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Caesarean Sections and For-Profit Status of Hospitals: Systematic Review and Meta-analysis

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Abstract

Objective – Financial incentives may encourage private for profit providers to perform more CS than non-profit hospitals. We therefore sought to determine the association of for-profit status of hospital and odds of caesarean section.

Design - Systematic review and meta-analysis.

Data sources - MEDLINE, Embase, and The Cochrane Database of Systematic Reviews from the first year of records through February 2016.

Eligibility criteria – To be eligible studies had to report data to allow the calculation of odds ratios (ORs) of CS comparing private for-profit hospitals with public or private non-profit hospitals in a specific geographic area.

Outcomes - The pre-specified primary outcome was the adjusted OR of births delivered by CS in private for-profit hospitals as compared with public or private non-profit hospitals, the pre-specified secondary outcome was the crude OR of CS in private for-profit hospitals as compared with public or private non-profit hospitals.

Results - 15 articles describing 17 separate studies in 4.1 million women were included. In a meta-analysis of 11 studies, the adjusted odds of delivery by CS was 1.41 higher in for-profit hospitals as compared with non-profit hospitals (95% CI 1.24 to 1.60) with no relevant heterogeneity between studies ($\tau^2 \leq 0.037$). Findings were robust across subgroups of studies in stratified analyses. The meta-analysis of crude estimates from 16 studies revealed a somewhat more pronounced association (pooled OR 1.84, 95% CI 1.49 to 2.27) with moderate to high heterogeneity between studies ($\tau^2 \geq 0.179$).

Conclusions – CS are more likely to be performed by for-profit hospitals as compared with non-profit hospitals. This holds true regardless of women's risk and contextual factors such as country, year, or study design. Since financial incentives are likely to play an important role, we recommend examination of incentive structures of for-profit hospitals to identify strategies that encourage appropriate provision of CS.

Strengths and limitations of this study

- ✓ Major strengths of our meta-analysis include a broad literature search, screening and data extraction performed in duplicate, careful exclusion of studies with overlapping populations and an exploration of study characteristics as a potential source of variation between studies.
- ✓ A major limitation of our meta-analysis lies in the variation between studies in design, number of hospital units' involved, size and characteristics of study population, type of data used, outcome measure and variables used in statistical analysis. Despite these differences, the results of the meta-analysis of adjusted estimates were surprisingly consistent.

Introduction

Caesarean section (CS) has greatly improved perinatal outcomes by reducing newborn and maternal mortality (1), but the increasing frequency of CS has raised concerns, particularly when performed in the absence of clear-cut medical indications (2, 3). OECD data reveal an average annual increase of 0.66% in member countries (4), and similar trends are evident elsewhere (2). CS rates, for example, in Brazil are particularly high at 45.9% (5). A recent analysis of national CS rates found that rates up to 19% were inversely correlated with maternal and neonatal mortality (6). Many countries have CS rates higher than 19%, even though there is no evidence to suggest that higher rates are associated with further decreases in maternal and neonatal mortality (6, 7). Higher CS rates increase the cost of care (3, 8) and may have negative effects on the health of mothers (9) and newborns (10).

CS rates vary considerably across regions and hospitals within countries, and a closer look at this variation may help to identify factors that contribute to higher than necessary rates (2). CS receive higher reimbursement than normal vaginal births in most health care systems (11, 12). We therefore hypothesized that financial incentives encourage private providers with an emphasis on profit to perform more CS than non-profit hospitals, and conducted a systematic review and meta-analysis to determine the association of for-profit status with the odds of delivery by caesarean section.

Methods

Data sources

We combined search terms referring to CS, such as 'operative delivery,' 'C section' 'Cesarean,' 'Cesarean delivery,' with search terms related to the design of studies such as 'small area

analysis,' 'medical practice variation,' and search terms related to determinants of variation and increase of CS rates. We did not restrict search by type of language or publication date. We searched MEDLINE, Embase, and the Cochrane Database of Systematic Reviews from inception to February 8, 2016, when the search was last updated. In addition, we manually searched the reference lists of all included studies and earlier systematic reviews that we identified.

Study selection and outcomes

To be eligible studies had to report data to allow the calculation of odds ratios (OR) of CS comparing private for-profit hospitals with public or private non-profit hospitals in a specific geographic area. The pre-specified primary outcome was the adjusted OR of births delivered by CS in private for-profit hospitals as compared with public or private non-profit hospitals, the pre-specified secondary outcome was the crude OR of CS in private for-profit hospitals as compared with public or private non-profit hospitals.

Data extraction

Two researchers (IH and XL) screened the papers and extracted data independently. Articles that were not published in English were reviewed by authors with knowledge of those languages. Differences were resolved by consensus. Data from full text articles were extracted onto a data extraction sheet designed to capture data on study population (history of previous CS, parity, risk factors for CS, characteristics of newborn) , study design (size, sampling strategy, cross sectional vs retrospective cohort study), data sources (birth registries, hospital records, surveys, insurance claims or census data), setting (country and period of data collection), type of CS analysed (planned, emergency, any CS including emergencies), and statistical analysis (including variables adjusted for). We extracted adjusted and/or unadjusted ORs of CS in private for-profit hospitals as compared with CS in public or private non-profit hospitals.

Analysis

We used standard inverse-variance random effects meta-analysis to combine ORs overall and stratified by type of reference group (i.e. public or private non-profit hospitals). An OR above 1 indicates that CS are more frequently performed in private for-profit hospitals than in public or private non-profit hospitals. We calculated the variance estimate τ^2 as a measure of heterogeneity between studies (13). We pre-specified a τ^2 of 0.04 to represent low heterogeneity, 0.16 to represent moderate, and 0.36 to represent high heterogeneity between studies (14). We conducted analyses stratified by study design, national CS rates, period of data collection, parity, history of previous CS, and type of CS analysed to investigate potential reasons for between-study heterogeneity and used chi-square tests to calculate p-values for interaction, or tests for linear trend in case of more than two ordered strata. National CS rates were classified into moderate (>15 to 20%), high (>20 to 40%) and very high (>40%) based on data reported by the World Health Organisation (5). All p-values are two-sided. We used STATA, release 13, for all analyses (Stata-Corp, College Station, Texas).

Patient involvement

No patients were involved in this study. We used data from published papers only.

Results

A total of 1621 records were identified by our search (Web Appendix 1): 886 from Medline: 494 from Embase; 221 from the Cochrane Database of Systematic Reviews and 20 from manual search. After removing duplicates, we screened 1397 records for eligibility, retained 373 records for a more careful examination of titles and abstracts, and excluded another 221 records because they failed to match eligibility criteria. We assessed the full texts of the 152 remaining records

and excluded another 113 that did not report private status of hospital, 21 that were otherwise irrelevant and three studies that had an overlapping population. This left us with a total of 15 articles describing 17 separate studies in 4.1 million women that were included in review and meta-analysis.

Characteristics of studies and populations are presented in Table 1 and Web Appendixes 2,3 and 4. Fifteen studies were cross-sectional, two were retrospective cohort studies. All studies were published in English, except for one study in French. Most studies were from France (4) and the U.S. (4). Exclusion criteria varied considerably: four studies excluded women aged 14 or below, three excluded multiparas, seven excluded women with previous CS, 13 excluded stillbirths and multiple births, five excluded cases with specific presentations of the foetus, and five studies excluded cases with other high risk factors for CS; 15 studies excluded preterm births. Twelve studies included the entire population of eligible cases, while five studies selected cases randomly. Seven studies used surveys, nine hospital records, four birth registries, two insurance claims and one census data. Five studies reported ORs of planned CS (including CS on maternal request) only, two reported emergency CS and 10 reported ORs of any CS. Web Appendix 4 presents the characteristics that estimates were adjusted for. Among 11 studies reporting adjusted estimates, the median number of characteristics adjusted for was 8 (range 2 to 124).

Figure 1 presents the meta-analysis of the 11 studies that reported adjusted ORs (15-25), with six studies using public non-profit hospitals as reference group, three private non-profit hospitals, and two using both. Overall, the odds of receiving CS was 1.41 higher in for-profit hospitals as compared with either of the two types of non-profit hospitals (95% CI 1.24 to 1.60), with no relevant heterogeneity between studies ($\tau^2 \leq 0.037$) and little evidence for an interaction between estimated ORs and type of reference group (P for interaction=0.20). Figure 2 presents results of

stratified analyses of adjusted odds ratios. Estimates varied to some extent between strata, but all tests for interaction or trend across subgroups were negative. Pooled estimates ranged from 1.20 to 1.62 across subgroups. There was little evidence to suggest secular trends (p for trend=0.13) or an association of ORs with national CS rates (p for trend=0.18). Figure 3 presents the meta-analysis of crude ORs with moderate to high heterogeneity between studies ($\tau^2 \geq 0.179$), a somewhat more pronounced average association (pooled OR 1.84, 95% CI 1.49 to 2.27) and again little evidence for an interaction between estimated ORs and type of reference group (P for interaction=0.48).

Discussion

Our systematic review and meta-analysis indicates that the odds of receiving a caesarean section are on average 1.4 times higher in private for-profit hospitals than in non-profit hospitals. Findings were robust across all subgroups of studies in stratified analyses. In particular, there was little evidence to suggest secular trends or an association with national CS rates.

Context

To our knowledge, this is the first meta-analysis to address the association of CS rates with for-profit status of hospitals. We are aware of three recent meta-analyses that examined the association of CS rates with obesity (26), ethnic origin (27), and labour induction (28). In a meta-analysis of unadjusted estimates from prospective and retrospective cohort studies, Poobalan et al. found a 53% increase in the odds of CS associated with maternal overweight and a 126% increase with obesity (26). Merry et al. found a 41% increase in the adjusted odds of CS associated with Sub-Saharan African origin, and a 99% increase associated with Somali origin of women. Estimates for South, North-African/West Asian and Latin American women were

similar but statistically not significant (27). Finally, in a meta-analysis of randomised trials, Mishanina et al. found expectant management to be associated with a 14% increase in the risk of CS (28). Our estimates of a 41% increase in adjusted odds of CS associated with for-profit status of hospital has a similar or larger magnitude than the associations found for the characteristics above, and are therefore obviously relevant for both clinical and policy decision making.

