‘THIS LINE ACROSS MY BELLY…’

Studies *in* Caesarean Section

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Birth of Caesar, Royal 16 G VII f.219, c. 1400

From the British Library Collection, accessible at:
https://www.bl.uk/collection-items/illustration-of-the-birth-of-caesar-from-a-compilation-of-ancient-history

The Line

This line across my belly…
It represents a change of plans.
It represents disappointment, loss,
A last minute bend in the road.
It represents overwhelming delight.

This line across my belly –
It represents a new beginning.
It represents hope, anticipation,
The start of a new season,
The end of yearning.

This line across my belly –
It represents a decision to move forward.
It represents sadness, love,
A voice of reason, a whisper of faith.

This line across my belly –
It represents a deep satisfaction,
An unquenchable happiness.
It's the scar of new life,
The mark of strength and endurance.
It's an ugly battle wound, a brilliant medal.
It's elation, it's treasure,
It's pleasure, it's bliss.

This line across my belly –
It's a reminder of resilience, of the answer,
The will to bounce back.
It's jagged, yet beautiful…
Numb and alive.
It's mine, it's ours.

This line across my belly –
It's a gift,
It's grace.
This line is yours…
My heart, my joy.

- Adriel Booker

"Childbirth is more **admirable** than conquest,
more **amazing** than self-defence,
and as ***courageous*** as either one."

- Gloria Steinem

Declaration

This is to certify that, to the best of my knowledge and belief, this thesis contains no material previously published or written by other persons except where due reference is made in the text of the thesis.

This thesis has not been submitted for any degree in any other university.

The work in this thesis is my own except where acknowledged.

Stephen James Robson

November, 2018

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Statement of Contributions

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IMPORTANT NOTE: There is no relationship between the develop of the 'Ten-Group (Robson) classification of caesarean sections' – Dr Michael S Robson of the National Maternity Hospital in Dublin, Republic of Ireland – and this author.

Abstract

Caesarean section is the commonest major surgery in Australia, as is the case in most developed nations. The rate of caesarean birth increased threefold over the last 25 years causing comment and debate in both the medical and lay press. Despite this interest and concern, much remains unknown about this important and, at times, life-saving operation. Analysis of data from the South Australian Perinatal Statistics collection regarding singleton term births during the period 1991 until 2009 revealed that increases in maternal age contributed to almost 75% of the increase in caesarean sections over the timeframe? Repeat caesarean section is another important determinant of overall rates, and it seems likely that interventions to improve the paternal perceptions of risk during a pregnancy might increase the chance that a couple will attempt a vaginal birth after a previous caesarean section. Concerns have been raised about associations between caesarean birth and childhood obesity, asthma, and other long-term neurodevelopmental outcomes. Using data from the Longitudinal Study of Australian Children (LSAC) it was found that caesarean birth is associated with a mix of positive and negative outcomes across early childhood, but there does not appear to be a strong association between caesarean birth and poorer health or neurodevelopmental outcomes in childhood. The LSAC dataset was also analysed to identify previously unsuspected risk factors for caesarean section. The final adjusted analyses revealed that, in addition to other known risk factors, maternal mental health problems during pregnancy increased the odds of caesarean birth, suggesting that the effects of additional screening and support for maternal mental health on caesarean rates should be the subject of prospective study. International data suggests that maternal choice is an important contributor to increased rates of caesarean birth. It is likely that a true prospective randomised study will never occur: a pilot study of a pragmatic prospective cohort study was undertaken and revealed the difficulties in recruiting to such a research endeavour, but did develop a methodology that could provide useful data. Finally, the World Health Organization (WHO) recommendation that caesearean section rates above 15% offer no additional benefit was critiqued and found to be flawed: the recommendation deals only with very short-term outcomes not long-term outcomes of importance to women and communities.

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Abbreviations used in the Thesis

ABS	Australian Bureau of Statistics
ACOG	American College of Obstetricians and Gynaecologists
AI	Anal incontinence
AIHW	Australian Institute of Health and Welfare
AMA	Australian Medical Association
AOR	Adjusted odds ratio
ART	Assisted reproductive treatment
BMI	Body mass index
CDMR	Caesarean delivery on maternal request
CSMR	Caesarean section at maternal request
CI	Confidence interval
COD	Caesarean on demand
CS	Caesarean section
DVD	Digital versatile disc
EPDS	Edinburgh postnatal depression score
FI	Faecal incontinence
FIGO	International Federal of Gynecology and Obstetrics
HDI	Human development index
IVF	*In-vitro* fertilization
PAHO	Pan-American Health Organisation
POP	Pelvic organ prolapse
MCCS	Maternal-choice caesarean section
MMR	Maternal mortality ratio
MMRate	Maternal mortality rate
NHS	National Health Service
NICE	National Institute for Clinical Evaluations
NICHD	National Institute of Child Health and Human Development
NIH	National Institutes of Health of the United States
NMR	Neonatal mortality rate
NPDC	National perinatal data collection
OECD	Organisation for Economic Co-operation and Development

OR	Odds ratio
PCC	Patient-choice caesarean
PFD	Pelvic floor dysfunction
PMR	Perinatal mortality rate
RANZCOG	Royal Australian and New Zealand College of Obstetricians and Gynaecologists
RCM	Royal College of Midwives
RCOG	Royal College of Obstetricians and Gynaecologists
RR	Relative risk
SUI	Stress urinary incontinence
SVB	Spontaneous vaginal birth
TGCS	Ten-group classification system
TOLAC	Trial of labour after caesarean section
TTN	Transient tachypnoea of the newborn
UI	Urinary incontinence
VBAC	Vaginal birth after caesarean
WHO	World Health Organization

Publications arising from the Thesis

1. Baghurst P, **Robson SJ**, Antoniou G, Scheil W, Bryce R. The association between increasing maternal age at first birth and decreased rates of spontaneous vaginal birth in South Australia from 1991 to 2009. *Aust N Z J Obstet Gynaecol* 2014; **54**(3): 237-43.

2. **Robson SJ**, Vally H, Abdel-Latif ME, Yu M, Westrupp E. Childhood health and developmental outcomes after Cesarean birth in an Australian cohort. *Pediatrics* 2015; **136**(5): e1285-93.

3. **Robson SJ**, Campbell B, Pell G, Wilson A, Tyson K, de Costa C, Permezel M, Woods C. Concordance of maternal and paternal decision-making and its effect on choice for vaginal birth after caesarean section. *Aust N Z J Obstet Gynaecol* 2015; **55**(3): 257-61. doi: 10.1111/ajo.12326.

4. **Robson SJ**, Vally H, Mohamed AL, Yu M, Westrupp EM. Perinatal and social factors predicting caesarean birth in a 2004 Australian birth cohort. *Women Birth* 2017; **30**(6): 506-510.

5. **Robson SJ**, de Costa CM. Thirty years of the World Health Organization's target caesarean section rate: time to move on. *Med J Aust* 2017; **206**(4): 181-185.

6. **Robson SJ**, de Costa C, Woods C, Ding P, Rane A. Maternal-choice caesarean section versus planned vaginal birth in low-risk primigravid women. *Aust N Z J Obstet Gynaecol* 2018.

One of the earliest printed illustrations of caesarean section. Purportedly the birth of Julius Caesar: a live infant being surgically removed from a dead woman. From Suetonius' *Lives of the Twelve Caesars*, 1506 woodcut.

Preface

During 2015 in Australia a caesarean section (CS) was performed, on average, every five minutes. In that year, a total of 101370 caesarean sections were undertaken, accounting for one third of the 304260 babies delivered in 2015.(AIHW, 2017) The number is likely to be higher this year. During the same time period, only 41414 appendicectomies were performed, and 61542 sets of tonsils removed.(AIHW, 2018) It seems incredible, then, that a procedure that is performed in the same numbers as all appendicectomies and tonsillectomies combined could remain a mystery. This is particularly so when birth is such a special event for every individual alive. As a joint statement from the Royal College of Midwives (RCM) and the Royal College of Obstetricians and Gynaecologists (RCOG) puts it:

> "Birth for a woman is a rite of passage and a family life event, as well as being the start of a lifelong relationship with her baby." (RCOG, 2007)

Birth captures the popular interest like few other topics. A search of the book catalogue of the National Library of Australia yields but a single volume dealing with the appendix or appendecectomy, the slim *Pathology of the Appendix* by Paul Myer (Chapman and Hull, 1994). Twenty books on tonsils or tonsillectomy reside in the library, with titles such as *Where did my tonsils go?* (Hazel Edwards, Harcourt Brace Jovanovic, 1989). In contrast, forty-two titles appear dealing solely or mainly with CS (not including other pregnancy topics and non-caesarean birth), with politically-charged titles such as *Motherhood, power and oppression* (edited by Marie Porter, Patricia Short, and Andrea O'Reilly, Women's Press, 2005), *VBAC-Letting your birth goddess roar* (by Toni Sherlock, Lulu Press, 2007), and even *The birth wars* by Mary Rose McColl (University of Queensland Press, 2009).

The incumbent British Monarch, Queen Elizabeth II, was delivered by CS in 1926, at a time when the procedure was usually performed only in desperation. In her book *Hail Caesar*, de Costa reminds us that in the era that Queen Elizabeth II was born, almost one out of 100 women delivered by CS succumbed to complications of the procedure.(de Costa, 2008) At that time the rate of

caesarean birth was under 5% and, according to de Costa who quotes from the press at the time, "childbirth [was] four times more dangerous that coalmining, and coalmining is men's most dangerous occupation." In the aftermath of the Second World War, in concert with the establishment of the British National Health Service (NHS), homebirth was increasingly abandoned and the move to hospital birth introduced in the developed world. Over this period, the number of babies delivered by caesarean section began to increase. Again, de Costa quotes obstetrician Ian Donald who wrote in 1959:

> "Caesarean section is now performed with increasing impunity, thanks largely to antibiotics, improved anaesthesia and the availability of blood transfusion … but it would be a great mistake to regard it as a means of finding a happy outcome to all our obstetric afflictions."(de Costa, 2008)

As is the case with many other surgical procedures, CS has improved in terms of safety even during the lifetime of many currently practicing obstetricians. Minkoff (2006) makes the following observation about the evolution of CS:

> "The balance of benefits and burdens associated with the performance of cesarean sections has changed dramatically in the last century. As an example, in the 1930s at Kings County Hospital in New York, cesarean sections were absolutely prohibited for patients who had been in labor for more than 12 hours, or whose membranes had been ruptured more than 4 hours. Those rules were directly related to the therapeutic armamentarium available at that time for the treatment of postoperative sepsis; women were taken to the hospital roof for sunshine and fresh air if they became febrile. If additional therapy proved necessary, the patient's husband was asked to donate blood. The latter occurred before Landsteiner discovered the Rh factor. Not surprisingly, that era was marked by both a high maternal mortality rate and a very low cesarean section rate."

Improvements in anaesthesia, antibiotic therapy, and blood transfusion practices all grew out of imperatives of the Second World War, a period of remarkable fecundity that is now known as the 'baby boom.' As the baby boomers themselves had children, the rate of caesarean birth increased slowly but inexorably to about 15% in the 1980s.(Wilkinson, *et al*, 1998; Arias, *et al*, 2003;

O'Leary, *et al*, 2007) From the early 1990s until the new millennium, however, the caesarean rate doubled again.

Increases in the rate of caesarean birth have attracted adverse comment from many quarters, with the term 'caesarean epidemic' used in both the lay and medical press. An excellent summary of the discussion in the lay press is presented by de Costa in *Hail Caesar*.(de Costa, 2008) This review will concentrate on comment and published evidence from the medical literature.

A typical view of caesarean birth is illustrated by the opening sentences of a research paper:

> "There is international concern about the growing proportion of women giving birth by caesarean section, particularly in high-income countries, given the increased risks in subsequent pregnancies (unexplained stillbirth, placenta accrete and percreta, placental abruption, decreased fertility, ectopic pregnancy and spontaneous abortion); increased infant morbidity (neonatal respiratory problems) and possible associations with childhood asthma, food allergies and childhood-onset type 1 diabetes. Caesarean section is also associated with slower maternal recovery from birth and places an additional burden on the resources of health services."(McLachlan, *et al*, 2012)

Other similar epidemiological studies reflect on the increasing rate of caesarean birth and contain statements such as:

> "The increasing in caesarean section rate over the 20 years of this study is likely to be multifactorial and reflects a complex social process affected by clinical status, obstetric practice and training, family and social pressures, the legal system, availability of technology, women's requests, and women's role models (celebrity elective caesarean delivery.
> "These changes in the management of labour and delivery highlight a number of areas of concern."(O'Leary, *et al*, 2007)

The World Health Organization (WHO) has publicised its 'ideal rate' of CS as between 10 and 15%, arguing that "caesarean section rates above a certain limit

have not shown additional benefit for the mother or the baby."(Gibbons, *et al*, 2010) This statement, like so many on the topic of CS, is not quite accurate: there are data suggesting that higher CS rates may be associated with overall reductions in mortality for normally-grown term babies without major congenital abnormalities (Matthews, *et al*, 2003).

'Prophylactic' caesarean section

In response to a litigation case of intrapartum fetal neurologic injury, Feldman and Freiman published *Prophylactic cesarean at term?*(Feldman and Freiman, 1985) They canvassed the then-provocative notion of informed consent for route of delivery, caesarean or vaginal, once fetal lung maturity was reached. "Prophylactic cesarean" was offered as a means of avoiding "the very real risks associated with passive anticipation of vaginal delivery" (Wax, Cartin, Pinette, *et al*, 2004)

The paper had little resonance until the late 1990s, when realisation that the practice might actually be common provoked an exponential rise in editorials, letters, research articles, and 'official opinions,' including those of the American College of Obstetricians and Gynecologists (ACOG) and the International Federation of Gynecology and Obstetrics (FIGO).(Wax, Cartin, Pinette, *et al*, 2004) The issue was addressed in an opinion article by the deputy editor of the *American Journal of Obstetrics and Gynecology*, Professor John Queenan as follows:

> "Given a clear delineation of risks (we will never know the absolutes), who is in the best position to decide on cesarean delivery? The mother undergoing the surgery? The advocate for the baby to be delivered? The father? The physicians performing the delivery? The pediatrician? The hospital administrator? The third-party payer? They all have definite interests and different points of view."(Queenan, 2004)

An editorial in *O&G Magazine* put it slightly differently:

> "If you were to deliver a baby by caesarean section for no reason other than a firm request from a woman, you would be in good company.

> Almost 70 percent of British obstetricians responding to an anonymous survey said they would do the same thing. In fact, similar surveys suggest that almost a third of obstetricians indicate a preference for elective caesarean delivery for themselves."(Robson, 2004)

The very decision to avoid attempting vaginal birth and undergo elective caesarean delivery in an otherwise uncomplicated pregnancy is seen as 'foolish' by some:

> "Ultimately, competent women are free to decline medical advice and treatment for rational and irrational reasons, or for no reason, even if, as a consequence, they or their fetus suffer death or injury. The law is clear that the unborn child has no independent status and that a mentally competent expectant mother's wishes must take precedence. Unfortunately, the law does not distinguish between the rights of a mentally competent but **foolish pregnant woman** and other adults. **Therefore, if caesarean section is the preferred mode of delivery by the mother, her choice, however foolish or irrational, must be respected**."(Amu, Rajendran, and Bolanj, 1998)

The body of work presented here will attempt to deal with some of these complex issues. Why might women ask for caesarean delivery? How satisfied are they with their choice? What factors inform their decision making about birth after CS? What other factors might drive the increase in caesarean births? Are there strategies that could, potentially, reduce the rate of caesarean birth? Does caesarean birth have an adverse effect on a child's long term health?

For the four years from November 2012 until November 2016, I had the privilege of Chairing the Women's Health Committee of the Royal Australian and New Zealand College of Obstetricians and Gynaecologists. During that time, we were tasked with first-principles revisions of the national guidance on maternal request CS and vaginal birth after CS. This allowed me access to a comprehensive and representative cross-section of the literature around caesarean birth, greatly enhancing the literature review in this thesis.

Chapter 1

Literature Review

1.1 Epidemiology of caesarean section

That the rate of caesarean delivery has risen over the last 20 years is widely known in both the medical and lay communities. The most recent data available for Australia, presented in the AIHW *Australian's Mothers and Babies 2015* report, reveals that the rate of caesarean birth is 33.3% - exactly one third of babies.(AIHW, 2017) Of 101370 caesarean births documented in the report, 62447 (61.6%) were performed before the onset of labour, while the remainder were performed intrapartum. After a long period of steady increase, the rate of CS in Australia has almost reached a plateau with no statistically significant increase in the rate between 2014 and 2015 (**Figure 1.1**).

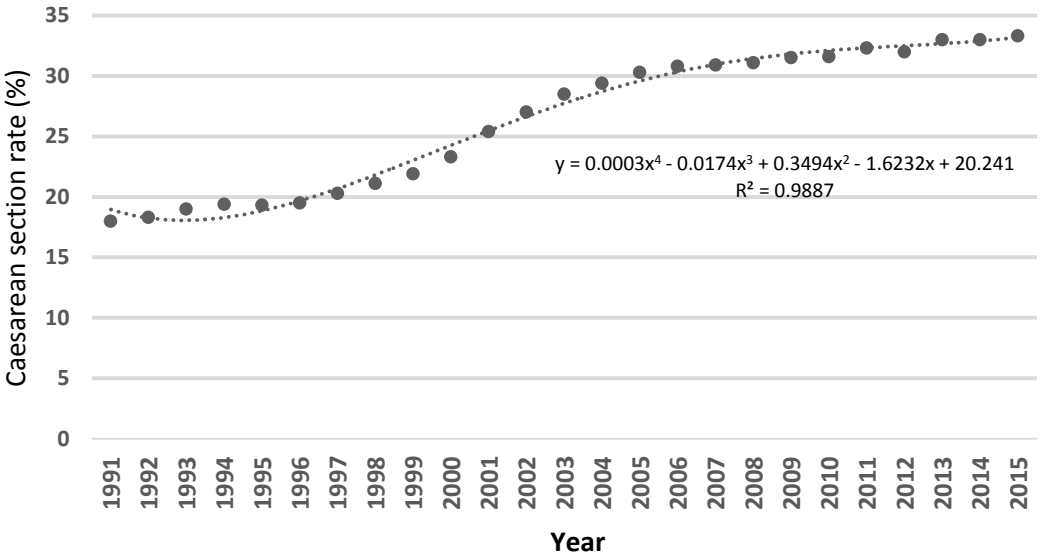


Figure 1.1 Overall rate of caesarean section in Australia (as a percentage) for the period 1991 to 2015 inclusive. Data from the annual AIHW *Australia's Mothers and Babies* reports (the full series accessible at: www.aihw.gov.au).

However over the last six years the rate of CS, when examined by age group, has show a slight reduction in the rate of CS in women under the age of 30 years (**Figure 1.2**). Data from other countries reveals a very similar pattern. For example, data from the United Kingdom demonstrates a very similar rise in the rate of caesarean section (**Figure 1.3**). Comparator international rates are presented in **Figure 1.4**, and WHO data regarding rates of increase for representative countries is shown in **Table 1.1**. The rising rate of caesarean birth has thus affected not only developed countries, but also developing countries. The causes of the overall increase are hypothesised to include increasing maternal age, increasing maternal obesity, abandonment of complex vaginal delivery, maternal requests for caesarean birth, and, repeat elective caesarean section.

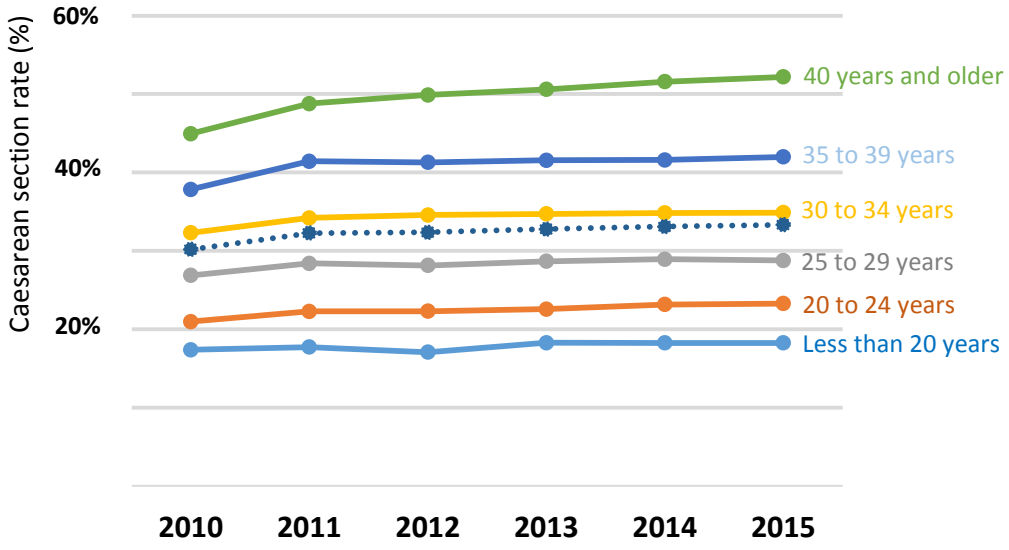


Figure 1.2 Age-stratified rates of caesarean section in Australia (as a percentage) for the period 2010 to 2015 inclusive. Data from the annual AIHW *Australia's Mothers and Babies* reports (the full series accessible at: www.aihw.gov.au).

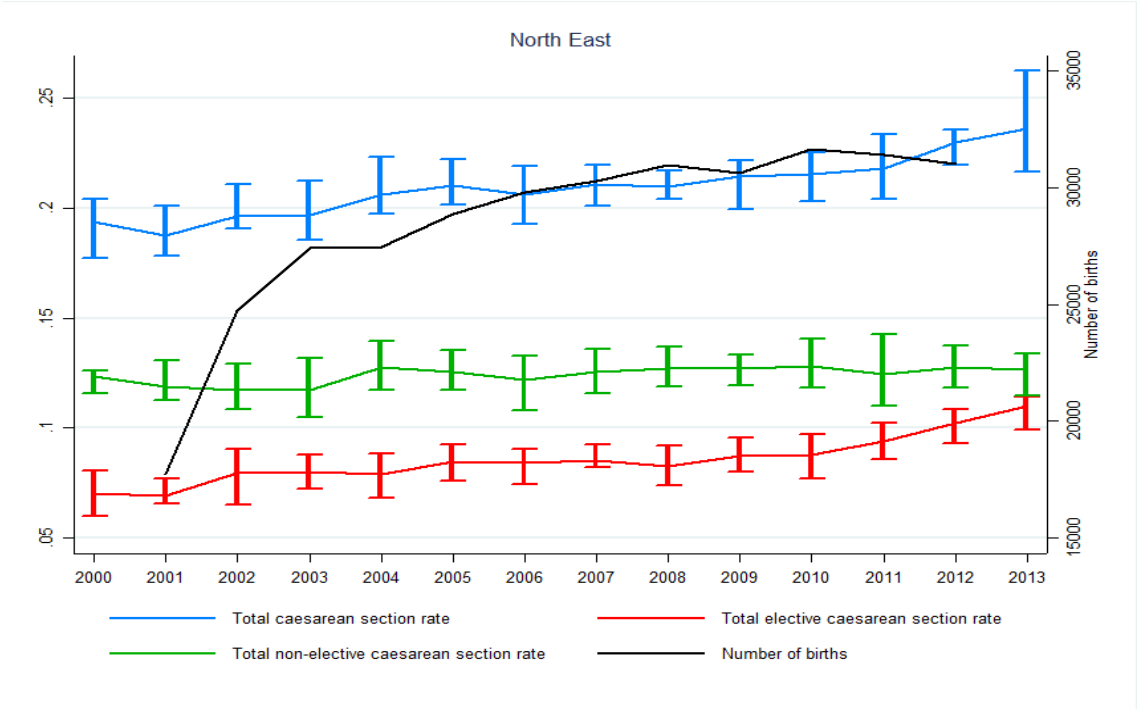


Figure 1.3 Rates of caesarean section in the United Kingdom (as a percentage) for the period 2000 to 2013 inclusive. Accessible at: http://www.deliveringbetter.com/blogs/caesarean-section-trends-in-the-english-nhs

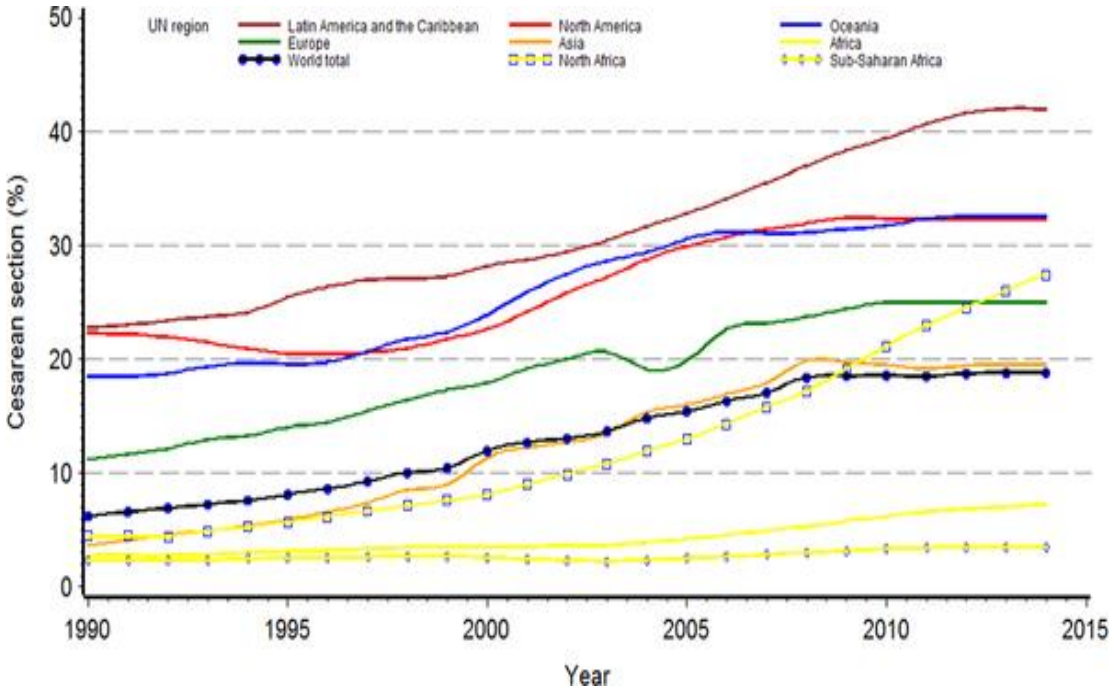


Figure 1.4 Rates of caesarean section by region (as a percentage) for the period 1990 to 2015 inclusive. From Betran, Ye, and Moller *et al*, 2016.

1.2 The Ten-Group (Robson) classification of caesarean sections

First published in 2001, the ten 'Robson categories' form a classification of prospectively-applied and mutually exclusive rates of CS in woman admitted for delivery using a few variables that are generally routinely recorded (**Figure 1.5**).(Robson MS, 2001)* The classification system was developed to assist institution-specific monitoring and auditing, offering a standardised comparison method that can be used at levels between individual institutions up to as large a scale as an entire country. It also offers a method of comparing the same institutions at different timepoints, to ascertain trends. The Robson classification (also known as the "TGCS-Ten Groups Classification System") has been used to analyse trends and determinants of caesarean section use in health-care facilities in both high-income and low-income countries, and has also been applied to state, national, and international datasets, including data from eight Latin American countries in the WHO *Global Survey of Maternal and Perinatal Health*. (Brennan *et al*, 2009; Delbaere *et al*, 2011; Abdel-Aleem *et al*, 2013; Kelly *et al*, 2013; Tan *et al*, 2014)

Robson Group	Characteristics
1	Nulliparas; single cephalic term pregnancy; spontaneous labour
2*a	Nulliparas; single cephalic term pregnancy; induced labour
2*b	Nulliparas; single cephalic term pregnancy; planned caesarean delivery
3	Multiparas without uterine scar; single cephalic term pregnancy; spontaneous labour
4*a	Multiparas without uterine scar; single cephalic term pregnancy; induced labour
4*b	Multiparas without uterine scar; single cephalic term pregnancy; planned caesarean delivery
5	Multiparas with a scarred uterus; single cephalic term pregnancy
6	Nulliparas; single breech delivery
7	Multiparas; single breech delivery (including women with a scarred uterus)
8	All women with a multiple pregnancy (including women with a scarred uterus)
9	All women with a single oblique or transverse pregnancy (including women with a scarred uterus)
10	All women with a single cephalic term pregnancy (including women with a scarred uterus)

Figure 1.5. The ten-group 'Robson' classification of caesarean sections.(Robson MS?, 2001)

* No relation to the author of this thesis

The 10-Groups classification was developed to identify well-defined, clinically relevant groups of women and to investigate differences in CS rates within these relatively homogeneous cohorts.(Robson, 2001) Unlike classifications based on indications for CS, the Robson classification is applicable to all women delivering in a specific setting, including women who do not deliver by CS: this make it a complete perinatal classification.(Torloni *et al*, 2011) The classification system is designed to be used prospectively. Since its categories are totally inclusive and mutually exclusive, any woman attending for delivery can be classified very soon after presentation, using simple characteristics that usually are routinely collected by obstetric care providers in any setting across the world.

The classification is characterised by simplicity, robustness, reproducibility, immediate clinical relevance, and the fact that data collection is prospective. These characteristics allow comparison and analysis of CS rates within and across these groups of women. In 2014, the World Health Organization conducted a systematic review to gather the experience of the users of the Robson Classification, and to assess the advantages and disadvantages of its adoption, implementation, and interpretation.(Betran *et al*, 2014) This review allowed identification of barriers, facilitators, and potential adaptations and included 73 publications from 31 countries that reported on the use of Robson Classification between 2000-2013. The review concluded that users – ranging from care providers to administrators – found the main strengths of this classification are its simplicity, robustness, reliability and flexibility. Vogel and colleagues (2015) studied deliveries in 21 countries and compared results from the WHO *Global Surveys of Maternal and Perinatal Health* reported for 2004–08 and 2010–11. The survey data were used to establish the average annual percentage change in CS rates per country. Countries were stratified according to Human Development Index (HDI) group (very high/high, medium, or low): the Robson criteria were applied to both survey datasets. Unsurprisingly, the CS rate increased over the interval between the two surveys (from 26·4% to 31·2%) in all countries except Japan – likely because the baseline rate of CS was high by internation standards at over 37%.(Ono *et al*, 2016) They found that rates of CS increased across most Robson groups and all HDI categories (**Table 1.1**). The rate of prelabour CS increased in very high/high and low HDI countries. As a consequence, the proportion of women who had previously undergone CS increased in moderate

and low HDI countries, as did the caesarean section rate in these women. This led the authors to comment:

> "Although increased caesarean section rates are not a novel finding, the greatest increases in caesarean section rates were generally recorded in the least developed countries where—compared with the high-income countries—the caesarean section rates of the first survey were lower, and a higher unmet need for caesarean section probably exists. Notably, some countries with high initial caesarean section rates still had high rates of growth of the procedure, such as Nicaragua (AAPC of caesarean section rate +9·4%) and Brazil (+8·5%), which supports previous reports of high caesarean section rates in many Latin American countries."

