caesarean section in various contexts, some women may still request this mode of delivery in the absence of any clinical reason. Underpinning these requests lay a range of personal factors, including fear of birth, perceived inequality and inadequacy of care, and family obligations, such as the need for a shorter recovery period so that women can care for other children at home.^[8, 50, 51] The cultural, institutional and professional settings in which decisions about mode of delivery are made may also play an important role.^[8]

Relatively small surveys of obstetricians' preferences have suggested that a significant minority of obstetricians would choose a delivery by elective caesarean section for themselves or their partner.^[52-54] It is hardly surprising, therefore, that similar views should prevail among some women of child-bearing age. We are not aware of any studies conducted by health economists that have attempted to quantify the relative contribution of health outcomes, non-health outcomes and process attributes to women's or obstetricians' decision-making about elective caesarean section. One study has estimated changes in willingness to pay, measured at pregnancy and postpartum, for maternity services in a fee-paying low income country setting.^[55] However, this study didn't disentangle the relative importance of

factors underpinning those valuations; neither did it focus specifically on the option of elective caesarean section.

Clearly, preference elicitation techniques developed or used by economists, such as contingent valuation or discrete choice experiments, should have a role in future research in this area. Regardless of the preferences of women or clinicians for attributes of elective caesarean section and alternative modes of delivery, the normative question of whether non-health outcomes and process attributes should influence the way intrapartum care is organised remains. Regulatory and reimbursement decisions in many jurisdictions are largely driven by concerns around clinical and, ultimately, cost-effectiveness. Convincing decision-makers about the need to incorporate factors of potential broader value remains a challenge to health economists working in the area.

6. Future Research Directions

The caesarean section rate has continued to increase in most industrialised countries. Routine data in many countries also provide evidence of increasing rates of elective caesarean section. This paper provides an overview of the health consequences associated with elective caesarean section for both the infant and the mother over the perinatal period and beyond. It highlights factors that complicate our understanding of the health consequences of elective caesarean section, including inconsistencies in definitions and coding of the procedure, the failure to adopt an intention to treat principle when drawing comparisons, and the widespread reliance on observational data. There are several health consequences of elective caesarean section we still know little about, including the long-term neurological sequelae for the infant and the future reproductive health of the mother. There is clearly a need for consistent coding of elective caesareans across routine data collection systems. Linkage across routine health

data collection systems, both on a cross-sectional and longitudinal basis, should increase our understanding of the health consequences of this and alternative modes of delivery. Given the reliance on individual-level observational data, approaches such as propensity score analysis and matching techniques will increasingly come into view for handling selection biases when drawing these comparisons.

The paper provides an overview of the economic costs associated with elective caesarean section. Evidence is presented to suggest that planned caesarean section may be less costly than planned vaginal birth in some clinical contexts, for example where the singleton fetus lies in a breech position at term.^[32] Even here, however, the inclusion of some women in labour at the start of the analyses conducted muddies the generalisations that can be made about elective caesareans *per se*. A more consistent pattern of evidence is presented when elective caesarean section (or caesarean section as a whole) is compared to vaginal delivery (either spontaneous or instrumented) in low risk or unselected populations. Elective caesareans (or caesareans as a whole) are consistently more expensive than vaginal deliveries. Nevertheless, the viewpoint of almost all published studies in this area is limited to that of the health care provider, and the time horizon generally short term, rarely extending beyond the postnatal period. Ideally, the economic costs associated with elective caesarean section and alternative modes of delivery should be estimated from data gathered in large-scale longitudinal studies as they become available. An early example of this is provided by the economic analyses based on the Grampian cohort study.^[33]