Strengths and limitations

A major limitation of our meta-analysis lies in the variation between studies in design, number of hospital units' involved, size and characteristics of study population, type of data used, outcome measure and variables used in statistical analysis. Despite these differences, the results of the meta-analysis of adjusted estimates were surprisingly consistent. Conversely, unadjusted estimates showed considerable heterogeneity between studies, which suggests confounding by both medical and non-medical factors as a reason for variation between studies. Among these factors are socio-economic status, preferences and clinical condition of women, foetus characteristics, medical care during pregnancy and delivery as well as physician, hospital and health system characteristics (2). Professionals often attribute higher rates of procedures to the gravity of clinical conditions of patient receiving an intervention. This argument is not supported by the data of this review as associations of CS rates with for-profit status were consistently found in analyses adjusted for a wide range of risk factors (see Web Appendix 4). Major strengths of our meta-analysis include a broad literature search, screening and data extraction performed in duplicate, careful exclusion of studies with overlapping populations and an exploration of study characteristics as a potential source of variation between studies.

Mechanisms

Financial incentives are the most likely causal mechanism behind the observed association. The literature has described the influence of supply factors in the type and amount of care provided for given condition (30-33). Private for-profit institutions focus on profit and may create financial incentive structures that encourage more resource-intensive (34) and expensive procedures (11, 35-37), since that will increase their profits. The payment model of hospitals and physicians is another important factor (11, 33, 35, 36, 38). Fee for service reimbursement may be more common for private for-profit hospitals and will encourage hospitals and physicians to provide more procedures than medically indicated (39-41) and will increase time-pressure on physicians to perform CS instead of waiting longer for a normal birth (42, 43). Finally, private for-profit institutions typically have a higher number of qualified physicians, more resources and better infrastructure (2, 33, 44-46), which will encourage overprovision of care in private for-profit institutions.

Implications for research

Although it appears unwise to delay immediate steps to improve clinical decision making for CS, further research would inform the persistent dilemma of misalignment between good care and financial incentives. Because financial incentives differ across and within countries, there is a need for additional context specific investigation of the economic drivers of overuse (47). Policy analysis focusing on for-profit hospitals should examine further the interplay of specific factors for each country or, ideally, individual contracts between insurers and providers within countries to identify financial incentives that cause private for-profit hospitals to perform more CS than non-profit hospitals. Such analyses should explore if financial incentives interact at the physician level, such as physician payment schemes, or at the hospital level, including informal or formal pressure on physicians to choose more expensive procedures or save time by performing a CS

instead of waiting longer for a normal birth. In some countries, such analyses should also extend to not for-profit hospitals, if fee for service payments are used regardless of for-profit status. The effects of the level and type of government regulation of hospitals, type of health insurance and implementation of clinical guidelines also require further study.

Implications for policy making

If clinical guidelines remain unclear and financial incentives prevail, CS may continue to increase worldwide. The persisting increase of CS rates in many health systems despite the growing recognition of CS overuse suggests that current clinical guidelines are not sufficient (2). Improving clinical decision making by providing clear clinical guidelines that are evidence based would be one step forward. Equally important is the alignment of financial incentives with the objective to improve care without increasing costs. The higher odds of CS in the for-profit sector suggest that physicians and hospitals are responsive to financial incentives. Changing reimbursement policies so that vaginal deliveries and CS are paid similarly could keep overall payments to physicians and hospitals approximately constant without encouraging unnecessary CS. Negative incentives, such as penalizing hospitals for high CS rates could also be considered, but require monitoring for unintended consequences (48). A decrease of unnecessary CS, a cost-effective use of resources and improved health outcomes for mothers and newborns should be the ultimate goal.

Conclusion

This systematic review and meta-analysis indicates that CS are more likely to be performed in for-profit hospitals as compared with non-profit hospitals. This holds true regardless of women's risk and contextual factors such as country, year, or study design. Since financial incentives are likely to play an important role, we recommend examination of incentive structures, including

reimbursement schemes, of for-profit hospitals to identify strategies that encourage best clinical judgment and outcome rather than rewarding expensive procedures that are clinically unnecessary and potentially harmful for mothers and newborns.

Acknowledgments

Contributorship Statement

IH, DCG and PJ have developed the idea for the study. IH, XL and DCG were involved in the study conception, preliminary literature review and design of the search strategy and the study protocol. IH, LS and XL were involved in screening and data extraction of papers. All authors reviewed data extraction output. IH, LS, BDC, PJ designed and performed the meta-analysis. IH,

LS, KT, BDC and PJ drafted the report, which was critically reviewed and approved by all authors.

Competing interests statement

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

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No funding was received to perform this study. All authors, had full access to all of the data (including statistical reports and tables) in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Data sharing statement

No additional unpublished data are available from the study.

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Table 1. Characteristics of included studies

Author	Year	Country	Study design	Number of cases	Number of hospital units	Year of data collection	Population	Sampling	Type of CS analysed	National CS rates**
Braveman et al.	1995	United States	Retrospective cohort study	213761	Unclear	1991	Primiparae; no previous CS; any risk	Consecutive	Any	High
Naiditch et al.	1997	France	Cross sectional	39880	944	1991	Primi- and multiparae; no previous CS; any risk	Random	Planned	Moderate
Gomes et al. A	1999	Brazil	Cross sectional	6750	8	1978-1979	Primi- and multiparae; with or without previous CS; any risk	Consecutive	Any	Very high
Gomes et al. B	1999	Brazil	Cross sectional	2846	10	1994	Primi- and multiparae; with or without previous CS; any risk	Consecutive	Any	Very high
Gonzalez-Perez et al.	2001	Mexico	Cross sectional	1716446	Unclear	1994-1997	Primi- and multiparae; with or without previous CS; any risk	Consecutive	Any	High
Korst et al.	2005	United States	Cross sectional	443532	288	1995	Primi- and multiparae; no previous CS; any risk	Consecutive	Emergency	High
Mossialos et al.	2005	Greece	Cross sectional	805	3	2002	Primi- and multiparae; with or without previous CS; any risk	Consecutive	Any	High
Carayol et al. A	2007	France	Cross sectional	1479	Unclear	1972, 1995, 1998, 2003	Primi- and multiparae; no previous CS; high risk	Random	Planned	Moderate
Carayol et al. B	2007	France	Cross sectional	6080	138	2001-2002	Primi- and multiparae; no previous CS; high risk	Random	Planned	Moderate
Xirasagar and Lin	2007	Taiwan	Cross sectional	739531	942	1997-2000	Primi- and multiparae; with or without previous CS; any risk	Consecutive	Planned*	High
Coonrod	2008	United States	Cross sectional	28863	40	2005	Primiparae; low risk	Consecutive	Any	High
Coulm et al.	2012	France	Cross sectional	9530	535	2010	Primi- and multiparae; no previous CS; low risk	Consecutive	Any	Moderate
Huesch et al.	2014	United States	Cross sectional	408355	254	2010	Primi- and multiparae; no previous CS; any risk	Consecutive	Planned	High
Raifman et al. A	2014	Brazil	Cross sectional	4918	Not Reported	1996	Primi- and multiparae; with or without previous CS; any risk	Random	Any	Very high
Raifman et al. B	2014	Brazil	Cross sectional	5768	Not Reported	2006	Primi- and multiparae; with or without previous CS; any risk	Random	Any	Very high
Schemann et al.	2015	Australia	Cross sectional	61894	81	2007-2011	Multiparae; with previous CS	Consecutive	Any	High
Sebastião et al.	2016	United States	Retrospective cohort study	412192	122	2004-2011	Primiparae; low risk	Consecutive	Emergency	High

*On maternal request

** National CS rates classified according to WHO data reported for 2008 into moderate (>15 to 20%), high (>20 to 40%) and very high (>40%)

Figure Legends

Figure 1: Adjusted odds ratios of caesarean section.

Figure 2: Stratified analyses.

Notes: *P for linear trend

Figure 3: Crude odds ratios of caesarean section.

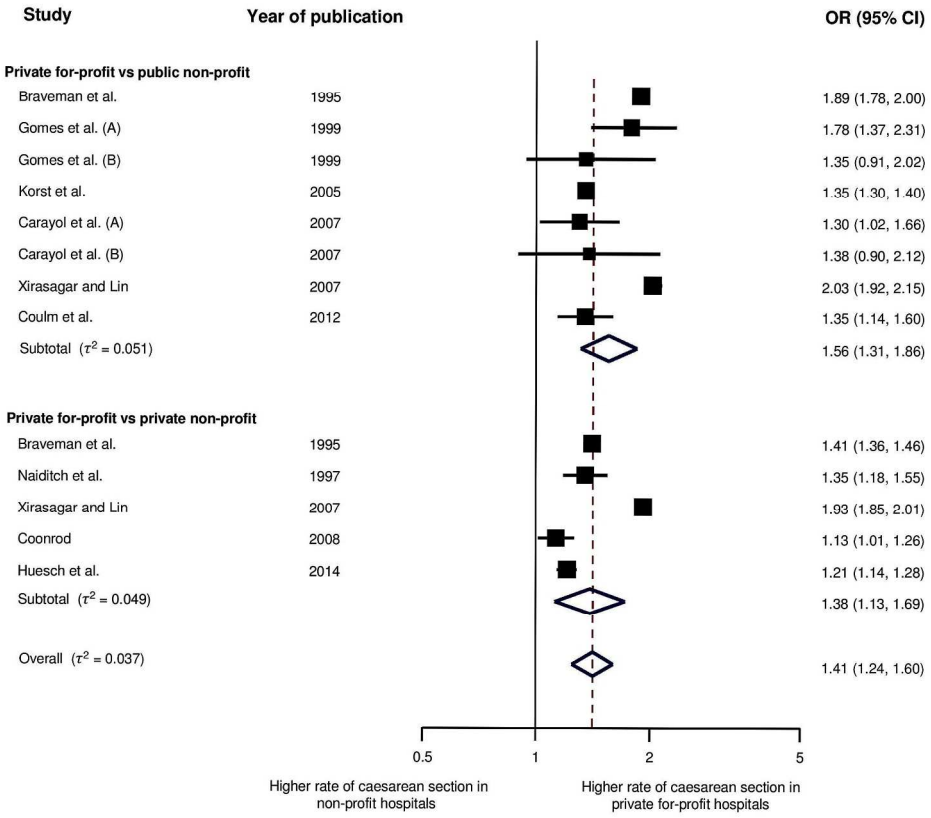


Figure 1: Adjusted odds ratios of caesarean section.