	Number of facilities	WHO Global Survey		WHO Multi-Country Survey		Time difference (years)*	Average change in caesarean section rate (% per year)*
		Deliveries, n (% of total deliveries)	Caesarean section rate, n (%)	Deliveries, n (% of total deliveries)	Caesarean section rate, n (%)		
Very high HDI countries							
Japan	10	3300 (1·4%)	653 (19·8%)	3536 (1·5%)	656 (18·6%)	2·50	−2·5%
Argentina	14	10673 (4·7%)	3747 (35·1%)	9785 (4·1%)	3799 (38·8%)	5·67	1·8%
High HDI countries							
Mexico	13	13724 (6·0%)	5463 (39·8%)	12682 (5·3%)	6023 (47·5%)	5·92	3·0%
Peru	16	15876 (7·0%)	5451 (34·3%)	15198 (6·4%)	6301 (41·5%)	5·67	3·4%
Brazil	5	5506 (2·4%)	1485 (27·0%)	5897 (2·5%)	2770 (47·0%)	6·83	8·5%
Ecuador	18	12372 (5·4%)	4989 (40·3%)	10197 (4·3%)	4639 (45·5%)	5·58	2·2%
Sri Lanka	13	14706 (6·5%)	4390 (29·9%)	17607 (7·4%)	5803 (33·0%)	3·58	2·8%
Sub-total for very high HDI and high HDI countries	89	76157 (33·4%)	26178 (34·4%)	74902 (31·3%)	29991 (40·0%)	..	..
Moderate HDI countries							
China	21	14532 (6·4%)	6711 (46·2%)	13249 (5·5%)	6304 (47·6%)	3·00	1·0%
Thailand	12	9745 (4·3%)	3321 (34·1%)	8952 (3·7%)	3531 (39·4%)	3·00	5·0%
Paraguay	6	3455 (1·5%)	1446 (41·9%)	3607 (1·5%)	1689 (46·8%)	5·75	2·0%
Philippines	14	11011 (4·8%)	1975 (17·9%)	10734 (4·5%)	2679 (25·0%)	2·58	13·6%
Vietnam	15	13077 (5·7%)	4690 (35·9%)	15427 (6·5%)	6466 (41·9%)	3·67	4·3%
Nicaragua	7	4341 (1·9%)	1161 (26·7%)	5244 (2·2%)	2353 (44·9%)	5·75	9·4%
India	20	24695 (10·8%)	4377 (17·7%)	30608 (12·8%)	5915 (19·3%)	3·83	2·3%
Cambodia	5	5534 (2·4%)	812 (14·7%)	4691 (2·0%)	1069 (22·8%)	2·83	16·8%
Sub-total for moderate HDI countries	100	86390 (37·9%)	24493 (28·4%)	92512 (38·7%)	30006 (32·4%)	..	..
Low HDI countries							
Kenya	20	19070 (8·4%)	3043 (16·0%)	20305 (8·5%)	4813 (23·7%)	6·83	6·0%
Nigeria	21	8895 (3·9%)	1286 (14·5%)	12053 (5·0%)	2462 (20·4%)	6·83	5·2%
Uganda	17	12102 (5·3%)	1823 (15·1%)	8753 (3·7%)	1766 (20·2%)	7·00	4·3%
Democratic Republic of the Congo	21	8575 (3·8%)	1125 (13·1%)	8345 (3·5%)	1782 (21·4%)	6·58	7·7%
Niger	11	8276 (3·6%)	440 (5·3%)	11032 (4·6%)	1080 (9·8%)	6·92	9·2%
Nepal	8	8346 (3·7%)	1702 (20·4%)	11242 (4·7%)	2682 (23·9%)	3·50	4·6%
Sub-total for low HDI countries	98	65264 (28·6%)	9419 (14·4%)	71730 (30·0%)	14585 (20·3%)	..	..
Overall total	287	227811 (100·0%)	60090 (26·4%)	239144 (100·0%)	74582 (31·2%)	..	..

Table 1.1 Rates of caesarean section taken from the WHO Global Surveys, including comparative rates of change. From Vogel *et al*, 2015.

Then they considered the changes in rate within the different Robson groups, they reported that:

> "Increased use of caesarean section surgery occurred across all HDI groups and most Robson groups, including an increase in the proportion of women undergoing a prelabour caesarean section (in very high/high and low HDI countries) and a rise in the proportion of women with a previous caesarean section (in moderate and low HDI countries). The nulliparous population was the largest contributor to the overall caesarean section rate, and therefore increasing use of obstetric interventions in this group (in very high/high and low HDI countries) drove rates higher. This situation is especially true in the very high/high HDI countries, where the proportion of nulliparous women increased, which probably represents a trend towards reduced parity in women in the higher HDI countries. This overall pattern suggests that the threshold for medically indicated caesarean section has become lower over time, or the use of elective caesarean section surgery has risen, or both. Increased use of this surgery without medical indication can potentially cause harm and increase the need for caesarean section in subsequent pregnancies that could otherwise have been avoided. Some authors have cited fear of litigation, intolerance of adverse outcomes related to vaginal deliveries, and popularity of caesarean section in women as reasons underpinning these trends."

Hehir and colleagues (2018) have recently applied the Robson Classification to all births in the United States from 2005-2014, with 27044217 deliveries having enough data to allow classification and inclusion over the ten-year study period. The found that the overall CS rate was 31.6%. Group three births (singleton, term, cephalic multiparas in spontaneous labour) were most common, while Group 5 births (those with a previous CS) accounted for the greatest number of CS deliveries, increasing from 27% of all caesarean births in 2005-06 to over 34% in 2013-14. Primiparous and multiparous women who had a pre-labour CS [Groups 2(b) and 4(b)] accounted for over one quarter of all caesarean deliveries. The

authors concluded that women with a previous CS represent an increasing proportion of all caesarean births.

Australian data show very similar proportions. A population-based study from New South Wales over the years 2009 to 2010 reported the overall CS rate to be 30.9%.(Lee, Roberts, Patterson, *et al*, 2013) The three groups making the greatest contribution to the overall CS rate all comprised women with a single cephalic pregnancy who gave birth at term, including: those who had had a previous CS (36.4% of all CSs); nulliparous women with an elective delivery (prelabour CS or labour induction, 23.4%); and nulliparous women with spontaneous labour (11.1%). Data for Australia from the state of New South Wales is presented in **Table 1.2**.(Stavrou *et al*, 2011)

Robson Group	Caesarean section rate in group	Contribution to overall caesarean section rate
1	13.3%	3.1
2	39.7%	5.2
3	2.2%	0.6
4	14.6%	1.8
5	76.3%	8.2
6	90.2%	1.8
7	83.3%	1.5
8	57.0%	0.9
9	77.8%	0.6
10	30.3%	1.5

Table 1.2. Data from the state of New South Wales in Australia showing the proportions of CS birth in each of the ten Robson categories, and the relative contribution to the overall CS rate for the state from each category.(Stavrou *et al*, 2011)

One third of women in Australia who gave birth to their first child in 1995 were aged 30 years or older, yet by 2015 this proportion had increased to 42% and included 15% who were aged 35 years or older.(**Figure 1.6**) Thus, women aged 35 years or older comprised 39623 births from a total of 251570 (15.8%) in 1998, compared to 67297 in 294540 (22.5%) in 2015, meaning an additional 27674 woman aged 35 years or older delivered with an overall CS rate for the group of 28011/67297 (41.6%). The CS rates within each age group have increased (**Figure 1.7**) resulting in an increase in the overall number of CS in absolute numbers (**Figure 1.8**).

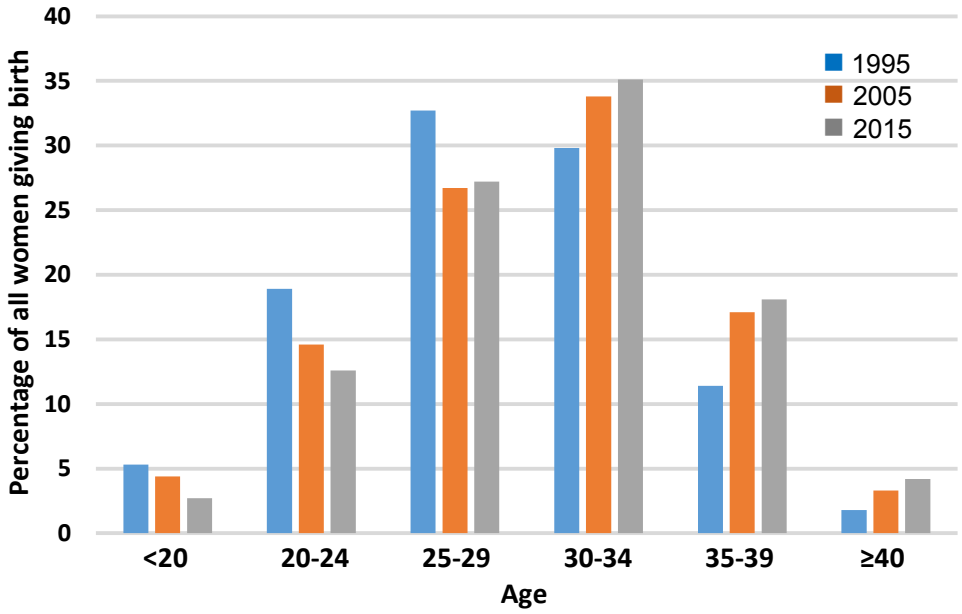


Figure 1.6. Demographic changes in the age of women giving birth in Australia in the calendar years 1995, 2005, and 2015: proportion (as a percentage) of women in each age group. From the AIHW *Australia's Mothers and Babies* dataset, accessible at: www.aihw.gov.au

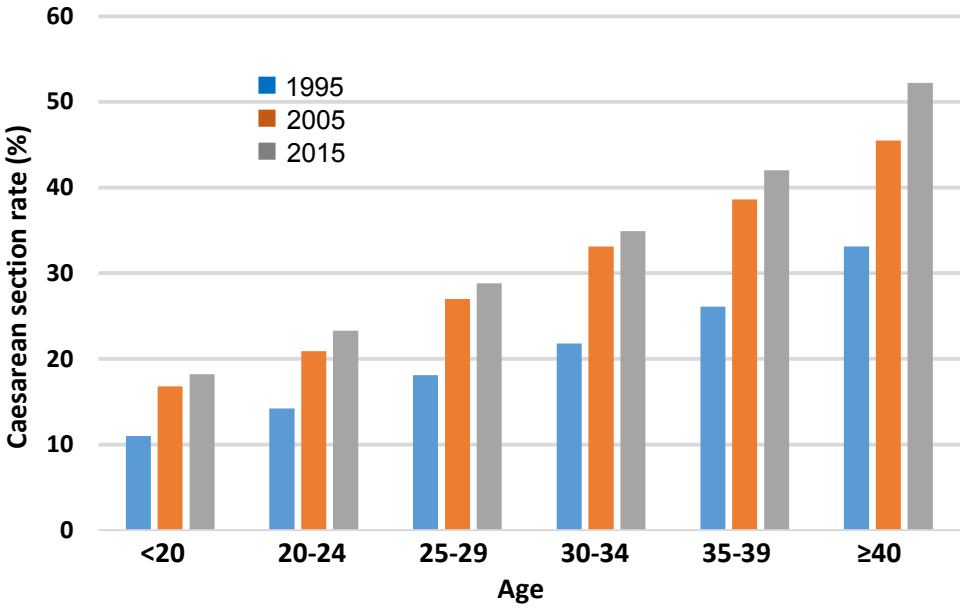


Figure 1.7. Age-stratified CS rates (as a percentage) in each age group for the years 1995, 2005, and 2015. From the AIHW *Australia's Mothers and Babies* dataset, accessible at: www.aihw.gov.au

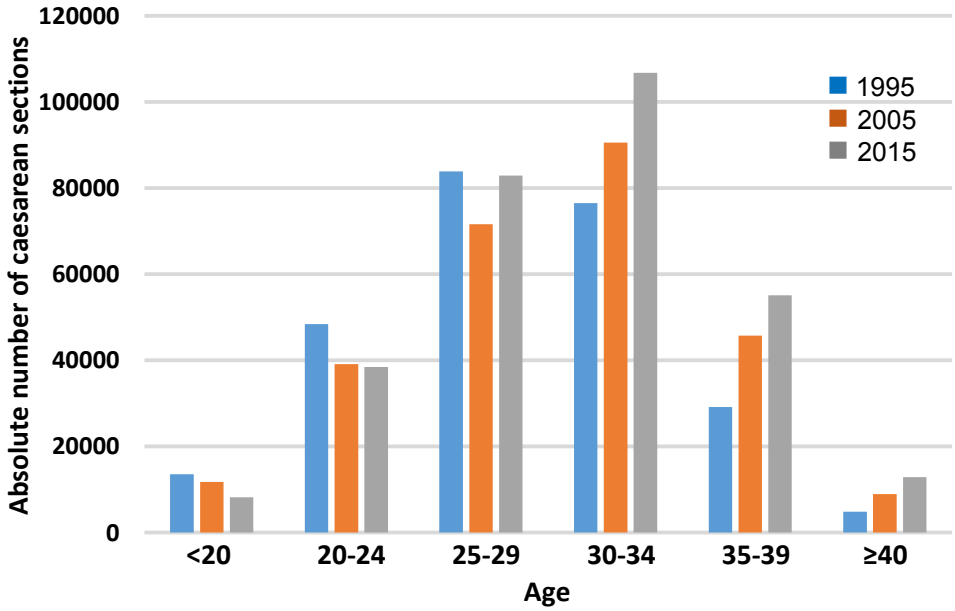


Figure 1.8. Absolute number of caesarean sections in each age group performed in Australia in the calendar years 1995, 2005, and 2015. From the AIHW *Australia's Mothers and Babies* dataset, accessible at: www.aihw.gov.au

Analysis of data from Western Australia confirmed the observations of the raw national caesarean section rates, noting that:

> "The most dramatic changes are in mothers older than 30 years. Our findings support earlier reports that increasing maternal age and nulliparity are both independent risks factors contributing to an increased likelihood of emergency caesarean section."(O'Leary, de Klerk, and Keogh, *et al*, 2007)

A study from New South Wales during the period 1994 to 2010, using unadjusted data and not taking into account parity or other factors, estimated that almost 20% of the increase in caesarean section rates over the period could be attributed to increasing maternal age alone.(Roberts, Rowlands, Nguyen, 2012) Looking specifically at first birth, Smith and colleagues reported that 38% of the increased incidence of primary caesarean section rate in Scotland over the period 1980 to 2005 was explainable by the increase in age of women at first birth, and they estimated that the odds of caesarean section increased by about 1.5 for every five year rise in maternal age.(Smith, Cordeaux, and White, *et al*, 2008) An almost identical trend has been noted in the United States.(Menacker, Declercq, and MacDorman, 2006)

1.4 Maternal obesity

Comprehensive population data regarding maternal obesity have been collected only relatively recently. However, for the population as a whole, the prevalence of obesity in Australia has increased over the last two decades with a steady shift towards the higher end of the Body Mass Index (BMI). After adjustment for age, around 63.4% of adult Australian women were either overweight or obese in 2014-15.(ABS, 2017) Data regarding the prevalence of overweight and obesity in Australia from the National Health Survey are presented in **Table 1.3**. It is important to note that, in an obstetric sense, although closely relate maternal age and obesity act independently on birth outcome.(Robilliard *et al*, 2017)

Weight class	Age group		
	18 – 24 years	25 – 34 years	35 – 44 years
Underweight (BMI < 18.5)	6.0%	2.3%	0.9%
Normal (18.5 - 25.0)	55.3%	45.4%	33.2%
Overweight (25.0 – 30.00)	22.0%	33.4%	37.4%
Obese (>30.0)	17.1%	19.0%	28.6%
Total overweight + obese	38.9%	52.4%	65.9%

Table 1.3 Prevalence of overweight and obesity in Australian women of reproductive age. Results of the Australian Bureau of Statistics (ABS) National Health Survey 2014-15.
4364.0.55.001 - *National Health Survey: First Results, 2014-15,* Accessible at:
http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.001 2014-15?OpenDocument

The prevalence of overweight and obesity in the Australian community is increasing, as shown in **Figure 1.6.**

Figure 1.9 Trends in obesity prevalence in Australia by age group. From Australian Bureau of Statistics (ABS)
4338.0 - Profiles of Health, Australia, 2011-13, Accessible at:
http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/4338.0~ 2011-13~Main%20Features~Overweight%20and%20obesity~10007

These trends are important as maternal obesity is associated with an increase in the rate of caesarean section.(Athukorala, *et al*, 2010; Dodd, Grivell, and Nguyen, *et al*, 2011) The mechanism for dysfunctional labour in obese women is likely to be similar to that of increasing maternal age: *in vitro* studies of uterine muscle from obese women have demonstrated reduced contractility of myometrial fibres.(Zhang, Bricker, and Wray, *et al*, 2007; Higgins, Martin, and Anderson, *et al*, 2010; Lowe and Corwin, 2011) The most recent data regarding BMI of women giving birth in Australia are shown in **Table 1.4.**

BMI	Proportion
< 18.5	3.9%
18.5 – 24.9	50.2%
25.0 – 29.9	25.9%
30.0 – 39.9	16.9%
40.0 – 49.9	2.7%
≥ 50.0	0.3%

Table 1.4 Distribution of BMI in women giving birth in Australia in 2015. From the *Australia's Mothers and Babies* series, accessible at: www.aihw.gov.au

A recent cohort study of Australian women confirmed the association between BMI and risk for CS, and these data are shown in **Table 1.4**.(Knight-Agarwal *et al*, 2016)

BMI (Kg/m^2)	n	aOR	95% CI
≤ 18	751	0.68	0.55 – 0.83
19 – 24	7431	**1.0**	**Reference**
25 – 29	3748	1.3	1.18 – 1.42
30 – 34	1598	1.8	1.61 – 2.06
35 – 39	737	2.6	2.1 – 3.2
≥ 40	592	2.7	2.3 – 3.2

Table 1.5 Adjusted odd ratios (OR) for caesarean birth in Australian women according to BMI during the period 2008 to 2013,

with BMI of 19 to 24 Kg/m2 as the reference. From Knight-Agarwal *et al*, 2016.

1.5 Changing patterns of obstetric practice

Before the decade of the 1990s, complex vaginal birth was more common. This included vaginal breech delivery, vaginal twin delivery, and challenging instrumental delivery. There has been a well-documented substitution of caesarean section at full dilatation in place of complex vaginal delivery in a proportion of cases.(Cargill, MacKinnon, Arsenault, *et al*, 2004; Klein, Liston, Fraser, *et al*, 2011; Unterscheider, McMenamin, Cullinane, 2011) Similarly, loss of experience in vaginal breech delivery and instrumental delivery from high station or rotational forceps deliveries have reduced.(Chinnock, Robson, 2007; Chinnock, Robson, 2009) AIHW data show that in 1995 in Australia, 77% of singleton breech deliveries were by CS – by 2015 the rate had increased to 87.7%. Similarly the rate of caesarean section for twin birth increased from 42.9% to 69.9% over the same 20 year time period.(AIHW, 2015)

It has been shown that increasing experience in clinical obstetrics – equating to 'seniority' in clinical practice of the obstetrician – acts on the CS rate at an institutional level. Thus, more experienced obstetricians more commonly have a lower CS rate at an institutional level.(Clapp *et al*, 2014) In Australia, there is no financial incentive favouring CS over VBAC, for example. Indeed, the opposite exists with higher rebate payments for trials of VBAC than for planned CS. However, it is recognised internationally that the complexity, and thus time required, of the consent process for VBAC can act as a disincentive to uptake of VBAC.(Stohl, 2017)

1.6 Maternal requests for caesarean section

A number of studies have suggested that maternal requests for caesarean section now make an important contribution to the increased caesarean section rate.(Kolas, Hofoss, and Dalveit, *et al*, 2003; Tranquilli and Giannubilo, 2004; Declercq, Menacker, and MacDorman, 2005; Meikle, Steiner, and Zhang, *et al*, 2005; Gossman, Joesch, and Tanfer, 2006; MacDorman, Menacker, and

Declercq, 2008; Zhang, Liu, and Meikle, *et al*, 2008; Stjernholm, Petersson, and Eneroth, 2010; Barber, Lundsberg, and Belanger, *et al*, 2011) Estimates of the contribution of maternal request for caesarean delivery, where no obstetric indication is present, range from 14% to 22% of elective pre-labour caesarean sections.(Ryding, 1993; Tranquilli and Garzetti, 1997; Wilkinson, McIlwain, and Boulton-James, *et al*, 1998; Eftekhar and Steer, 2000; Saisto, Salmela-Aro, and Nurmi, *et al*, 2001; Kolas, Hofoss, and Daltveit, *et al*, 2003; Schindl, Birner, and Reingrabner, *et al*, 2003) A study from Australia, where anonymous data were obtained from Australian obstetricians, estimated that approximately 17% of all elective caesarean section were at maternal request, representing between 8500 and 12400 births every year.(Robson, Tan, and Adeyemi, *et al*, 2009) Analysis of population data during the period 1984 to 2003 from Western Australia also reported a likely increase in the rate of maternal request caesarean section over the period, with maternal-request caesarean section possibly contributing to 7% of all caesarean births.(O'Leary, de Klerk, and Keogh, *et al*, 2007)

Studies suggest that women request caesarean delivery for many reasons. In some cases, 'tocophobia' - fear of childbirth - is a key factor. Such fears commonly revolve around fears of death, fetal injury, or genital tract injury.(Ryding, 1993). A survey of 3283 women at 583 Swedish prenatal clinics reported that only 92 of 1284 (7.2%) primigravid woman preferred caesarean delivery.(Hildingsson, Radestad, and Rubertson, *et al*, 2002) That study reported that the only significant predictor was tocophobia. Parous women could request caesarean because of adverse experiences surrounding previous labour and birth (Ryding, 1991; Ryding, 1993) It has been suggested that psychotherapy on a frequent and regular basis by trained personnel directed against these fears is likely to result in almost two thirds of these women ultimately choosing vaginal delivery.(Sjogren and Thomassen. 1997; Ryding, 1993; Saisto, Salmela-Aro, and Nurmi, *et al*, 2001; Wax, Cartin, and Pinette, *et al*, 2004) It has been suggested that appropriately treated woman with tocophobia who are supported with an attempt at vaginal birth viewed their birth experience as good as, or more favorably than, patients without fear of childbirth. (Sjogren, 1998; Schindl, Birner, and Reingrabner, *et al*, 2003)

An study of Australian women who had undergone elective, maternal request, caesarean section found the most commonly-expressed reason was because of

concerns about risks to their baby.(Robson, Carey, and Mishra, *et al*, 2008) The other common reasons given were concerns about incontinence and prolapse in the future, and of vaginal trauma at birth. Reasons *least* frequently reported were, 'I did not want uncertainty about timing/convenience', 'other members of my family had difficulties in labour', and 'I was concerned about loss of control'. Respondents reported high levels of satisfaction with their birth, and only 10% reported a desire for more than two caesarean deliveries.

Those findings were consistent with a Swedish survey of women who requested caesarean delivery at a public hospital clinic in Sweden.(Wiklund, Edman, and Andolf, 2007), and information about motivation was available for 70 women. The most commonly reported motivating factor in the Swedish study group was also tocophobia, defined by the investigators as, 'anxiety for the health of the unborn child and/or their own life' was the second most commonly reported reason. The Australian study did not allow for the very general reason 'tocophobia', but asked instead about fears of 'loss of control' and 'pain', and respondents listed these as motivating factors less commonly.(Robson, Carey, and Mishra, *et al*, 2008) In the Swedish study, the mean level of satisfaction was 8.3/10, significantly higher than a control group who attempted vaginal birth (6.7/10, $P < 0.05$), and respondents to the Australian study also reported high levels of satisfaction with their birth.(Wiklund, Edman, and Andolf, 2007; Robson, Carey, and Mishra, *et al*, 2008)

A number of studies have attempted to document doctors' and midwives' attitudes toward caesarean on request.(Lilford, Van Coeverden de Groot, and Moore, *et al*, 1990; Al-Mufti, McCarthy, and Fisk, 1996; Dickson and Willett, 1999; Cotzias, Paterson-Brown, and Fisk, 2001; McGurgan, Coulter-Smith, and O'Donovan, 2001; Gonen, Tami, and Degani, 2002; Land, Parry, and Rane, *et al*, 2001; MacDonald, Pinion, and MacLeod, 2002). Those studies questioned doctors in the United Kingdom, New Zealand, Ireland, Canada, and Israel. Between 7% and 30% of obstetricians and 4.4% of midwives preferred caesarean delivery for their own pregnancy. The same studies revealed that up to 80% of obstetricians would be willing to perform caesarean sections in otherwise uncomplicated pregnancies if requested. The reasons given by respondents in these surveys included 'fear of childbirth' (27%), avoidance of perineal injury (93%), or injury to the baby (24–39%) as reasons for their chosen delivery method. Also noted were fear of anal

(83%) or urinary (81%) incontinence, sexual dysfunction (59%), 'convenience' (up to 39%), 'control' (39%), and concerns about pain (7%) as leading to elective caesarean.(Al-Mufti, McCarthy, and Fisk, 1996; Land, Parry, and Rane, *et al*, 2001; Wright, Wright, and Simpson, *et al*, 2001)

1.7 Outcomes of caesarean section

Keag and colleagues published an extensive and comprehensive systematic review of adverse outcomes of CS just before submission of this thesis.(Keag *et al*, 2018) I summarize the findings presented in that publication below:

1.7.1 Pelvic floor dysfunction.

Data from 11 papers were included in the meta-analysis, with follow-up ranging from 12 months postnatal to age 80 years. Compared to vaginal delivery, CS was associated with reduced odds of urinary incontinence (OR 0.56, 95% CI 0.47 - 0.66, $p < 0.000011$) Similar results were seen when sensitivity analysis was performed, excluding two low-quality studies. Compared to vaginal delivery, CS was associated with reduced odds of pelvic organ prolapse (OR 0.29, 95% CI 0.17 - 0.51, $p = 0.005$). There was no statistically significant difference in rates of faecal incontinence (1.04, 95% CI 0.73 - 1.48, $p = 0.82$). There was no statistically significant association of mode of delivery with pelvic pain (OR 0.74, 95% CI 0.54 - 1.00, $p = 0.05$).

1.7.2 Subsequent reproductive outcomes

Meta-analysis of 11 studies showed an association between CS and increased odds of subfertility when compared to vaginal delivery (OR 1.60, 95% CI 1.45 - 1.76, $p < 0.00001$) However, between-study heterogeneity was high in this meta-analysis ($I2 = 99\%$) due to the varying follow-up periods, varying cohort numbers, and study periods. Sensitivity analysis excluding four studies with <50,000 participants did not alter these results (OR 1.64, 95% CI 1.46 - 1.84, $p < 0.00001$).

Women with previous CS also had increased odds of having placenta accreta compared to women with a previous vaginal delivery (4OR 2.95, 95% CI 1.32 to 6.60, $p = 0.008$). In a sensitivity analysis excluding one study with a pre-1980

cohort, the association was no longer statistically significant (OR 5.32, 95% CI 0.67 to 44.26; p = 0.11). When compared with women with previous vaginal delivery, women with a previous CS also had increased odds of placental abruption (OR 1.38, 95% CI 1.27 to 1.49, p < 0.00001 and uterine rupture (OR 25.81, 95% CI 10.96 to 60.76, p < 0.00001.

1.7.3 Childhood outcomes

Thirty-five manuscripts met the inclusion criteria. As studies had multiple cohorts and different follow-up periods, meta-analyses were divided according to age or duration of follow-up. Meta-analysis showed an association between CS and increased odds of asthma in children aged up to 12 years compared to vaginal delivery (OR 1.21, 95% CI 1.11 to 1.32, p < 0.00001). There was significant heterogeneity between the studies (I2 = 75%). Eight studies (n = 44,131) assessed allergies, hypersensitivity, dermatitis, or atopic conditions, evaluating a variety of outcomes - there was no statistically significant association between mode of delivery and odds of hypersensitivity/allergy/dermatitis/atopy in the meta-analysis. There was moderate heterogeneity between the studies (I2 = 51%). Compared with vaginal delivery, CS was associated with increased odds of childhood overweight (OR 1.22, 95% CI 1.06 to 1.41, p = 0.007). In a meta-analysis of 3 studies, CS was associated with reduced odds of inflammatory bowel disease when compared with vaginal delivery (OR 0.73, 95% CI 0.69 to 0.79, p < 0.00001)

1.7.4 Subsequent pregnancy

There was no statistically significant association between previous mode of delivery and preterm labour, small for gestational age, low birth weight (<2,500 g) or neonatal death. When compared with women with previous vaginal delivery, women with previous CS had increased odds of miscarriage (OR 1.17, 95% CI 1.03 to 1.32, p = 0.01), ectopic pregnancy (OR 1.21, 95% CI 1.04 to 1.40, p = 0.02), and stillbirth (OR 1.27, 95% CI 1.15 to 1.40, p < 0.00001). There was no statistically significant association of mode of delivery with subsequent perinatal mortality (OR 1.11, 95% CI 0.89 to 1.39, p = 0.22). Women with previous CS had increased odds of having placenta previa compared to women with a previous vaginal delivery (OR 1.74, 95% CI 1.62 to 1.87, p < 0.00001). Women with

previous CS had reduced odds of postpartum haemorrhage (OR 0.72, 95% CI 0.55 to 0.95, p = 0.02).

1.8 Acute maternal outcomes

No randomised trials have compared planned vaginal birth with planned caesarean birth in women at low risk of complications. Wax has described the features of such an 'ideal' trial:

> "[The] design would account for potentially confounding effects of obstetrical complications, maternal co-morbidities, and previous deliveries on outcome. The population would include term and near-term singleton, vertex-presenting fetuses. Clinical significant and valid morbidity measures would serve as primary outcomes, evaluated by an intent-to-treat basis by planned delivery route."(Wax, 2006)

In the absence of such an ideal trial, data from other research designs are available to provide comparisons. Lee and D'Alton have subsequently reviewed the literature and concluded, "While the safest route of delivery may be an uncomplicated vaginal delivery, accurately predicting who will achieve this outcome is presently not possible."(Lee and D'Alton, 2008) Similarly, the comprehensive review of Viswanathan and colleagues concluded that, "the knowledge base rests chiefly on indirect evidence from proxies possessing unique and significant limitation."(Viswanathan, Visco, and Hartmann, *et al*, 2006)

A study of births from 37 to 42 completed weeks of gestation was undertaken using population data for births in Nova Scotia, Canada, during the period 1988 until 2001.(Allen, O'Connell, and Liston, *et al*, 2003) The study group comprised women having their first baby with no obstetric or medical complications in the pregnancy, with pregnancies complicated by major fetal malformations, induction of labour, or fetal growth restriction excluded. The dataset included 17714 women planning vaginal birth, and 721 undergoing caesarean section without labour. The major findings were that the rate of febrile morbidity was higher in the planned caesarean group (RR 2.2, 95% CI 1.1, 4.5) while post-partum haemorrhage was more common in the planned vaginal birth group (RR 1.6; 95% CI 1.1, 2.4) and most of the haemorrhage occurred in women undergoing

instrumental or emergency caesarean delivery. 'Composite' morbidity (blood transfusion, wound infection, haematoma requiring drainage, and other 'trauma') was otherwise similar between the two groups (RR 0.8, 95% CI 0.6, 1.1).