The paper also provides an overview of economic evaluations associated with elective caesarean section. There are several aspects of the management of elective caesareans for which cost-effectiveness evidence is lacking, for example the appropriate timing of antibiotic prophylaxis to reduce post-operative maternal infective morbidity rates. All existing economic evaluations of aspects of elective caesarean section are based on decision-analytic

models. Although modelling-based economic evaluations are inevitable in several circumstances, trial-based economic evaluations offer some distinct advantages. Perhaps most importantly, access to individual patient data permits a wide range of statistical and econometric techniques, for example to examine the relation between events of interest and health-related quality of life, or to explore sub-group differences.^[56] Randomised controlled trials that involve the option of elective caesarean section are likely to be required in several clinical contexts, for example, preterm breech, a breech presentation that is diagnosed in the second stage of labour, delivery of twin and triplet pregnancies, and delivery of ‘small for gestational age’ babies.^[2] These trials should ideally incorporate prospective economic evaluations and measure and value both costs and health consequences over the long-term. Such evidence is required to inform the efficient allocation of scarce resources in this area.

Finally, the paper highlights the paucity of evidence on the value pregnant women, clinicians and other groups in society place on the option of elective caesarean section. We are not aware of any preference elicitation studies in this area. Particular attention should be paid to ensuring the attributes valued in these studies reflect women’s views of elective caesarean section. Synthesising these preferences within a broader economic evaluation framework will be a challenge, particularly if they reflect concerns around non-health outcomes or process attributes, such as avoiding labour pain or perceptions of the quality of care provided.

7. Conclusions

This paper provides an overview of the health economic implications of elective caesarean section. It provides a succinct summary of the evidence surrounding the health consequences,

economic costs, cost-effectiveness and preferences associated with elective caesarean section.

Directions for future research of relevance to health economists are outlined.

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Conflicts of interest

None

Author contributions

SP designed this review article, synthesised and interpreted the relevant information, and wrote the article. KK conducted the literature reviews and extracted relevant data from selected studies. SP acts as the guarantor for the overall content.

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Table 1: Caesarean section rates from 1900 to 2010 within 31 developed countries

	1990	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Australia	17.5	23.1	25.1	26.8	28.2	29.1	30.0	30.3	30.6	30.8	31.2	-
Austria	-	16.8	18.0	19.8	20.7	22.8	23.8	25.1	26.5	27.1	28.2	28.2
Belgium	10.4	16.3	16.3	17.4	17.6	17.8	-	-	17.3	19.7	-	-
Canada	19.1	20.9	22.2	23.4	24.8	25.3	26.2	26.3	26.6	26.4	26.2	-
Czech Republic	7.6	12.9	13.3	14.1	15.3	16.0	17.1	18.4	19.6	20.5	21.2	22.5
Denmark	12.6	12.9	13.6	16.0	15.3	16.5	17.3	17.4	17.7	16.6	20.6	21.1
Estonia	6.3	14.6	15.5	15.0	16.4	17.2	18.9	19.0	20.0	20.0	20.7	20.4
Finland	13.5	15.8	16.5	16.4	16.2	16.4	16.3	16.1	16.3	16.5	15.7	16.1
France	13.9	17.2	17.8	18.5	18.6	18.7	19.1	19.5	19.9	19.9	20.0	20.3
Germany	15.7	20.9	22.0	23.7	24.8	26.0	26.7	27.8	28.5	29.4	30.3	31.4
Hungary	-	-	-	-	-	27.1	29.2	29.3	30.3	31.44	32.52	-
Iceland	11.8	17.7	16.8	17.4	17.9	16.4	15.6	17.2	16.9	16.1	15.8	-
Ireland	10.5	20.7	21.2	21.8	23.4	24.5	25.1	24.6	25.4	25.6	26.0 [‡]	26.1
Israel	9.9	14.7	16.1	16.8	16.7	16.6	17.3	17.5	17.4	17.7	17.3	16.5
Italy	20.8	33.3	34.9	36.2	37.3	38.4	38.6	39.0	38.6	38.5	38.4	-
Korea	-	-	33.6	36.9	36.7	36.7	36.3	35.1	35.3	35.4	35.1	35.2
Luxembourg	-	21.9	24.3	25.6	26.1	26.8	27.2	27.1	29.0	30.1	29.3	29.3
Mexico	-	28.2	30.4	33.2	34.7	37.0	38.2	39.5	40.7	43.9	42.0	44.8
Netherlands	7.5	11.9	13.6	13.5	13.5	13.6	13.6	13.8	13.9	14.3	14.8	-
New Zealand	-	20.2	21.2	22.2	22.2	22.3	22.7	23.9	22.8	22.8	24.0	23.5
Norway	12.7	13.7	15.6	16.1	15.6	15.2	15.9	15.9	17.2	17.1	16.8	-
Poland	-	-	-	-	15.7	16.4	18.5	19.5	19.0	19.3	22.8	26.0
Portugal	18.6	23.9	25.4	25.7	26.6	27.0	27.8	31.0	31.2	32.7	33.0	-
Slovak Republic	8.7	14.7	16.6	17.8	18.5	19.2	20.7	21.9	23.5	24.7	27.0	-
Slovenia	8.6	11.0	12.5	13.7	14.4	14.3	15.5	16.4	16.8	17.0	17.8	19.1
Spain	14.2	21.4	22.2	23.2	23.6	24.0	24.8	25.6	25.0	24.6	24.9 [‡]	25.5
Sweden	10.4	14.5	15.6	16.1	16.5	16.7	17.1	17.6	17.7	17.0	17.5	16.8
Switzerland	18.6	-	-	24.2	25.1	25.7	26.7	28.8	30.0	31.6	32.4	32.8
Turkey	-	-	-	-	-	-	-	29.7	36.0	37.7	42.7	-
United Kingdom	11.3	22.1	22.6	23.1	22.5	22.7	23.6	23.2	23.7	23.4	23.9	24.0
United States	22.7	22.9	24.4	26.1	27.5	29.1	30.3	31.1	31.8	32.3	32.9	-