629x523mm (96 x 96 DPI)

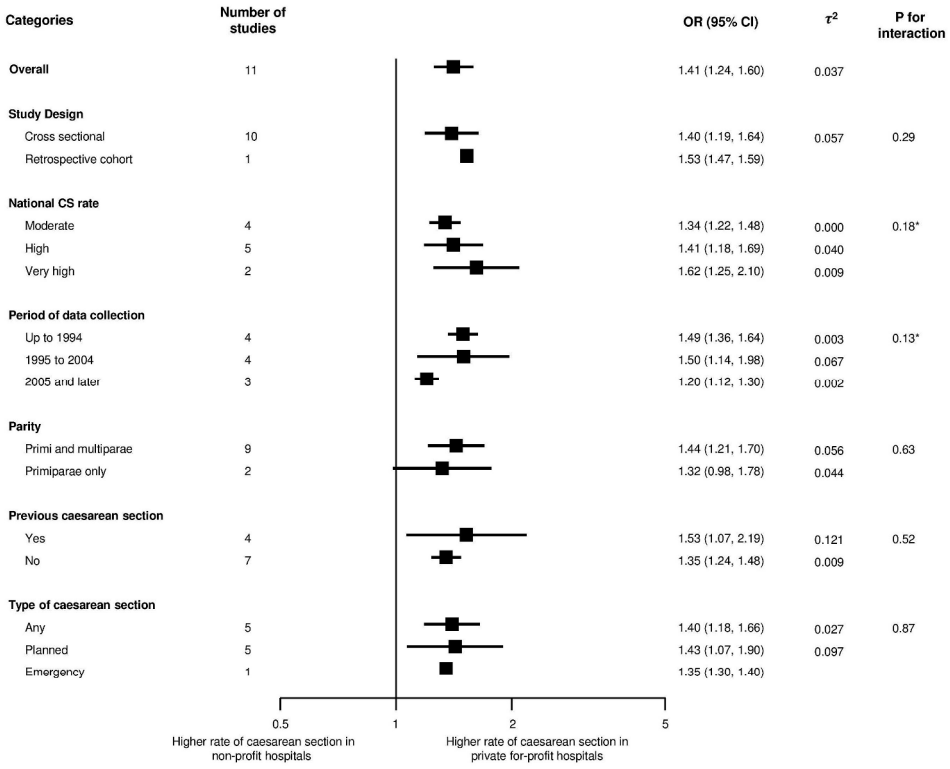


Figure 2: Stratified analyses. / Notes: *P for linear trend

753x588mm (96 x 96 DPI)

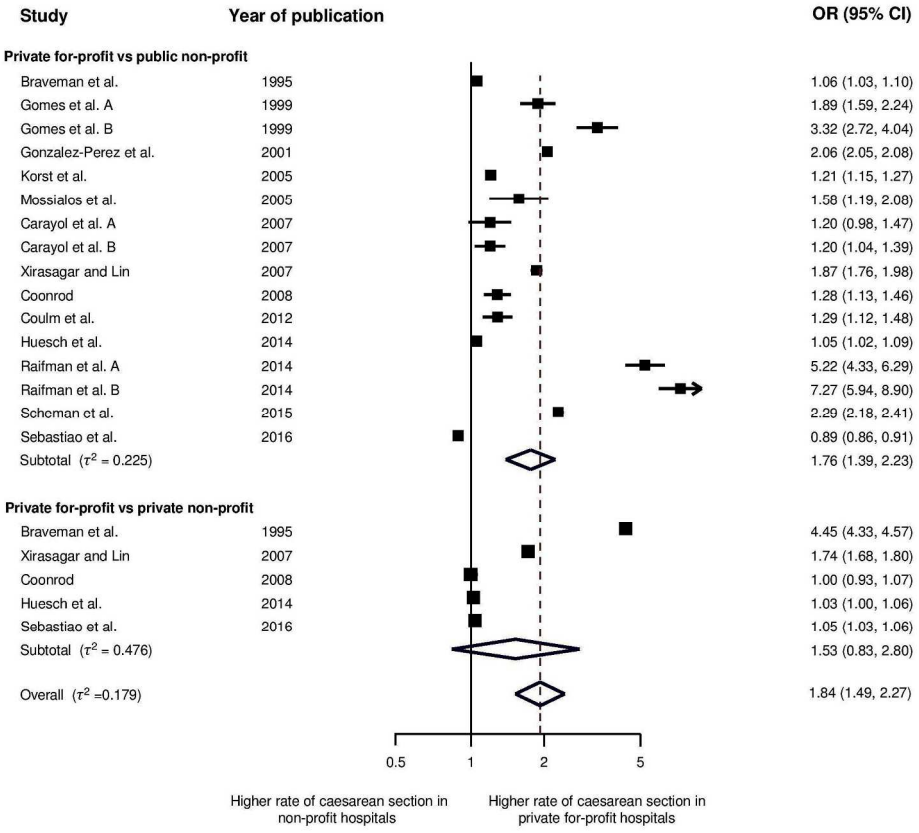


Figure 3: Crude odds ratios of caesarean section.

635x545mm (96 x 96 DPI)

What this study adds?

What is already known in this topic?

Financial incentive structures may encourage more resource-intensive and expensive procedures particularly in private for-profit institutions.

Fee for service reimbursement will encourage hospitals and physicians to provide more procedures than medically indicated and will increase time-pressure on physicians to perform CS instead of waiting longer for a normal birth.

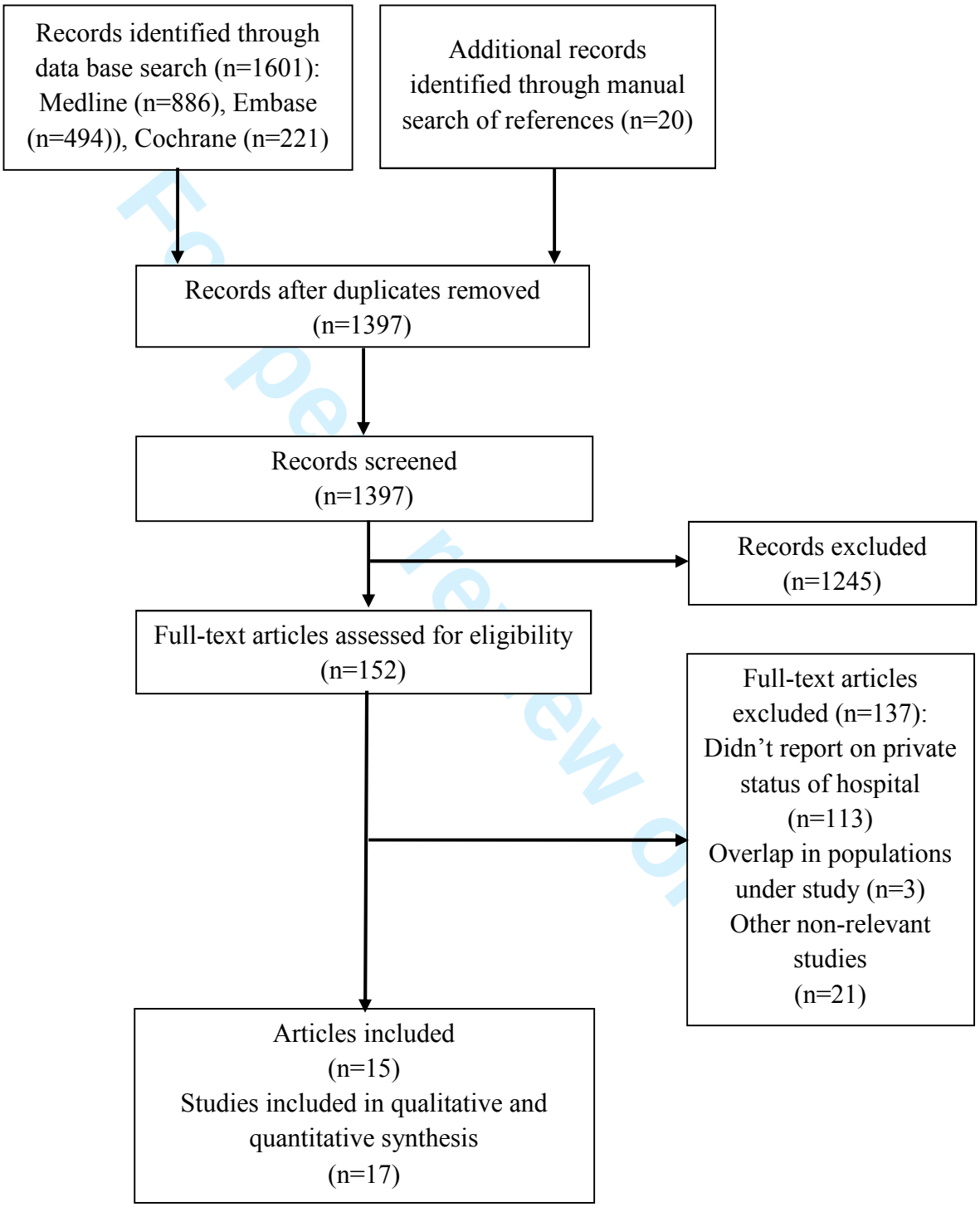
Private for-profit institutions typically have a higher number of qualified physicians, more resources and better infrastructure which will encourage overprovision of care in private for-profit institutions.

What this study adds?

Our meta-analysis indicates that the odds of delivery by caesarean section are on average 1.4 times higher in private for-profit hospitals than in non-profit hospitals.

Increased odds of delivery by caesarean in private for-profit hospitals are found independently of women's or newborn's risk factors and across different contexts, including different countries, time periods and study designs.