Wax (2006) collated data from the available retrospective cohort studies using the proxy of planned caesarean section for fetal breech presentation, and found that adverse maternal outcomes occurred in between 2.4% and 15.7% of planned caesarean births, compared to between 5.1% and 18.9% of planned vaginal births.(Obwegeser, Ulm, and Simon, *et al*, 1996; Irion, Almagbaly, and Morabia, 1998; Golfier, Vandoyer, and Ecochard, *et al*, 2001; Lashen, Fear, and Sturdee, 2002; Belfrage and Gjessing, 2002) A formal meta-analysis of the pooled data demonstrated a summary odds ratio of 1.02 (95% CI 0.77, 1.34) with no difference in maternal morbidity by planned delivery route.(Wax, 2006)

Three prospective randomised trials of breech presentation comparing short term maternal outcomes of planned vaginal delivery with planned caesarean section were subject to meta-analysis, reporting an increase in maternal morbidity in the planned caesarean section arm (RR 1.29, 95% CI 1.03, 1.61) although Wax notes that two of the trials were small and included data from deliveries from the late 1970s (some of it from intrapartum caesarean sections), when caesarean technique was different.(Collea, Chein, and Quilligan, 1980; Gimovsky, Wallace, and Schifrin, *et al*, 1983; Hannah, Hannah, and Hewson, *et al*, 2000; Hofmeyr and Hannah, 2003; Wax, 2006) Taking the 'term breech trial' as the best and most recent direct comparison of planned caesarean section with planned vaginal birth, there were no significant differences between the groups by overall maternal morbidity (RR 1.13; 95% CI 0.92, 1.39) or by individual complication (bleeding and transfusion, wound complications, and febrile morbidity).(Hannah, Hannah, and Hewson, 2000)

The NICE guidelines include a tabular summary of maternal outcomes (**Appendices 1 and 2**) that summarise the available data.(NICE, 2012) Although the guideline notes that almost all of the data are of 'low quality,' the conclusions are as follows:

> "Planned caesarean section is associated with reduced rates of vaginal injury, early postpartum haemorrhage, and obstetric shock. Planned

vaginal birth is associated with a reduced postpartum inpatient stay, lower risk of hysterectomy, and cardiac arrest. There appear to be no differences in the rates of pulmonary embolism, wound infection, injury to the bladder or ureter, uterine rupture, or acute renal failure. The data were conflicting on rates of thrombosis and embolism."

One final point is that where sterilisation procedures are offered at the time of CS, it is possible to perform a salpingectomy (rather than the traditional ligation procedure). Salpingectomy now is associated with a reduced risk of ovarian cancer in later life, in addition to the beneficial effect of ovarian visual inspection.(Castellano *et al*, 2017)

Summary: *There are no suitable studies directly comparing acute maternal outcomes between planned caesarean section and planned vaginal birth in women at low risk (single fetus in cephalic presentation in an otherwise uncomplicated pregnancy). The available proxy data suggest that women undergoing planned caesarean section are slightly more likely to have febrile morbidity, but other outcomes appear to be little different.*

1.9 Long term maternal reproductive outcomes

Since the majority of women in Australia and elsewhere will have more than one child, it is important to examine the longer term reproductive consequences of caesarean delivery. These can be divided into anatomical risks (abnormal placentation including placenta accreta and placenta percreta) and other reproductive risks (placental abruption, and effects on fertility, including ectopic pregnancy or early pregnancy loss).

The effect of a previous caesarean section on subsequent fertility is very difficult to study, since not becoming pregnant will not be apparent on any population database. Several older epidemiologic studies have suggested that women who have a primary caesarean section may be less likely to become pregnant subsequently. For example, a retrospective cohort study reported that women who had a primary caesarean delivery had an almost 25% lower chance of subsequently becoming pregnant compared to women who delivered

vaginally.(Hall, Campbell, and Lemon, 1999) Another study of over 70000 Finnish women found that age-adjusted rates of subsequent pregnancy were 79% in women delivered vaginally, compared to 58% delivered by caesarean section.(Hemminki, Shelly, and Gissler, 2005). One further similar study found that by five years after a first birth, only 29% of women delivered vaginally had not had another child, compared to 42% of those delivered by caesarean section.(Jolly, Walker, and Bhabra, 1999) Studies of more recent data reveal a similar, statistically significant reduction in subsequent pregnancy after primary caesarean section, but much smaller in magnitude.(Mollison, Porter, and Campbell, *et al*, 2005)

Why a primary caesarean delivery should affect future fertility is unclear. Gilliam (2006) has reviewed the literature and proposes that any or all of the following biological mechanisms could potentially explain this association: scarring, adhesion formation and abnormal placentation; negative psychosocial factors related to the birth including negative emotions, marital adjustment, and problems with bonding and breastfeeding; and, increased maternal age and pre-existing subfertility.

Should pregnancy occur for a second time, the findings of an effect on early pregnancy development and loss are conflicting. A Finnish retrospective cohort study reported that ectopic pregnancy was more likely (Hemminki, Shelly, and Gissler, 2005) whereas a case-control study did not.(Kendrick, Tierney, and Lawson, *et al*, 1996) Another rare complication is ectopic gestation occurring in the caesarean section scar, but data on this are scarce (Jurkovic, Hillaby, and Woelfer, *et al*, 2003; Maymon, Halperin, and Mendlovic, *et al*, 2004) and this has also been noted in women who have not undergone caesarean section, for example after myomectomy or uterine perforation.(Robson, Pozza, and Kerin, 2001)

Kennare and colleagues undertook a population-based study comparing the subsequent birth outcomes of 8725 women who were delivered by caesarean section in their first birth, with 27313 women who had a vaginal delivery for their first birth during the period 1998 to 2003.(Kennare, Tucker, and Heard, *et al*, 2007) After logistic regression the caesarean delivery cohort had increase odds for malpresentation (OR 1.84; 95% CI 1.65, 2.06), placenta praevia (OR 1.66,

95% CI 1.30, 2.11), placenta accreta (OR 18.79, 95% CI 2.28, 864.6), preterm birth (OR 1.17, 95% CI 1.04, 1.31), and, stillbirth (OR 1.56, 95% CI 1.04, 2.32). The authors estimated that 1536 primary caesarean sections were needed to generate one additional subsequent case of placenta accreta. The overall conclusion was that caesarean delivery is associated with increased risks for adverse obstetric and perinatal outcomes in the next pregnancy, but since information about the reasons for the primary caesarean section was not considered, there could well have been confounding factors related to the indications for the first caesarean birth.

Smith and colleagues studied data extracted from the Scottish Morbidity Record relating to mode of birth in a cohort of over 100 000 babies delivered between 1980 and 1998.(Smith, Pell, and Dobbie, 2003) They linked this data with subsequent pregnancy outcomes in a separate dataset (the Scottish stillbirth and infant death enquiry, 1985 – 1998). They estimated the relative risk of unexplained antepartum stillbirth after 34 weeks of gestation in second pregnancies after caesarean section at 2.74 (95% C.I. 1.74 - 4.30), although in absolute terms this represented an additional risk of approximately 0.45 stillbirths per 1000 deliveries. It should be noted that the classifications of death were not made by the authors themselves, who relied on database coding based on the Wigglesworth classification, the difficulties of which have been previously noted.(Froen, Arnestad, and Frey, *et al*, 2001) A much larger study using United States perinatal mortality data for deaths from 1995-7, including over 11 million births, found no association between prior caesarean section and subsequent unexplained stillbirth (0.8/1000 births for no prior caesarean delivery vs 0.7/1000 for one prior caesarean delivery (RR 0.90, 95% CI 0.76, 1.0]) (Bahtiyar, Julien, and Robinson, *et al*, 2006). It can thus be stated that if there is a risk for unexplained stillbirth arising from a previous caesarean delivery, then the effect is very small. That said, it may be that all the risk resides with non-white mothers. Salihu and colleagues' study of a birth cohort of almost 400 000 women noted that the absolute and adjusted risks for stillbirth were elevated exclusively in black women with a previous caesarean section (OR 1.4, 95% CI 1.1, 1.7).(Salihu, Sharma, and Kristensen, *et al*, 2006)

A body of evidence suggests that primary caesarean section is associated with abnormal placentation in subsequent pregnancies, and although the exact

mechanism for this remains unclear it is likely to involve the uterine scar affecting implantation and placental migration.(Gilliam, 2006) A retrospective population-based study from the United States reported that, after controlling for maternal age, the odds for abruption in a subsequent pregnancy after caesarean section were 1.3 (95% CI 1.1, 1.5) compared to a first vaginal birth.(Lydon-Rochelle, Holt, and Easterling, 2001) The study found a similar relationship was found for placenta praevia (OR 1.4; 95% CI 1.1, 16). Other similar studies have reported similar risk increases for these complications. (Gilliam, Rosenberg, and Davis, 2002; Hemminki, Shelly, and Gissler, 2005)

Although potentially catastrophic complications such as morbidly adherent placentation (placenta accreta or percreta) become more common with repeat caesarean deliveries, several more recent prospective studies have reported that increases in the odds for these and other serious complications of repeat caesarean delivery only reach statistical significance at the third or subsequent caesarean section.(Usta, Hobeika, and Musa, *et al*, 2005; Nisenblat, Barak, and Griness, *et al*, 2006; Silver, Landon, and Rouse, *et al*, 2006). The risk of iatrogenic bladder and ureteric injury increases with repeat CS, however the rate is higher in emergency CS during a failed trial of VBAC than for planned repeat elective CS.(Phipps *et al*, 2005)

Finally, the effect of primary caesarean section on delivery of the next and subsequent pregnancies is clearly important. Large observational studies report a risk of rupture of the scar in subsequent labour and attempted vaginal birth (McMahon, Luther, and Bowes, *et al*, 1996; Mozurkewich and Hutton, 2000; Landon, Hauth, and Leveno, *et al*, 2004) although a smaller, more recent prospective study reported no cases of scar rupture with attempted vaginal birth after caesarean section.(Crowther, Dodd, and Hiller, *et al*, 2012) Rupture of the uterine scar is a cause of perinatal death.(Smith, Pell, and Cameron, *et al*, 2002)

Summary: *Primary caesarean section may be associated with a range of adverse long term reproductive effects, including reduced subsequent fertility, abnormal implantation and placentation, abruption, and possibly stillbirth.*

1.10 Subsequent birth after previous caesarean delivery

As the rate of primary caesarean section has increased, so too has the proportion of the obstetric population who will have had a previous caesarean delivery. For those women who become pregnant again, a choice will be faced as to the mode of delivery – either an attempt at vaginal birth, or a plan for another caesarean section. Over the last decade, more emphasis has fallen on women's choice in decision making.(Emmett, Shaw, and Montgomery, *et al*, 2006) The NICE guidelines state that any decision making regarding mode of birth after a previous caesarean section should consider maternal preferences and priorities, as well as discussion of risks.(NICE, 2011) Repeat caesarean section now accounts for 28% of all caesarean births in the United Kingdom.(Crowther, Dodd, and Hiller, *et al*, 2012) Importantly, the proportion of women who plan for a repeat elective caesarean section in this circumstance is a key determinant of the overall rate of caesarean birth.

The probability of achieving a vaginal delivery after a previous caesarean section has been reported as ranging between 43% and 80%.(Cowan, Kinch, and Ellis, *et al*, 1994; Stone, Halliday, Lumley, *et al*, 2000; Crowther, Dodd, and Hiller, *et al*, 2012) It is recognised that the proportion of women attempting a VBAC has been declining in Australia and overseas, possibly affected by negative reports of an increase in the risk of maternal and infant complications related to VBAC.(Black, Kaye, and Jick, 2005; Yeh, Wactawski-Wende, and Shelton, *et al*, 2006; Homer, Johnston, and Foureur, 2011) The recognised risks of VBAC include uterine rupture and perinatal death.(Lydon-Rochelle, Holt, and Easterling, *et al*, 2001; Smith, Pell, and Cameron, *et al*, 2002) As a result, the rate of elective repeat caesarean section in the next pregnancy after a caesarean have risen to levels as high as 83% in Australia and almost 90% in the US.(Crowther, Dodd, and Hiller, *et al*, 2012)

Both approaches to birth after previous caesarean section carry with them the potential both for benefits and harms. Risks of planned VBAC include haemorrhage, need for blood transfusion, endometritis, uterine rupture, perinatal death, and hypoxic ischaemic encephalopathy.(Guise, Eden, and Emeis, *et al*, 2010) Similarly, women planning a repeat elective caesarean section face increases in the risk of surgical complications, placenta accreta, and risks of

multiple caesareans and their infants are at risk of respiratory morbidity.(Guise, Eden, and Emeis, *et al*, 2010)

A comprehensive systematic review of the non-randomised literature comparing elective repeat caesarean section with VBAC concluded that the current literature was ‘‘significantly flawed,’’ and that future research ‘‘should focus on comparability of the groups, specificity of the intervention, and standard outcome measures.’’(Guise, Eden, and Emeis, *et al*, 2010) In the RCOG *Green Top Guideline* on delivery after previous caesarean birth, the following statement is made:

> “New evidence is emerging to indicate that VBAC may not be as safe as originally thought. These factors, together with medico-legal fears, have led to a recent decline in clinicians offering and women accepting planned VBAC in the UK and North America.”(RCOG, 2015)

The concession that attempting a vaginal birth in the setting of previous caesarean section “may not be as safe as previously thought” is based on data from both the United States (Landon, Hauth, and Leveno, *et al*, 2004) and the United Kingdom (Smith, Pell, and Cameron, *et al*, 2002). These were both retrospective population studies. There are no randomised controlled trials comparing planned VBAC with elective repeat caesarean section. However, a non-randomised prospective study published in 2012 represented a major step forward in the level of evidence available. Crowther and colleagues recruited 2345 women with one prior caesarean delivery, and who were suitable candidates for VBAC at term, from 14 Australian maternity hospitals.(Crowther, Dodd, and Hiller, *et al*, 2012) The women were mostly assigned by patient preference (n = 2,323), but with a small nested group of 22 women who agreed to be randomised to either the planned VBAC arm (yielding a total of 1225 patient preference subjects and 12 randomised subjects) or the elective repeat caesarean arm (yielding 1098 patient preference and ten randomized subjects). Only 43% of women in the planned VBAC group achieved a vaginal delivery. The study found that the risk of fetal death or liveborn infant death prior to discharge, or serious infant outcome, was significantly lower for infants born in the elective repeat caesarean section group as compared with infants in the planned VBAC group (0.9% versus 2.4%; RR 0.39; 95% CI 0.19, 0.80). Fewer women in the elective repeat caesarean group

had a major haemorrhage (0.8% versus 2.3%; RR 0.37; 95% CI 0.17, 0.80). The authors concluded that among women with one prior caesarean, planned elective repeat caesarean section was associated with a lower risk of fetal and infant death or serious infant outcome, compared to attempting VBAC.

A study by the National Institute of Child Health and Human Development (NICHD) Maternal–Fetal Medicine Units Network attempted to overcome many of the shortcomings of previous studies by having a large sample size, a prospective cohort design, and by using standardised definitions for assessing outcomes. (Landon, Hauth, and Leveno, *et al*, 2004) However, the results were undermined by the fact that the group delivered by elective repeat caesarean section included women in whom planned VBAC was absolutely or relatively contraindicated, such as women with placenta praevia, high numbers of previous caesarean births, or maternal medical disorders. It is likely that the presence of these conditions may have led to an overestimate of the risk of adverse outcomes associated with repeat caesarean section.

Maternal choice – whether to attempt VBAC after a previous caesarean section, or to opt for elective repeat caesarean delivery – has been studied. One study revealed that the majority of mothers interviewed believed that VBAC carries a higher risk than repeat caesarean section.(McGrath and Phillips, 2009) Although most study participants reported that their doctor had discussed the risks and benefits of each mode of delivery, the findings led researchers to conclude that most mothers have already made up their minds about birth options following a prior caesarean delivery and sought psycho-social support in their decision, rather than detailed clinical information about risks and benefits, from their health practitioners.

A review of studies examining women's decision making in the context of previous caesarean section identified 'family factors' – speed of recovery in particular – as a very important factor.(Eden, Hashima, and Osterweil, 2004) Other prominent considerations identified in the review were a wish to avoid pain, specific desires to 'experience vaginal birth,' and issues relating to safety for baby and mother. A prospective study undertaken to explore women's experiences of decision making in this setting concluded, not surprisingly, that many women found decision making challenging, and that the process was associated with

prolonged anxiety.(Emmett, Shaw, and Montgomery, *et al*, 2006) A subsequent randomised trial of use of a decision-aid tool, conducted by the same investigators, reported that use of such a tool 'reduced decisional conflict' and may have contributed to a non-significant trend to increased rates of vaginal birth.(Montgomery, Emmett, and Fahey, *et al*, 2007) Further studies of 'decision support interventions,' incorporating use of an educational DVD and home visit by a dedicated midwife, was well received by candidate women, but did not appear to contribute to increasing rates of vaginal birth.(Farnworth, Robson, and Thomson, *et al*, 2008)

Summary: *The majority of women whose first child is delivered by caesarean section will have their second and subsequent children delivered by another caesarean section. Attempts to change this proportion, with the use of either 'decision aids' or 'decision support interventions' have been described, but their effect on birth outcomes is unclear. Decision making about mode of birth after a previous caesarean section is clearly complex, but no study has ever examined the paternal contribution to this process.*

1.11 Neonatal outcomes

Any discussion of neonatal outcomes must include consideration of both the immediate neonatal course, and longer-term outcome. Fundamental to understanding the outcomes of caesarean birth is an examination of data regarding the outcomes of babies delivered by elective caesarean section. Studies of neonatal outcomes reveal in increase in the rates of adverse outcomes of both respiratory and non-respiratory complications (such as hypogylcaemia, hypothermia, and admissions to special care and neonatal intensive care facilities).(Lee and D'Alton, 2008) Elective caesarean delivery is also associated with a reduced rate of intracranial haemorrhage, neonatal hypoxia and hypoxic encephalopathy, and trauma such as brachial plexus injury and other fetal injuries. There is also a reduction in the rate of unexplained stillbirth, since late term stillbirth is effectively eliminated as an entity.

It is recognized that elective caesarean delivery has a potential for increased respiratory morbidity.(Lee and D'Alton, 2008) The incidence of severe

respiratory compromise requiring mechanical ventilation is reduced to one in 10000 newborns if elective caesarean delivery is performed after 39 weeks gestation.(Morrison, Rennie, and Milton, 1995) However, there is insufficient evidence to determine whether it is solely gestational age that accounts for the differential risk of neonatal respiratory morbidity associated with caesarean compared with vaginal delivery, or whether other factors are also involved.(Lee and D'Alton, 2008) Morrison and colleagues prospectively evaluated over 33 000 deliveries at 37 weeks gestation or more and found that respiratory morbidity was significantly higher for babies delivered by caesarean section before the onset of labor (35/1000) compared with cesarean during labor (12/1000) (OR 2.9, 95% CI 1.9, 4.4), and compared with vaginal delivery (5.3/1000, OR 6.8, 95% CI 5.2, 8.9).(Morrison, Rennie, and Milton, 1995) The authors attributed these findings to the widely held belief that passage through the birth canal accompanied by exposure to endogenous steroids and catecholamines released during a normal delivery improve the neonatal transition from amniotic fluid to breathing air.(Jain and Dudell, 2006)

Studies have reported an increased risk for respiratory distress and admission to neonatal intensive care units in term infants born by caesarean, although these diagnoses are more likely to include transient tachypnea of the newborn (TTN), persistent pulmonary hypertension, and hypoxic respiratory failure rather than ''hyaline membrane disease.''(Lee and D'Alton, 2008)

Neonatal encephalopathy, a syndrome of disturbed neurologic function that occurs in the first week after birth, is manifest by difficulty with initiation and maintainance of respiration, depression of tone and reflexes, altered level of consciousness, and often seizures.(Hankins, Clark, and Munn, 2006) In a Western Australian case-control study, the prevalence of moderate to severe newborn encephalopathy was 3.8 per 1000 term live births, and the condition carried a neonatal mortality rate of approximately 9%.(Badawi, Kurinczuk, and Keogh, *et al*, 1998). The investigators reported a number of risk factors for moderate or severe neonatal encephalopathy. However, they estimated that purely pre-labour events accounted for 69% of affected infants, and that in 2% of cases the causes were unknown. They also estimated that intrapartum hypoxia *alone* accounted for only 4% of the cases, but that a combination of antepartum risk factors exacerbated by intrapartum hypoxia might account for a proportion as large as

25% of cases. In women who underwent pre-labour elective caesarean section, they reported a reduction of 83% in the risk of moderate or severe neonatal encephalopathy. Modeling by Hankins and colleagues, using these data, calculated that if the at-risk population of women were delivered by 39 weeks of gestation, it would reduce the number of cases of moderate to severe newborn encephalopathy by approximately 83%.(Hankins, Clark, and Munn, 2006). The authors concluded that, "if a substantial percentage of the moderate to severe encephalopathic children go on to develop cerebral palsy, then such a dramatic reduction in its occurrence would have a significant impact on the incidence of cerebral palsy nationally and equate to substantial savings in health care dollars as well as human resources."

Hankins' group draws attention to data of the Maternal–Fetal Medicine Unit Network's publication on maternal and perinatal outcomes associated with a trial of labor after prior caesarean delivery.(Landon, Hauth, and Leveno, 2004) In that series of over 30000 women, the proportion in the trial of labor group who were diagnosed with hypoxic ischemic encephalopathy was 0.0782%. In comparison, those who had an elective repeat caesarean delivery had no cases of neonatal encephalopathy.

Trauma to the fetus during delivery is another issue raised during discussion of caesarean birth.(Hankins, Clark, and Munn, 2006) One analysis concluded that prophylactic caesarean delivery in the situation of antenatally-recognised macrosomia would likely result in 1000 caesarean sections being required, and millions of dollars spent, to avert a single permanent brachial plexus palsy.(Rouse and Owen, 1999). Similarly, Mollberg and colleagues reported that population data from Sweden demonstrated that 85% of infants with a birthweight of 5 Kg or more had their weight underestimated by antenatal ultrasound reports, and they estimated that 333 abdominal deliveries would have to be performed to avoid a single case of obstetric brachial plexus palsy even for babies with a birthweight of 5 Kg or more.(Mollberg, Hagberg, and Bager, *et al*, 2005) Other studies of the management of fetal macrosomia have reported similar findings.(Mocanu, Greene, and Byrne, *et al*, 2000; Boulet, Salihu, and Alexander, 2004; Alsunnari, Berger, and Sermer, *et al*, 2005; Chauhan, Grobman, and Gherman, *et al*, 2005)

Although caesarean section is not completely protective against brachial plexus injury, the risk is much lower with caesarean section than with vaginal birth. Gherman and colleagues have calculated that if one took the three million women each year in the United States who will reach their 39th week of gestation undelivered, and if they opted for delivery by cesarean secion, it would eliminate approximately 4500 cases of shoulder dystocia.(Gherman, Ouzounian, and Satin, *et al,* 2003) The likelihood of injury with these deliveries at 39 weeks and beyond, which will encompass larger birthweights, is approximately 25% for brachial plexus injury, thus accounting for 1125 injuries. If one quarter of these injuries prove to be permanent, then 281 children per year in the United States would have a permanent brachial plexus palsy. Gherman's group notes that, "clearly, the overwhelming majority of these could be eliminated by cesarean birth." Other groups have confirmed these estimates.(Chauhan, Rose, and Gherman, *et al*, 2005) Hankins and colleagues note that the lifetime cost of a permanent brachial plexus palsy was estimated in 2005 to be $1 million, and this figure does not take into account potential loss of productivity and earnings capacity of the injured individual nor any other injuries.(Hankins, Clark, and Munn, 2006) They conclude that planned caesarean delivery for suspected macrosomic babies would yield an offset of $280 to 600 million per year in other potential costs.

One group has reported an overall perinatal mortality secondary to shoulder dystocia of 1.2%, which increased to 6.2% if the mother had diabetes mellitus.(Christoffersson and Rhydstroem, 2002) A European study specifically addressed infants in cephalic presentation with birthweights greater than 4.5 Kg and reported the perinatal mortality to be 0.6% when shoulder dystocia complicated the delivery, compared with 0.3% when no shoulder dystocia occurred.(Gudmundsson, Henningsson, and Lindqvist, 2005)

Traumatic fetal injuries not associated with shoulder dystocia are associated with difficulties in delivery.(Hankins, Clark, and Munn, 2006) Such injuries include laryngeal rupture, thoracic spinal cord injury, facial nerve palsy, and fractured humerus. In the majority of these cases, delivery occurred with singleton infants in vertex presentation at or near term. Gudmundsson and colleagues estimated the risk of birth injuries in an institution favoring trial of vaginal birth when there was doubt about the best mode of delivery.(Gudmundsson, Henningsson, and Lindqvist, 2005) They analysed term singleton cephalic vaginal deliveries

occurring at a time when the institution's total caesarean section rate was a remarkable 9%. They reported a total of 318 injuries in 282 infants, yielding an incidence of one injury for every 51 vaginal births.

Reviewing these data, Hankins and colleagues conclude that trauma to the newborn can occur with caesarean section, but is much more likely with malpresentations, premature infants, or in the setting of emergency delivery, as compared to elective scheduled cesarean section at 39 weeks.(Hankins, Clark, and Munn, 2006) They conclude that, "although trauma is also associated with cesarean delivery, it is an order of magnitude less than occurs with vaginal delivery and almost unheard of with elective cesarean delivery of the vertex fetus at term."

Lastly, Signore and colleagues have modeled neonatal mortality and morbidity in elective caesarean delivery, and concluded that:

> "Neonatal mortality was increased among elective cesarean deliveries, but perinatal mortality was higher with routine expectant management due to fetal deaths. Respiratory morbidity was substantially more common among infants delivered by elective cesarean delivery, whereas intracranial hemorrhage and brachial plexus injury were less common. We conclude that the fetal/neonatal impact of elective cesarean is mixed, but any improvement in perinatal health is likely to be small."(Signore, Hemachandra, and Klebanoff, 2006)

1.12 Breastfeeding

An important aspect of neonatal and infant health is breastfeeding. Breast milk increases resistance to infection and probably other non-infectious diseases, and may reduce the risk of atopic illness (eczema and asthma).(Linacre, 2007) Rates of breastfeeding have increased since a nadir in the 1970s, when fewer than half of all babies received any breast milk, to a state where close to 90% of Australian children under three years had ever been breastfed, receiving breastmilk either exclusively, or as part of their diet in combination with breastmilk substitutes or solid food.(Linacre, 2007)

Isolated reports have suggested that caesarean section, both elective and emergency, is associated with slightly lower rates of breastfeeding, with authors speculating that the inability of women to breastfeed comfortably in the immediate postpartum period seems to be the most likely explanation for this association. (Zanarda, Svegliado, and Cavallin, *et al*, 2010) However, such an uncontrolled study is likely to be very misleading. Australian population data reveal that older and more educated mothers are much more likely to still be breastfeeding their children (either exclusively or in combination with breast milk substitutes and/or solid food) at 6 and 12 months of age.(Linacre, 2007) For mothers aged 30 years or over, 54% were still breastfeeding their baby at 6 months of age, compared with 38% for mothers aged 18–29 years. Mothers aged 30 years or over were also twice as likely to be breastfeeding their babies at 12 months of age (28%) compared with mothers aged 18–29 years (14%). Similarly, almost two-thirds (64%) of mothers with a post-school qualification at the level of associate diploma or above were breastfeeding their babies at 6 months of age, compared with 41% of those with no post-school qualification. By the time their babies were 12 months old, nearly twice as many mothers with an associate diploma or above (35%) were still breastfeeding their child compared with women with no post-school qualification (17%).

A large study from the United States reported that women's decision making about breast feeding was usually made made either before pregnancy, or during the first trimester. (Arora, McJunkin, and Wehrer, *et al*, 2000) The most common reasons women breastfed were 'benefits for the infant's health,' 'naturalness,' and, 'emotional bonding with the infant.' The most common reasons bottle-feeding was chosen included 'the mother's perception of father's attitude,' 'uncertainty regarding the quantity of breast milk,' and, 'return to work.' Mode of delivery was not identified as influential in any way. A prospective cohort study of women giving birth by CS found no differences in mother-to-infant bond according to whether CS was performed as an emergency or as a planned procedure.(Forti-Buratti *et al*, 2017)

1.13 Longer term child health outcomes

Some authors have nominated an association between caesarean delivery and certain long term adverse outcomes for children - asthma, food allergies, and, diabetes. It is worth examining the basis for these claims.

Bager and colleagues hypothesised that an observed increase in asthma and atopic disease in children might be associated with the increase in caesarean birth rates, and undertook a systematic review and meta-analysis.(Bager, Wohlfahrt, and Westergaard, 2008) They identified 26 studies of suitable quality, but their funnel plot was highly suggestive of publication bias – only studies that reported an increased incidence had been published. They concluded that:

> "Delivery by caesarean section was found to be associated with a moderately increased risk of allergic rhinitis, asthma, hospitalization for asthma, and perhaps food allergy/food atopy, but not with inhalant atopy and eczema/atopic dermatitis. As only 1–4% of cases of allergic outcomes were attributable to caesarean section, the increased use of caesarean section during the last decades is unlikely to have contributed much to the allergy epidemic observed during the same period."

In a similar vein, Cardwell and colleagues noted that the rate of caesarean section had risen in parallel with an observed increase in the prevalence of type one diabetes in children, and speculated that differences in gut flora associated with caesarean birth might predispose children to diabetes.(Cardwell, Stene, and Joner, *et al* 2008). Sixteen suitable studies were identified yielding data for 9938 children. The odds ratio for type 1 diabetes in the group delivered by caesarean section was 1.23 (95% CI 1.15, 1.32). However, it is important to note that mothers of the children who developed diabetes had increased odds of maternal diabetes of any type (OR 4.92, 95% CI 3.93, 6.16) and specifically of type 1 diabetes in the mother (OR 4.03, 95% CI 1.76, 9.20). Furthermore, the affected babies were more likely to be macrosomic (OR 1.12, 95% CI 1.02, 1.21) and to be born to mothers older than 35 years (OR 1.11, 95% CI 1.01, 1.23) suggesting important differences between the groups. It was not possible to adjust for any history in the mother. Thus, this is a small effect derived from retrospective data from observational studies, so it is very likely this is weak evidence.