Source: OECD Health Data, 2011;^[57] # Estimate

Table 2: Characteristics of studies reporting economic costs by mode of delivery; studies including a caesarean section comparator published since 2000

Study	Date of cohort	Location	Type of study	Currency	Price date	Comparison groups	Type of costs	Cost vs charges	Time horizon	Data sources	Quality#
Allen et al. [20, 21]	1985-2002	Canada	Retrospective cohort	US\$	2004	VD (n=16,690); AVD (n=5,846); CS labour (n=4,218); CS elective (n=859)	Direct medical (excluded overheads)	Costs	Until discharge	Administrative database	12/12 12/12
Bost [22]	2000-2001	USA (Texas)	Retrospective cohort	US\$	Not specified	VD; Attempted vaginal delivery; Elective CS by parity (nulliparous vs multiparous)	Direct medical (excluded overheads, MD, NICU)	Costs	Until discharge	Financial database	9/12
Clark et al. [23]	Not applicable	USA	Decision analysis	US\$	Not specified	Repeat elective CS; Planned TOL after CS	Direct medical (excluded MD)	Costs	Long-run (not specified)	Hospital financial database	9/12
Comas et al. [24]	2006-2007	Spain (Barcelona)	Cross-sectional study	Euro €	Not specified	Spontaneous VD (n=575); Instrumental VD (n=171); CS (n=280)	Direct medical (hospital)	Costs	9 months pre-birth to 3 months post-partum	Hospital cost accounting system	11/12
Declercq et al. [25]	1998-2003	USA	Retrospective cohort	US\$	Inflated to 2003	Planned VD (n=240,754); Planned CS (n=3,334)	Hospital	Charges (hospital-specific)	Until 12 months postpartum	State-level linked vital statistics and discharge records	9/12
Dimaio et al. [26]	1999	USA (Florida)	Retrospective cohort	US\$	Not specified	Repeat elective CS (n=65); Planned TOL after CS (n=139)	Direct medical (excluded MD)	Costs	Until discharge	Medical records; financial database	11/12
Heer et al.	2003	Germany	Retrospective	Euro€	Not	VD (n=70);	Hospital	Costs	Until	Medical	10/12