Appendix 1. The flow diagram of review



Appendix 2. Reported exclusion criteria

Authors	Source population	Women age 14 and below	Women from racial or ethnic minorities	Primiparae	Multiparae	Women with previous CS	Women with no previous CS	Women with uterine scars	Stillbirth	Multiple births (twin or more)	Not in labour	Cephalic presentation	Breach presentation	Other malpresentation of foetus	Preterm birth (less than 37 weeks)	Other risk factors for CS
Braveman et al.	All births in State of California, United States				+	+			+	+					+	
Naiditch et al.	All births in 944 maternity units in France	+				+			+	+					+	+
Gomes et al. A	All births in Ribeirão Preto, State of São Paulo, Southeast Brazil								+	+					+	
Gomes et al. B	All births in Ribeirão Preto, State of São Paulo, Southeast Brazil								+	+					+	
Gonzalez-Perez et al.	All births in Mexico															
Korst et al.	All births in State of California, United States					+			+	+	+				+	+
Mossialos et al.	All births in the three hospitals in Athens, Greece															
Carayol et al. A	All births in Metropolitan France					+			+	+		+		+	+	
Carayol et al. B	All births in 138 maternity units in France					+		+	+	+		+		+	+	
Xirasagar and Lin	All births in Taiwan								+	+					+	+
Coonrod	All births in State of Arizona, United States		+		+				+	+			+	+	+	
Coulm et al.	All births in all maternity units in France					+			+	+			+	+	+	+
Huesch et al.	All births in State of California, United States	+				+									+	+
Raifman et al. A	All births in Brazil	+							+	+					+	
Raifman et al. B	All births in Brazil	+							+	+					+	
Schemann et al.	All births in 81 hospitals in New South Wales, Australia			+			+								+	
Sebastião et al.	All births in 122 hospitals in State of Florida, United States				+				+	+	+		+	+	+	

Appendix 3. Characteristics of data used for analysis

Author	Survey	Hospital records	Birth certificates/registry	Insurance claims	Census data
Braveman et al.			+		+
Naiditch et al.		+		+	
Gomes et al. A	+				
Gomes et al. B	+				
Gonzalez-Perez et al.			+		
Korst et al.		+			
Mossialos et al.		+			
Carayol et al. A	+	+			
Carayol et al. B	+	+			
Xirasagar and Lin				+	
Coonrod			+		
Coulm et al.	+	+			
Huesch et al.		+			
Raifman et al. A	+				
Raifman et al. B	+				
Schemann et al.		+			
Sebastião et al.		+	+		

Appendix 4. Covariates used for statistical adjustment

Author \ Covariates	Maternal preconception status											Maternal clinical characteristics				Foetus characteristics								
	Ethnicity	Education level	Marital status	Economic status	Employment	Insurances status	Urban versus rural	Geographic origin	Spoken language	Body mass index	Maternal age	Parity	Previous caesarean section	Pre-existing (before pregnancy) conditions	Conditions developed during pregnancy	Gestational age	Birth weight	Number of live births	Foetal characteristics	Prenatal care	Birth characteristics	Provider characteristics	Other variables	Total number of covariates adjusted for
Braveman et al.	+	+	+	+		+			+		+			+			+		+	+	+	++		15
Naiditch et al.											+	+											+	3
Gomes et al. A		+	+	+	++	+					+	+		++		+	+			+	+	+		16
Gomes et al. B		+	+	+	++	+					+	+		++		+	+			+	++	+		18
Gonzalez-Perez et al.																								0
Korst et al.	+					+					+										+	++		7
Mossialos et al.																								0
Carayol et al. A		+									+	+				+	+				+	+		7
Carayol et al. B		+						+			+	+												4
Xirasagar and Lin											+											+		2
Coonrod	+	+				+					+			++	+	+	+		+	+	+	++		20
Coulm et al.		+						+		+	+	+				+	+					+		8
Huesch et al.	+			+		+					+			++	++				++	+	++	++	++	124
Raifman et al. A																								0
Raifman et al. B																								0
Schemann et al.																								0
Sebastião et al.																								0

+ One covariate adjusted for ++ Two or more covariates adjusted for

Gonzales-Perez et al, Mossialos et al, Raifman et al, Schemann et al and Sebastião et al only reported crude estimates.

Research Checklist

According to MOOSE statement for meta-analyses of observational studies

Reporting of background should include	**Where to find in manuscript**
Problem definition	Manuscript (page 4)
Hypothesis statement	Manuscript (page 4)
Description of study outcome(s)	Manuscript (page 5)
Type of exposure or intervention used	Manuscript (page 5)
Type of study designs used	Manuscript (page 4)
Study population	Manuscript (page 4)
Reporting of search strategy should include	
Qualifications of searchers (eg, librarians and investigators)	Manuscript (page 5)
Search strategy, including time period included in the synthesis and keywords	Manuscript (pages 4-5), Supplment 1
Effort to include all available studies, including contact with authors	Manuscript (page 5)
Databases and registries searched	Manuscript (page 5)
Search software used, name and version, including special features used (eg, explosion)	Manuscript (page 5)
Use of hand searching (eg, reference lists of obtained articles)	Manuscript (page 5)
List of citations located and those excluded, including justification	Appendix 1 and Supplement 2
Method of addressing articles published in languages other than English	Manuscript (page 5)
Method of handling abstracts and unpublished studies	Manuscript (page 5)
Description of any contact with authors	No contact made
Reporting of methods should include	
Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	Manuscript (page 5)
Rationale for the selection and coding of data (eg, sound clinical	Manuscript (page 5)

principles or convenience)	
Documentation of how data were classified and coded (eg, multiple raters, blinding, and interrater reliability)	Manuscript (pages 5-6)
Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	Manuscript (page 6) Appendix 4
Assessment of study quality, including blinding of quality assessors; stratification or regression on possible predictors of study results	Manuscript (page 5) Table 1, Appendix 2-4
Assessment of heterogeneity	Manuscript (page 6)
Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	Manuscript (page 5)
Provision of appropriate tables and graphics	Manuscript, Table 1, Figure 1-3 and Web Appendixes 1-4
Reporting of results should include	
Graphic summarizing individual study estimates and overall estimate	Figure 1-3
Table giving descriptive information for each study included	Table 1
Results of sensitivity testing (eg, subgroup analysis)	Figure 2
Indication of statistical uncertainty of findings	Manuscript, Figure 1-3
Reporting of discussion should include	
Quantitative assessment of bias (eg, publication bias)	Manuscript (page 8)
Justification for exclusion (eg, exclusion of non—English-language citations)	Manuscript (page 8)
Assessment of quality of included studies	Manuscript (page 8)
Reporting of conclusions should include	

Consideration of alternative explanations for observed results	Manuscript (pages 9-11)
Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	Manuscript (page 11)
Guidelines for future research	Manuscript (page 10)
Disclosure of funding source	Manuscript (page 12)

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Caesarean Sections and For-Profit Status of Hospitals: Systematic Review and Meta-analysis

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Caesarean Sections and For-Profit Status of Hospitals: Systematic Review and Meta-analysis

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Key words

caesarean section, for-profit hospital, non-profit hospital, financial incentives, medical practice variation, health services

Word count

2515 words excluding title page, abstract, references, figures and tables.

Abstract

Objective – Financial incentives may encourage private for profit providers to perform more CS than non-profit hospitals. We therefore sought to determine the association of for-profit status of hospital and odds of caesarean section.

Design - Systematic review and meta-analysis.

Data sources - MEDLINE, Embase, and The Cochrane Database of Systematic Reviews from the first year of records through February 2016.

Eligibility criteria – To be eligible, studies had to report data to allow the calculation of odds ratios (ORs) of CS comparing private for-profit hospitals with public or private non-profit hospitals in a specific geographic area.

Outcomes - The pre-specified primary outcome was the adjusted OR of births delivered by CS in private for-profit hospitals as compared with public or private non-profit hospitals; the pre-specified secondary outcome was the crude OR of CS in private for-profit hospitals as compared with public or private non-profit hospitals.

Results - 15 articles describing 17 separate studies in 4.1 million women were included. In a meta-analysis of 11 studies, the adjusted odds of delivery by CS was 1.41 higher in for-profit hospitals as compared with non-profit hospitals (95% CI 1.24 to 1.60) with no relevant heterogeneity between studies ($\tau^2 \leq 0.037$). Findings were robust across subgroups of studies in stratified analyses. The meta-analysis of crude estimates from 16 studies revealed a somewhat more pronounced association (pooled OR 1.84, 95% CI 1.49 to 2.27) with moderate to high heterogeneity between studies ($\tau^2 \geq 0.179$).

Conclusions – CS are more likely to be performed by for-profit hospitals as compared with non-profit hospitals. This holds true regardless of women's risk and contextual factors such as country, year, or study design. Since financial incentives are likely to play an important role, we recommend examination of incentive structures of for-profit hospitals to identify strategies that encourage appropriate provision of CS.

Strengths and limitations of this study

- ✓ Major strengths of our meta-analysis include a broad literature search, screening and data extraction performed in duplicate, careful exclusion of studies with overlapping populations and an exploration of study characteristics as a potential source of variation between studies.
- ✓ A major limitation of our meta-analysis lies in the variation between studies in design, number of hospital units' involved, size and characteristics of study population, type of data used, outcome measure and variables used in statistical analysis. Despite these differences, the results of the meta-analysis of adjusted estimates were surprisingly consistent.

Introduction

Caesarean section (CS) has greatly improved perinatal outcomes by reducing newborn and maternal mortality (1), but the increasing frequency of CS has raised concerns, particularly when performed in the absence of clear-cut medical indications (2, 3). OECD data reveal an average annual increase of 0.66% in member countries (4), and similar trends are evident elsewhere (2). CS rates, for example, in Brazil are particularly high at 45.9% (5). A recent analysis of national CS rates found that rates up to 19% were inversely correlated with maternal and neonatal mortality (6). Many countries have CS rates higher than 19%, even though there is no evidence to suggest that higher rates are associated with further decreases in maternal and neonatal mortality (6, 7). Higher CS rates increase the cost of care (3, 8) and may have negative effects on the health of mothers (9) and newborns (10).

CS rates vary considerably across regions and hospitals within countries, and a closer look at this variation may help to identify factors that contribute to higher than necessary rates (2). CS receive higher reimbursement than normal vaginal births in most health care systems (11, 12). We therefore hypothesized that financial incentives encourage private providers with an emphasis on profit to perform more CS than non-profit hospitals, and conducted a systematic review and meta-analysis to determine the association of for-profit status with the odds of delivery by caesarean section.

Methods

Data sources

We combined search terms referring to CS, such as ‘operative delivery,’ ‘C section’ ‘Cesarean,’ ‘Cesarean delivery,’ with search terms related to the design of studies such as ‘small area

analysis,' 'medical practice variation,' and search terms related to determinants of variation and increase of CS rates. We did not restrict search by type of language or publication date. We searched MEDLINE, Embase, and the Cochrane Database of Systematic Reviews from inception to February 8, 2016, when the search was last updated. Full details are given in Web Appendix 4. In addition, we manually searched the reference lists of all included studies and earlier systematic reviews that we identified.

Study selection and outcomes

To be eligible studies had to report data to allow the calculation of odds ratios (OR) of CS comparing private for-profit hospitals with public or private non-profit hospitals in a specific geographic area. The pre-specified primary outcome was the OR of births delivered by CS in private for-profit hospitals as compared with public or private non-profit hospitals adjusted for confounding factors as specified by individual investigators. The pre-specified secondary outcome was the crude OR of CS in private for-profit hospitals as compared with public or private non-profit hospitals. Studies were included if they reported data on either primary or secondary outcome.