1.14 Pelvic organ prolapse and caesarean section

Pelvic organ prolapse (POP) is distortion of the normal pelvic anatomy and relationships, such that intestines or rectum, bladder, or uterus reach an abnormal location with respect to the normal relationships. Many factors are associated with an increase risk of prolapse, including obesity, chronic lung disease, and previous hysterectomy, but the most important risks are pregnancy, number of births, episiotomy, instrumental delivery, and prolonged second stage.(Mant, Painter, and Vessey, 1997; Samuelsson, Victor, and Tibblin, *et al*, 1999; Richter, 2006)

The normal pelvic anatomical relationships are maintained by the pelvic floor muscles (the levatores ani) and the endopelvic fascia.(Richter, 2006) The pelvic floor muscles, including the iliococcygeus muscles and the puborectalis and pubococcygeus muscles, require an intact innervation to maintain a resting tone and to provide reflexive response to increases in intrabdominal pressure, for example with coughing. The innervation of the pelvic floor muscles arises from the anterior nerve roots of S2, S3, and S4, and the pelvic course of these nerves renders them susceptible to traction injury during vaginal birth.(Handa, Harris, and Ostergard, 1996) In addition to the muscular supports, the system of ligamentous supports to the pelvic side wall – the endopelvic fascia – envelops the pelvic organs to provide support.(DeLancy, 2003)

Hallock and Handa (2016) recently have reviewed the epidemiology of pelvic floor disorders (PFDs) POP, urinary incontinence (UI) and anal incontinence (AI) and report that – in developed countries – estimates suggest a lifetime prevalence of one in four. Importantly, "severe and symptomatic POP is much more common in vaginally parous [compared to] nulliparous women. Among multiparous women, the increase is most dramatic with the first birth." By way of further analysis, the authors estimate that vaginal birth increases the odds of POP with an odds ratio of almost ten, but that additional vaginal births did not increase the odds for prolapse any further. They also point out that CS is "not associated with prolapse."

> "Epidemiologic studies of parous women suggest a strong association between vaginal (versus cesarean) delivery on the odds of prolapse later in life… a history of one or more vaginal births [is] strongly associated with pelvic organ prolapse…Urinary incontinence, most notably SUI, is also strongly associated with vaginal childbirth."

Hallock and Handa (2016) also point out that vaginal delivery is associated with greater severity and bothersomeness of urinary incontinence, particularly of stress urinary incontinence but not overactive bladder. Similarly, anal incontinence is more common among vaginally parous women, although the impact of vaginal delivery is 'less dramatic' than for other PFDs. The authors found that labour, in the absence of vaginal birth, does not appear to modify the later development of PFDs.

> "Among women who have delivered exclusively by caesarean (i.e., across all their births), the risk of PFD does not appear to be increased by a history of active labour or complete cervical dilation prior to CD. In contrast, operative vaginal birth appears to be a powerful risk factor for the development of PFDs. Compared with un-instrumented vaginal delivery, operative delivery (by forceps or vacuum) significantly increases the odds for all PFDs, with the highest increase for POP (OR 7.5, 95% CI 2.7–20.9)."

Retrospective reviews have reported that women undergoing surgical procedures to treat POP are of greater parity and are less likely to have had a caesarean delivery than other women.(Carley, Turner, and Scott, *et al*, 1999) Other similar studies have confirmed these relationships, and reveal that young age at first birth, obesity, and forceps delivery are more common in women undergoing surgery for POP.(Chiaffarino, Chatenoud, and Dindelli, *et al*, 1999; Rinne and Kirkinen, 1999; Maolli, Ivy, and Meyn, *et al*, 2003) Cross-sectional studies have also reported that the greater the parity, the more likely a woman is to have POP.(Hendrix, Clark, and Nygaard, *et al*, 2002; Krebs and Langhoff-Roos, 2003)

Studies of the effect of mode of delivery are surprisingly scarce, considering the well-recognised relationship between birth and POP. One prospective study, where a formal measurement of POP was undertaken at six weeks post-partum,

found that pre-labour caesarean delivery was only partially protective against POP.(Sze, Sherard, and Dolezal, 2002) Another similar study reported similar findings.(O'Boyle, O'Boyle, and Calhoun, *et al*, 2005) A prospective study of 182 nulliparous women was undertaken, where a validated questionnaire and formal POP-Q chart was performed at 20 weeks of gestation, then postnatally at one and five years.(Elenskaia, Thakar, and Sultan, *et al*, 2011) This revealed that symptoms and findings were worse at all postnatal visits after a vaginal delivery, whereas caesarean delivery was not associated with any long-term changes.

Summary: *Pregnancy appears to be an important risk factor for pelvic organ prolapse in later life, but there are few data to confirm whether pre-labour caesarean delivery is protective.*

1.15 Urinary incontinence and caesarean section

Urinary incontinence (UI) is extremely common in the community, with studies revealing that as many as half of all adult women report involuntary loss of urine at times.(Thom, 1996) Although studies have repeatedly confirmed that vaginal birth is a strong independent risk factor for UI in pre-menopausal women, other factors (such as medical conditions and functional impairments) tend to overwhelm the effect of birth in older women.(Nygaard, 2006) In any consideration of UI and its relationship to mode of birth, it is important to note that definitions of what exactly constitutes UI vary considerably between studies.(Nygaard, 2006)

It is clear the simply being pregnant is strongly associated with transient UI.(Thorp, Norton, and Wall, *et al*, 1999) As a corollary, women who reported UI during a pregnancy were more likely to have continuing UI for up to ten years after birth.(Foldspang, Hvidman, and Mommsen, *et al*, 2004) This effect also seems to influence any potential protective effect of caesarean birth on UI: women who did not have pregnancy-related UI in the first place were less likely to have UI after caesarean birth.(Wilson, Herbison, and Herbison, 1996) Women who reported UI in the early postpartum period were also more likely to have continuing urinary continence problems, so a protective effect of caesarean delivery on women who were continent of urine in pregnancy was likely to

endure.(Viktrup, Lose, and Rolff, *et al*, 1992; Macarthur, Glazener, and Wilson, *et al*, 2006)

Most studies report that caesarean section, whether performed before the onset of labour or during labour, is protective against subsequent UI.(Chaliha, Khullar, and Stanton, *et al*, 2002; Burgio, Zyczynski, and Locher, *et al*, 2003; Schytt, Lindmark, and Waldenstrom, 2004; Casey, Schaffer, and Bloom, 2005; Glazener, Herbison, and Macarthur, *et al*, 2006; Eason, Labrecque, and Marcoux, *et al*, 2006) However, it is worth noting that these studies largely reported findings after one vaginal birth, and a single study of the effect of multiple births reported no difference in the rate of UI between different modes of delivery.(Klein, Kaczorowski, and Firoz, *et al*, 2005)

Surprisingly, most studies do not examination outcomes according to whether the caesarean section was performed before labour, or intrapartum. The results of those small studies that did differentiate are conflicting. One study reported no significant differences (Wilson, Herbison, and Herbison, 1996), while another two studies reported lower rates of UI for pre-labour caesarean section compared to intrapartum caesarean section.(Mason, Glenn, and Walton, *et al*, 1989; Groutz, Rimon, and Peled, *et al*, 2004)

Cross-sectional studies of post-menopausal women have largely found that pregnancy increases the rate of UI, but that mode of delivery does not.(Kuh, Cardozo, and Hardy, 1999; Fritel, Ringa, and Varnoux, *et al*, 2005; McKinnie, Swift, and Wang, *et al*, 2005) The exception to this is the large, population-based EPICONT study that reported a greater than two-fold increase in the rate of 'moderate' or 'severe' UI in women who had at least one vaginal delivery compared to women delivered exclusively by caesarean section.(Rortveit, Hannestad, and Daltveit*, et al*, 2001) Of note, the authors of the EPICONT study concluded that the risk of 'severe' UI would be halved, at a population level, if all deliveries were by caesarean section. A single study of twin sister pairs reported that twins who had never been pregnant had the lowest rates of UI, with the highest rates in those delivering vaginally, and an intermediate rate where delivery was by caesarean section.(Goldberg, Abramov, and Botros, *et al*, 2005)

The largest prospective study of its kind, the ProLong study, was a longitudinal study of all women who delivered over a 12-month period (1993/94) in three maternity units, in Aberdeen (UK), Birmingham (UK) and Dunedin (New Zealand), and were followed up 12 years later. (MacArthur, Glazener, and Lancashire, *et al*, 2011) At six years post-partum, women who had responded to a three-month questionnaire were sent another questionnaire, and at 12 years all women who had replied at 3 months were contacted a third time (including those who were nonresponders at 6 years), except for known subsequent deaths or those who had requested no further contact in their 6-year questionnaire.

Twelve-year data were obtained for 3763 women, representing 49% of the original cohort. The full summary of results is presented in **Table 1.5**. With respect to urinary incontinence at 12 years postpartum, compared to women who had only spontaneous vaginal births, women who had no vaginal births and thus *all* of the deliveries by either elective pre-labour caesarean section (OR 0.43, 95% CI 0.29, 0.63), emergency caesarean section (OR 0.46, 95% CI 0.030, 0.69), or a mixture of either (OR 0.49, 95% CI 0.35, 0.68), had odds ratios for urinary incontinence that was significantly reduced. This protective effect was not present if the women had even one vaginal birth.

The sole randomised study, the well-known Term Breech Trial, reported an increased rate of UI in women undergoing planned vaginal delivery, compared to planned caesarean section, at three months, but no statistically significant difference by two years.(Hannah, Hannah, and Hodnett, *et al*, 2002)

Summary: *Urinary incontinence is common in general, becoming more so with increasing age. In the short term, caesarean delivery (whether pre-labour or intrapartum) appears to protect against urinary incontinence in the short term, but after the age of menopause, this difference has faded. Simply having been pregnant is the important risk factor in the long term, irrespective of the mode of delivery.*

Table 3. Logistic regression subsidiary models of urinary and faecal incontinence at 12 years and delivery mode history, subdividing type of section

Variable	Total	UI symptoms *n* (%)	OR (95% CI)	FI symptoms *n* (%)	OR (95% CI)
Delivery mode history					
Only SVD	1852	1013 (54.7)	Reference	213 (11.5)	Reference
Only prelabour CS	124	48 (38.7)	0.43 (0.29–0.63)	13 (10.5)	0.82 (0.45–1.50)
Only postlabour CS	109	44 (40.4)	0.46 (0.30–0.69)	10 (9.2)	0.75 (0.38–1.50)
Only CS/pre- and post-labour	170	70 (41.2)	0.49 (0.35–0.68)	24 (14.1)	1.13 (0.71–1.79)
SVD + CS	293	174 (59.4)	1.14 (0.89–1.48)	39 (13.3)	1.06 (0.74–1.54)
Any forceps	956	491 (51.4)	0.81 (0.69–0.95)	160 (16.7)	1.48 (1.18–1.85)
Any vacuum, no forceps	248	139 (56.0)	0.97 (0.74–1.28)	27 (10.9)	0.91 (0.59–1.40)

CS, caesarean section; OR, odds ratio; SVD, spontaneous vaginal delivery.
Age at first birth, number of births and body mass index not shown.

Table 1.6. Outcomes of the ProLong study, showing the odds ratios for urinary and faecal incontinence at 12 years.(MacArthur, Glazener, Lancashire, *et al*, 2011)

1.16 Anal incontinence and caesarean section

Anal incontinence (AI) is a term that encompasses involuntary loss of flatus or faeces. When faecal incontinence is the predominant condition, the more specific term faecal incontinence (FI) is used. For obvious reasons, AI and FI can have dramatic effects on a woman and may lead to social isolation and a markedly reduced quality of life.(Failkow, Melville, and Lentz, *et al*, 2003; MacMillan, Arend, and Merrie, *et al*, 2004; Melville, Fan, and Newton, *et al*, 2005) As well as increasing age and other cognitive problems such as depression, important independent risk factors for AI include increasing parity, operative vaginal delivery, and anal sphincter injury.(Melville, Fan, and Newton, *et al*, 2005)

The mechanisms of anal continence are complex and require correct anatomy of the puborectalis and other pelvic floor muscles, as well as normally functioning innervation of the rectum and anal sphincter. The genesis of most cases of AI after pregnancy and birth is thought to involve damage to either the musculature, the nerves, or both.(Snooks, Swash, and Mathers, *et al*, 1990; Sultan, Kamm, and Hudson, *et al*, 1993; Fornell, Wingren, and Kjolhede, 2004) Various studies have reported rates of AI as high as 25% in the first twelve months after vaginal birth, with the highest risk following instrumental delivery and with obstetric anal sphincter injuries (OASIS).(Sultan, Kamm, and Hudson, *et al*, 1993; Zetterstrom,

Lopez, and Anzen, *et al*, 1999; MacArthur, Glazener, and Wilson, *et al*, 2001; Eason, Labrecque, and Marcoux, *et al*, 2002)

In Australia, anal sphincter injury may occur in up to 4% of vaginal deliveries.(Robson, Laws, and Sullivan, 2009) In the world literature, incidence rates as high as 18% have been reported in first births.(Sultan, Kamm, and Hudson, *et al*, 1993; Aitkins Murphy and Feinland, 1998; Handa, Danielson, and Gilbert, 2001) This is important, because as many as one third of women will report AI in the twelve months after an anal sphincter injury.(Zetterstrom, Lopez, and Anzen, *et al*, 1999) The most important risk factors for anal sphincter injury include a birthweight of 4 Kg or greater, instrumental (forceps or ventouse) delivery, and midline episiotomy.(Donnelly, Fynes, and Campbell, *et al*, 1998; Handa, Danielson, and Gilbert, 2001; Fenner, Genberg, and Brahma, *et al*, 2003)

The prevalence of AI in women who have had an anal sphincter injury and those who have not becomes more comparable over time. A retrospective cohort study of women whose youngest child was 30 years or more reported no differences between groups irrespective of the mode of birth or recollection of birth complications.(Nygaard, Rao, and Dawson, 1997). However, a prospective study did find that a diagnosis of anal sphincter injury predicted subsequent AI at five years after the birth.(Pollack, Nordenstam, and Brismar, *et al*, 2004) Similarly, a retrospective cohort study reporting symptoms 14 years after birth found that AI was more common in women with a history of sphincter injury than those without.(De Leeuw, Vierhout, and Struijk, *et al*, 2001)

Since there is clearly an association between vaginal birth (and its complications) and AI, it is important to describe what is known about caesarean delivery. A study of 270 identical twins reported that intrapartum caesarean delivery reduced the risk of subsequent AI, although the effect was not statistically significant.(Abramov, Sand, and Botros, *et al*, 2005) In MacLennan's study from South Australia, where over 3000 women were surveyed randomly by telephone, rates of AI were reported as 2% in nulliparous women, 4% in women who delivered by caesarean section only, 4.6% in women who had spontaneous vaginal births, and 3.9% in women who had instrumental vaginal births.(MacLennan, Taylor, and Wilson, *et al*, 2000)

Data from the prospective ProLong study of 3763 women at 12 years postnatal revealed that there was no clear protective effect of elective caesarean birth. With respect to faecal incontinence, compared to women who had only spontaneous vaginal births, women who had no vaginal births and thus *all* of the deliveries by either elective pre-labour caesarean section (OR 0.82, 95% CI 0.45, 1.50), emergency caesarean section (OR 0.75, 95% CI 0.38, 1.50), or a mixture of either (OR 1.13, 95% CI 0.71, 1.79), no differences were found in symptoms of faecal incontinence.

In an underpowered study of women ten months after birth, Lal and colleagues interviewed 100 women who had delivered vaginally, and compared them to 80 women who had undergone planned pre-labour caesarean section and 104 women who had been delivered by emergency intrapartum caesarean section.(Lal, Mann, and Callender, *et al*, 2003) They found no differences in the rates of AI or faecal soiling between the three groups. In a prospective randomised study, multivariate analysis revealed that forceps delivery and sphincter injury were independent risk factors for AI.(Eason, Labrecque, and Marcoux, *et al*, 2002) Another prospective randomized study, the 'term breech trial' of Hannah and colleagues, reported data regarding AI at two years post- delivery and found no differences between the various delivery groups when analysed either by 'intention to treat' or by delivery mode.(Hannah, Whyte, and Hannah, *et al*, 2004)

Fenner (2006), reviewing the available data regarding AI and mode of birth, draws the following conclusions:

> "Anal incontinence following vaginal delivery is strongly associated with overt and occult sphincter lacerations and operative vaginal delivery. Pregnancy in and of itself appears to increase the risk of anal incontinence, regardless of delivery mode. Elective cesarean section has not been shown to decrease the risk of anal incontinence. The majority of current studies lack the power, matched controls, and long-term follow up to make recommendations concerning the mode of delivery and the impact on anal incontinence especially as women age. Prospective studies using standardized definitions, validated tools for symptom assessment and impact on quality of life, and careful documentation of obstetric variables

are needed to help understand and prevent this socially debilitating condition."

Summary: *Anal incontinence appears to result from instrumental birth and anal sphincter injury. Pregnancy itself contributes to anal incontinence, and caesarean section does not appear to have a strong protective effect in itself, except that it greatly reduces the risk of other delivery interventions that impart risk.*

1.17 Maternal mortality associated with caesarean birth

Caesarean section was originally a peri- or postmortem procedure, and it is only in the last century that mortality associated with the procedure reached acceptable levels.(Vadnais and Sachs, 2006) In current obstetric practice, the risk of maternal death attributable to mode of birth is very small, irrespective of whether this is vaginal or by caesarean section. However, a precise estimate of any additional risk of maternal death attributable to caesarean has proven difficult to obtain.(Vadnais, and Sachs, 2006)

Three very dated publications described an increase in the risk of death, but these were likely to be strongly confounded, and used very old data.(Evrard and Gold, 1977; Rubin, Peterson, and Rochat, *et al*, 1981; Varner, Daly, and Goplerud, *et al*, 1982) Two studies have reported an increase in the risk of maternal mortality with emergency caesarean section as compared to elective caesarean section.(Feldman and Friedman, 1985; Minkoff and Chervenak, 2003) Vadnais and Sachs undertook a systematic review to examine attributable risk of maternal mortality related to elective caesarean section, and identified only nine publications suitable for inclusion.(Vadnais and Sachs, 2006) The reviewers concluded that there were 'significant limitations in the studies available,' due to 'poor study design' and 'inadequate power.' Their overall conclusion was:

> "To date, the strongest publications suggest there may not be an increased risk of maternal death with elective cesarean delivery as compared with vaginal delivery; however, there are inadequate data to accurately demonstrate the present-day risk of maternal mortality with cesarean delivery."

Summary: *Data regarding the risk of maternal mortality associated with elective caesarean section are very limited. The available evidence suggests that the maternal mortality rate is not measurably difference from that associated with vaginal birth.*

1.18 Economic aspects of elective caesarean section

Economic analyses in health tend to examine only costs (cost analysis) or both costs and effects (cost-benefit analysis).(Zupancic, 2006) Studies that provide information about whether an intervention or treatment saves money, as well as costs money, aim to determine whether these treatments provide 'value for money.' It is accepted that caesarean section is associated with an increased period of inpatient stay compared to uncomplicated vaginal delivery. Increased average length of stay (ALOS) increases bed occupancy rates and acuity, and increased occupancy rates may be associated with reduced patient satisfaction, stress on staff and resources, and increased costs to maintain safe practice.(Druzin and El-Sayed, 2006)

> "Caesarean section without labour does appear to be more expensive than uncomplicated vaginal delivery, but studies are seriously methodologically flawed, with few randomised trials, inadequate power, the omission of important types of costs including those accruing to patients, and the failure to report costs and effects together."(Zupancic, 2006)

Again, the problem that is seldom accounted for is summarized as follows:

> "It is well known that the overall costs of caesarean section are higher compared with vaginal delivery. However, in specific circumstances, such as with vaginal birth after caesarean section, cost of elective caesarean section may often be lower that a failed trial of labour. These data suggest that detailed analysis of clinical situations needs to be performed to avoid making incorrect generalizations."(Druzin and El-Sayed, 2006)

1.19 Economic evaluations of VBAC

In addition to other considerations, it is important to understand the health economic implications of the choice for either repeat CS or attempted VBAC. For a variety of reasons, many associated with methodology, the economic impact of this particular birth choice is difficult to model accurately.(Rogers *et al*, 2017) Although some studies have reported CS to be the more costly option (Traynor and Peaceman, 1998; Shorten *et al*, 1998), those data are nearly 20 years old and

more recent studies have not shown a major difference.(Friedman *et al,* 2015) Indeed, there are data suggesting that planned CS may have equivalent cost implications to a trial of VB or may actually provide cost savings when factors such as anaesthesia are taken into account.(Clark *et al,* 2000*;* Bost 2003; Kazandjian *et al,* 2007)

Rogers and colleagues (2017) undertook a comprehensive systematic review to summarise economic evaluations that compared attempted VBAC with planned CS for women with a singleton pregnancy and uncomplicated previous CS. The authors concluded that a trial of VBAC is a cost-effective strategy for women with a low-risk, singleton gestation pregnancy. However, they found several scenarios under which planned CS would be the preferred strategy in an economic sense. In particular: where there is a 'low likelihood' of a trial of VBAC yielding a vaginal birth; where there is an increased likelihood of uterine rupture; and, where there is a likelihood of stress urinary incontinence. The authors noted that there was great variation in costing methods used across studies, and that, "the true cost incurred by hospitals is difficult to ascertain as it requires a micro-costing approach whereby all resources used are identified, measured, and valued. These costs are seldom published or generalisable to other facilities."

1.20 Recovery after caesarean section

Studies specifically addressing maternal recovery from caesarean birth have only dealt with recovery from the first birth, and have not even begun data collection until three months after birth. The largest such study, the *Australian Maternal Health Study* was designed to investigate the health of women having their first baby from early pregnancy up to 18 months postpartum. (Brown, McDonald, and Krastev. 2008; Woolhouse, Brown, and Krastev, *et al*, 2009; Brown, Donath, and MacArthur, *et al*, 2010; Gartland, Brown, and Donath, *et al*, 2010; Brown, Gartland, and Donath, *et al*, 2011; Gartland, Brown, and Hemphill, *et al*, 2011; Woolhouse, Gartland, and Hegarty, *et al*, 2011) Over 1500 women were recruited to the study from six metropolitan public maternity hospitals in Melbourne between June 2003 and December 2005. Data were collected via questionnaires and telephone interviews at regular intervals during and after pregnancy. Women completed a baseline questionnaire at around 15 weeks' gestation of pregnancy, and follow-up questionnaires at 3, 6, 12 and 18 months postpartum and two

computer assisted telephone interviews at 30 weeks' gestation and 9 months postpartum. Detailed information on pregnancy complications, labour and birth events and postpartum complications were obtained from hospital medical records.

The primary aim of that study was to investigate changes in women's health from the early stages of pregnancy through to eighteen months after the birth of a first child. More prosaic issues regarding recovery, such as being able to lift a baby stroller into a car or complete a load of family washing were not covered in any way.

There are few studies of even simple aspects of recovery after caesarean section. A study of advice given to women about driving after caesarean section revealed that 65% were advised to wait for 6 weeks or longer before driving.(Sedgely, Rickard, and Morris, 2012) However, 72% of women reported they had driven by six weeks, and 35% by three weeks. The respondents reported minimal discomfort and rarely discontinued driving. The same study reported the advice given by midwives and doctors about driving, and revealed inconsistent advice ranging from no advice to eight weeks of driving abstinence. The study found that women are driving earlier than advised with minimal reported complications.

1.21 "Maternal choice" caesarean section

Maternal request caesarean section (MCCS) is also referred to in the literature as caesarean delivery on maternal request (CDMR), patient choice caesarean (PCC), and caesarean on demand (COD).(Wax, Cartin, and Pinette, *et al*, 2004) The most widely-accepted definition of MCCS is 'caesarean delivery for a singleton pregnancy on maternal request at term in the absence of any medical or obstetric indications.'(Reddy and Spong, 2006) Few areas of obstetric practice generate as much debate and disagreement as MCCS. Proponents of MCCS commonly find support for maternal choice in the principle of patient autonomy: that women should have a pivotal role in decision-making regarding their obstetric care (Paterson-Brown, 1998; Paterson-Brown and Fisk, 1997; Kerr-Wilson, 2001). In contrast, opponents commonly appeal to the clinical dictum *primum non nocere* – 'first do no harm' – arguing that potential risks to women and their babies from a liberal policy toward caesarean delivery outweigh other considerations. (Stirrat

and Dunn, 1999; Van Roosmalen, 1999; Amu, Rajendran, and Bolanji, 1998) The fundamental and quite remarkable issue is that despite the fact that almost one in three babies is now delivered by CS, there is scant evidence to guide practice in this area. A systematic review of the available evidence concluded that, "There is no evidence from randomised controlled trials upon which to base any practice recommendations regarding planned caesarean section for non-medical reasons at term." (Lavender, *et al*, 2006).

1.22 Ethical considerations in caesarean section at the woman's request

Wax and colleagues have posed the question, "Can an elective cesarean for a woman with an uncomplicated pregnancy be ethically justified?"(Wax, Cartin, Pinette, *et al*, 2004) The fundamental principles underpinning ethical deliberation, as we understand it, include respect for autonomy, beneficence, non-maleficence, and justice.(Gillon, 1994; Chervenak and McCullough, 1996) In short, *autonomy* is the obligation to present all reasonable management alternatives for a particular patient's situation, and assist the patient to choose their preferred option within a framework of informed consent. Wax reminds us that patients have the so-called negative right – to decline reasonable treatment – but not necessarily the positive right to demand unreasonable treatment.(Wax, Cartin, and Pinette, *et al*, 2004) *Beneficence* is the doctor's obligation to try to improve a person's health and overall welfare. *Non-maleficence* is the imperative to do no harm, enshrined in the well-known Latin phrase *primum non nocere*. Considerations of *justice* take the broader perspective, that patients are treated with fairness and the greater good of society is considered when decisions regarding allocation of healthcare resources are made. An additional characteristic, *veracity* – maintaining truthfulness when discussing treatment with patients – is sometimes added to the list.(Minkoff, Powderly, and Chervenak, *et al*, 2004)

The International Federation of Obstetrics and Gynaecology (FIGO), through its Committee for the Ethical Aspects of Human Reproduction, addressed caesarean delivery for nonmedical reasons in 1999.(FIGO, 1999). The committee opinion was that caesarean section is a surgical procedure associated with potential hazards to mother and fetus, and greater resource allocation than vaginal delivery, which is safer in the long and short term for both mother and fetus. The committee

opinion concedes that “hard evidence on risks and benefits of elective cesarean are lacking,” but the authors concluded that “performing cesarean section for nonmedical reasons is not ethically justified.”

Just over a decade later, the British National Institute for Health and Clinical Excellence (NICE) issued a new guideline that reviewed the extant literature for elective caesarean section, and drew a very different conclusion.(NICE, 2011) From the official press release issued at the time of the guidelines:

> “Dr Gillian Leng, NICE Deputy Chief Executive, said: “This guideline is not about offering free caesareans for all on the NHS; it is about ensuring that women give birth in the way that is most appropriate for them and their babies. For women who ask for a caesarean section in the absence of any clinical indication, physical or mental, the guideline says they should be asked why they are requesting the operation, and be provided with full information about the risks and benefits. They should also be offered the opportunity to discuss the procedure with other members of the obstetric team. If, after this, they still want to have a caesarean section, they should be allowed to have one.”
>
> (**http://www.nice.org.uk/newsroom/pressreleases/CaesareanSection.jsp**)

How things have changed from comments such as those of Amu and colleagues (Amu, Rajendran, and Bolanji, 1998), “if caesarean section is the preferred mode of delivery by the mother, her choice, however foolish or irrational, must be respected,” to the new position of Dr Leng of NICE:

> “For a very small number of women, their anxiety about childbirth will lead them to ask for a caesarean section. The new recommendations in this guideline mean that these fears will be taken seriously and women will be offered mental health support if they need it. If the woman's anxiety is not allayed by this support, then she should be offered a planned caesarean section.”
>
> **(http://www.nice.org.uk/newsroom/pressreleases/CaesareanSection.jsp)**

NICE prefaces its recommendations on caesarean section as follows:

> "Treatment and care should take into account women's needs and preferences. Pregnant women should be offered evidence-based information and support to enable them to make informed decisions about their care and treatment.
>
> "Good communication between healthcare professionals and pregnant women is essential. It should be supported by evidence-based written information tailored to the woman's needs. Treatment and care, and the information women are given about it, should be culturally appropriate.
>
> "If the woman agrees, families and carers should have the opportunity to be involved in discussions and decisions about treatment and care. Families and carers should also be given the information and support they need." (NICE, 2011)

By the ethical principle of autonomy, the doctor should first explore the patient's reason for requesting cesarean as part of adequate informed consent.(Wax, Cartin, and Pinette, *et al*, 2004) Often, concerns leading to the request could be allayed and nonmedical cesarean thereby avoided. However, autonomy does not endow positive rights to request otherwise unproven or potentially injurious treatment. Justice and allocation of resources must also be considered. Although noting that planned caesarean section is more expensive than uncomplicated vaginal delivery, Zupancic reviewed the literature regarding cost-benefit of maternal-request caesearan section and concluded:

> "The cost implications of [maternal request caesarean section] are unclear and will depend largely on whether future studies establish that the practice has clinical benefits. The economic literature to date is limited to elective cesarean section rather than maternal request delivery. Cesarean section without labor does appear to be more expensive than uncomplicated vaginal delivery, but studies are seriously methodologically flawed, with few randomized trials, inadequate power, the omission of important types of costs including those accruing to patients, and the failure to report costs and effects together. The economic outcomes associated with elective cesarean section are critically important. In the absence of a rigorously demonstrated benefit, any increased expenditure

> on an intervention will reduce the resources that are available for other medically necessary care. High-quality economic evaluations with a societal perspective should be undertaken prospectively alongside any large clinical studies so that the results are available to decision makers and clinicians as policy is being planned."(Zupancic, 2008)

Thus, important data regarding cost of elective caesarean versus planned vaginal delivery, and short and long-term sequelae, including future reproductive and healthcare costs, is not yet available.(Wax, Cartin, and Pinette, *et al*, 2004)

As this review of medical outcomes has summarised, it is difficult to interpret the evidence supporting one mode of delivery over another. For this reason, making a judgement about beneficence and non-maleficence is challenging. Wax and colleagues, in their review, take this apparent equipoise into account when they summarize the ethical decision making about accession to maternal requests for caesarean section thus:

> "In the absence of a specific patient request for elective cesarean, the lack of hard data favoring this procedure does not obligate the obstetrician to initiate discussion regarding relative risks and benefits versus vaginal delivery. However, if a patient requests cesarean, continues this request after informed counseling, and the physician believes that cesarean will promote the overall health of the patient and fetus more than vaginal delivery, then elective cesarean is ethically justified. If the physician does not believe that cesarean offers such benefits, the physician should ethically decline to perform cesarean and consider referral to another provider."(Wax, Cartin, and Pinette, *et al*, 2004)

An opponent of maternal-request caesarean section, former RANZCOG President Dr Christine Tippett made the following points in a personal statement:

> "On balance the current evidence does not support primary caesarean section as a safer option for mother and fetus in either the short of the long term. However, the question remains as to whether or not a mother has a right to request a caesarean section. It is clearly the responsibility of the medical practitioner to inquire as to the reason for the request and as part

> of the process of obtaining adequately informed consent must discuss the consequences of the intervention. The notion of autonomy recognizes that a patient can decline treatment but is does not carry an obligation that the practitioner undertakes a procedure that is medically unproven or potentially harmful nor does it support a patient dictating medical choices for non-medical reasons."(Tippett, 2004)

In support, former President of the AMA, Dr David Molloy, responded:

> "The fact that many women are making these choices is of great concern to the natural birth lobby. A majority of women will continue to choose natural childbirth as their preferred option and so they should. However lobby groups should not seek to take away the full spectrum of birthing choices for women or attempt to coerce women into their way of doing things. Women can now choose when they want to become pregnant, get assistance if they are having trouble falling pregnant, and finally choose when and how they will have their babies. There are now lots of safe ways to have a baby and women's choices need to be respected and protected."(Molloy, 2004)

1.23 Ethical discussions regarding attempted vaginal birth after a previous caesarean section

Ethical discussions of patient selection and choice for attempted VBAC have been well summarised by Chervenak and McCullough (1996) and Charles (2012) – I use their material as the basis of this entire section.