[27]		(Munich)	cohort		specified	Planned CS (n=30)		returns (insurance)	discharge	records; hospital database	
James et al. [28]	1995-1997	UK	Decision analysis	GBP£	1997	ECV for uncomplicated breech pregnancy; assisted breech delivery; elective CS	Hospital	Costs	Up to the point of delivery	Hospital records	12/12
Kamath et al. [29]	2005-2008	USA (Denver)	Retrospective cohort	US\$	2008	Repeat elective CS without labour (n=239); Repeat elective CS with labour (n=104); VBAC (n=244); Failed VBAC (n=85)	Hospital	Costs	Until discharge	Medical invoices; hospital records	10/12
Kazandjian et al. [30]	2004	USA (Maryland)	Retrospective cohort	US\$	Not specified	VD (n=141); CS (n=186)	Direct medical	Charges	Until discharge	Hospital charts	9/12
Khan and Zaman [31]	2008	Pakistan (Islamabad)	Retrospective cohort	US\$	2008	SVD (n=68); CS (n=65)	Hospital, Household	Costs	Until discharge	Hospital records; accounts; interviews	12/12
Palencia et al. [32]	1997 - 2000	Multinational	RCT	CAN\$	2002	Planned VD (n=511) or CS (n=514) for breech presentation	Direct medical	Costs	Until 6 weeks postpartum	RCT data	12/12
Petrou and Glazener [33]	1990-1991	Scotland	Retrospective cohort	GB£	1999-2000	SVD (n=894); Instrumental VD (n=168); CS (n=180)	Hospital and community health services	Costs	Until 2 months postpartum	Medical case notes; computerised hospital discharge records; self-completed questionnaires	12/12
Sarowar et al. [34]	2006-2007	Bangladesh (Dhaka)	Retrospective cohort	US\$	2006	Normal Delivery (n=11);	Hospital	Costs	Until 6 weeks postpartum	Hospital records	12/12

Abbreviations: AVD, assisted vaginal delivery; CS, Caesarean section; ECV, external cephalic version; MD, medical doctor; NICU, neonatal intensive care unit; RCT, randomised control trial; SVD, spontaneous vaginal delivery; TOL, trial of labour; VBAC, vaginal birth after caesarean; VD, Vaginal delivery.

Study quality assessed using 12 relevant criteria (items 1, 2, 3, 4, 5, 6, 7, 8, 9, 13, 14, 22) extracted from the CHEERS reporting checklist.^[35]

Table 3: Characteristics of economic evaluations; studies including a caesarean section comparator published since 2000

Study	Location	Type of study	Sample size	Currency	Price date	Comparison groups	Type of costs	Cost versus charges	Time horizon	Data sources	Quality#
Chen et al. [39]	USA	Decision analytic model	Hypothetical cohort of 7000 women	US\$	1998	Elective CS versus usual care in HIV-infected women	Medical system; Third party payers	Costs	Lifetime	Published literature; National databases	21/24
Chung et al. [40]	USA (Stanford)	Decision analytic model	Based on hypothetical 30-year old parturient	US\$	2000	Elective CS versus planned TOL after CS	Societal; Medical	Costs	Lifetime	Financial database	17/24
Culligan et al. [41]	USA	Decision analytic model	Hypothetical cohort of 100,000 deliveries	US\$	Not reported	Spontaneous labour followed by either vaginal delivery or CS versus ultrasound followed by elective CS in cases of macrosomia	Societal	Costs	Lifetime	Published literature; Expert opinion	22/24
Fawsitt et al. [42]	Ireland	Decision analytic model	Hypothetical cohort of 10000 women	Euro€	2010	ERCD versus planned TOL after CS	Direct medical	Costs	Six weeks	Resource use inventory; Hospital database; Published literature	22/24
Grobman et al. [43]	USA	Decision analytic model	Hypothetical cohort of 100,000 women	US\$	1999	Elective CS versus planned TOL after CS	Medical system; Third party payers	Costs	Completion of reproductive lives	Published literature; Expert opinion	22/24
Halpern et al. [44]	USA	Decision analytic model	4958 HIV-infected women delivering annually	US\$	1998	Elective CS versus VD by antiretroviral therapy regimen	Direct medical	Costs	Lifetime	Published literature	20/24