Data extraction

Two researchers (IH and XL) screened the papers and extracted data independently. Articles that were not published in English were reviewed by authors with knowledge of those languages. Differences were resolved by consensus. Data from full text articles were extracted onto a data extraction sheet designed to capture data on study population (history of previous CS, parity, risk factors for CS, characteristics of newborn) , study design (size, sampling strategy, cross sectional vs retrospective cohort study), data sources (birth registries, hospital records, surveys, insurance claims or census data), setting (country and period of data collection), type of CS analysed

(indication for CS established before labour (i.e. planned), indication for CS established during labour, any CS irrespective of indication), and statistical analysis (including variables adjusted for). We extracted adjusted and/or unadjusted ORs of CS in private for-profit hospitals as compared with CS in public or private non-profit hospitals.

Analysis

We used standard inverse-variance random effects meta-analysis to combine ORs overall and stratified by type of reference group (i.e. public or private non-profit hospitals). An OR above 1 indicates that CS are more frequently performed in private for-profit hospitals than in public or private non-profit hospitals. We calculated the variance estimate τ^2 as a measure of heterogeneity between studies (13). We pre-specified a τ^2 of 0.04 to represent low heterogeneity, 0.16 to represent moderate, and 0.36 to represent high heterogeneity between studies (14). We conducted analyses stratified by study design (cross sectional versus retrospective cohort study), national CS rates (moderate, high, very high), period of data collection (up to 1994, between 1995 to 2004, 2005 and later), parity (primi and multiparae combined versus primiparae only), history of previous CS, and type of CS analysed (indication for CS established before labour (i.e. planned CS), indication for CS established during labour, any CS irrespective of indication) to investigate potential reasons for between-study heterogeneity and used chi-square tests to calculate p-values for interaction, or tests for linear trend in case of more than two ordered strata. National CS rates were classified into moderate (>15 to 20%), high (>20 to 40%) and very high (>40%) based on data reported by the World Health Organisation (5). All p-values are two-sided. We used STATA, release 13, for all analyses (Stata-Corp, College Station, Texas).

Patient involvement

No patients were involved in this study. We used data from published papers only.

Results

A total of 1621 records were identified by our search (Figure 1): 886 from Medline: 494 from Embase; 221 from the Cochrane Database of Systematic Reviews and 20 from manual search. After removing duplicates, we screened 1397 records for eligibility, retained 373 records for a more careful examination of titles and abstracts, and excluded another 221 records because they failed to match eligibility criteria. We assessed the full texts of the 152 remaining records and excluded another 113 that did not report private status of hospital, 21 that were otherwise irrelevant and three studies that had an overlapping population. This left us with a total of 15 articles describing 17 separate studies in 4.1 million women that were included in review and meta-analysis.

Characteristics of studies and populations are presented in Table 1 and Web Appendixes 1,2 and 4. Fifteen studies were cross-sectional, two were retrospective cohort studies. All studies were published in English, except for one study in French. Most studies were from France (4) and the U.S. (4). Exclusion criteria varied considerably: four studies excluded women aged 14 or below, three excluded multiparas, seven excluded women with previous CS, 13 excluded stillbirths and multiple births, five excluded cases with specific presentations of the foetus, and five studies excluded cases with other high risk factors for CS; 15 studies excluded preterm births. Twelve studies included the entire population of eligible cases, while five studies selected cases randomly. Seven studies used surveys, nine hospital records, four birth registries, two insurance claims and one census data. Five studies reported ORs of CS indicated before labour (including CS on maternal request) only, two reported CS indicated during labour and 10 reported ORs of any CS. Web Appendix 3 presents the characteristics that estimates were adjusted for. Among 11

studies reporting adjusted estimates, the median number of characteristics adjusted for was 8 (range 2 to 124).

Figure 2 presents the meta-analysis of the 11 studies that reported adjusted ORs (15-25), with six studies using public non-profit hospitals as reference group, three private non-profit hospitals, and two using both. Overall, the odds of receiving CS was 1.41 times higher in for-profit hospitals as compared with either of the two types of non-profit hospitals (95% CI 1.24 to 1.60), with no relevant heterogeneity between studies ($\tau^2 \leq 0.037$) and little evidence for an interaction between estimated ORs and type of reference group (P for interaction=0.20). Figure 3 presents results of stratified analyses of adjusted odds ratios. Estimates varied to some extent between strata, but all tests for interaction or trend across subgroups were negative. Pooled estimates ranged from 1.20 to 1.62 across subgroups. There was little evidence to suggest secular trends (p for trend=0.13) or an association of ORs with national CS rates (p for trend=0.18). Figure 4 presents the meta-analysis of crude ORs with moderate to high heterogeneity between studies ($\tau^2 \geq 0.179$), a somewhat more pronounced average association (pooled OR 1.84, 95% CI 1.49 to 2.27) and again little evidence for an interaction between estimated ORs and type of reference group (P for interaction=0.48).

Discussion

Our systematic review and meta-analysis indicates that the odds of receiving a caesarean section are on average 1.4 times higher in private for-profit hospitals than in non-profit hospitals. Findings were robust across all subgroups of studies in stratified analyses. In particular, there was little evidence to suggest secular trends or an association with national CS rates. Even though, a test for trend across periods of data collection was negative, we found the association

between for-profit status of hospitals and odds of CS less pronounced in recent years. In view of the negative test for trend, this could be a chance finding. Alternatively, this may reflect attempts of care providers and policy makers to attenuate raising CS rates over time.

Context

To our knowledge, this is the first meta-analysis to address the association of CS rates with for-profit status of hospitals. We are aware of three recent meta-analyses that examined the association of CS rates with obesity (26), ethnic origin (27), and labour induction (28). In a meta-analysis of unadjusted estimates from prospective and retrospective cohort studies, Poobalan et al. found a 53% increase in the odds of CS associated with maternal overweight and a 126% increase with obesity (26). Merry et al. found a 41% increase in the adjusted odds of CS associated with Sub-Saharan African origin, and a 99% increase associated with Somali origin of women. Estimates for South, North-African/West Asian and Latin American women were similar but statistically not significant (27). Finally, in a meta-analysis of randomised trials, Mishanina et al. found expectant management to be associated with a 14% increase in the risk of CS (28). Our estimate of a 41% increase in adjusted odds of CS associated with for-profit status of hospital has a similar or larger magnitude than the associations found for the characteristics above and therefore appears relevant for both clinical and policy decision making. Our systematic review indicates agreement across 17 studies performed in seven countries as to the direction of this association, even though the magnitude of the association shows some variability.

Strengths and limitations

A major limitation of our meta-analysis lies in the variation between studies in design, number of hospital units' involved, size and characteristics of study population, type of data used, outcome

measure and variables used in statistical analysis. Despite these differences, the results of the meta-analysis of adjusted estimates were surprisingly consistent. Conversely, unadjusted estimates showed considerable heterogeneity between studies, which suggests confounding by both medical and non-medical factors as a reason for variation between studies. Among these factors are socio-economic status, preferences and clinical condition of women, foetus characteristics, medical care during pregnancy and delivery as well as physician, hospital and health system characteristics (2). Professionals often attribute higher rates of procedures to the gravity of clinical conditions of patient receiving an intervention. This argument is not supported by the data of this review as associations of CS rates with for-profit status were consistently found in analyses adjusted for a wide range of risk factors (see Web Appendix 3). Major strengths of our meta-analysis include a broad literature search, screening and data extraction performed in duplicate, careful exclusion of studies with overlapping populations and an exploration of study characteristics as a potential source of variation between studies.

Mechanisms

Financial incentives are likely to contribute to the observed association. The literature has described the influence of supply factors in the type and amount of care provided for given condition (29-32). Private for-profit institutions focus on profit and may create financial incentive structures that encourage more resource-intensive (33) and expensive procedures (11, 34-36), since that will increase their profits. The payment model of hospitals and physicians is another important factor (11, 32, 34, 35, 37). Fee for service reimbursement may be more common for private for-profit hospitals and will encourage hospitals and physicians to provide more procedures than medically indicated (38-40) and will increase time-pressure on physicians to perform CS instead of waiting longer for a normal birth (41, 42). Health insurers can

encourage overprovision of CS as they tend to reimburse hospitals and physicians better for CS than for vaginal delivery (11, 43, 44). Finally, private for-profit institutions typically have a higher number of qualified physicians, more resources and better infrastructure (2, 32, 45-47), which will encourage overprovision of care in private for-profit institutions.

Implications for research

Although it appears unwise to delay immediate steps to improve clinical decision making for CS, further research would inform the persistent dilemma of misalignment between good care and financial incentives. Because financial incentives differ across and within countries, there is a need for additional context specific investigation of the economic drivers of overuse (48). Policy analysis focusing on for-profit hospitals should examine further the interplay of specific factors for each country or, ideally, individual contracts between insurers and providers within countries to identify financial incentives that cause private for-profit hospitals to perform more CS than non-profit hospitals. Such analyses should explore if financial incentives interact at the physician level, such as physician payment schemes, or at the hospital level, including informal or formal pressure on physicians to choose more expensive procedures or save time by performing a CS instead of waiting longer for a normal birth. In some countries, such analyses should also extend to not for-profit hospitals, if fee for service payments are used regardless of for-profit status. The effects of the level and type of government regulation of hospitals, type of health insurance and implementation of clinical guidelines also require further study.

Implications for policy making

The persisting increase of CS rates in many health systems despite the growing recognition of CS overuse suggests that current clinical guidelines are not sufficient (2). Improving clinical decision making by providing clear clinical guidelines that are evidence based would be one step

forward. Equally important is the alignment of financial incentives with the objective to improve care without increasing costs. The higher odds of CS in the for-profit sector suggest that physicians and hospitals are responsive to financial incentives. Changing reimbursement policies so that vaginal deliveries and CS are paid similarly could keep overall payments to physicians and hospitals approximately constant without encouraging unnecessary CS but will not guarantee an elimination of overuse. Negative incentives, such as penalizing hospitals for high CS rates could also be considered, but require monitoring for unintended consequences (49). A decrease of unnecessary CS, a cost-effective use of resources and improved health outcomes for mothers and newborns should be the ultimate goal.

Conclusion

This systematic review and meta-analysis indicates that CS are more likely to be performed in for-profit hospitals as compared with non-profit hospitals. This holds true regardless of women's risk and contextual factors such as country, year, or study design. Since financial incentives are likely to play an important role, we recommend examination of incentive structures, including reimbursement schemes, of for-profit hospitals to identify strategies that encourage best clinical judgment and outcome rather than rewarding expensive procedures that are clinically unnecessary and potentially harmful for mothers and newborns.