Given considerations of patient autonomy and a patient's right to refuse treatment, it is clear that a competent patient has a near-absolute right to refuse treatment and leave the hospital. However, if the patient refuses one treatment repeat elective caesarean section, but remains under an obstetrician's care, then she is effectively requesting an alternative treatment in trial of VBAC, which is a 'positive' right. Whenever a patient invokes a positive right to an alternative form of medical management, the physician has some say in whether to participate. Thus, autonomous choices that invoke 'positive' rights are more restricted.

When a patient requests an alternative form of medical management, her doctor can refuse unless the requested treatment is in keeping with what Chervenak and McCullough call the 'beneficence model.' Under such a model, a physician cannot refuse a patient's request for alternative treatment **as long as the treatment is reasonable**, by which they mean that it has the potential to benefit the patient. To lessen the 'creep of personal bias' by the treating doctor and to clarify the relationship between beneficence and reason, they define the beneficence model in this way:

> "The beneficence model makes a peculiar claim: to interpret reliably the interests of any patient from medicine's perspective. This perspective is provided by accumulated scientific research, clinical experience, and reasoned responses to uncertainty. It is thus not a perspective peculiar or idiosyncratic to any particular physician."

Based on such a model, a doctor ought not refuse to accommodate any request for alternative treatment that is supported by scientific research and clinical experience. This point is crucial because it shows that a significant number of women should have a right to request a trial of labour after caesarean. A last criterion about reasoned responses to uncertainty has to do with the nature of clinical judgments. Since many prognoses are based on statistical evidence, there is always room for error. However, when making these decisions, Chervenak and McCullough argue, we only need to be reasonably certain that the therapy will have some benefit (or not cause harm) based on scientific and clinical evidence.

Charles strongly asserts that given the evidence regarding VBAC, a woman who meets the general criteria for a trial of labour and wishes to have one is not making an unreasonable or irrational request. However, that opinion pre-dates the conclusions of the Australian prospective VBAC study showing that attempted VBAC results in vaginal birth less than half of the time, and that adverse outcomes for mother and baby are significantly increased with attempted vaginal birth as compared to repeat elective caesarean section.(Crowther, Dodd, and Hiller, *et al*, 2012) These new data call into question the basis of this ethical debate.

Charles cites the following in her paper:

> "A primary concern raised by obstetricians when considering a trial of labour after caesarean is the possibility of uterine rupture. According to ACOG's own statistics, however, when the woman has a low transverse uterine incision, the risk of uterine rupture is less than 1 percent, and in the studies reviewed by the NIH group, there were no maternal deaths as a result of uterine rupture. The risk is slightly higher for the fetus. In the case of uterine rupture, there was a 3 percent risk of fetal death for term infants.* While not insignificant, we can see that this is still a very low risk of fetal death."

Many obstetricians and, indeed, others would argue that a 3% chance of fetal death is not low by any standard and many parents would be unhappy about embarking on a strategy that increases the risk of death of an otherwise healthy baby.

Charles argues that,

> "The patient's decision does not have to coincide with what the physician believes is the best option. The requirement of the beneficence model is less cumbersome. The patient must only make a decision that is reasonable—that is, a decision that has 'a not-insignificant rate of success' and is consistent 'with promoting the interests of the patient as construed in the beneficence model.'"

* The 3% risk applies to the case of uterine rupture

Chapter 2

Data Sources and Statistical Methods used in the Studies

In addition to the datasets compiled from the prospective studies of attempted vaginal birth after a previous CS (published as Robson *et al*, 2015) and maternal-choice caesarean section (published as Robson *et al*, 2018), several large national datasets were used to obtain data contributing to various analyses. Also, analysis of these studies used statistical methods more advanced than descriptive statistics, and standard linear and logistic regression modelling. Details of these datasets and the statistical methods used in their analysis are set out on this section of the thesis.

2.1 Datasets

2.1.1 The Australian National Perinatal Data Collection

The Australian National Perinatal Data Collection (NPDC) commenced in 1991, its purpose to collect national information on the pregnancy and childbirth of mothers, and the characteristics and outcomes of their babies. The NPDC dataset is used to support not only annual and interval reporting – for example, the *Australia's mothers and babies* annual reports - but also other specialist reports, indicator-based reports, and customised data requests. The characteristics of the NPDC are described in detail (used as the basis of the description here) on the AIHW website, accessible at: https://www.aihw.gov.au/getmedia/6b0df6b6-12bb-4607-9460-380cbfb0da98/aihw-per-91-inbrief-appendixes.pdf.aspx

Perinatal data is collected after each birth by midwives and/or other birth attendants. The data is collected from clinical and administrative records and information systems. This data includes records of antenatal care, intrapartum and birth care, as well as data from the early postnatal period.

Each of the states and territories has separate systems for the collection of data, and these datasets are forwarded to the relevant state and territory health

department to form the state or territory perinatal data collection. A standardised extract of electronic data from each state and territory collection is then provided to the AIHW on an annual basis. Records received from states and territories are anonymous but do include a unique set of identification numbers so that the source record can be identified internally but not by the public. Data is checked for completeness, validity, and logical errors before inclusion in the national collection.

The Perinatal National Minimum Dataset (NMDS) was first specified in 1997 and remains an agreed data set for national reporting. Each of the states and territories collects more information than is specified in the Perinatal NMDS. Births reported to the AIHW include births in hospitals, in birth centres, and in the community. The Australian National health data dictionary defines a 'live birth' as the complete expulsion or extraction from its mother of a baby, of any gestation, that shows signs of life; and a 'stillbirth' is the complete expulsion or extraction of a baby, of at least 20 weeks' gestation or weighing at least 400 grams at birth (the weight expected of a baby at 20 weeks' gestational age), which shows no signs of life. The Perinatal NMDS and the NPDC require that either the birthweight or the gestational age conditions are met for both live births and stillbirths. This means that the very small number of live births occurring before 20 weeks' gestation and weighing less than 400 grams are not included in the NPDC, although they may have been included in jurisdictional perinatal data collections. These births obviously were not relevant to any of the studies in this thesis.

2.1.2 The South Australian Perinatal Data Collection

The South Australian Perinatal Data Collection was accessed for one of the studies in this thesis. This access was directly from the South Australian Department of Health, not from the downstream NPDS. This data is provided under legislation, the South Australian Health Commission (Pregnancy Outcome Statistics) Regulations 1999. This collection utilises notifications of births in South Australia made by midwives and neonatal nurses on the Supplementary Birth Record (SBR) shown in **Figure 2.1**. Details regarding this dataset can be obtained at:

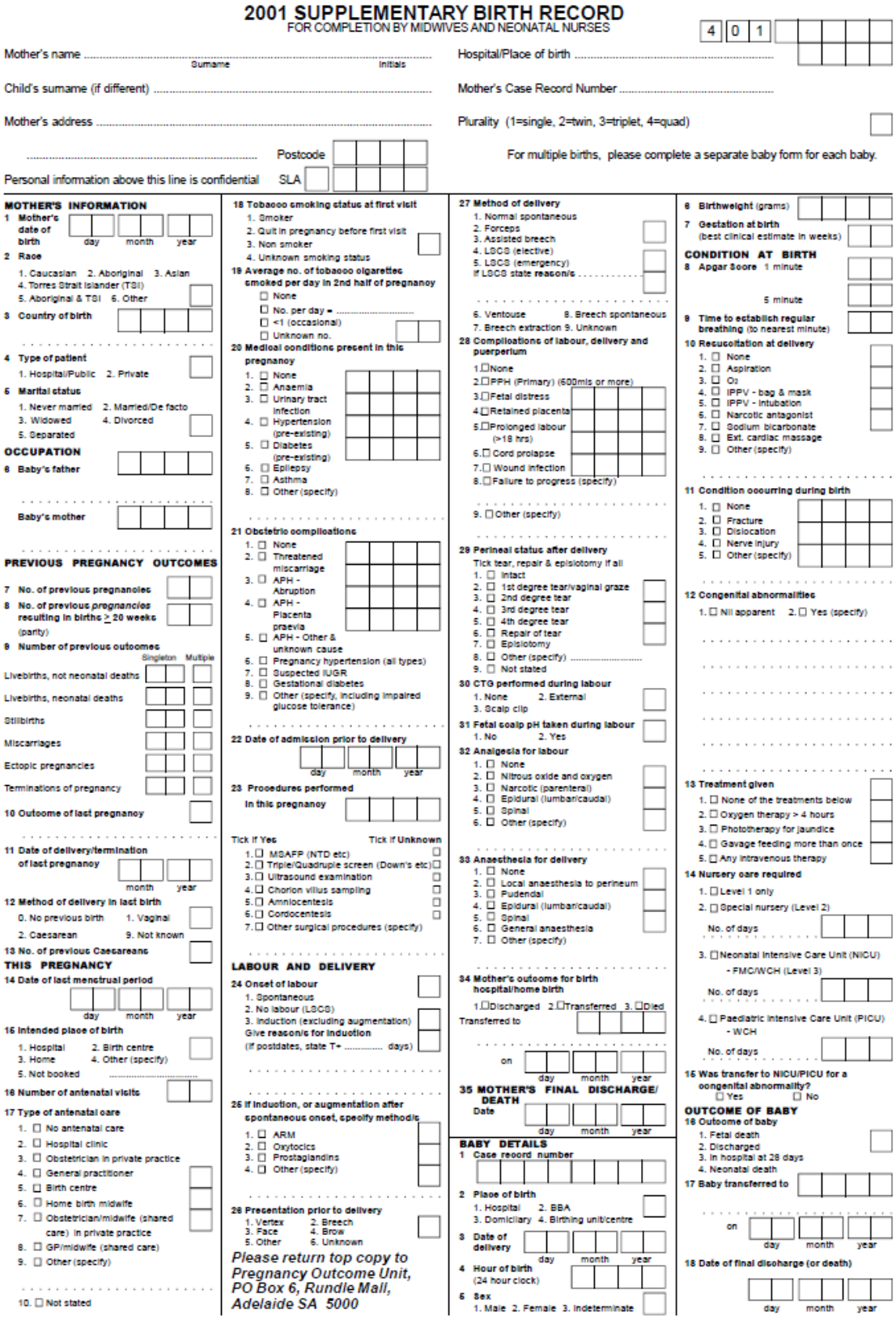
http://www.sahealth.sa.gov.au/wps/wcm/connect/public+content/sa+health+internet/about+us/health+statistics/pregnancy+outcome+statistics

2.1.3 The Australian Institute of Health and Welfare (AIHW) National Procedural Database

Contained in the commentary paper regarding the World Health Organization (WHO) paper on the optimal rate of caesarean section is data in surgical procedures performed in Australia.(Robson and de Costa, 2017) These data were obtained from the Australian Institute of Health and Welfare (AIHW) national procedural database. The AIHW national procedural database holds information collected through the National Health Information Agreement as required by, and specified, in the National Minimum Data Set relating to hospitals. The data is supplied by all Australian state and territory health authorities. Procedures use an agreed national standard, the *Australian Classification of Health Interventions* (ACHI), which is largely based around the Australian National Medical Benefits Schedule (MBS). Validation studies of the AIHW dataset have reported 99.5% agreement with "true" morbidity in a female population (kappa = 0.86).(Roberts *et al*, 2008) To provide a denominator for calculation of age-stratified incidence rates, annual point estimates for the total female population were obtained from the Australian Bureau of Statistics (ABS).

2.1.4 The Longitudinal Study of Australian Children

The 'Longitudinal Study of Australian Children' (LSAC) is a major study following the development of 10,000 children and families from all parts of Australia. The study has its website at: https://growingupinaustralia.gov.au/ The LSAC is an ongoing study conducted as a partnership between the Australian Department of Social Services, the Australian Institute of Family Studies, and the Australian Bureau of Statistics. The LSAC commenced in 2004, when a representative sample of Australian children was recruited in two cohorts: families with children aged from four to five at recruitment, and families with children under the age of one year (the 'birth cohort'). Data is collected every two years from study informants, including the child (when of an appropriate age), parents, carers, and teachers. The seventh round of data collection (wave seven) was completed in early 2017, and wave eight is now underway.



2001 SUPPLEMENTARY BIRTH RECORD
FOR COMPLETION BY MIDWIVES AND NEONATAL NURSES

4 0 1

Mother's name ..... Surname Initials

Hospital/Place of birth .....

Child's surname (if different) .....

Mother's Case Record Number .....

Mother's address .....

Plurality (1=single, 2=twin, 3=triplet, 4=quad)

..... Postcode

For multiple births, please complete a separate baby form for each baby.

Personal information above this line is confidential SLA

MOTHER'S INFORMATION

1 Mother's date of birth day month year

2 Race
1. Caucasian 2. Aboriginal 3. Asian
4. Torres Strait Islander (TSI)
5. Aboriginal & TSI 6. Other

3 Country of birth

4 Type of patient
1. Hospital/Public 2. Private

5 Marital status
1. Never married 2. Married/De facto
3. Widowed 4. Divorced
5. Separated

OCCUPATION

6 Baby's father

Baby's mother

PREVIOUS PREGNANCY OUTCOMES

7 No. of previous pregnancies

8 No. of previous pregnancies resulting in births ≥ 20 weeks (parity)

9 Number of previous outcomes

	Singleton	Multiple
Livebirths, not neonatal deaths		
Livebirths, neonatal deaths		
Stillbirths		
Miscarriages		
Ectopic pregnancies		
Terminations of pregnancy		

10 Outcome of last pregnancy

11 Date of delivery/termination of last pregnancy month year

12 Method of delivery in last birth
0. No previous birth 1. Vaginal
2. Caesarean 9. Not known

13 No. of previous Caesareans

THIS PREGNANCY

14 Date of last menstrual period day month year

16 Intended place of birth
1. Hospital 2. Birth centre
3. Home 4. Other (specify)
5. Not booked .....

18 Number of antenatal visits

17 Type of antenatal care
1. ☐ No antenatal care
2. ☐ Hospital clinic
3. ☐ Obstetrician in private practice
4. ☐ General practitioner
5. ☐ Birth centre
6. ☐ Home birth midwife
7. ☐ Obstetrician/midwife (shared care) in private practice
8. ☐ GP/midwife (shared care)
9. ☐ Other (specify)
10. ☐ Not stated

18 Tobacco smoking status at first visit
1. Smoker
2. Quit in pregnancy before first visit
3. Non smoker
4. Unknown smoking status

19 Average no. of tobacco cigarettes smoked per day in 2nd half of pregnancy
☐ None
☐ No. per day = ...
☐ <1 (occasional)
☐ Unknown no.

20 Medical conditions present in this pregnancy
1. ☐ None
2. ☐ Anaemia
3. ☐ Urinary tract infection
4. ☐ Hypertension (pre-existing)
5. ☐ Diabetes (pre-existing)
6. ☐ Epilepsy
7. ☐ Asthma
8. ☐ Other (specify)

21 Obstetric complications
1. ☐ None
2. ☐ Threatened miscarriage
3. ☐ APH - Abruption
4. ☐ APH - Placenta praevia
5. ☐ APH - Other & unknown cause
6. ☐ Pregnancy hypertension (all types)
7. ☐ Suspected IUGR
8. ☐ Gestational diabetes
9. ☐ Other (specify, including impaired glucose tolerance)

22 Date of admission prior to delivery day month year

23 Procedures performed in this pregnancy

Tick if Yes	Tick if Unknown
1. ☐ MSAFP (NTD etc)	☐
2. ☐ Triple/Quadruple screen (Down's etc)	☐
3. ☐ Ultrasound examination	☐
4. ☐ Chorion villus sampling	☐
5. ☐ Amniocentesis	☐
6. ☐ Cordocentesis	☐
7. ☐ Other surgical procedures (specify)	

LABOUR AND DELIVERY

24 Onset of labour
1. Spontaneous
2. No labour (LSCS)
3. Induction (excluding augmentation)
Give reason/s for induction
(If postdates, state T+ ..... days)

25 If induction, or augmentation after spontaneous onset, specify method/s
1. ☐ ARM
2. ☐ Oxytocics
3. ☐ Prostaglandins
4. ☐ Other (specify)

26 Presentation prior to delivery
1. Vertex 2. Breech
3. Face 4. Brow
5. Other 6. Unknown

Please return top copy to Pregnancy Outcome Unit, PO Box 6, Rundle Mall, Adelaide SA 5000

27 Method of delivery
1. Normal spontaneous
2. Forceps
3. Assisted breech
4. LSCS (elective)
5. LSCS (emergency)
If LSCS state reason/s .....
6. Ventouse 8. Breech spontaneous
7. Breech extraction 9. Unknown

28 Complications of labour, delivery and puerperium
1 ☐ None
2 ☐ PPH (Primary) (600mls or more)
3 ☐ Fetal distress
4 ☐ Retained placenta
5 ☐ Prolonged labour (>18 hrs)
6. ☐ Cord prolapse
7. ☐ Wound infection
8. ☐ Failure to progress (specify)
9. ☐ Other (specify)

29 Perineal status after delivery
Tick tear, repair & episiotomy if all
1. ☐ Intact
2. ☐ 1st degree tear/vaginal graze
3. ☐ 2nd degree tear
4. ☐ 3rd degree tear
5. ☐ 4th degree tear
6. ☐ Repair of tear
7. ☐ Episiotomy
8. ☐ Other (specify) .....
9. ☐ Not stated

30 CTG performed during labour
1. None 2. External
3. Scalp clip

31 Fetal scalp pH taken during labour
1. No 2. Yes

32 Analgesia for labour
1. ☐ None
2. ☐ Nitrous oxide and oxygen
3. ☐ Narcotic (parenteral)
4. ☐ Epidural (lumbar/caudal)
5. ☐ Spinal
6. ☐ Other (specify)

33 Anaesthesia for delivery
1. ☐ None
2. ☐ Local anaesthesia to perineum
3. ☐ Pudendal
4. ☐ Epidural (lumbar/caudal)
5. ☐ Spinal
6. ☐ General anaesthesia
7. ☐ Other (specify)

34 Mother's outcome for birth hospital/home birth
1 ☐ Discharged 2 ☐ Transferred 3. ☐ Died
Transferred to
on day month year

35 MOTHER'S FINAL DISCHARGE/DEATH
Date day month year

BABY DETAILS

1 Case record number

2 Place of birth
1. Hospital 2. BBA
3. Domiciliary 4. Birthing unit/centre

3 Date of delivery day month year

4 Hour of birth (24 hour clock)

6 Sex
1. Male 2. Female 3. Indeterminate

8 Birthweight (grams)

7 Gestation at birth (best clinical estimate in weeks)

CONDITION AT BIRTH

8 Apgar Score 1 minute

5 minute

9 Time to establish regular breathing (to nearest minute)

10 Resuscitation at delivery
1. ☐ None
2. ☐ Aspiration
3. ☐ O2
4. ☐ IPPV - bag & mask
5. ☐ IPPV - intubation
6. ☐ Narcotic antagonist
7. ☐ Sodium bicarbonate
8. ☐ Ext. cardiac massage
9. ☐ Other (specify)

11 Condition occurring during birth
1. ☐ None
2. ☐ Fracture
3. ☐ Dislocation
4. ☐ Nerve injury
5. ☐ Other (specify)

12 Congenital abnormalities
1. ☐ Nil apparent 2. ☐ Yes (specify)

13 Treatment given
1. ☐ None of the treatments below
2. ☐ Oxygen therapy > 4 hours
3. ☐ Phototherapy for jaundice
4. ☐ Gavage feeding more than once
5. ☐ Any intravenous therapy

14 Nursery care required
1. ☐ Level 1 only
2. ☐ Special nursery (Level 2)
No. of days
3. ☐ Neonatal Intensive Care Unit (NICU) - FMC/WCH (Level 3)
No. of days
4. ☐ Paediatric Intensive Care Unit (PICU) - WCH
No. of days

15 Was transfer to NICU/PICU for a congenital abnormality?
☐ Yes ☐ No

OUTCOME OF BABY

16 Outcome of baby
1. Fetal death
2. Discharged
3. In hospital at 28 days
4. Neonatal death

17 Baby transferred to
on day month year

18 Date of final discharge (or death) day month year

Figure 2.1 Data collection form used for the South Australian Perinatal Dataset

The LSAC investigates the effect of children's social, economic, and cultural environments on their wellbeing over the life course: it examines questions about development and wellbeing with questions spanning parenting, family relationships, education, child care, and health. The major aim of the LSAC project is to identify policy opportunities for improving support for children, young people and their families, and to identify opportunities for early intervention. The LSAC is funded by the Department of Family and Community Services as part of the *Stronger Families and Communities Strategy*, with a total of $20.2 million allocated to the study over nine years. The survey results are to be used by the research community as well the Department of Family and Community Services, and a range of other Commonwealth and State and Territory departments.

The rich dataset was designed to add to the understanding of early childhood development, inform social policy debate, and to identify opportunities for early intervention and prevention strategies in policy areas concerning children: parenting, family relationships and functioning, early childhood education and schooling, child care, and health.

2.1.4.1 Study participants

Data is obtained from multiple participants in the study including the child's parents, as well as child care providers and teachers, the child (when of an appropriate age), and interviewers who will undertake direct observations and assessments. The inclusion of a face-to-face interviews with the primary parent (usually, but not always, the child's biological mother) as well as a supplementary interview with the non-primary parent, LSAC exceeds most existing studies in the depth and quality of the data collected. Data from child care providers, preschool and primary school teachers are collected through written questionnaires. Data on characteristics of the children's communities will also be gathered.

2.4.1.2 Sample design

The obtain cohorts representative of all Australian children in each of the selected age cohorts, a clustered sample design was chosen. This approach provided the opportunity to gather multiple observations within a community, thus increasing

the capacity of the study to analyse community-level effects. It also offered the opportunity to conduct face-to-face interviews cost-effectively. Clusters are based on postcodes, but due to the costs involved face-to-face interviews with families in remote areas were not be possible. Thus, a major strength of LSAC is the large and nationally representative nature of its sample: for almost all characteristics, the sample distribution is only marginally different to the Australian Census distribution.(Nicholson and Sansom, 2003; Australian Institute of Family Studies, 2004)

2.2 Statistical methods

2.2.1 Natural splines

Many datasets of natural phenomena not only are non-linear but also are such that it is difficult to perform regressions using polynomial functions. Typically, data will show changes known as 'knots.' The concept and rationale for the use of splines is as follows.(Wegman and Wright, 1983) Some data distributions are difficult to model and analyse, and a distribution such as that in Figure provides an example:

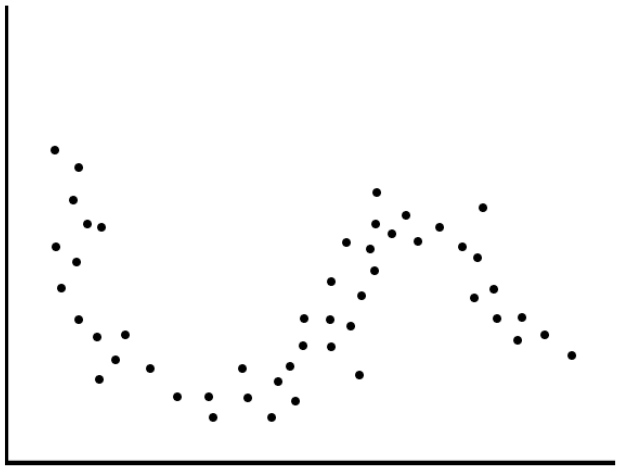


Figure 2.2 Example dataset shown as a scatter plot.

If a standard linear regression using the method of least squares is used the result, typically, will be correct but of little value in an analytical sense (**Figure 2.3**).

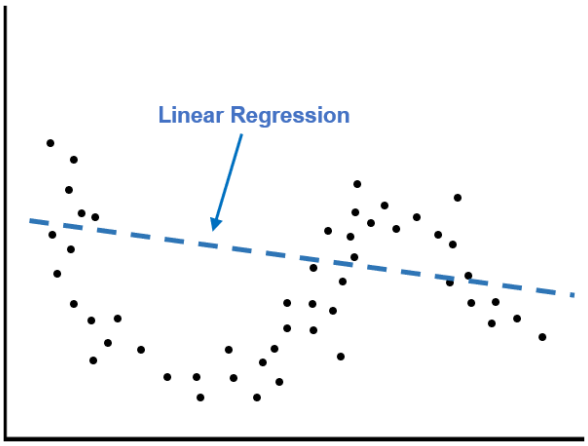


Figure 2.3 Linear regression performed on the example dataset.

Such a linear regression, clearly, does not describe the data distribution. Similarly, the use of a polynomial regression can be of limited value (**Figure 2.4**).

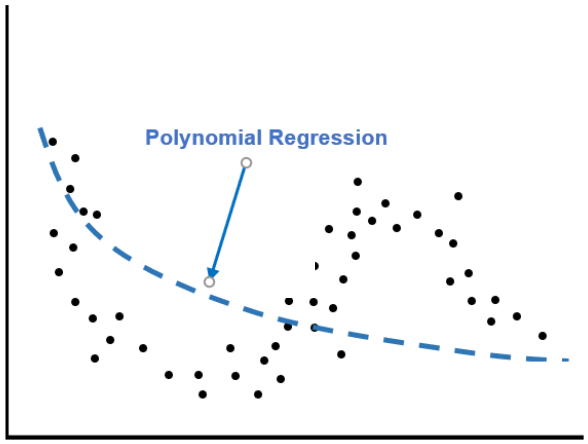


Figure 2.4 Polynomial regression performed on the example dataset.

To overcome these inherent difficulties with such data distributions, a technique known as 'spline smoothing' can be used. Points of sharp inflection in the data distribution are termed 'knots' and the individual regressions are smoothed at the knots. For so-called linear or 'natural' spline regression the terms of the form $(u)_+$ must have the value u if u is positive, and 0 otherwise. To bring about joining of the lines, it is necessary to eliminate several intercept-difference parameters and define the system with k knots for $a_1 \ldots a_k$ as follows:

$$E(Y \mid X) = \beta_0 + \beta_1 X + \beta_2 (X - a_1)_+ + \beta_3 (X - a_2)_+ + \ \ldots + \beta_k - 1 (X - a_k)_+$$

A spline smoothing will take a form similar to **Figure 2.5**:

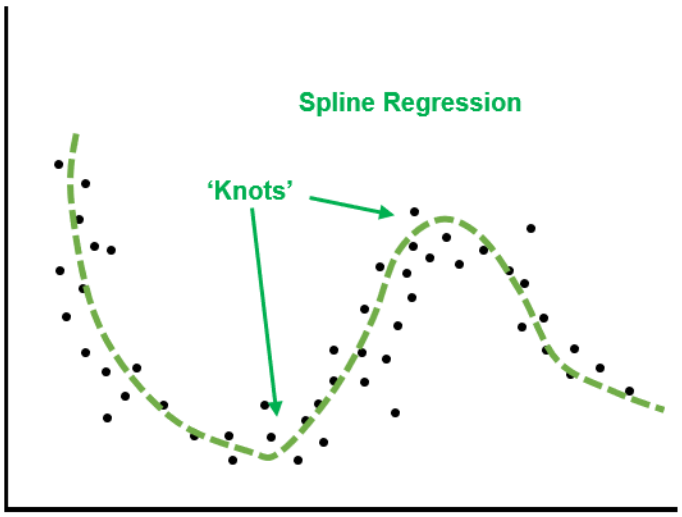


Figure 2.5 Spline smoothing performed on the example dataset.

2.2.2 Markov Chain Monte Carlo (MCMC) method

In the papers using the highly non-linear and complex multivariate datasets from the LSAC (see above), multiple imputations were performed using an iterative Markov Chain Monte Carlo (MCMC) method to deal with categorical variables in the models. The Markov Chain Monte Carlo method is a technique used when sampling from a complicated distribution where it is difficult to simulate or model a process generating the distribution.(van Ravenzwaaij *et al*, 2018)

The sampling problem can be expressed as follows:

> With D as the distribution over a finite set of values X, it is only possible to have 'black box' (that is, the algorithm for distribution is not known) access to the resulting probability distribution function $p(x)$. The output of $p(x)$ is the probability of having the sample value $x \in X$ as specified by the distribution D. Thus, the aim is to develop an efficient randomized algorithm A that gives an output from the distribution X with a probability of any given x of approximately $p(x)$.

Such an algorithm would allow estimation of the expected value of any random variable $f : X \rightarrow \mathbb{R}$. Thus, it would be possible to take a large sample $S \subseteq X$ using

the solution to the sampling problem and compute the average value of f on that sample.

The "Markov chain" is the technical term for a random walk on a graph. Using a directed graph $G = (V,E)$ with each 'edge' represented by $e = (u,v) \in E$, all values $P_{u,v}$ must form a probability distribution: that is, for any vertex $x \in V$ the set of all values $P_{x,y}$ on the outgoing edges (x,y) must sum to 1 (since this is a probability distribution and the sum of all probabilities is obviously 1). The whole object $(V,E,\{p_e\}_{e \in E})$ is termed a *Markov chain*.

As an example, and using pain states as the vertices for point of illustration, and transitions between pain states as the 'walks' between vertices (where the sum of probabilities for each of the walks is 1), a simplified diagram of 'random walks' is shown in **Figure 2.6** below:

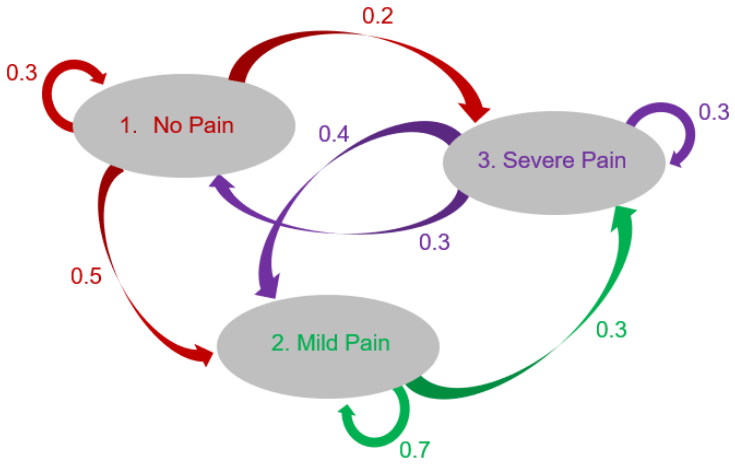


Figure 2.6 Simpified diagram showing 'random walks' between three pain states, with individual walk probabilities totalling 1.

The *fundamental theorem of Markov chains* (also called the stationary distribution theorem) states that for a very long 'random walk,' the probability that you will end up at any particular vertex v is independent of where you started.

It is important to recognize that the stationary distribution theorem is not true of every Markov chain, only those where the graph G is strongly connected. For the purposes of this modelling, 'strongly connected' means that there is a path from every vertex to every other vertex, although these do not need to be in both directions, and no edge can have a zero probability. Expressed mathematically:

For every vertex $v \in V(G)$, an infinite random walk started at v will return to v with a probability of 1.