Herbst [45]	USA	Decision analytic model	100 pregnant women	US\$	Not reported	Elective CS versus induction of labour versus expectant management for macrosomia	Direct medical	Reimbursement costs	Not specified	Published literature	17/24
Mrus et al. [46]	USA	Decision analytic model	Not applicable	US\$	1997	Elective CS versus VD in HIV-infected women	Societal	Costs; Charges	Lifetime	Published literature	22/24
NICE Guideline [2]	UK	Decision analytic model	Not applicable	GB£	2009/10	Planned VD versus planned CDMR	NHS and personal social services	Costs	Until discharge (costs); Lifetime (QALYs)	Published literature	22/24
Plunkett et al. [47]	USA	Decision analytic model	Not applicable	US\$	2001	Elective CS versus CS only for obstetric indications to prevent perinatal HCV transmission	Direct medical	Costs	Lifetime	Published literature	22/24
Schakman et al. [48]	USA	Decision analytic model	Not applicable	US\$	2003	Elective CS versus CS only for obstetric indications to prevent perinatal HCV transmission	Societal	Costs	Lifetime	Published literature; National databases	23/24
Xu et al. [49]	USA	Decision analytic model	Not applicable	US\$	2007	CDMR versus TOL for primigravid women	Societal	Costs	Lifetime	Published literature	22/24

Abbreviations: CDMR, caesarean delivery on maternal request; CS, caesarean section; ERCD, elective repeat caesarean delivery; HCV, hepatitis C virus; TOL, trial of labour; TOLAC, trial of labour after caesarean; VD, vaginal delivery.

Study quality assessed using all 24 criteria extracted from the CHEERS reporting checklist.^[35]

Appendix 1: Search strategy

Research studies on the costs and cost-effectiveness of aspects of elective caesarean section were identified by searches of the following electronic bibliographic databases: PubMed, MEDLINE, EMBASE, CINAHL, The Cochrane Library (CDSR), Web of Knowledge and Google Scholar.

In order for the analyses to be considered appropriate to the modern context, studies were excluded from the literature search if they were published before 2000. Studies were also excluded if the abstract was not published in English language or if the focus was animal research. The MESH terms used in all searches were:

“Caesarean section” or “Cesarean section” or “Cesarean section” or “C section” or "Laparotomy" or "Hysterotomy" – [All Fields] and [MeSH Terms]

Combined with:

"Economics" or "Economic" or "Cost" or "Financial" or “cost-effectiveness”- [All Fields] and [MeSH Terms], “Burden” - [All Fields]

Appendix 2: Results of studies reporting economic costs by mode of delivery; studies including a caesarean section comparator published since 2000

Study	Date of cohort	Location	Results
Allen et al. [20]	1985-2002	Canada	(i) Mean cost (SD): VD: \$1,340 (1058); AVD: \$1,594 (1387); CS labour: \$2,137 (2252); CS elective: \$1,532 (1214)
Allen et al. [21]			(ii) Cumulative mean (range) cost through to third delivery by first delivery type: VD: \$6,425 (3,170 – 107,215); AVD: \$7,288 (3688 – 190,902); CS labour: \$9,524 (4801 – 57642); CS elective: \$7,213 (4539 – 16560)
Bost [22]	2000-2001	USA (Texas)	Mean cost: Nulliparous VD: \$779; Attempted vaginal delivery: \$972; CS elective: \$918 Multiparous VD: \$734; Attempted vaginal delivery: \$853; CS elective: \$918
Clark et al. [23]	Not applicable	USA	Cost per mode of delivery after previous CS: VBAC success rate 70%: Planned TOL: \$2,611; Elective CS: \$3,042 VBAC success rate 60%: Planned TOL: \$2,762; Elective CS: \$3,042 VBAC success rate 50%: Planned TOL \$2,915; Elective CS: \$3,042
Comas et al. [24]	2006-2007	Spain (Barcelona)	Mean (SD) total cost per delivery: Spontaneous vaginal delivery: €3,682 (1,748); Instrumental vaginal delivery: €4,064 (1,222); CS: €5,815 (3,232)
Declercq et al. [25]	1998-2003	USA	Initial hospital stay: Mean cost (95% CI): Planned VD \$2,513 (2,507–2,519) ; Planned CS \$4,373 (4,304–4,441) Mean length of stay (days) (95% CI): Planned VD 2.4 (2.43–2.44); Planned CS 4.3 (4.27–4.35) Subsequent rehospitalisation: Mean cost (95% CI): Planned VD \$5,436 (5,221–5,651); Planned CS \$6,100 (4,745–7,455) Mean length of stay (days) (95% CI): Planned VD 3.9 (3.75–4.04); Planned CS 4.3 (3.56–5.12)
Dimaio et al. [26]	1999	USA (Florida)	Mean hospital cost (SD) per mode of delivery after previous CS: Elective repeat CS: mother-infant dyad \$5,949 (2365), mothers \$4,155 (661), infants \$1,794 (2122) TOL: mother-infant dyad \$4,863 (2151), mothers \$3,675 (936), infants \$1,187 (1761) Successful TOL: \$4,411, Failed TOL: \$6,272
Heer et al. [27]	2003	Germany (Munich)	Mean total cost: VD: €1,737; Planned CS: €2,835
James et al. [28]	1995-1997	UK	The mean additional costs for ECV, assisted breech delivery and elective caesarean over and above a normal birth were £186.70, £425.36 and £1,955.22, respectively