Acknowledgments

Contributorship Statement

IH, DCG and PJ have developed the idea for the study. IH, XL and DCG were involved in the study conception, preliminary literature review and design of the search strategy and the study protocol. IH, LS and XL were involved in screening and data extraction of papers. All authors reviewed data extraction output. IH, LS, BDC, PJ designed and performed the meta-analysis. IH, LS, KT, BDC and PJ drafted the report, which was critically reviewed and approved by all authors.

Competing interests statement

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Funding statement

No funding was received to perform this study. All authors, had full access to all of the data (including statistical reports and tables) in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Data sharing statement

No additional unpublished data are available from the study.

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Table 1. Characteristics of included studies

Author	Year	Country	Study design	Number of cases	Number of hospital units	Year of data collection	Population	Sampling	Type of CS analysed	National CS rates**
Braveman et al.	1995	United States	Retrospective cohort study	213761	Unclear	1991	Primiparae; no previous CS; any risk	Consecutive	Any	High
Naiditch et al.	1997	France	Cross sectional	39880	944	1991	Primi- and multiparae; no previous CS; any risk	Random	Before labour	Moderate
Gomes et al. A	1999	Brazil	Cross sectional	6750	8	1978-1979	Primi- and multiparae; with or without previous CS; any risk	Consecutive	Any	Very high
Gomes et al. B	1999	Brazil	Cross sectional	2846	10	1994	Primi- and multiparae; with or without previous CS; any risk	Consecutive	Any	Very high
Gonzalez-Perez et al.	2001	Mexico	Cross sectional	1716446	Unclear	1994-1997	Primi- and multiparae; with or without previous CS; any risk	Consecutive	Any	High
Korst et al.	2005	United States	Cross sectional	443532	288	1995	Primi- and multiparae; no previous CS; any risk	Consecutive	During labour	High
Mossialos et al.	2005	Greece	Cross sectional	805	3	2002	Primi- and multiparae; with or without previous CS; any risk	Consecutive	Any	High
Carayol et al. A	2007	France	Cross sectional	1479	Unclear	1972, 1995, 1998, 2003	Primi- and multiparae; no previous CS; high risk	Random	Before labour	Moderate
Carayol et al. B	2007	France	Cross sectional	6080	138	2001-2002	Primi- and multiparae; no previous CS; high risk	Random	Before labour	Moderate
Xirasagar and Lin	2007	Taiwan	Cross sectional	739531	942	1997-2000	Primi- and multiparae; with or without previous CS; any risk	Consecutive	Before labour*	High
Coonrod et al.	2008	United States	Cross sectional	28863	40	2005	Primiparae; low risk	Consecutive	Any	High
Coulm et al.	2012	France	Cross sectional	9530	535	2010	Primi- and multiparae; no previous CS; low risk	Consecutive	Any	Moderate
Huesch et al.	2014	United States	Cross sectional	408355	254	2010	Primi- and multiparae; no previous CS; any risk	Consecutive	Before labour	High
Raifman et al. A	2014	Brazil	Cross sectional	4918	Not Reported	1996	Primi- and multiparae; with or without previous CS; any risk	Random	Any	Very high
Raifman et al. B	2014	Brazil	Cross sectional	5768	Not Reported	2006	Primi- and multiparae; with or without previous CS; any risk	Random	Any	Very high
Schemann et al.	2015	Australia	Cross sectional	61894	81	2007-2011	Multiparae; with previous CS	Consecutive	Any	High
Sebastião et al.	2016	United States	Retrospective cohort study	412192	122	2004-2011	Primiparae; low risk	Consecutive	During labour	High

*On maternal request

** National CS rates classified according to WHO data reported for 2008 into moderate (>15 to 20%), high (>20 to 40%) and very high (>40%)

Figure Legends

Figure 1: The flow diagram of review

Figure 2: Adjusted odds ratios of caesarean section.

Figure 3: Stratified analyses.

Notes: *P for linear trend

Figure 4: Crude odds ratios of caesarean section.

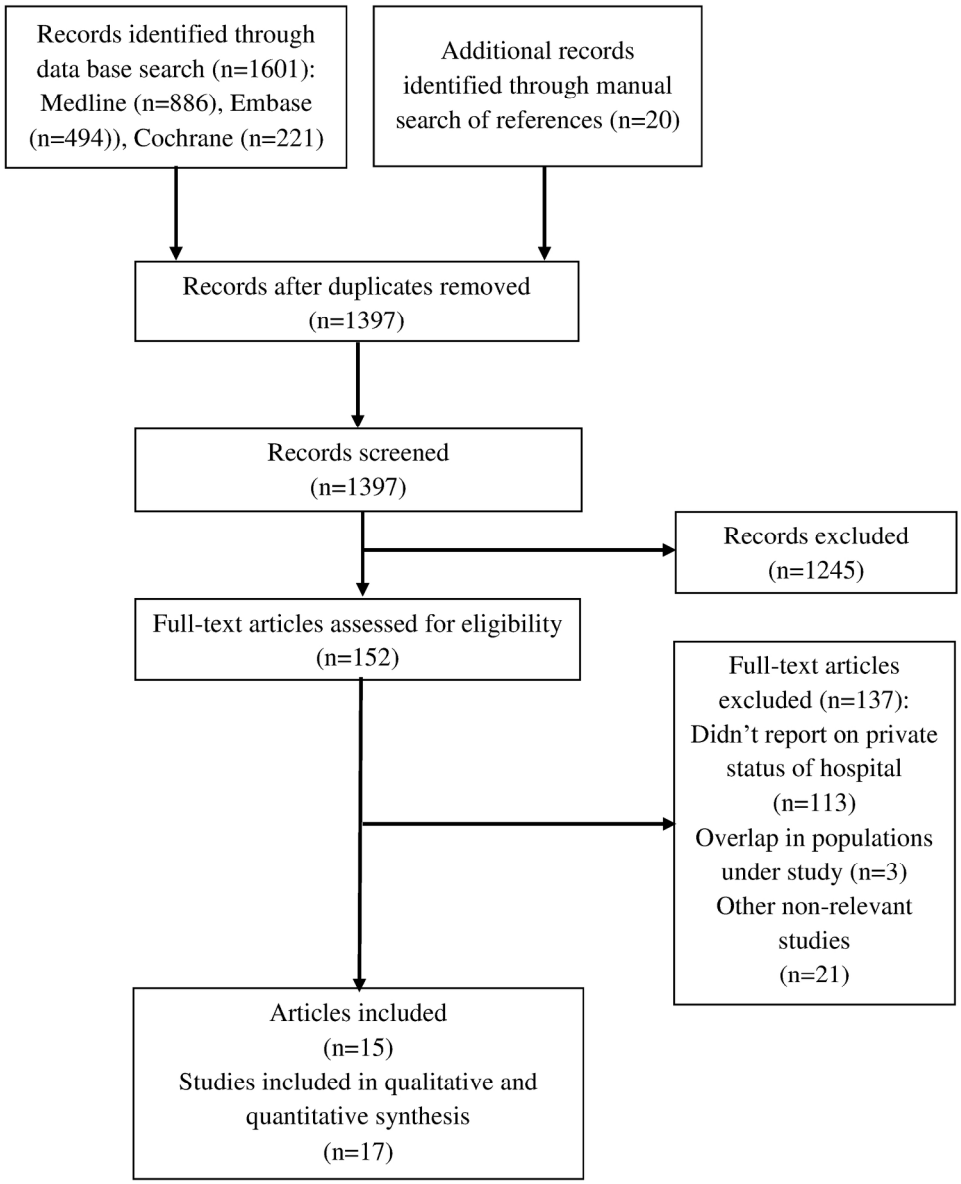

Figure 1: The flow diagram of review

195x241mm (300 x 300 DPI)

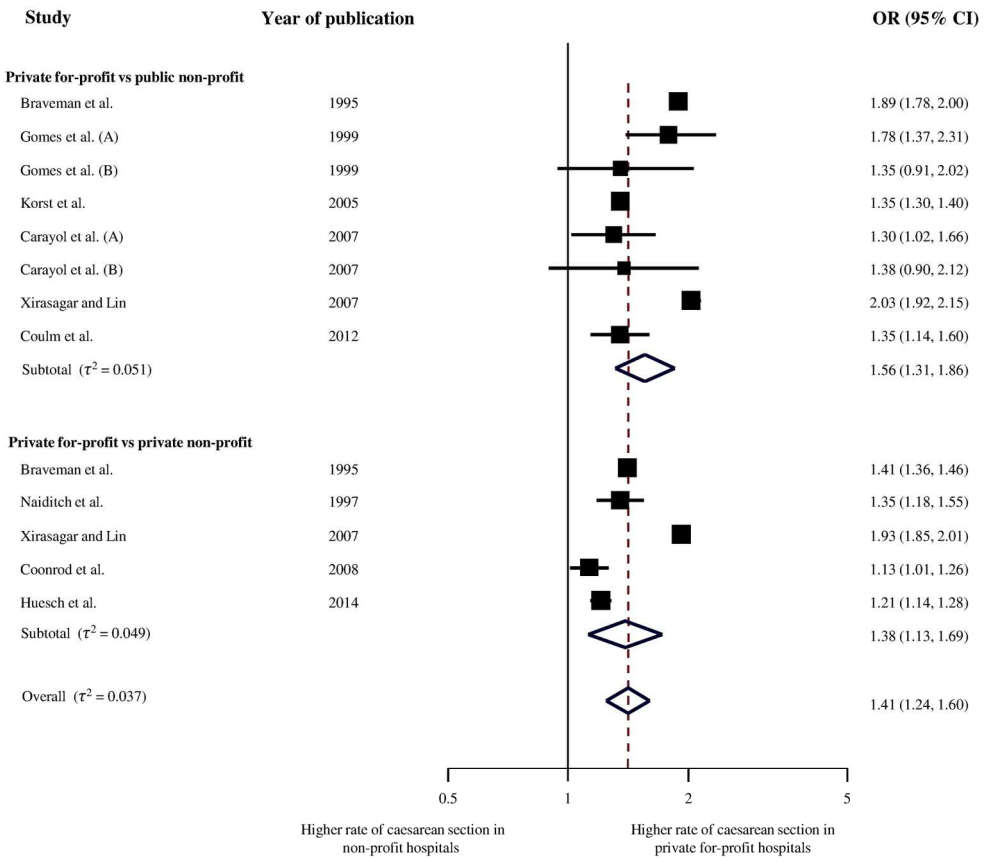

Figure 2: Adjusted odds ratios of caesarean section.