In terms of linear algebra, the transition probabilities can be expressed in the form of a matrix A where entry $a_{ji} = p_{(i,j)}$ if there is an edge $(i,j) \in E$ and zero otherwise. In matrix format, the rows and columns correspond to the vertices of the walk G, and each column i forms the probability distribution of the state transition from i to some other state in each step of the random walk. Thus, in a random walk in state i with probability q_i, the j-th entry of the A_q is the probability that after one more step in the random walk, the vertex j will be reached. Using this interpretation, the stationary distribution is a probability distribution π such that $A\pi = \pi$.

Chapter 3

The Effect of Increasing Maternal Age on Rates of Caesarean Birth

There is a strong association between maternal age and CS in Australia. In 1995 the overall national CS rate was 16.4%: the rate for women aged 30 to 34 years was 19.1%; for women age 35 to 39 years it was 22.7%; and, for women aged 40 years and older it was 27.1%. By 2015, the rates had increased to 34.9%, 42.5%, and 52.2% respectively. These changes are given even more importance since the age distribution of women giving birth in Australia has changed over the last twenty years. In 1995, 28.6% of first births occurred to women aged 30 years and older, and only 6.9% of first births were to women aged 35 years or more. Twenty years later, in 2015, almost half of first births (46.8%) occurred in women aged 30 years or more (a 64% increase) and 14.6% in women aged 35 or more (an increase of 112%). This change is of more than academic interest. These data are shown in **Figure 3.1.**

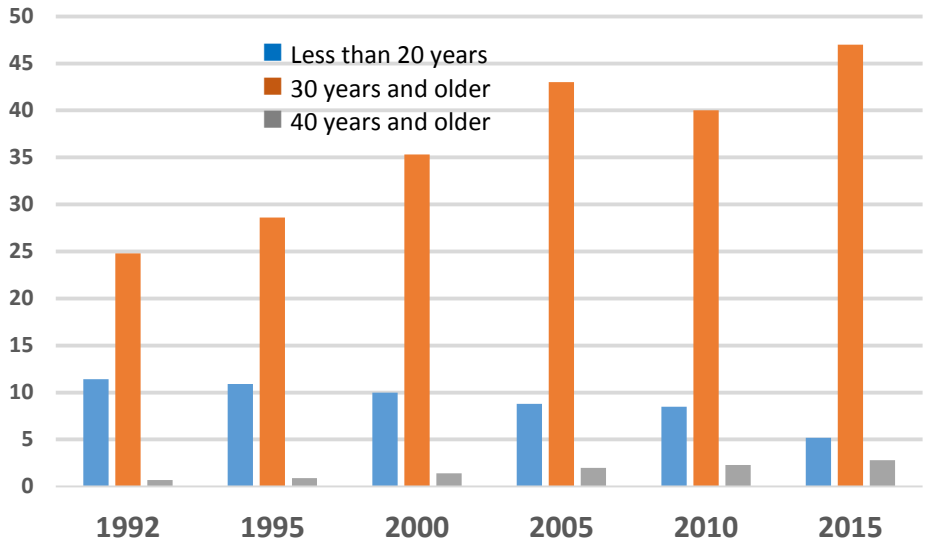


Figure 3.1 Proportion (as a percentage) of first births in different age groups. Data from the *Australia's Mothers and Babies* Series.(AIHW, 2015)

A number of retrospective studies from the UK and elsewhere also have revealed a strong association between maternal age and CS rates.(Jolly *et al*, 2000; Cleary-Goldman *et al*, 2005; Yogev *et al*, 2010; Wang *et al*, 2011; Kenny *et al,* 2013; Laopaiboon *et al*, 2014; Vaughan *et al*, 2014) The association has led authors to conclude that, "older nulliparous women and their obstetricians should be the target of future efforts to control [caesarean section] rates."(Gareen *et al*, 2003)

The exact contribution of maternal age to CS rates has received less attention. Smith and colleagues (2008) reported that 38% of the increased incidence of primary CS in Scotland over the period 1980–2005 could be explained by the increase in age of women at first birth. They estimated that the odds of CS increased by about 1.5 for every five-year rise in maternal age. The perinatal database of South Australia is of a similar size to that used in Smith's study: we set out to undertake a similar study to estimate the magnitude of the effect of maternal age when other variables could be included in modelling.

Original Article

The association between increasing maternal age at first birth and decreased rates of spontaneous vaginal birth in South Australia from 1991 to 2009

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Background: Caesarean section rates in Australia rose over the period 1999–2009, as did maternal age at first birth. The contribution of the rise of maternal age to the rise in caesarean sections remains unclear.
Aims: To estimate the effect of increasing maternal age on the incidence of emergency caesarean section or instrumental delivery in term singleton first births in South Australia.
Methods: We undertook a population-based study of 117 981 term singleton first births, which followed labour during the period 1991–2009, using data from the South Australian Perinatal Statistics Collection. The main outcome measures were deliveries other than spontaneous vaginal births (SVB) (emergency caesarean section or instrumental birth) and emergency caesarean section alone. Logistic regression analysis was performed.
Results: Increasing maternal age at first birth was found to be associated with delivery other than SVB and emergency caesarean section. The adjusted odds of delivery other than SVB increased multiplicatively by approximately 1.49 (95% CI, 1.47–1.51) per five-year rise in maternal age, and the odds of emergency caesarean section increased multiplicatively by approximately 1.39 (95% CI, 1.37–1.42) per five-year rise. Although there are likely to be many reasons for the effect, increases in maternal age at first birth made a contribution in up to 75% of the observed increase in delivery other than SVB from 44.0% to 49.6% over the study period.
Conclusions: Rising maternal age at first birth appeared to contribute to a large proportion of the increase in deliveries other than SVB in South Australia.

Key words: caesarean section, labour, logistic regression, maternal age, population.

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Chapter 4

Does Caesarean Birth Affect Childhood Health and Development?

One of the arguments against liberal use of CS is that maternal mortality associated with pregnancy, birth, and complications in the early neonatal period has represented a significant public health problem, particularly in developing countries.(Magne *et al*, 2017) Concerns also have been expressed that babies born by CS may have a greater risk of acute respiratory complications, and are less likely to be breastfed than those born vaginally.(O'Shea *et al,* 2010) Authors also have pointed out that vaginal birth is associated with a surge of plasma cortisol and catecholamines in the baby that occurs during passage through the birth canal.(Lagercrantz, 2016). These physiological effects are thought to positively impact neonatal blood sugar levels, blood pressure, alveolar liquid absorption that can contribute to TTN, and body temperature: all of these effects are assumed to contribute to adaptation to *ex-utero* life.(Magne *et al*, 2017) Caesarean birth, by contrast, is thought to attenuate these physiological changes and transitions, leading to 'negative effects' on the neonate.(Lagercrantz, 2016).

More recently, evidence has been presented that CS is a risk factor not only for acute 'negative effects' on children, but also for the development of longer term metabolic and immune diseases, conditions of which the incidence is increasing worldwide. A number of studies have linked caesarean birth to alterations in stress responses, immune function, and epigenetic processes in children.(Ronca *et al,* 2006; Salminen *et al,* 2004; Round and Mazmanian, 2009; Schlinzig *et al*, 2009) For example, meta-analysis of almost 1000 patients with type one diabetes suggested that CS was associated with a slightly increased risk after adjustment for gestational age, maternal diabetes and other potentially influential confounders.(Cardwell *et al*, 2008) The findings of the meta-analysis were supported by data from several cohort and case-control studies.(Cardwell *et al*, 2008; Algert *et al,* 2009) However, a population study from Denmark of almost two million Danes delivered between 1973 and 2012 did not find a similar relationship with diabetes.(Sevelsted *et al,* 2015) What it did reveal was an increased risk of asthma, systemic connective tissue disorders, juvenile arthritis, inflammatory bowel diseases, immune deficiency, and leukemia in those born by

CS. The inconsistency between these studies highlights the difficulty of using retrospective, data-poor studies to test for causal relationships.

Other studies have suggested that elective – but not emergency - CS is associated with development of coeliac disease (Mårild *et al,* 2012) and inflammatory bowel disease.(Kristensen *et al,* 2016) Another meta-analysis reported that children delivered by CS faced higher risks of allergic rhinitis, food allergies, atop, and asthma.(Bager *et al,* 2008; Black *et al,* 2015) However, other studies yielded contradictory results.(Papathoma *et al*, 2016) A number of small studies have reported that children born by CS are more likely to be obese or overweight, however it remains unclear whether this is confounded by maternal obesity – large women are more likely to undergo CS and also more likely to have obese children.(Wang *et al,* 2013; Kuhle *et al,* 2015; Li *et al,* 2013)

What, then, is the possible mechanism for such effects on health and development? An important theory is that CS alters the establishment of the gut microbiota of babies, with a consequent effect on their exposure to bacterial antigens.(Magne *et al*, 2017) One of the important ways that bacterial transmission occurs from mother to baby is thought to be birth, and the microbiota of each individual may in turn shape an individual's immune responses.(Endo *et al,* 2015) There is a theoretical basis for this: animal studies have shown that alterations in the intestinal microbiota early in life can increase bodyweight and adiposity, and these effects seem to be more pronounced if the alteration occurs prior to weaning.(Cho *et al,* 2012) Development of a 'normal' microbiota is favoured by oligosaccharides, nucleotides, and other factors contained in human breastmilk.(Mackie *et al,* 1999) In addition to the birth process, other factors are known to influence development of the intestinal microbiota including use of formula, and other genetic, environmental, and lifestyle factors.(Yatsunenko *et al,* 2012)

It has been theorized that CS alters the 'normal' bacterial colonisation if the fetus has no direct contact with the maternal vaginal microbiota during birth, and also because antibiotics commonly are administered during CS.(Isolauri *et al,* 2012) However, this would only apply to planned CS where there is no contract with the vagina, and many women receive antibiotics during labour for reasons such as group-B streptococcus colonisation or fever. Although there is evidence that

conditions such as asthma, obesity, and diabetes are associated with differences in an individual's microbiota, it remains unclear whether such changes are a cause or a consequence of the conditions, and indeed whether they represent vestigial changes from the acquisition of the microbiota at birth.(Carding *et al,* 2015) One very small study reported that children who were overweight at seven years of age had fewer *Bifidobacterium* sp. at six and 12 months of age compared with children who were normal weight at 7 years of age.(Kalliomäki *et al,* 2008) Beyond that, evidence for a causal relationship is currently lacking. In the end, an individual's microbiota is likely to be influenced by many things. In this study, the opportunity became available to use the LSAC dataset to examine whether prospectively-gathered data about all of the many and varied influences on a child's health and development and, for the first time, have the capacity to control for many additional factors.

Childhood Health and Developmental Outcomes After Cesarean Birth in an Australian Cohort

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abstract

BACKGROUND AND OBJECTIVES: Concerns have been raised about associations between cesarean delivery and childhood obesity and asthma. However, published studies have not examined the long-term neurodevelopmental outcomes or fully addressed confounding influences. We used data from the LSAC (Longitudinal Study of Australian Children) to explore the relationship between cesarean delivery and physical and socio-emotional outcomes from 0 to 7 years, taking into account confounding factors.

METHODS: Data were from 5 waves of LSAC representing 5107 children born in 2003 and 2004. Outcome measures included: global health, asthma, BMI, use of prescribed medication, general development, medical conditions and/or disabilities, special health care needs, and socio-emotional development. Models adjusted for birth factors, social vulnerability, maternal BMI, and breastfeeding.

RESULTS: Children born by cesarean delivery were more likely to have a medical condition at 2 to 3 years (odds ratio: 1.33; P = .03), use prescribed medication at 6 to 7 years (odds ratio: 1.26; P = .04), and have a higher BMI at 8 to 9 years (coefficient: 0.08; P = .05), although this last effect was mediated by maternal obesity. Parent-reported quality of life for children born by cesarean delivery was lower at 8 to 9 years (coefficient: –0.08; P = .03) but not at younger ages. Contrasting this finding, cesarean delivery was associated with better parent-reported global health at 2 to 3 years (odds ratio: 1.23; P = .05) and prosocial skills at age 6 to 7 years (coefficient: 0.09; P = .02).

CONCLUSIONS: Cesarean delivery was associated with a mix of positive and negative outcomes across early childhood, but overall there were few associations, and these were not consistent across the 5 waves. This study does not support a strong association between cesarean delivery and poorer health or neurodevelopmental outcomes in childhood.

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Dr Robson conceptualized the study, was involved in the design of the study and the interpretation of findings, provided content expertise, and was the primary author of the article; Drs Vally and Mohamed were involved in the design of the study, the interpretation of findings, and the drafting and revising of the manuscript; Ms Yu completed the data cleaning and analysis, and contributed to drafting the manuscript; Dr Westrupp led the funding application for the study and the data analysis for the paper, and co-drafted and revised the manuscript with Dr Robson; and all authors approved the final manuscript.

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Chapter 5

Paternal factors and influences affecting the uptake of attempted vaginal birth after previous caesarean section

For women whose first birth is caesarean, the most likely outcome is that all her subsequent births occur by CS. (Brennan DJ *et al*, 2009; Homer *et al*, 2011) For this reason an important area that influences the CS rate is decision making about whether to try for vaginal birth after previous cesarean section (VBAC). It is clear that a number of factors are associated with increases in the rate of caesarean birth in Australia and elsewhere: the increasing age of women giving birth (Smith *et al*, 2008 ; Essex *et al*, 2013; Klemetti R *et al*, 2013); the increasing prevalence of obesity in pregnant women (Athukorala *et al*, 2010; Dodd *et al*, 2011); and, the fact that many women will become pregnant after a prior CS. While it is clear that population-level changes in maternal age and physical condition are unlikely, there exists the possibility that increasing the uptake of attempted vaginal birth after prior CS (VBAC) could affect the overall rate of CS.

Population-level studies report a decline in the proportion of eligible women attempting VBAC, falling from about one half to one third over a decade, with a similar fall in the rate at which vaginal birth is achieved, from two thirds to one half.(Homer *et al*, 2011) Unfortunately, when strategies designed to increase the uptake and chance of success of attempted VBAC are studied, almost all seem to have little or no effect.(Catling-Paull *et al*, 2011; Khunpradit *et al*, 2011)

The single – and, indeed, spectacular – success appears to be in China. With the so-called 'one child policy,' the national rate of CS in China was reported as 35% in 2014.(Li *et al*, 2017) However, some regions had considerably higher rates of CS, indeed approaching 60% or higher.(Li *et al*, 2017) With relaxation of the 'one child policy,' it is likely that broad reassessment of "the risk to benefit ratio of a caesarean section now that more woman can have another pregnancy."(Liang *et al*, 2018) In other words, when a woman could only reasonably expect to have once child, the rate of CS was not expected to have any effect in a subsequent birth as subsequent birth was unlikely. Indeed, Liang and colleagues (2018) found that the contribution to CS was only 8.6% before relaxation of the one child

policy, whereas it is closer to 30% in Australia.(Homer *et al*, 2011) As women found themselves at liberty to have more than one birth, the proportion of all births reported as attempted VBAC more than doubled in the Chinese study. However, this was entirely in the age group less than 30 years, with no change in women in older age groups. Overall the rate of CS in the study fell from 45.3% to 41.1% over the five-year period. It is thus difficult to assess the applicability of these data from China, as intriguing and impressive as they are, to the Australian setting.

It is likely that the majority of women facing a choice for birth following a prior CS believe that attempting VBAC places them at greater risk if they chose another CS.(McGrath *et al*, 2010) However, risk alone is not the sole factor influencing their decision. The duration of recovery after birth, for example, and other similar pragmatic considerations are likely to influence their opinions. (Eden *et al*, 2004; Emmett *et al*, 2011) Such decisions – where factors related to family play a role – will commonly involve a joint decision with the woman's partner. Yet there is a very limited literature regarding paternal influences on these choices.

In other aspects of pregnancy decision-making, such as the timing of pregnancy, have been shown to be influenced by partners.(Tough *et al*, 2007) It is also clear that there is a strong wish for involvement in decision-making about birth by partners. (Johansson *et al*, 2013A; Johansson *et al*, 2013B) These considerations lead, naturally, to the question of whether paternal influences and hence this study.

Original Article

Concordance of maternal and paternal decision-making and its effect on choice for vaginal birth after caesarean section

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Background: The proportion of women who plan for a repeat elective caesarean section (CS) is one of the major determinants of the overall rate of CS, and programs aiming to reduce the rate of CS have not been greatly successful. To date, there appear to have been no large studies directly addressing paternal influences on decision-making regarding vaginal birth after caesarean (VBAC). This study aimed to compare the reactions of fathers and mothers to the prospect of VBAC.

Methods: Couples were recruited from three Australian hospitals and were eligible with a singleton pregnancy, a normal morphology ultrasound, and where there was no condition in the new pregnancy that would preclude a vaginal birth. Questionnaires were scheduled for 20 weeks' gestation, 32–36 weeks' gestation and six weeks postnatal and were sent separately to each partner.

Results: Seventy-five couples completed the full sets of questionnaires during the study period. In total, 31 women (41%) ultimately attempted vaginal delivery, and 44 (59%) were delivered by planned CS. When the paternal rating of risk fell between the second and third trimesters, the couple were likely to attempt VBAC ($P < 0.05$). Where the maternal rating of importance was 3 or less, 92% had a planned CS compared to 63% for the same paternal scores ($P = 0.02$).

Conclusion: This study suggests that interventions that improve the paternal perceptions of risk during a pregnancy might increase the chance that a couple will attempt VBAC.

Key words: caesarean section, decision-making, paternal, vaginal birth after caesarean.

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Chapter 6

Are there additional predictors of caesarean birth that could be addressed?

As the rate of CS has increased across both the developed and the developing world, a great deal of attention has been turned to the reasons for the increase and potential ways of controlling the rate. These concerns have been expressed in the literature, as an issue of public health concern, for at least two decades.(van Roosmalen *et al*, 1995) However, attempts to control the rate of CS have not had a good record of success, with the exception seen in mainland China following relaxation of the 'one child policy' where regional rates of CS peaked at 60% but subsequently fell slightly.(Li *et al*, 2017)

It seems likely that cultural and social changes, just as much as medical advances, have led to an evolution in attitudes to CS for women, their families, and those caring for them. Thirty years ago psychosocial factors as indications for CS – such as 'tocophobia' or, indeed, maternal requests for CS in the absence of any medical indication – were rarely discussed and almost absent from the medical literature.(Mylonas and Friese, 2015) The rise in CS rates in both developed and developing countries has prompted a search for the many and varied influences on caesarean birth.

The evolving 'risk profile' of mothers and their fetuses is also cited as reason for the observed increases in CS rate internationally.(Franz and Husslein, 2010; Briand, *et al*. 2012; Guihard and Blondel, 2001) A number of influences on the CS rate are relatively easy to discern and have been discussed at length in this thesis so far. For example the trend to increasing maternal age, particularly that increasing age at which many women are having their first birth, is one important reason for the increase in CS rates.(Franz and Husslein, 2010; Briand, Dumont, and Abrahamowicz, *et al*, 2012; Guihard and Blondel, 2001)

Along with age also comes increasing incidences of conditions such hypertension and diabetes mellitus.(Franz and Husslein, 2010) Another important influence is that of obesity, since this is associated with development of diabetes and

hypertensive complications of pregnancy. Among primiparous women with overweight or obesity, the caesarean delivery rate is doubled and among multiparous women, maternal BMI ≥30 doubles the risk for CS.(Pettersen-Dahl *et al*, 2018) The indication of CS for failure to progress or cephalopelvic disproportion seems to be the major factor contributing to the increase in primary CS in obese women, and rates of intrapartum primary CS prior to achieving active labour increase with increasing obesity class in nulliparous women.(Kawakita *et al*, 2016)

Infertility treatment, previous CS, and hypertension all have significant effects on the mode of delivery.(Rénes *et al*, 2018) The role of assisted reproduction and IVF is sometimes cited due to the increased rate of multiple pregnancy, but with single embryo transfer policies in Australia the rate of multiple pregnancy in IVF is actually reducing.(Miller *et al*, 2016) Previous CS is one of the commonest reasons for a caesarean birth. For women eligible for trial of vaginal birth after a previous CS, the rate of planned repeat CS is high and not in agreement with many institutional and jurisdictional guidelines. Some characteristics of women are associated with planned repeat CS, but the main determinants appear to be very individual and at unit level, which suggests that non-medical reasons are involved in the decision process.(Bartolo *et al*, 2016)

Changes in labour management protocols and associated guidelines have not been shown to reduce the primary CS rate and, indeed, have led to increases in maternal and neonatal morbidity.(Rosenbloom *et al*, 2017) Small unit-based audits of indications for CS have reported some 'successes' in CS rate reductions but these have not translated to a population level.(Paracchini *et al*, 2017; Javernick and Dempsey, 2017) Systematic reviews have reported that assessment and support in early labour does not have a clear impact on rate of CS, but may increase maternal satisfaction with giving birth.(Kobayashi *et al*, 2017) Algorithms that use parameters such as maternal age, BMI, height, fetal abdominal circumference, and fetal head circumference can, in combination, be used to better determine the overall risk of CS in nulliparous women at term. A risk score can be used to inform women of their individualised probability of CS. Yet while such a 'risk tool' may be useful for reassuring most women regarding their chance of achieving vaginal delivery, they may have the unintended

consequence of encouraging some women to avoid a trial of labour.(Burke *et al*, 2017)

However it is clear that societal changes in general are playing an important role in the way that birth is viewed.(Mylonas and Friese, 2015) For this reason elements that play a part in decision-making about birth include cultural (Potter and Hopkins, 2002; Potter JE, *et al*. 2008; Minkoff and Chervenak, 2003), social (Wiklund *et al*, 2006; Wiklund *et al*, 2007; Sahlin *et al*, 2013; Hofberg and Ward, 2004) and even financial influences.(Potter and Hopkins, 2002) There is also evidence that a perception in both the public and the profession that CS is a very safe procedure is contributing to the increase in CS rates.(NICE, 2012) Venturalli and colleagues (2018), in a recent review, do not hold back in their assessment:

> "The rising rate of caesarean section registered in the recent years … often reflects inappropriate clinical behaviour and a wrong tendency that assimilates caesarean section as a defensive practice. In a relevant percentage of cases, the indication to CS is given by specialists in other disciplines, even when specific guidelines do not give clear recommendation about the route of delivery. For this reason, refusal of non-obstetrical indications for caesarean section, when scientific support is lacking, could be a useful and safe strategy to further reduce the rate of unnecessary caesarean sections."

Birth in a private hospital, husband's employment status, even time of birth all have been found to influence the odds for CS in primiparous women.(Oner *et al*, 2016) Without irony, the authors concluded that, "medical reasons are not the only reasons" for CS. It is no secret that financial incentives may encourage private for-profit providers to perform more caesarean section (CS) than non-profit hospitals. 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.(Hoxha *et al*, 2017a) The authors concluded that CS are more likely to be performed by for-profit hospitals as compared with non-profit hospitals. This held true regardless of women's risk and contextual factors such as country, year, or study design. In another similar meta-analysis by the same group, the adjusted odds of delivery by CS was 1.13 higher among privately insured women as compared with women

with public insurance coverage (95% CI 1.07 to 1.18).(Hoxha *et al*, 2017b) Although the effect was found to be small on average and variable in its magnitude, it was present in all analyses performed. In Australia, the Medical Benefits Schedule (MBS) provides a financial reward for attempting VBAC – the rebate payable for this is higher than that for planned CS. However, the rebate for an uncomplicated labour management and vaginal birth (whether an instrumental or an unassisted delivery) remains the same as that for a planned CS.

It is highly likely that other subtle factors also are influential, but very difficult to study in population-level data. A study of almost 1800 Norwegian women revealed that 8% reported a fear of vaginal birth, often referred to as tocophobia.(Størksen *et al*, 2015) A previous negative overall birth experience exerted the strongest impact on fear of childbirth, followed by impaired mental health and poor social support. Tocophobia was strongly associated with a preference for elective caesarean section (aOR 4.6, 95% CI 2.9-7.3). A previous negative overall birth experience was highly predictive of elective caesarean section (aOR 8.1, 95% CI 3.9-16.7) and few women without such experiences did request caesarean section. These results led the authors to suggest that women with tocophobia may have identifiable vulnerability characteristics, such as poor mental health and poor social support. Another similar study reported increased post-traumatic stress symptoms in women who preferred delivery by CS but who ultimately delivered vaginally, compared to women who both preferred vaginal delivery and delivered vaginally.(Garthus-Niegel *et al*, 2014) In one study, almost one quarter of changed from preferring vaginal birth to elective CS after their first childbirth. Determinants found to be positively associated with this change included actual delivery by elective CS (OR 106.3, 95% CI 14.7-767.4) intrauterine growth restriction (OR 19.5, 95% CI 1.1-353.6), actual delivery by emergency CS (OR 8.4, 95% CI 3.4-20.6), higher family income (OR 3.2, 95% CI 1.1-8.8), use of epidural analgesia (OR 2.6, 95% CI 1.0-6.8), and higher trait anxiety score (OR 1.1, 95% CI 1.0-1.3). The most important reason for women who changed from preferring vaginal birth to elective cesarean section was, again, tokophobia (24.4%).(Pang *et al*, 2008)

The project described in this chapter was an attempt to use the data-rich LSAC dataset to focus on the mother and her social situation and how this might impact on the chances of CS.

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Original Research – Quantitative

Perinatal and social factors predicting caesarean birth in a 2004 Australian birth cohort

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ABSTRACT

Background: The proportion of babies born by caesarean section in Australia has almost doubled over the last 25 years. Factors known to contribute to caesarean such as higher maternal age, mothers being overweight or obese, or having had a previous caesarean do not completely account for the increased rate and it is clear that other influences exist.
Aim: To identify previously unsuspected risk factors associated with caesarean using nationally-representative data from the Longitudinal Study of Australian Children.
Methods: Data were from the birth cohort, a long-term prospective study of approximately 5000 children that includes richly-detailed data regarding maternal health and exposures during pregnancy. Logistic regression was used to examine the contribution of a wide range of pregnancy, birth and social factors to caesarean.
Findings: 28% of 4862 mothers were delivered by caesarean. The final adjusted analyses revealed that use of diabetes medication (OR = 3.1, 95% CI = 1.7–5.5, $p < 0.001$) and maternal mental health problems during pregnancy (OR = 1.3, CI = 1.1–1.6, $p = 0.003$) were associated with increased odds of caesarean. Young maternal age (OR = 0.6, CI = 0.5–0.7, $p < 0.001$), having two or more children (OR = 0.7, CI = 0.6–0.9, $p < 0.001$), and fathers having an unskilled occupation (OR = 0.7, CI = 0.6–1.0, $p = 0.036$) were associated with reduced odds of caesarean.
Conclusion: Our findings raise the prospect that the effect of additional screening and support for maternal mental health on caesarean rate should be subject of prospective study.

Statement of significance

Problem or issue
The rate of caesarean birth in Australia is increasing and remains over 30%, with no obvious reduction in recent years.

What is already known
Increases in the caesarean birth rate have been associated with factors such as advancing maternal age, maternal overweight and obesity, and private insurance.

What this paper adds
Maternal psychological conditions may be an independent risk factor for caesarean birth. Early screening for, and treatment of, these conditions should be subject to prospective study as a possible way of helping reduce women's risk of caesarean birth.

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at: www.growingupinaustralia.gov.au/. Of the contactable families selected, the families of 5107 infants (a 64% initial response rate) in the birth cohort commenced participation in 2004. Our study draws on data from wave one, when children were aged 3–18 months. Data were collected by face-to-face interview and self-report questionnaire by the parent who knew the child best, of which 98.6% were the child's biological mother. LSAC was approved by the Australian Institute of Family Studies Ethics Committee. Mothers were excluded from this current study if the pregnancy was complicated by breech presentation at birth (N = 67), multiple birth (N = 165), and where the mode of birth was unspecified (N = 21) or missing (N = 3), yielding a final sample of 4862 mothers for analysis.

2.2. Measures

Data available included whether their child had been born preterm (<37 weeks), had been born with low birth weight (<2500 kg), or whether the child had required a ventilator or intensive care after birth. For data analysis in the current study, we collapsed mode of birth data to a binary variable (CS or vaginal). In the self-report questionnaire, mothers were asked a series of questions about the circumstances around the pregnancy and birth. These questions included whether they smoked or drank during pregnancy, whether they had taken a list of prescribed medication such as antibiotics, blood pressure tablets, or any 'over the counter' medicines during pregnancy, and whether the pregnancy had been complicated by hypertension and/or diabetes. All questions were answered with 'yes' or 'no' responses.

Data about birth outcomes (gestational age, birth weight, use of ventilator, intensive care) and data about medication use in pregnancy were collected during the face-to-face interview with the mother. All other data used in the current study was drawn from the mother or father-report questionnaire. Characteristics of mothers and the family included maternal age and education, single parent status, maternal and paternal employment, child Aboriginal and Torres Strait Islander status, number of children in the household, and whether English was the primary language spoken at home. Maternal mental health was assessed using one item where mothers were asked "During this pregnancy, did you have problems with stress, anxiety or depression?" (Yes/No). Mothers were classified as having been born overseas if they were born outside of Australia or New Zealand. Geographic remoteness of the household was classified using the Accessibility/Remoteness Index of Australia.[27]

2.3. Statistical analysis

Variables were analyzed in Stata version 13.1[28] using the survey methods procedure to weight the analyses for participants' unequal probability of selection into the sample, and the multi-stage, clustered sampling design.[29] Data were imputed to handle missing data due to a lower completion rate of the parent-report questionnaire compared to the face-to-face interview. The majority of variables had very little missing data (<1%). Eight variables had missing 1–17%, where higher rates of missing were found for maternal report of alcohol or smoking during pregnancy, and father report questions (occupation and education). Multivariate multiple imputation was performed using an iterative Markov Chain Monte Carlo (MCMC) method, with fully conditional specification (ICE 'chained' method). The augmented-regression option was used to handle perfect prediction, given the large number of categorical variables in our final models. The imputation model included all pregnancy, birth and social variables, with wave one sample weights and cluster variables (postcodes and strata) entered as 'regular' non-imputed variables into the imputation equation. Thirty imputations for each dataset were requested and successfully produced.

Logistic regression analyses were then undertaken to estimate the odds ratio and 95% confidence intervals for significant risk factors for CS. Three analysis steps were used to examine the associations between CS and each of the pregnancy, birth and social factors. In the first step, unadjusted (univariate) logistic regression analyses were performed with CS as the binary dependent variable and each of the pregnancy, birth and social factors as independent variables in the models. In the second step, adjusted models were run with significant variables ($p < 0.1$) from step one in separate models for (a) the pregnancy and birth factors, and (b) the social factors. In the third step, final adjusted models were run grouping all significant factors ($p < 0.1$) from step two.

3. Results

Of the 4862 mothers included in the final sample, 1374 (28.2%) gave birth by CS. Differences in pregnancy, birth and social characteristics for children born by CS compared to children born vaginally are reported in Table 1. A number of pregnancy factors were associated with CS in the unadjusted models. Maternal smoking in pregnancy was associated with lower odds for CS. The use of any prescribed medication, medication for diabetes or hypertension, 'heartburn,' or indeed any other over-the-counter medications was associated with increased odds for CS. Furthermore, maternal mental health problems, reported diabetes, and high blood pressure were also associated with increased odds of CS. All of the birth factors were associated with moderately increased odds, from close to 50% for preterm birth or low birth weight, up to 84% for child requiring ventilator support, and 91% for children admitted to intensive care after birth.