			The total expected cost of the respective care pathways for "ECV accepted" and "ECV not accepted" (including the probability of adverse events) were £1,452 and £1,828 respectively.
Kamath et al. [29]	2005-2008	USA (Denver)	Mean cost (95% CI): Elective repeat CS without labour: mother \$6,030 (\$4,543, \$8,572); neonate \$2,094 (\$1,400, \$4,742); total \$8,239 (\$6,212, \$13,968) Elective repeat CS with labour: mother \$6,073 (\$4,319, \$8,745); neonate \$2,103 (\$1,414, \$4,007); total \$8,331 (\$5,995, \$11,310) VBAC: mother \$4,345 (\$2,761, \$7,374); neonate \$1,453 (\$797, \$3,067); total \$5,853 (\$3,793, \$10,333) Failed VBAC: mother \$7,292 (\$5,295, \$11,162); neonate \$2,129 (\$1,336, \$5,470); total \$9,338 (\$6,631, \$16,275)
Kazandjian et al. [30]	2004	USA (Maryland)	Mean cost: VD \$17,624; CS \$13,805
Khan and Zaman [31]	2008	Pakistan (Islamabad)	Mean cost: SVD: Hospital perspective US\$40; patient perspective US\$79 CS: Hospital perspective US\$162; patient perspective US\$204
Palencia et al. [32]	1997 – 2000	Multinational	Mean cost (SE): (i) All women (breech presentation): planned CS: \$7,165 (110); planned VD: \$8,042 (175); mean cost difference (95% credible interval: –877 (–1286 to –473) (ii) First birth (breech presentation): planned CS: \$7,255 (121); planned VD: \$8,440 (208); mean cost difference (95% credible interval: –1185 (–1663 to –719) (iii) At least one prior birth (breech presentation): planned CS: \$7,071 (188); planned VD: \$7,559 (284); mean cost difference (95% credible interval: –488 (–1163 to 166)
Petrou and Glazener [33]	1990-1991	Scotland	(i) Initial Hospital stay: Mean cost (95% CI): SVD £1431.3 (1410.7– 1451.9); instrumental VD £1969.7 (1918.4– 2020.9); CS £2923.5 (2880.1–2966.9) Mean LOS (SD): SVD 4.4 (1.8); instrumental VD 5.8(1.9); CS 7.1(1.8) (ii) Subsequent rehospitalisation: Mean cost (95% CI): SVD £1697.7 (1674.4– 1720.9); instrumental VD £ 2262.0 (2203.6– 2320.4); CS £ 3200.2 (3147.7–3252.8) Mean LOS (SD): SVD 14 (1.6); instrumental VD 3(1.8); CS 3 (1.7)
Sarowar et al. [34]	2006-2007	Bangladesh (Dhaka)	Mean cost for 6 weeks care post birth: Caesarean section: without complication \$89.98; with complication \$117.12 Normal Delivery: without complication \$43.63; with complication \$112.46