165x144mm (300 x 300 DPI)

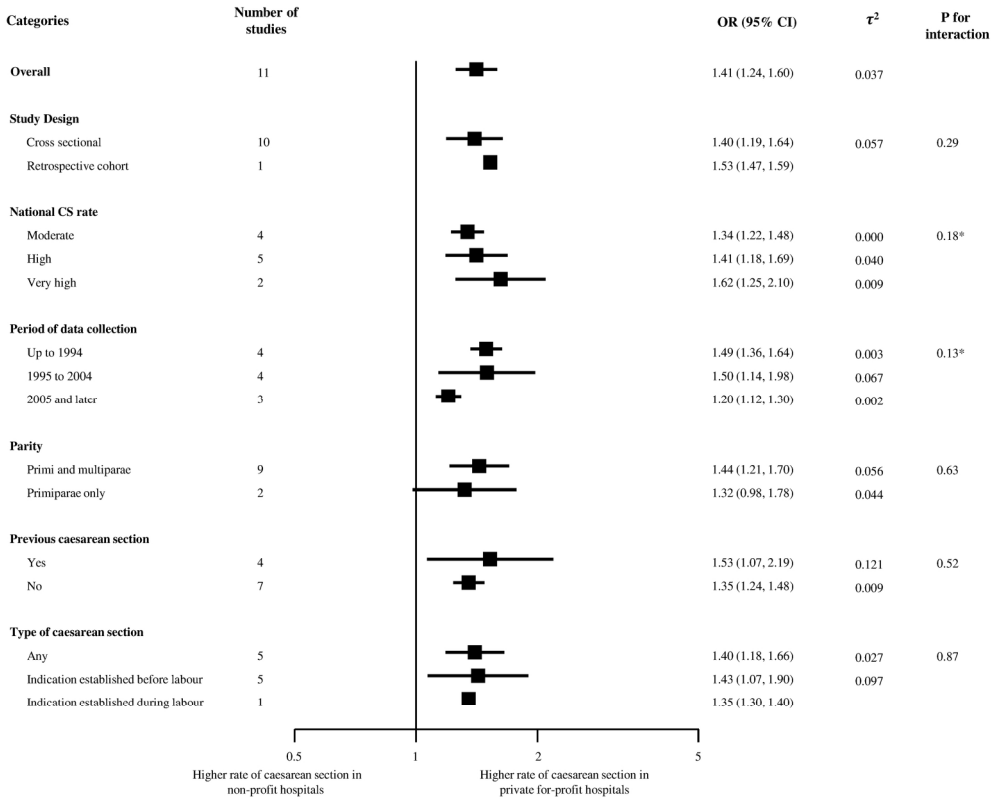

Figure 3: Stratified analyses./*P for linear trend

187x153mm (300 x 300 DPI)

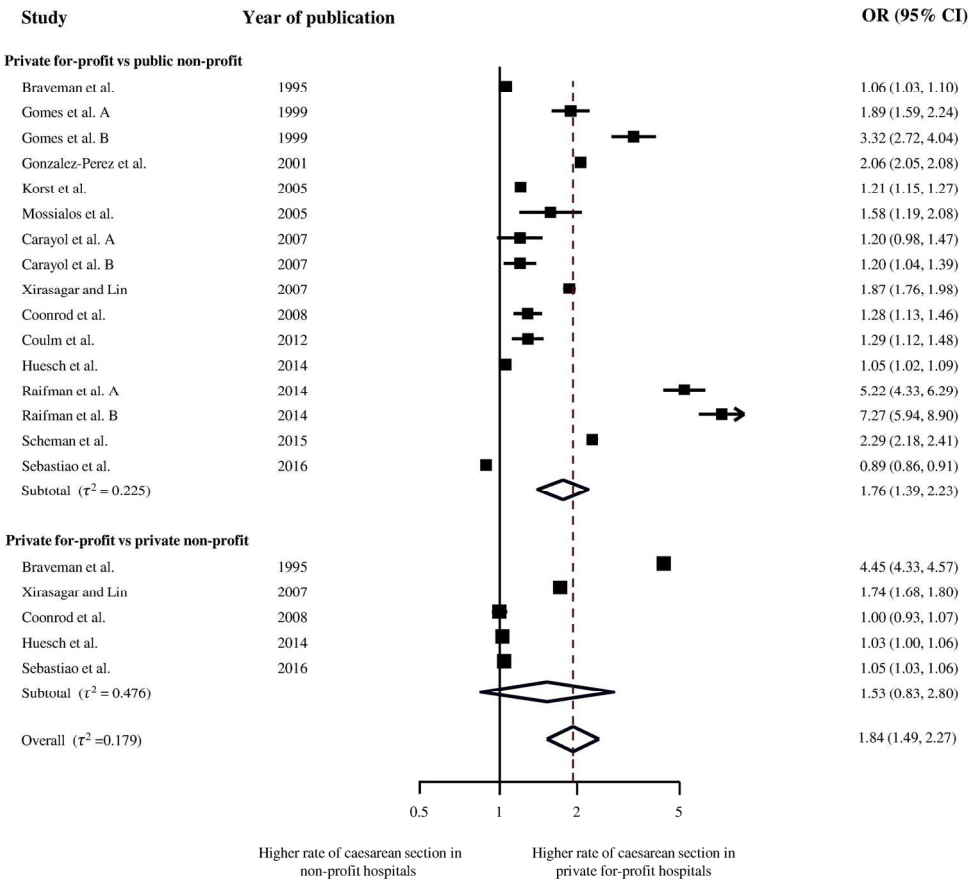

Figure 4: Crude odds ratios of caesarean section.

171x153mm (300 x 300 DPI)

What this study adds?

What is already known in this topic?

Financial incentive structures may encourage more resource-intensive and expensive procedures particularly in private for-profit institutions.

Fee for service reimbursement will encourage hospitals and physicians to provide more procedures than medically indicated and will increase time-pressure on physicians to perform CS instead of waiting longer for a normal birth.

Private for-profit institutions typically have a higher number of qualified physicians, more resources and better infrastructure which will encourage overprovision of care in private for-profit institutions.

What this study adds?

Our meta-analysis indicates that the odds of delivery by caesarean section are on average 1.4 times higher in private for-profit hospitals than in non-profit hospitals.

Increased odds of delivery by caesarean in private for-profit hospitals are found independently of women's or newborn's risk factors and across different contexts, including different countries, time periods and study designs.

Appendix 1. Reported exclusion criteria

Authors	Source population	Women age 14 and below	Women from racial or ethnic minorities	Primiparae	Multiparae	Women with previous CS	Women with no previous CS	Women with uterine scars	Stillbirth	Multiple births (twin or more)	Not in labour	Cephalic presentation	Breach presentation	Other malpresentation of foetus	Preterm birth (less than 37 weeks)	Other risk factors for CS
Braveman et al.	All births in State of California, United States				+	+			+	+					+	
Naiditch et al.	All births in 944 maternity units in France	+				+			+	+					+	+
Gomes et al. A	All births in Ribeirão Preto, State of São Paulo, Southeast Brazil								+	+					+	
Gomes et al. B	All births in Ribeirão Preto, State of São Paulo, Southeast Brazil								+	+					+	
Gonzalez-Perez et al.	All births in Mexico															
Korst et al.	All births in State of California, United States					+			+	+	+				+	+
Mossialos et al.	All births in the three hospitals in Athens, Greece															
Carayol et al. A	All births in Metropolitan France					+			+	+		+		+	+	
Carayol et al. B	All births in 138 maternity units in France					+		+	+	+		+		+	+	
Xirasagar and Lin	All births in Taiwan								+	+					+	+
Coonrod et al.	All births in State of Arizona, United States		+		+				+	+			+	+	+	
Coulm et al.	All births in all maternity units in France					+			+	+			+	+	+	+
Huesch et al.	All births in State of California, United States	+				+									+	+
Raifman et al. A	All births in Brazil	+							+	+					+	
Raifman et al. B	All births in Brazil	+							+	+					+	
Schemann et al.	All births in 81 hospitals in New South Wales, Australia			+			+								+	
Sebastião et al.	All births in 122 hospitals in State of Florida, United States				+				+	+	+		+	+	+	

Appendix 2. Characteristics of data used for analysis

Author	Survey	Hospital records	Birth certificates/registry	Insurance claims	Census data
Braveman et al.			+		+
Naiditch et al.		+		+	
Gomes et al. A	+				
Gomes et al. B	+				
Gonzalez-Perez et al.			+		
Korst et al.		+			
Mossialos et al.		+			
Carayol et al. A	+	+			
Carayol et al. B	+	+			
Xirasagar and Lin				+	
Coonrod et al.			+		
Coulm et al.	+	+			
Huesch et al.		+			
Raifman et al. A	+				
Raifman et al. B	+				
Schemann et al.		+			
Sebastião et al.		+	+		

Appendix 3. Covariates used for statistical adjustment

Author \ Covariates	Maternal preconception status											Maternal clinical characteristics				Foetus characteristics								
	Ethnicity	Education level	Marital status	Economic status	Employment	Insurances status	Urban versus rural	Geographic origin	Spoken language	Body mass index	Maternal age	Parity	Previous caesarean section	Pre-existing (before pregnancy) conditions	Conditions developed during pregnancy	Gestational age	Birth weight	Number of live births	Foetal characteristics	Prenatal care	Birth characteristics	Provider characteristics	Other variables	Total number of covariates adjusted for
Braveman et al.	+	+	+	+		+			+		+			+			+		+	+	+	++		15
Naiditch et al.											+	+											+	3
Gomes et al. A		+	+	+	++	+					+	+		++		+	+			+	+	+		16
Gomes et al. B		+	+	+	++	+					+	+		++		+	+			+	++	+		18
Gonzalez-Perez et al.																								0
Korst et al.	+					+					+										+	++		7
Mossialos et al.																								0
Carayol et al. A		+									+	+				+	+				+	+		7
Carayol et al. B		+						+			+	+												4
Xirasagar and Lin											+											+		2
Coonrod et al.	+	+				+					+			++	+	+	+		+	+	+	++		20
Coulm et al.		+						+		+	+	+				+	+					+		8
Huesch et al.	+			+		+					+			++	++	+			++	+	++	++	++	124
Raifman et al. A																								0
Raifman et al. B																								0
Schemann et al.																								0
Sebastião et al.																								0

+ One covariate adjusted for ++ Two or more covariates adjusted for

Gonzales-Perez et al, Mossialos et al, Raifman et al, Schemann et al and Sebastião et al only reported crude estimates.