Two social factors were associated with increased odds for CS. Higher annual household income (per $10K increase) was associated with an 11% increase in odds for CS, while maternal age of 35 years or older, when compared to mothers aged 30–35 years at recruitment, was associated with 22% increased odds. In contrast, other social factors were associated with lower odds of CS. Maternal age less than 30 years, father working in an unskilled occupation, first language other than English, having two or more children in the household, fathers reporting a high educational level, and mother working in an unskilled occupation were all associated with decreased odds for CS.

Table 2 presents data from the first set of adjusted models split by (a) pregnancy and birth factors; and (b) social factors. In the first adjusted model, maternal smoking was the only factor associated with decreased odds of CS. Use of diabetes, heartburn and over-the-counter medications during pregnancy, maternal mental health problems, and child admission to intensive care, all continued to predict increased odds for CS. In the second adjusted model, annual household income and maternal age 35 years or older continued to predict high odds of CS. Younger maternal age, first language other than English, having two or more children in the household, and father's unskilled occupation predicted lower odds for CS.

Data from the fully adjusted model are presented in Table 3. Factors in pregnancy or related to birth conveyed the highest odds of CS; these were use of diabetes medication, child admission to intensive care, use of heartburn medication, and maternal mental health problems during pregnancy. The social factors were maternal age greater than 35, and higher annual household income. Four social factors were associated with lower odds of CS: maternal age less than 30, families with two or more children, fathers with an unskilled occupation, and families speaking a language other than English at home.

Table 2
Two adjusted models for (a) pregnancy and birth factors; and (b) social factors predicting odds of caesarean section (N = 4,862).

	OR (95% CI)	p
Model 1: Pregnancy and birth factors		
Maternal smoking in pregnancy	0.72 (0.58, 0.89)	0.003
Use of any medication in pregnancy	1.10 (0.93, 1.29)	0.284
Use of diabetes medication	2.51 (1.36, 4.61)	0.003
Use of blood pressure tablets	1.04 (0.62, 1.77)	0.870
Use of heartburn medication	1.48 (1.05, 2.10)	0.026
Use of over-the-counter medication	1.28 (1.05, 1.55)	0.015
Maternal mental health problems in pregnancy	1.21 (1.01, 1.45)	0.039
Maternal diabetes in pregnancy	1.15 (0.82, 1.61)	0.432
Maternal high blood pressure in pregnancy	1.30 (0.94, 1.79)	0.113
Child born preterm (<37 weeks)	0.98 (0.69, 1.38)	0.891
Child born with low birth weight (<2500 g)	1.12 (0.77, 1.63)	0.538
Child admitted to intensive care	1.66 (1.34, 2.06)	<0.001
Child needed ventilator support	1.10 (0.77, 1.56)	0.613
Model 2: Social factors		
Annual household income	1.05 (1.01, 1.09)	0.021
Language other than English	0.79 (0.64, 0.97)	0.023
Maternal age (<30 years)	0.61 (0.51, 0.71)	<0.001
Maternal age (30–35 years)	Reference	
Maternal age (>35 years)	1.27 (1.08, 1.49)	0.003
Single parent family	1.15 (0.85, 1.57)	0.364
2 or more children in household	0.74 (0.64, 0.85)	<0.001
Father's education less than Year 12	0.94 (0.81, 1.09)	0.386
Mother unskilled occupation	1.05 (0.87, 1.28)	0.606
Father unskilled occupation	0.74 (0.56, 0.97)	0.032

Note: OR (95% CI) denotes odds ratio from logistic regression analysis (with 95% confidence interval).

Table 3
Final adjusted model with pregnancy, birth and social factors predicting odds of caesarean section (N = 4,862).

	OR (95% CI)	p
Maternal smoking in pregnancy	0.87 (0.70, 1.09)	0.238
Use of any medication in pregnancy		
Use of diabetes medication	3.09 (1.74, 5.51)	<0.001
Use of heartburn medication	1.56 (1.13, 2.15)	0.007
Use of over-the-counter medication	1.08 (0.89, 1.32)	0.417
Maternal mental health problems in pregnancy	1.31 (1.10, 1.57)	0.003
Child admitted to intensive care	1.82 (1.51, 2.19)	<0.001
Annual household income	1.05 (1.01, 1.10)	0.011
Language other than English	0.79 (0.64, 0.96)	0.021
Maternal age (<30 years)	0.62 (0.53, 0.73)	<0.001
Maternal age (30–35 years)	Reference	
Maternal age (>35 years)	1.25 (1.07, 1.47)	0.007
2 or more children in household	0.74 (0.64, 0.85)	<0.001
Father unskilled occupation	0.74 (0.57, 0.98)	0.036

Note: OR (95% CI) denotes odds ratio from logistic regression analysis (with 95% confidence interval).

4. Discussion

We sought to identify the birth, pregnancy and social factors associated with CS in a large representative cohort of Australian families. The rate of CS in the cohort was similar to the Australian national rate of 28.5% at the time of recruitment (the year 2004) (28.2% vs 28.5%,).[30] Our findings were consistent with the well-recognized association between maternal age and CS. Women reporting use of medication for diabetes during pregnancy, another previously-reported risk factor for adverse pregnancy outcomes, and admission of child to intensive care after birth were also both associated with an increased likelihood of CS.

Our study is one of the first to examine the relationship between CS and a range of maternal and socio-economic factors simultaneously. The findings support previous research showing an association between pregnancy and social factors and rates of CS.[9–12,18,19] We found that the father's occupation was associated with CS — families with fathers in unskilled occupations were less likely to undergo CS. This association may well be a surrogate for access to private health insurance, since the rate of CS is, in general, lower in public hospitals.[31] Higher household income was associated with an increased likelihood of CS. In contract, families with two or more children, or where a language other than English was used at home, were less likely to undergo a CS. Unexpectedly, the presence of maternal mental health problems during pregnancy increased the odds for CS.

The main driver for this study was to identify early factors that might be amenable to modification. As such, a novel and potentially important finding was the association between maternal mental health problems and CS where the strength of association was at least as strong as the association found between CS and maternal age over 35 years, a well-established risk factor for CS. While mental health problems are common in Australia, affecting approximately one in five adults,[32] this was the first Australian study, and one of the first internationally, to examine maternal mental health as a risk factor for CS. These findings also relate to research evidence showing a relationship between maternal fear of birth and higher rates of CS.[33]

Our study findings build on evidence from the two Swedish population studies described earlier. One study linked data from the Swedish National Inpatient Care Registry 1996–2006 with hospital perinatal records for over 17,000 women, and found that hospital admissions in the five years prior to index birth were associated with an increased risk of elective CS (adjusted OR 2.16, 95% CI 1.34, 4.42), and emergency CS (adjusted OR 1.60, 95% CI 1.09, 2.37), as well as with markers of mental ill-health in pregnancy identified in perinatal records.[21] Another study examined 6000 nulliparous women and found that report of stress (adjusted OR 1.66, 95% CI 1.34, 2.06), sleep difficulties (adjusted OR 1.57, 95% CI 1.14, 2.16), and worry (adjusted OR 1.41, 95% CI 1.10, 1.79) were all associated with an increased rate of emergency CS in first-time mothers.[20]

Speculation on the reason that maternal mental health problems might affect birth outcomes has centred on two possible mechanisms. Firstly, that neuroendocrine-regulated pathways could be affected by maternal anxiety, stress and mood disorders so as to increase the workload of the fetal heart, thus increasing the likelihood of fetal distress.[20,34] Excessive secretion of maternal stress hormones can provoke the release of placental corticotrophin-releasing hormone (CRH), leading to a cascade of events affecting birth outcomes.[34] Alternatively, the presence of maternal mood disorders may be a surrogate for other predisposing factors, such as chronic medical conditions, social disadvantage, or stressful life events.[20,34] In either case, detection in early pregnancy could potentially prompt appropriate evaluation of the pregnant woman and allow remedial management. It would be important to consider these effects using large-scale prospective research methods. For example, prior research has shown a relationship between increased rates of CS and maternal requests for CS.[34] It is possible that this relationship is mediated by women's mental health in pregnancy.

Although we used data from a large prospective study, there are limitations. Data were collected in 2004, and it is possible that trends related to CS have changed in the past decade. Further, data regarding previous CS were unavailable, and it is difficult to identify the proportion of emergency and elective caesarean births. Also, a single item descriptor was used to measure maternal mental health problems as a screening tool but validated screening instruments were not used and it is unclear whether women who reported mental health problems received a formal diagnosis, further investigation, or any treatment. These limitations apply to

other similar studies[20,21,34] and so there is a need to address the question of mental health and CS in prospective studies.

5. Conclusions

In summary, our findings have identified the contribution of maternal mental health problems and the use of diabetes medication during pregnancy as influential risk factors, adding to the existing pregnancy and social factors known to be associated with caesarean birth. There are a small number of other studies suggesting similar links, and our study adds further support by utilizing Australian population-representative data. We believe that further prospective studies should now be undertaken to examine a potential link between maternal mental health problems and pregnancy outcomes, to determine whether screening and early intervention might reduce the overall rate of caesarean birth in Australia.

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Chapter 7

A patient-preference restricted cohort study of maternal-request caesarean section

D'Souza (2013) makes the following observations in a review article on MCCS:

> "The past decade has seen an unprecedented rise in the demand for caesarean sections on maternal request [MCCS], in the absence of any medical or obstetric indication… The debate on the medical, ethical and cost implications of rising rates of caesarean section on maternal request have prompted the issuing of numerous guidelines over the past few years, including one by the National Institute of Health and Clinical Excellence (NICE) in the UK. All these guidelines are uniformly less critical of CSMR than guidelines issued even a decade ago."

Yet a different view of the NICE guidance, written from the perspective of an ethicist, is offered by Professor Dominic Wilkinson, a Consultant Neonatologist and Director of the Oxford Uehiro Centre for Practical Ethics (www.practicalethics.ox.ac.uk):

> "Should a father dive into a flowing stream to aid his daughter, struggling to keep her head above water? Should a mother donate a kidney to her child with renal failure? Is it ethical for a parent to work two or three jobs so that they can pay private health insurance or school fees for their children? In all of these situations most of us would think that it is commendable for a parent to take these actions. We applaud and approve of a parent who decides to take on some personal risk, who sacrifices his or her own wellbeing and health in order to prevent a risk of serious harm to their child.
>
> *"How* morally important it is for parents to make these sacrifices depends on the balance between the risks to the child and those to the parent. But it is appropriate for a parent to give greater weight to the risks to their child than to themselves. Indeed, we might well be critical of a parent who failed to do so.

"What then, of a mother who decides to undergo abdominal surgery in order to reduce the risk of her child suffering brain injury, or being admitted to intensive care? Shouldn't we also applaud this decision?

"Not according to the public responses to a new guideline on caesarean section recently released by the National Institute of Clinical Effectiveness (NICE). NICE have recommended that women who request caesarean section at term should be permitted this choice after counselling about the risks and benefits of this mode of delivery.

"Previously, at least in the UK, doctors would often decline requests for an elective section unless there was a 'medical indication'. NICE now recommends that if doctors are unwilling to perform a caesarean at maternal request they should refer the mother to another physician. The new NICE guideline has been criticized as 'madness,' and an example of 'gynophobia'.

"The change in advice by NICE reflects a shift over time in the risks of caesarean section.

"Caesarean section was once thought to impose significant (even if small) risks of maternal death. However, the evidence reviewed by NICE suggests that with current anaesthetic practice the risks to the mother are extremely small. (One possibility that is difficult to tease out from the data is that mothers may have an increased risk with subsequent pregnancies because of the surgical scar in their uterus.)

"In essence, decisions about the mode of delivery weigh up risks and benefits to the mother, and risks and benefits to the baby. There are definite downsides to elective caesarean section – mostly for the mother. It is associated with longer hospital stay, and small increases in the risk of hysterectomy and cardiac arrest.

"But there are also potential benefits, and these are particularly for the baby –reduced risks of the baby being admitted to neonatal intensive care,

and probable (but hard to prove) small reductions in the risk of very serious complications for the baby including bleeding in the brain, death in the womb, and brain damage from lack of blood supply during labour.

"The NICE report quotes evidence that most mothers requesting elective caesarean section are motivated by the perceived safety benefits to the baby. Most mothers don't make such choices for cosmetic reasons, nor because they are 'too posh to push'. Sometimes mothers have had bad experiences with previous deliveries, or they may have been influenced by the experiences of friends or family members.

"It is not clear whether overall the benefits of elective caesarean section outweigh the risks, or justify the additional expense of delivery by caesarean section. There will doubtless continue to be debate about the interpretation of epidemiological studies, and the relative risks to both mother and child. But, the cases mentioned at the start of this article suggest that it is rational and ethically appropriate for mothers to weigh the risks to their child more heavily than the risks to themselves.

"It is entirely reasonable for a mother to accept some personal risk in order to reduce a potentially devastating harm to her child. Elective caesarean section can be a morally commendable choice." (Wilkinson, 2011)

This passage from Professor Wilkinson captures the two essential issues at the heart of the 'controversy' regarding CSMR: that there is little direct evidence to guide both practice and decision making; and, that it can be difficult to reconcile the principle of patient autonomy (Entwistle *et al*, 2010) with what might be described as 'medical paternalism.'(Wyatt, 2001)

Comparisons of maternal and neonatal outcomes between women with no obstetric indication for CS who choose and undergo CS, and those who attempt vaginal birth are difficult to make, and there are no published randomised controlled studies. As a surrogate, women undergoing elective primary caesarean section for breech presentation have been used as a surrogate variable for planned caesarean sections in the absence of randomised trials.(Karlstrom *et al*, 2013) CSMR is typically not an accurately reported condition and has no explicit code

in the ICD- 10.3, making it difficult to study in terms of risks and benefits: this is particularly so from an 'intention-to-treat' perspective.

When making direct comparisons of caesarean birth with vaginal birth, it is clear that important differences in both maternal and neonatal outcomes are quantifiable. In some studies morbidity associated with elective caesarean section is found to be more common than that associated with vaginal birth: for example, there may be an increased risk of postpartum infection (Burrows *et al*, 2004; Leth *et al*, 2009) as well as haemorrhage (Villa *et al,* 2007) and thromboembolic complications.(Koroukian, 2004) Yet other studies report no differences in short- term medical maternal outcomes between primiparous women undergoing elective caesarean section and those undergoing vaginal delivery.(Larsson *et al* , 2011; Karlstrom *et al,* 2013)

Similarly, perinatal outcomes may be influenced by mode of delivery. The most consistent association reported is with respiratory morbidity, estimated to be two to three times greater after CS. (Van den Berg *et al,* 2001; Hansen *et al,* 2008; Tito *et al,* 2009) However, the difference in respiratory morbidity is only significant for births before 39 weeks (Wilmink *et al,* 2010; Bialit *et al,* 2010) Other possible morbidities that might be more common following CS are neonatal hypoglycaemia and hypothermia, yet these data are now decades old.(Hagnevik *et al,* 1984; Christensson *et al,* 1993) Studies have also reported that babies born by CS may have delayed and shorter duration of breastfeeding, and issues with 'maternal-neonatal' bonding (Lobel and DeLuca, 2007) and, again, these findings are contradicted by other studies.(Klint Calander *et al*, 2010)

A recent large cohort study (Karlstrom *et al,* 2013) summarised their results as follows:

> "Overall, maternal and infant morbidity was low irrespective of mode of delivery. The results of this study show that the risk for complications such as bleeding, infections and trouble breastfeeding were equal, irrespective of the mode of caesarean section. Infants born by caesarean section had more complications regardless of whether surgery was performed based on maternal request (no reported medical indication) or occurred after spontaneous onset of labour."

However, the authors captured the difficulties in such studies well:

> "[While] a significant strength of the study was the use of the Medical Birth Register, which has a high coverage of all births in Sweden… incorrect classification may exist, and missing data are common for maternal characteristics such as smoking, civil status, and weight. Another limitation with the register data is the retrospective design. **In general, the lack of randomised controlled trials is a problem**. In this study the control group comprised women planning a vaginal birth with a spontaneous onset of labour and a vaginal delivery most probably also included women with high risk. **A Cochrane review concludes that there is a need for alternative research methods to gather data on the outcomes associated with different ways of giving birth, because no evidence from randomised controlled trials exits**."

The prospect of a prospective randomised trial comparing attempted vaginal birth with elective CS in low-risk women has been discussed for many years.(Robson and Ellwood, 2003) While there are likely to be many MCCS cases performed in Australia (Robson *et al*, 2009) it is easy to anticipate difficulties with recruitment. The majority of births in Australia are performed in public hospitals (AIHW, 2017) and many jurisdictional Health Departments have strict prohibitions on MCCS (NSW Health Department Policy Directive, 2010). It is also unclear what proportion of women with an uncomplicated pregnancy would wish for elective CS, and perhaps more importantly whether women who seek MCCS would accede to being randomised to attempted vaginal birth. Also, research in women having their pregnancy and birth managed in private hospitals are a much less common group for recruitment to a randomised prospective trial. Since there is a financial cost to them, it is unclear how many women who are paying for birth would wish to participate in such a study.

A potential solution to this set of conundra is the approach taken by Crowther and colleagues (2012) in their study, *Planned vaginal birth or elective repeat caesarean section: patient preference restricted cohort with nested randomised trial*. Of 2345 women recruited to the study, only 20 agreed to be randomised. The authors made the following insightful statement:

> "Although the randomised controlled trial is regarded as the 'gold standard' research methodology for assessing the effects of health care interventions, some research questions cannot be fully answered using this design, particularly where patients have strong treatment preferences, and decline randomisation as in our setting. Given our experience here and the recognised difficulty of recruitment to randomised trials related to VBAC, it seems unlikely that large randomised trials will be conducted, although these may still be possible in other health care settings."

We set out to develop a methodology that could be used to take such a similarly pragmatic approach to MCCS.

2.1 Recruitment

Recruitment to the study was our first consideration: we made the assumption that women seeking private maternity care in Australia would likely contain a higher proportion planning MCCS. Thus, our recruitment strategy was to contact all specialist obstetricians in Australia who identified as providing 'private obstetric care' to seek assistance in recruitment. The RANZCOG website (www.ranzcog.edu.au) hosts an interactive feature, 'Locate an obstetrician gynaecologist.' We used this to search the database and identify all those listed on at the time who indicated they offered private obstetrics. A covering letter (**Figure 7.1**) and two pads of tear-off recruitment flyers (**Figures 7.2** and **7.3**) were posted to every obstetrician identified from the publicly-available College database. We also felt that having specialist obstetricians identify suitable participants would decrease the chance of recruitment of women not meeting the inclusion criteria.

No direct face-to-face contact with study participants was planned, so we set up two separate websites (to minimise the risk of inadvertent recruitment to the wrong arm of the study). The domain names (www.caesareanstudy.net and www.birthstudy.net) were purchased and hosted through Melbourne IT (www.melbourneIT.com.au) and the website design undertaken by Mr Alex Fahey of Unique Ideas Australia (www.uia.com.au). Contact with participants

was through email. In addition to demographic and outcome information, we used a number of validated instruments and Likert scales.

Recruitment and patient flow are as follows:

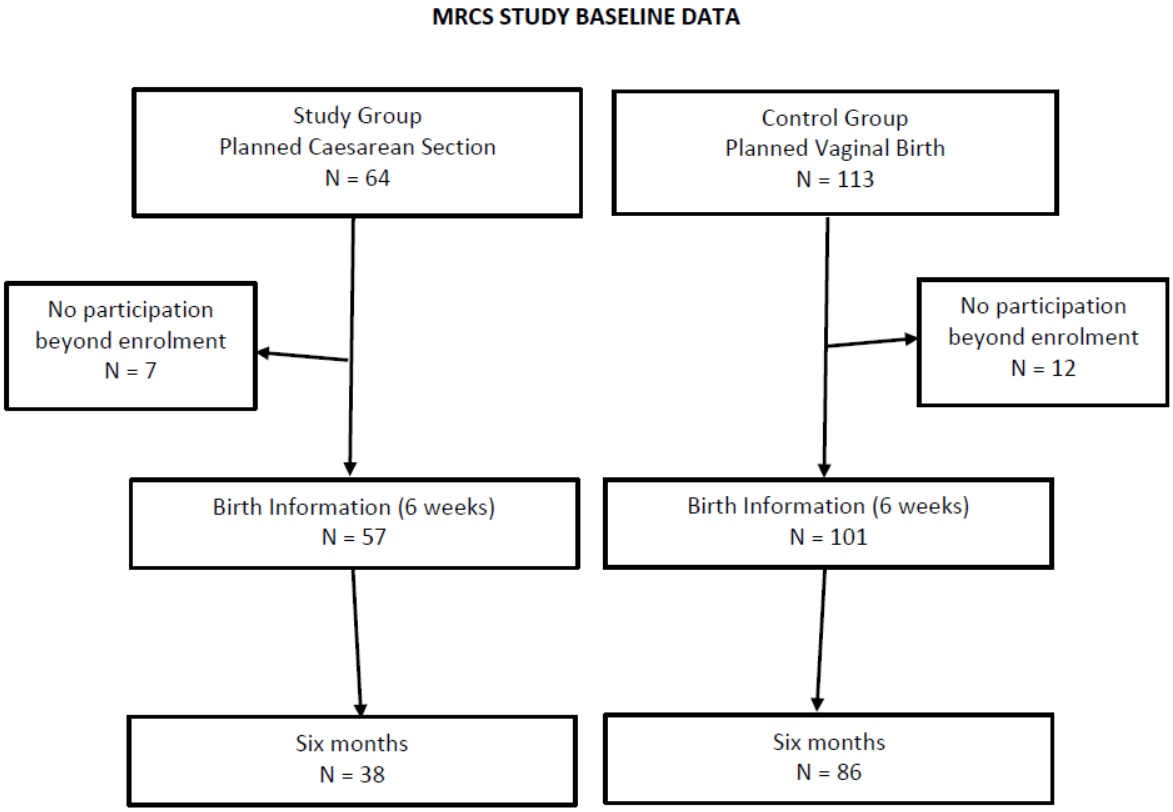

Figure 7.1 Covering letter sent with recruiting pads to every private obstetrician in Australia, accompanying the recruiting flyers (**Figures 7.2** and **7.3**)

JAMES COOK UNIVERSITY
AUSTRALIA

Is this your first pregnancy?
Are you planning a vaginal birth?

You are invited to take part in a University research study comparing the health outcomes of women planning a vaginal birth with women planning a caesarean birth.

The study will use **e-mail questionnaires** to follow the health of women before and after their birth. We seek volunteers to participate who are:

- **Aged 18 years or older**
- **In their first ongoing pregnancy**
- **Have a single baby (not twins!)**
- **The baby is head-down (not in a breech position)**
- **There are no other major health issues**

If you agree to be involved in this study you will be invited, with your consent, to **register online** and complete **four voluntary 15 minute e-mail surveys** at the following times:

- **Before your baby is born**
- **6 weeks after your baby is born**
- **6 months after your baby is born**
- **18 months after your baby is born**

All information will be completely confidential and private.

Taking part in this study is **completely voluntary** and you could **withdraw at any time**.

If you would like more information, or if you would like to register, please visit the confidential website:

www.birthstudy.net

The website is managed by James Cook University in Queensland. If you have any questions or comments please contact us anytime on **study@birthstudy.net** or Ph: (07) 4050 6313

We will not contact you separately to the automated email reminders unless you specifically request us to do so. Your registration will be de-activated at the end of the study period. We will store your completed questionnaires safely according to National Health and Medical Research Council (NH&MRC) privacy requirements.

This study is completely voluntary and you can withdraw from the study at any time without explanation or prejudice by not completing questionnaires and logging off the website. You can cancel your registration at any time by selecting the 'cancel my registration' button on the website. Your registration will then be removed and you will have the option to request that any unprocessed data be deleted.

Your responses and contact details will be strictly confidential. The data from the study will be used in research publications and reports to the academic health community. You will not be identified in any way in these publications.

We thank you for your time in considering this research project.

Figure 7.2 Recruiting flyer for the planned vaginal birth arm of the study.

JAMES COOK UNIVERSITY
AUSTRALIA

Is this your first pregnancy?
Are you planning a caesarean birth?

You are invited to take part in a University research study comparing the health outcomes of women planning a caesarean birth with women planning a vaginal birth.

The study will use **e-mail questionnaires** to follow the health of women before and after their birth. We seek volunteers to participate who are:

- **Aged 18 years or older**
- **In their first ongoing pregnancy**
- **Have a single baby (not twins!)**
- **The baby is head-down (not in a breech position)**
- **There are no other major health issues**

If you agree to be involved in this study you will be invited, with your consent, to **register online** and complete **four voluntary 15 minute e-mail surveys** at the following times:

- **Before your baby is born**
- **6 weeks after your baby is born**
- **6 months after your baby is born**
- **18 months after your baby is born**

All information will be completely confidential and private.

Taking part in this study is **completely voluntary** and you could **withdraw at any time.**

If you would like more information, or if you would like to register please visit the confidential website:

www.caesareanstudy.net

The website is managed by James Cook University in Queensland. If you have any questions or comments please contact us anytime on **study@caesareanstudy.net** or Ph: (07) 4050 6313

We will not contact you separately to the automated email reminders unless you specifically request us to do so. Your registration will be de-activated at the end of the study period. We will store your completed questionnaires safely according to National Health and Medical Research Council (NH&MRC) privacy requirements.

This study is completely voluntary and you can withdraw from the study at any time without explanation or prejudice by not completing questionnaires and logging off the website. You can cancel your registration at any time by selecting the 'cancel my registration' button on the website. Your registration will then be removed and you will have the option to request that any unprocessed data be deleted.

Your responses and contact details will be strictly confidential. The data from the study will be used in research publications and reports to the academic health community. You will not be identified in any way in these publications.

We thank you for your time in considering this research project.

Figure 7.3 Recruiting flyer for the planned caesarean birth arm of the study.

Aust N Z J Obstet Gynaecol 2018; 1–5

ANZJOG

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SHORT COMMUNICATION

Maternal-choice caesarean section versus planned vaginal birth in low-risk primigravid women

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Conflicts of Interest: The authors report no conflicts of interest.

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Rising rates of caesarean section (CS) have been attributed, in part, to maternal-choice CS (MCCS). There are few published data regarding maternal and perinatal risks comparing MCCS with planned vaginal birth (VB) in uncomplicated first pregnancies to inform choice. We report the results of a pragmatic patient-preference cohort study of private patients in Australia: 64 women planning MCCS and 113 women planning VB. There were few differences in outcome between the two groups. The study highlighted the well-recognised difficulties in undertaking prospective research into MCCS.

KEYWORDS

caesarean section, labour, logistic regression, maternal age, population

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7.2 Additional results

In addition to the published results, a number of other results from the surveys are available. It is likely these will be published in due course, but are presented here.

At the time of the study – and to this day - there are no health-related quality-of-life (HRQoL) instruments or scales that are specific to pregnancy or postpartum conditions. The SF-36 and SF-12 of the Medical Outcomes Study (MOS) were the two most frequently used measures of HRQoL, followed by the World Health Organization's Quality of Life Scale-BREF (WHOQoL-BREF) and Mother-Generated Index (MGI), respectively.(Mogos *et al*, 2013) While there is thus no single HRQoL applicable to a pregnant group, the SF-12 (available at www.qualitymetric.com) is widely used in pregnancy research (Mogos *et al*, 2013; Vinturache *et al*, 2015; Robinson *et al*, 2016) and is shorter (Jenkinson *et al*, 1997) and thus was our choice. We also used the Edinburgh Postnatal Depression Scale (EPDS) as the most widely used screening tool for postpartum depression (PPD).(Cox *et al*, 1987; Gibson *et al*, 2009)

To compare the distribution of Likert, EPDS, and SF-12 scores, t-tests were performed. In each case an F-test was performed on the unpaired samples to test for variance. Based on these results, t-tests were then performed based on the F-test result (either equal or unequal variances) to calculate t-statistics and p-values with significance set at the 0.05 level).

7.2.1 Physical and mental health status at recruitment

The distribution of SF-12 scores in the physical and mental domains are presented in **Figures 7.4** and **7.5**. There were no significant differences between the cohorts in each arm.

7.2.2 Continence at recruitment

After a review of the instruments available (Smith and Kobashi, 2011) we selected the I-QOL instrument (Patrick *et al*, 1999) and this was used at recruitment, early postnatal, and at six months. There was no significant difference in reported urinary continence between the two groups at recruitment (**Figure 7.6**).