Abbreviations: AVD, assisted vaginal delivery; CI, Confidence interval; CS, Caesarean section; ECV, external cephalic version; LOS, length of stay; MD, medical doctor; NICU, neonatal intensive care unit; RCT, randomised control trial; SD, standard deviation; SVD, spontaneous vaginal delivery; TOL, trial of labour; VBAC, vaginal birth after caesarean; VD, Vaginal delivery.

Appendix 3: Results of economic evaluations; studies including a caesarean section comparator published since 2000

Study	Location	Cost components	Cost-effectiveness results	Sensitivity analyses
Chen et al. [39]	USA	VD no complications: \$2,269 VD with complications: \$3,230 CS no complications: \$4,316 CS with complications: \$5,576	Base case ICER was \$37,284 per case of perinatal transmission prevented with the elective CS delivery strategy.	The elective CS delivery strategy remained cost-effective during the univariate sensitivity analyses.
Chung et al. [40]	USA	Mean hospital cost (range) per mode of delivery after previous CS: Successful TOL: \$4,950 (\$3,900 –\$6,000) Failed TOL: \$8,414 (\$7,000 –\$10,000) Elective repeat CS: \$7,244 (\$5,900 –\$8,600)	Base case ICER for elective repeat CS over TOL was \$112,023 per QALY gained. Assumed a 75% probability of successful VBAC.	If probability of successful VBAC <0.65, elective repeat CS was the dominant choice. If probability was between 0.65 and 0.74 elective repeat CS was the cost effective method. TOL was cost-effective between the range of 0.75 and 0.76 and dominant when the probability of successful VBAC was greater than 0.76.
Culligan et al. [41]	USA	Uncomplicated VD: \$4,187 Complicated VD: \$5,618 Uncomplicated elective CS: \$7,361 Complicated elective CS: \$10,364 Uncomplicated non-elective CS: \$8,740 Complicated non-elective CS: \$12,494	For every 100,000 deliveries, the standard care policy cost \$850,581,000 and the elective CS policy cost \$847,370,000. New policy resulted in cost saving of \$3,211,000 for every 100,000 deliveries. Expected quality of life for mother/new-born dyad was 0.917 for standard care and 0.923 for the elective CS policy. Standard care approach resulted in 53.2 QALYs and the elective CS policy resulted in 53.6 QALYs.	If the probability of urinary incontinence resulting from a VD decreased from 0.245 to 0.217 or the probability of urinary incontinence resulting from an elective CS was raised from 0.05 to 0.072, this would result in monetary costs being equal for the two programmes. If the costs of urinary incontinence were lowered by 13 per cent, or if the cost of vaginal delivery were lowered by 10 per cent, then the standard care policy would be less costly.
Fawsitt et al. [42]	Ireland	Mean cost: TOL: €1,830.73 ERCD: €4,039.87	The ICER for a TOL was dominant. The probability that TOL was cost-effective was 100 per cent.	A TOLAC was cost-effective if the probability of success was 67%. Varying the success rate between 64% and 69% did not alter the cost-effectiveness results.
Grobman et al. [43]	USA	VD after TOL: \$3,578 Elective CS: \$5,511 CS after TOL: \$6,889	The prevention of one major adverse neonatal outcome (death or cerebral palsy) requires 1591 CS deliveries and a cost of more than \$2.4 million.	Sensitivity analysis confirmed the robustness of the analyses.
Halpern et al. [44]	USA	VD without postpartum morbidity: \$5,876 VD with postpartum morbidity: \$9,319 CS without postpartum morbidity: \$9,982 CS with postpartum morbidity: \$11,654	No ART: Elective CS results in both better outcomes and decreased costs in comparison with VD. Ziduvudine prophylaxis: Additional cost per life year saved is \$17 and cost per case avoided is \$1,131 Combination ART: Additional cost per life year saved is \$1,697 and cost per case avoided is \$112,693	Elective CS is less cost-effective (compared to VD) when vertical transmission rates with VD are already low, and more cost-effective when these transmission rates are higher. If the transmission rate with elective CS is higher than in the base-case model, combination ART with VD results in both decreased costs and better outcomes.