Appendix 4 - Search Strategy

1. For Medline (PubMed)

(((((((causes OR determinants OR statistics OR rates OR factors OR decision* OR physician* OR socioeconomic OR state medicine OR evidence-based OR hospital OR hospitals OR hospitalization OR hospitalized OR uncertain* OR educational status OR social class OR obstetric* OR gynecolog* OR supply OR distribut* OR utilization OR insurance OR choice OR attitude OR patient OR economics OR maternal OR accessib* OR health service* OR rural population OR urban population[Title/Abstract])) NOT medline[sb])) OR ("Decision Making"[Mesh] OR "Physician's Practice Patterns"[Mesh] OR "Socioeconomic Factors"[Mesh] OR "State Medicine"[Mesh] OR "Evidence-Based Medicine"[Mesh] OR "Hospitals"[Mesh] OR "Uncertainty"[Mesh] OR "Educational Status"[Mesh] OR "Hospital Costs"[Mesh] OR "Physician Incentive Plans"[Mesh] OR "Social Class"[Mesh] OR "Obstetrics and Gynecology Department, Hospital"[Mesh] OR "supply and distribution"[Subheading] OR "utilization"[Subheading] OR "Insurance"[Mesh] OR "Choice Behavior"[Mesh] OR "Attitude to Health"[Mesh] OR "Patient Participation"[Mesh] OR "Physician-Patient Relations"[Mesh] OR "Economics, Hospital"[Mesh] OR "Maternal Health Services"[Mesh] OR "Health Services Accessibility"[Mesh] OR "Health Services Research"[Mesh] OR "Rural Population"[Mesh] OR "Urban Population"[Mesh]))) OR factors OR rates OR statistics OR causes OR determinants AND (((((operative delivery OR caesarean section OR cesarean section OR c-section OR c section OR caesarean OR cesarean OR caesarean delivery OR cesarean delivery OR caesarean rates OR cesarean rates)))) OR cesarean section [MeSH Terms])) AND ((((("Catchment Area (Health)"[Mesh] OR "Small-Area Analysis"[Mesh])))) OR ((((small area analysis OR small area analyses OR medical practice variation OR regions OR geographic variation OR variation)))))

2. Embase (Ovid SP)

	# ▲	Searches	Results	Search Type	Actions
	1	decision making/	134077	Advanced	Display More »
	2	professional practice/ or group practice/ or health care practice/ or medical practice/	129049	Advanced	Display More »
	3	socioeconomics/	110558	Advanced	Display More »
	4	state medicine.mp. or national health service/	54605	Advanced	Display More »
	5	evidence based medicine/	80825	Advanced	Display More »
	6	hospital/	216188	Advanced	Display More »
	7	uncertainty/	6158	Advanced	Display More »
	8	educational status/	36032	Advanced	Display More »
	9	"hospital cost"/	13192	Advanced	Display More »
	10	physician incentive plans.mp. or personnel management/	49572	Advanced	Display More »
	11	social class/	26291	Advanced	Display More »
	12	hospital department/	21809	Advanced	Display More »
	13	obstetrics/	27326	Advanced	Display More »
	14	gynecology/	29917	Advanced	Display More »
	15	12 or 13	54283	Advanced	Display More »

☐	16	12 and 15	413	Advanced	Display More ≫
☐	17	health care distribution/	2333	Advanced	Display More ≫
☐	18	health care utilization/	36879	Advanced	Display More ≫
☐	19	insurance/	33934	Advanced	Display More ≫
☐	20	choice behavior.mp.	765	Advanced	Display More ≫
☐	21	attitude to health/	81021	Advanced	Display More ≫
☐	22	patient participation/	16400	Advanced	Display More ≫
☐	23	doctor patient relation/	81043	Advanced	Display More ≫
☐	24	health economics/	33098	Advanced	Display More ≫
☐	25	obstetric procedure/	550	Advanced	Display More ≫
☐	26	health care access/	34433	Advanced	Display
☐	27	health services research/	27579	Advanced	Display More ≫
☐	28	geographic distribution/	132846	Advanced	Display More ≫
☐	29	rural population/	30219	Advanced	Display More ≫
☐	30	urban population/	35323	Advanced	Display More ≫
☐	31	causes/	0	Advanced	Delete More ≫
☐	32	determinants/	1	Advanced	Display More ≫
☐	33	statistics/	301146	Advanced	Display More ≫
☐	34	rates/	0	Advanced	Delete More ≫
☐	35	factors/	0	Advanced	Delete More ≫
☐	36	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 29 or 30 or 32 or 33	1340916	Advanced	Display More ≫
☐	37	cesarean section/	59755	Advanced	Display More ≫
☐	38	(caesarean section or cesarean section or c-section or c section or caesarean or cesarean or caesarean delivery or cesarean delivery or caesarean rates or cesarean rates or operative delivery).ti,ab,tw.	53950	Advanced	Display Delete More ≫
☐	39	37 or 38	73014	Advanced	Display More ≫
☐	40	(small area analysis or small area analyses or small aeraor medical practice variation or regions or geographic variation or variation or variations).ti,ab,tw.	964890	Advanced	Display More ≫
☐	41	28 or 40	1082827	Advanced	Display More ≫
☐	**42**	**36 and 39 and 41**	**357**	**Advanced**	Display More ≫

3. Cochrane Database of Systematic Reviews

Caesarean section

Supplement 1 – List of included studies

1. Braveman P, Egerter S, Edmonston F, Verdon M. Racial/ethnic differences in the likelihood of cesarean delivery, California. American Journal of Public Health. 1995;85(5):625-30.
2. Naiditch M, Levy G, Chale JJ, Cohen H, Colladon B, Maria B, et al. [Cesarean sections in France: impact of organizational factors on different utilization rates]. J Gynecol Obstet Biol Reprod (Paris). 1997;26(5):484-95.
3. Gomes UA, Silva AA, Bettiol H, Barbieri MA. Risk factors for the increasing caesarean section rate in Southeast Brazil: a comparison of two birth cohorts, 1978-1979 and 1994. Int J Epidemiol. 1999;28(4):687-94.
4. Gonzalez-Perez GJ, Vega-Lopez MG, Cabrera-Pivaral C, Munoz A, Valle A. Caesarean sections in Mexico: are there too many? Health Policy Plan. 2001;16(1):62-7.
5. Korst LM, Gornbein JA, Gregory KD. Rethinking the cesarean rate: how pregnancy complications may affect interhospital comparisons. Med Care. 2005;43(3):237-45.
6. Mossialos E, Allin S, Karras K, Davaki K. An investigation of Caesarean sections in three Greek hospitals: the impact of financial incentives and convenience. Eur J Public Health. 2005;15(3):288-95.
7. Carayol M, Blondel B, Zeitlin J, Breart G, Goffinet F. Changes in the rates of caesarean delivery before labour for breech presentation at term in France: 1972-2003. Eur J Obstet Gynecol Reprod Biol. 2007;132(1):20-6.
8. Carayol M, Zeitlin J, Roman H, Le Ray C, Breart G, Goffinet F. Non-clinical determinants of planned cesarean delivery in cases of term breech presentation in France. Acta Obstet Gynecol Scand. 2007;86(9):1071-8.
9. Xirasagar S, Lin HC. Maternal request CS--role of hospital teaching status and for-profit ownership. Eur J Obstet Gynecol Reprod Biol. 2007;132(1):27-34.
10. Coonrod DV, Drachman D, Hobson P, Manriquez M. Nulliparous term singleton vertex cesarean delivery rates: institutional and individual level predictors. Am J Obstet Gynecol. 2008;198(6):694 e1-11; discussion e11.
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12. Huesch MD, Currid-Halkett E, Doctor JN. Measurement and risk adjustment of prelabor cesarean rates in a large sample of California hospitals. Am J Obstet Gynecol. 2014;210(5):443 e1-17.
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Research Checklist

According to MOOSE statement for meta-analyses of observational studies

Reporting of background should include	**Where to find in manuscript**
Problem definition	Manuscript (page 4)
Hypothesis statement	Manuscript (page 4)
Description of study outcome(s)	Manuscript (page 5)
Type of exposure or intervention used	Manuscript (page 5)
Type of study designs used	Manuscript (page 4)
Study population	Manuscript (page 4)
Reporting of search strategy should include	
Qualifications of searchers (eg, librarians and investigators)	Manuscript (page 5)
Search strategy, including time period included in the synthesis and keywords	Manuscript (pages 4-5), Supplment 1
Effort to include all available studies, including contact with authors	Manuscript (page 5)
Databases and registries searched	Manuscript (page 5)
Search software used, name and version, including special features used (eg, explosion)	Manuscript (page 5)
Use of hand searching (eg, reference lists of obtained articles)	Manuscript (page 5)
List of citations located and those excluded, including justification	Figure 1 and Supplement 1
Method of addressing articles published in languages other than English	Manuscript (page 5)
Method of handling abstracts and unpublished studies	Manuscript (page 5)
Description of any contact with authors	No contact made
Reporting of methods should include	
Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	Manuscript (page 5)
Rationale for the selection and coding of data (eg, sound clinical	Manuscript (page 5)

principles or convenience)	
Documentation of how data were classified and coded (eg, multiple raters, blinding, and interrater reliability)	Manuscript (pages 5-6)
Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	Manuscript (page 6) Appendix 3
Assessment of study quality, including blinding of quality assessors; stratification or regression on possible predictors of study results	Manuscript (page 5) Table 1, Appendix 1-3
Assessment of heterogeneity	Manuscript (page 6)
Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	Manuscript (page 5)
Provision of appropriate tables and graphics	Manuscript, Table 1, Figure 1-4 and Web Appendixes 1-3
Reporting of results should include	
Graphic summarizing individual study estimates and overall estimate	Figure 2-4
Table giving descriptive information for each study included	Table 1
Results of sensitivity testing (eg, subgroup analysis)	Figure 3
Indication of statistical uncertainty of findings	Manuscript, Figure 2-4
Reporting of discussion should include	
Quantitative assessment of bias (eg, publication bias)	Manuscript (page 8)
Justification for exclusion (eg, exclusion of non—English-language citations)	Manuscript (page 8)
Assessment of quality of included studies	Manuscript (page 8)
Reporting of conclusions should include	

Consideration of alternative explanations for observed results	Manuscript (pages 9-11)
Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	Manuscript (page 11)
Guidelines for future research	Manuscript (page 10)
Disclosure of funding source	Manuscript (page 12)