			Population based analyses indicated that elective CS could prevent 239 paediatric HIV cases annually with a saving of over \$4 million.	
Herbst [45]	USA	Vaginal delivery: \$3,376 Elective CS: \$5,200 Emergency CS: \$6,500	Expectant management was the preferred strategy at a cost of \$4,014.33 per injury-free child, compared with elective CS at a cost of \$5,212.06 and induction at a cost of \$5165.08.	Expectant management is the preferred method if the incidence of shoulder dystocia and permanent injury remain <10%.
Mrus et al. [46]	US	Vaginal delivery: \$2,930 VD with complications: \$3,809 Elective CS: \$4,102 Emergency CS: \$4,395	Elective CS: cost per birth \$10,600, QALYs 38.7 per mother and child pair. VD: cost per birth \$15,500, QALYs 38.2 per mother and child pair.	Results were robust over a wide range of assumptions. Only when the HIV transmission rate fell below 1.3% or the relative risk of transmission with elective CS exceeded 0.89 did the elective CS cost more than VD.
NICE Guideline [2]	UK	Planned VD: £1,954 Planned CS: £2,664	The ICER for planned VD was dominant with a probability of cost-effectiveness of 100% across cost-effectiveness thresholds.	Planned vaginal birth versus planned CDMR: Planned vaginal birth dominated CDMR with a probability of cost-effectiveness of 100%.
Plunkett et al. [47]	USA	Elective CS: \$6,001 Emergency CS: \$7,502 Vaginal delivery: \$3,116	Elective CS: cost \$45,814, QALYs 29.1821. Standard care: cost \$44,653, QALYs 29.1487 ICER: \$34,812 per QALY gained.	Elective CS would be cost-effective if perinatal HCV transmission rates were to reduce from 7.75 to 1.7% or less. At a discount rate of 0% elective CS dominated standard care. When a 5% discount rate was applied elective CS was no longer cost-effective.
Schackman et al. [48]	USA	Uncomplicated VD: \$4,490 Complicated VD: \$5,560 Uncomplicated CS: \$6,946 Complicated CS: \$8,553	1) Probability of child developing chronic HCV infection was 50%: ICER for elective CS over standard care was \$6,100 per QALY gained 2) Probability of child developing chronic HCV infection was 25%: ICER for elective CS over standard care was \$3,900 per QALY gained	Results were sensitive to the efficacy of C-section in preventing transmission, the probability of vaginal delivery without a recommendation, and rates of maternal acceptance of the recommendation.
Xu et al. [49]	USA	Mean cost (95% CI): TOL: \$13,283 (7,861-23,829) CDMR: \$14,259 (8,964-24,002)	TOL: Mean cost \$13,283; Mean QALYs 57.87 CDMR: Mean cost \$14,259; Mean QALYs 58.21 Mean difference in costs (95% CI): \$976 (-\$7,863 to \$7,935) Mean difference in QALYs (95% CI): 0.35 (-0.24 to 1.10)	In 12.14% of the iterations, CDMR was dominated by TOL whereas in 33.32% of the iterations, CDMR was the dominant strategy. In the other 54.54% of the iterations, one delivery scheme was less costly and the other generated higher QALYs. The probability of CDMR being cost-effective never exceeded 88% for any cut-off for the cost-effectiveness ratio.

Abbreviations: ART, antiretroviral therapy; CDMR, caesarean delivery on maternal request; CS, caesarean section; ERCD, elective repeat caesarean delivery; HCV, hepatitis C virus; HIV, Human immunodeficiency virus; ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life year; TOL, trial of labour; TOLAC, trial of labour after caesarean; VBAC, vaginal

birth after caesarean; VD, vaginal delivery.