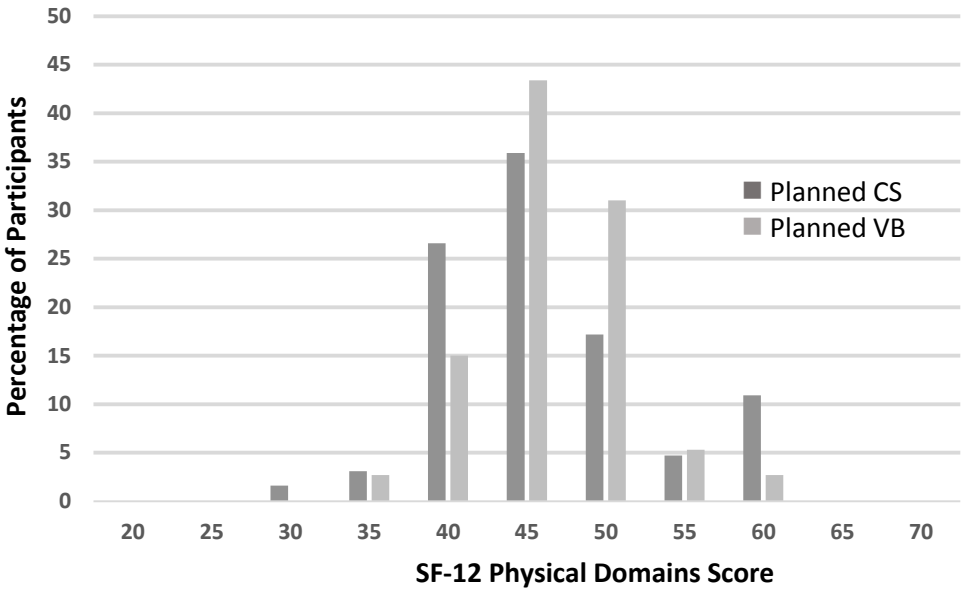

Figure 7.4 Distribution of scores for the SF-12 physical domains at the time of recruitment to the study for the planned caesarean section (CS) and planned vaginal birth (VB) groups.
(t-statistic = -0.38, p = 0.35)

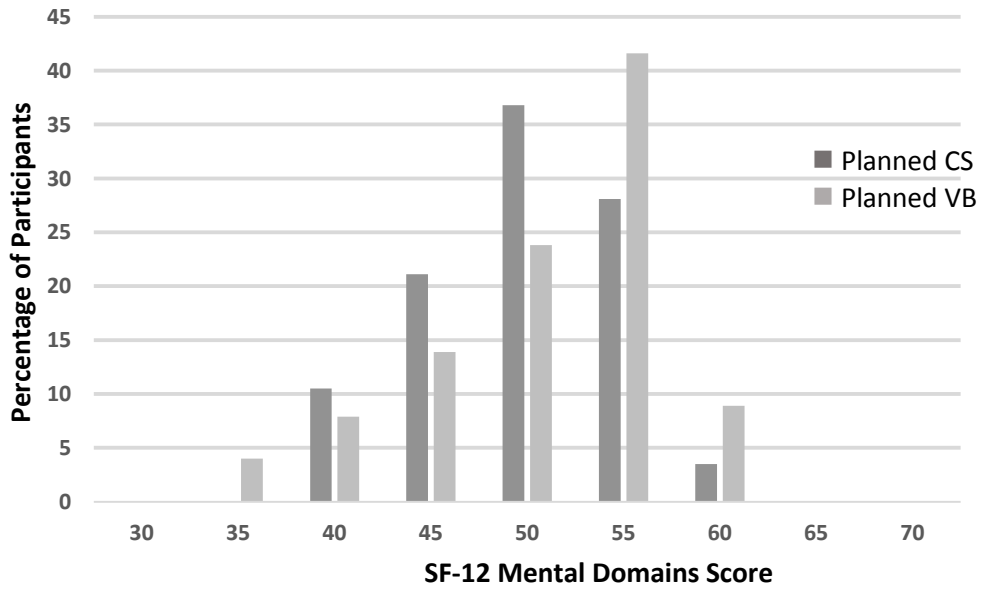

Figure 7.5 Distribution of scores for the SF-12 mental domains at the time of recruitment to the study for the planned caesarean section (CS) and planned vaginal birth (VB) groups.
(t-statistic -1.46; p = 0.73)

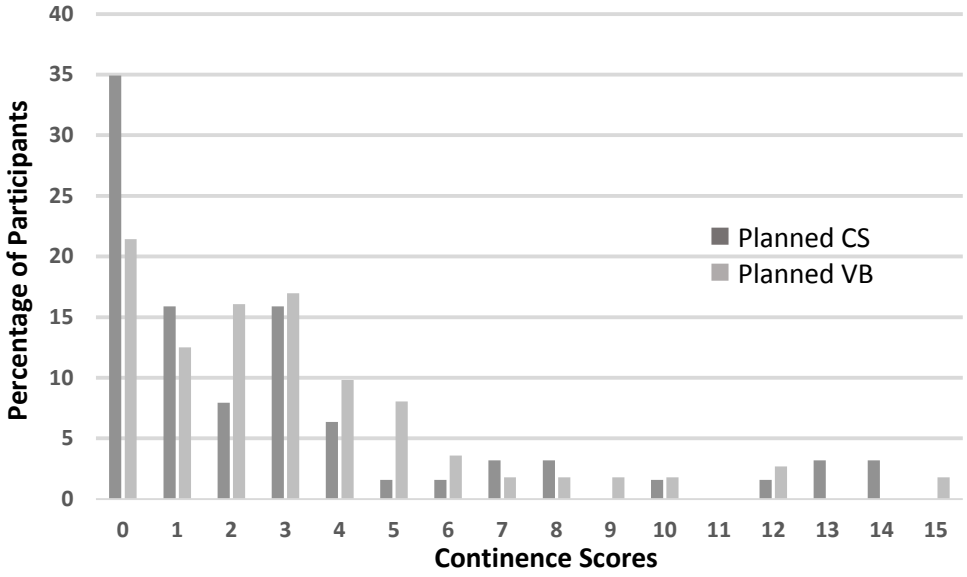

Figure 7.6 Distribution of continence scores at recruitment for the planned caesarean section (CS) and planned vaginal birth (VB) groups.
(t-statistic = -0.47; p = 0.32)

7.3 Postnatal Survey Responses at six to eight weeks

7.3.1 Satisfaction with the birth experience

At the six- to eight-week postnatal visit, in addition to the data regarding birth outcomes, women where asked, "*All things considered, how satisfied were you with the birth of your baby?*" They were provided with a ten-point Likert scale on which to rate their level of satisfaction. The satisfaction ratings in the MCCS group were significantly higher than in the planned VB group (**Figure 7.7**).

7.3.2 Experience of Pain

Respondents were asked, "*How would you rate your level of pain in the week after your baby was born?*" and provided with a 10-point Likert score (1 = 'no pain at all'; 10 = 'worst possible pain'). There was no significant difference in the

distribution of pain scores between the two groups (t-statistic = -0.24; p = 0.41). (**Figure 7.8**)

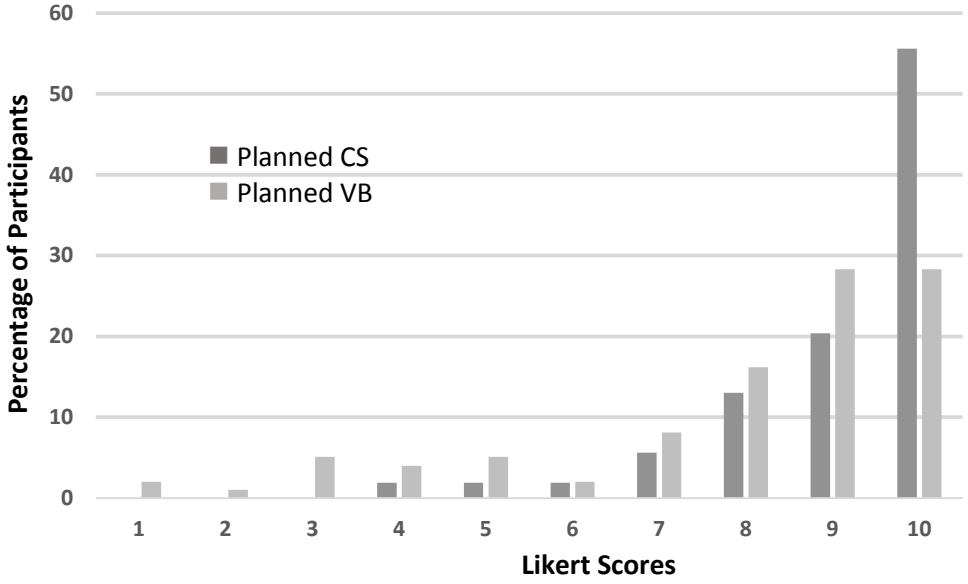

Figure 7.7 Distribution of Likert scale scores for the question, "*All things considered, how satisfied were you with the birth of your baby?*" for the planned caesarean section (CS) and planned vaginal birth (VB) groups. (t-statistic 3.8; $p < 0.005$)
(1 = 'completely unsatisfied'; 10 = 'couldn't be more satisfied')

7.3.3 Edinburgh Postnatal Depression Score

The EDPS was administered at the postnatal survey point: there was no significant difference in scores between the two groups (**Figure 7.9**).

7.3.4 SF-12 Scores

There was no difference in the distribution of scores in the SF-12 physical domains (**Figure 7.10**), but the distribution of scores in the mental domains was significantly different between the two groups, with lower scores in the MCCS group suggesting poorer mental health (**Figure 7.11**).

7.3.5 Continence

The distribution of scores between the two groups was significantly different, with self-reported urinary continence better in the MCCS group than the planned VB group (**Figure 7.12**).

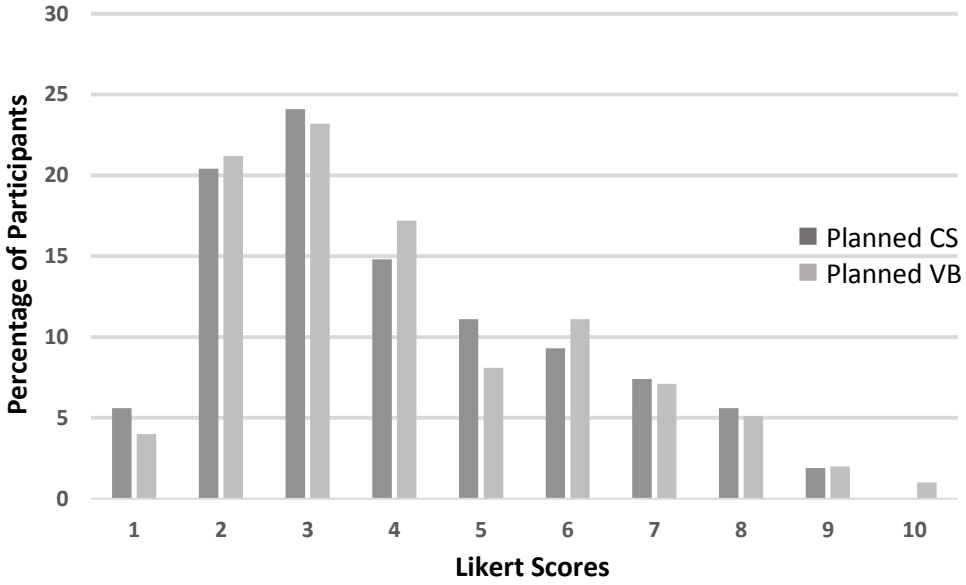

Figure 7.8 Distribution of Likert scale scores for the question, "*How would you rate your level of pain in the week after your baby was born?*" for the planned caesarean section (CS) and planned vaginal birth (VB) groups. (t-statistic = -0.24; p = 0.41)
(1 = 'no pain at all'; 10 = 'worst possible pain')

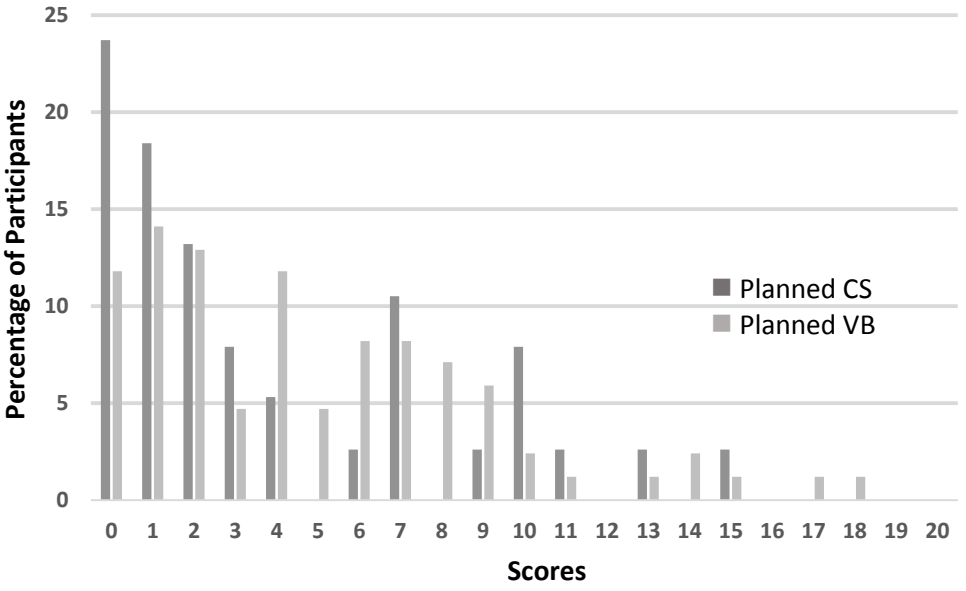

Figure 7.9 Distribution of scores for the Edinburgh Postnatal Depression Scale (EPDS) at six to eight weeks post-natal for the planned caesarean section (CS) and planned vaginal birth (VB) groups. (*p* = 0.91)

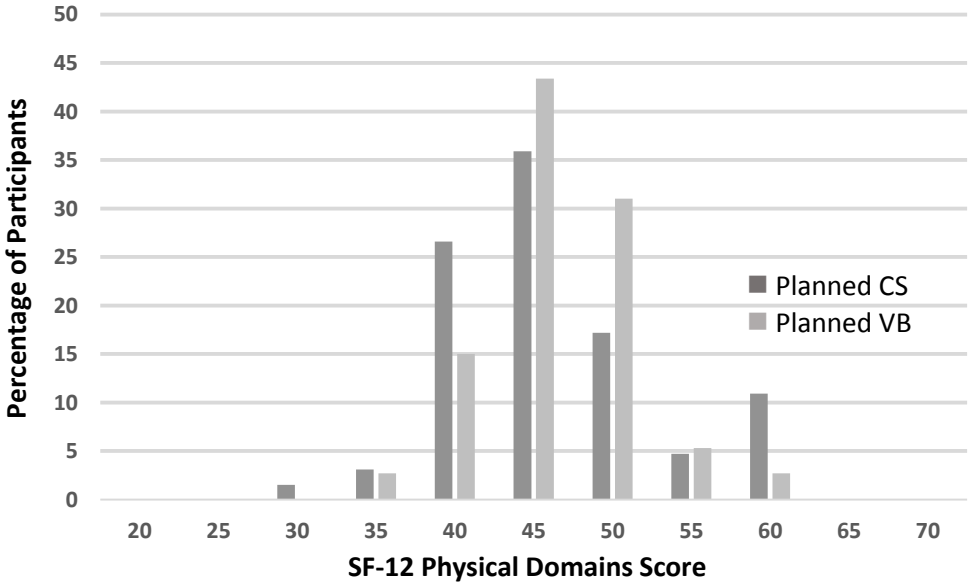

Figure 7.10 Distribution of scores for the SF-12 physical domains at six to eight weeks post-natal for the planned caesarean section (CS) and planned vaginal birth (VB) groups. (t-statistic = -0.38; p-value = 0.35)

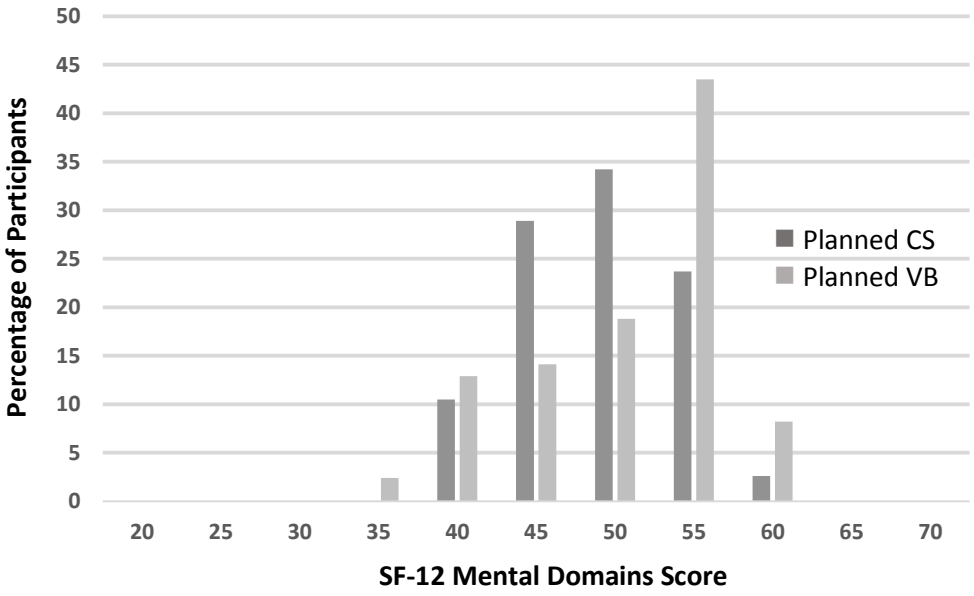

Figure 7.11 Distribution of scores for the SF-12 mental domains at six to eight weeks post-natal for the planned caesarean section (CS) and planned vaginal birth (VB) groups. (t-statistic = 2.46; $p < 0.005$)

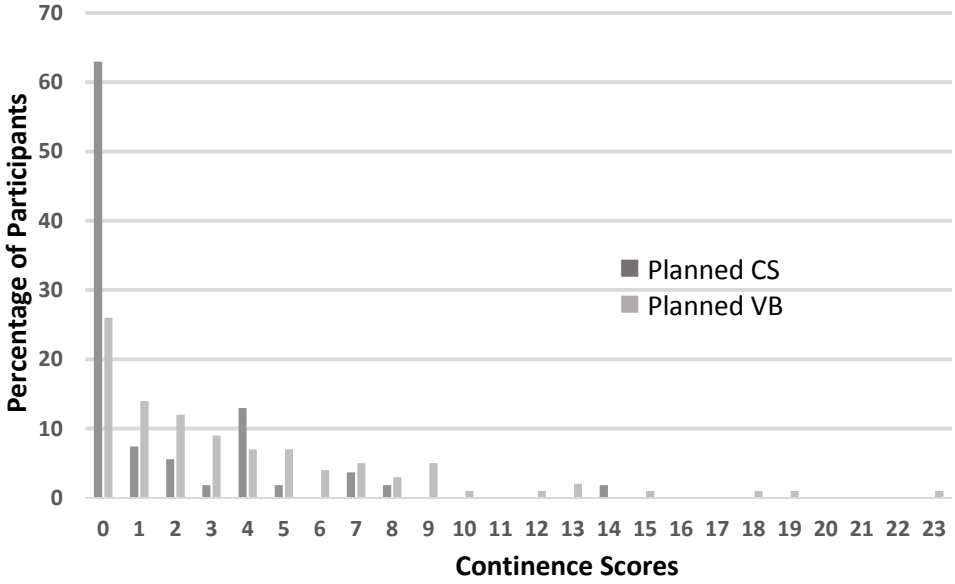

Figure 7.12 Distribution of continence scores at six to eight weeks postnatal for the planned caesarean section (CS) and planned vaginal birth (VB) groups. (t-statistic = -3.85; $p < 0.005$)

7.4 Postnatal Survey Responses at six months

7.4.1 SF-12 Scores

By six months postnatal, there were no significant differences in the distribution of scores in either the physical or mental domains of the SF-12 (**Figures 7.13** and **7.14**).

7.4.2 Continence

There was no significant difference in the distribution of continence scores between the two groups (**Figure 7.15**).

7.4.3 Breast feeding at six to eight weeks and six months

At six to eight weeks postnatal, the MCCS group were significantly less likely to be exclusively breast feeding, but there was no difference in rates of any breast feeding.(**Table 7.1**) At the six month survey, there was no significant difference in breast feeding rates.

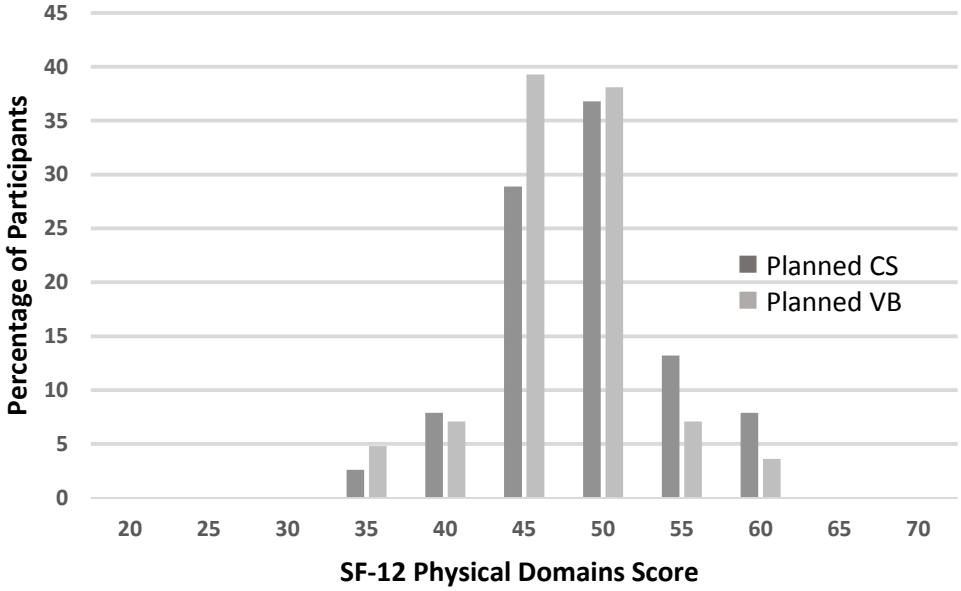

Figure 7.13 Distribution of scores for the SF-12 physical domains at six months post-natal for the planned caesarean section (CS) and planned vaginal birth (VB) groups. (t-statistic = 1.34; p = 0.091)

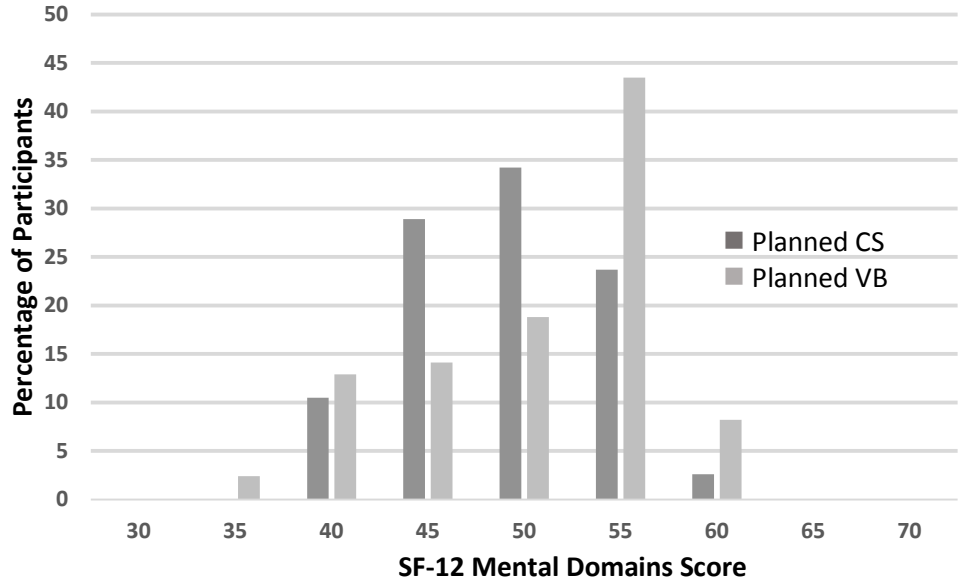

Figure 7.14 Distribution of scores for the SF-12 mental domains at six months post-natal for the planned caesarean section (CS) and planned vaginal birth (VB) groups. (t-statistic = -1.44; p = 0.76)

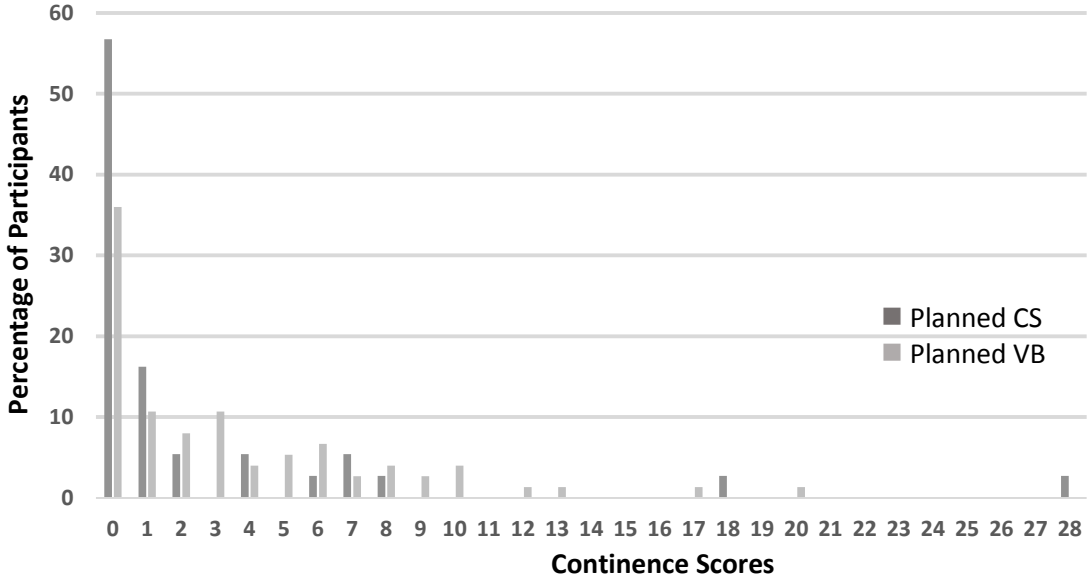

Figure 7.15 Distribution of continence scores at six months postnatal for the planned caesarean section (CS) and planned vaginal birth (VB) groups. (t-statistic = -0.49; p = 0.31)

	MCCS	Planned VB	RR	95% CI	p-value
6 – 8 weeks					
Exclusive BF	52.7%	74.7%	0.71	0.53-0.93	<0.005*
No BF	23.6%	12.1%	1.95	0.89-4.27	0.07
6 months					
No BF	34.2%	16.3%	2.1	1.01-4.26	0.03

Table 7.1 Rates of breast feeding (BF) in the MCCS and planned VB groups at six to 8 weeks, and 6 months postnatal, with relative risk (RR), 95% confidence intervals (CI) and *p*-values.

7.5 Conclusions

Our attempt at developing a methodology for a pragmatic prospective study of MCCS highlighted a number of issues. In the first instance, recruitment was difficult. The nature of private obstetric practice is such that specialists are busy and are less likely to be attuned to recruitment and participation in research trials in the way teaching hospital staff are. A potential way around this would be to

engage research assistants to engage directly with specialists and their practices. By the time women deliver in hospitals, the opportunity to take an 'intention-to-treat' approach is essentially lost. The logistics and costs of taking such a direct face-to-face recruitment approach are highly likely to make this prohibitive.

A corollary of this is that many women – and their obstetricians – may be unwilling to disclose that their birth choice was not made on obstetric or medical grounds, but on non-medical factors. Indeed, it remains unclear whether private health insurance (PHI) providers would support such choices. There is anecdotal evidence that many MCCS are undertaken with 'obstetric indications' assigned to them, perhaps in some instances to disguise the true nature of the choice. This would also be a very difficult issue to overcome.

Despite a direct recruitment campaign with a personal mailout to every obstetrician in the country - an effort that even attracted media attention at the time (**Figure 7.16**) - we recruited in total only 177 women across the whole country. The results were interesting but of completely uncertain significance, and of essentially no generalisability at all. This result, for several years of effort, was deeply disappointing and served to highlight the innate difficulties in studying MCCS in a prospective way.

Another recently-published study aiming to discern women's decision making regarding MCCS had a similar sample size.(Tuschy, *et al*, 2018) The study compared responses from 93 women who had planned MCCS with a control group of 109 women planning VB. The authors reported that women planning MCCS had "lower social support, were less educated, more anxious, and had a lower sensitivity for physical pain compared to women seeking for spontaneous delivery."

The Sydney Morning Herald

LIFESTYLE HEALTH & WELLNESS

Caesarean births a better option for mothers?

By Julia Medew
13 August 2011 – 12:00am

FOR years, women have been labelled "too posh to push" for choosing caesarean births without medical reasons, but a controversial new study suggests they may be picking a better path for themselves and their babies.

Dr Stephen Robson, an associate professor of obstetrics at Australian National University, is recruiting 1000 pregnant women to test the long-held view that vaginal deliveries are better than caesareans for healthy women with uncomplicated pregnancies.

The study, which requires 500 women choosing a caesarean and 500 planning a vaginal birth, will look at psychological and physical outcomes for the women and their babies, including depression and breastfeeding rates.

Dr Robson said that although an estimated 10,000 Australian women chose to have caesareans each year without medical reasons, no one had ever comprehensively studied their outcomes because research tended to focus on women with problems. "From a medical point of view, it's difficult to counsel people because no one can give a reasonable comparison of what the risks are for women who are otherwise healthy," he said.

Figure 7.16 Example of media story on the study, published in the *Sydney Morning Herald* on 13th August, 2011.

Accessible at:
https://www.smh.com.au/lifestyle/health-and-wellness/caesarean-births-a-better-option-for-mothers-20110812-1ir24.html

D'Souza and Arulkumaran (2013) capture the key issues succinctly:

> "The paucity of evidence either in favour or against, the poor understanding of long-term health and financial implications and the complex ethical issues surrounding [MCCS] make counselling extremely challenging. Needless to say, [MCCS] has generated enormous interest both in the media and among health-care providers, and many national and international bodies have now issued guidelines on the topic."

Since our study was published some interesting data have come to light and are summarised here. A new survey of registrars training in obstetrics and

gynaecology in the UK reported that only 6% of respondents had opted for MCCS in their first pregnancy, and that 21% reported that they would choose MCCS. (Aref-Adib M *et al*, 2018) The reasons given included concerns about pelvic floor injury, safety of the baby, and convenience. Almost half of the respondents (46.4%) 'disagreed or strongly disagreed' with undertaking MCCS. The authors concluded that, "our results are encouraging: positive attitudes of trainees towards vaginal delivery may help to reduce the rising caesarean rate."

A population-based study of births in Sweden during the period 2002 to 2004 (Moller *et al*, 2017) found that psychiatric disorders were more common in women giving birth by MCCS compared to the other women (11.2% vs 5.5%, $p < 0.001$), however they were more likely to have been diagnosed with a psychiatric condition before birth as well (39.8% vs. 24.2%, $p < 0.001$). The authors concluded that women requesting MCCS are "a vulnerable group requiring special attention… [and] this vulnerability should be taken into account when deciding on mode of delivery."

A systematic review has suggested that women requesting MCCS had higher antepartum depression and anxiety levels but no different postpartum depression levels than women who delivered vaginally, although the outcomes for women who planned VB but underwent unplanned CS were explored only superficially.(Olieman *et al*, 2017) However, the authors concluded that, "If women resolutely persist in wishing an [MCCS] despite adequate counselling and/or psychiatric treatment, the risk of developing depressive and PTSD symptoms in case of vaginal delivery should be taken into account, and an [MCCS] may be considered as a valid alternative."

Lerner-Geva and colleagues (2016) reported a multi-centre case-control study of 429 women who underwent MCCS and 429 matched controls who delivered vaginally (however, with no women who underwent emergency or unplanned CS). The reported the predictors of MCCS as increasing age, single status,' decreasing level of religiosity,' and never having engaged, or ceasing sports activity during pregnancy. 'Above average income' reduced the probability of MCCS. The authors reported the most frequent reasons for choosing MCCS were concern for pain (21.9%), concern for their own or baby's health (20.4% and 16.5%, respectively), and 'emotional aspects' (10.0%).

Our attempt to undertake a pragmatic and prospective cohort study of MCCS was, at best, partially successful. It seems very likely that the subject will continue to be informed by indirect evidence of a quality that is not necessarily generalisable.

Chapter 8

Is the World Health Organization's "target rate" for caesarean birth truly meaningful?

At a meeting hosted jointly hosted by the World Health Organization (WHO) and the Pan American Health Organization (PAHO) in Fortalenza, Brazil, in April of 1985, an interdisciplinary group of reproductive health experts concluded that: "there is no justification for any region to have a rate higher than 10-15%."(PHAO, 1985) The panel's conclusion was reported as unanimous and was drawn from a review of the data available at the time, mainly from northern European countries. Those data suggested that good maternal and perinatal outcomes were associated with a rate of caesarean section of between 10 and 15%.

This recommendation subsequently was carried in every edition of the WHO publication *Monitoring emergency obstetric care* from that time until 2009.(WHO, 2009) In the 2009 edition, the recommendation was replaced with a statement: "there is no empirical evidence for an optimum percentage or range of percentages… what matters most is that all women who need caesarean sections actually receive them." This was a major reversal, but in the wake of this change many authors continued to cite the original WHO recommendation. Presumably in response to this, the WHO published a stand-alone statement on CS in 2015, the *WHO Statement of caesarean section rates** (**Figure 8.1**). The statement begins as follows:

> "Since 1985, the international healthcare community has considered the ideal rate for caesarean sections to be between 10% and 15%. Since then, caesarean sections have become increasingly common in both developed and developing countries. When medically justified, a caesarean section

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(Accessible at: http://www.who.int/reproductivehealth/publications/maternal_perinatal_health/cs-statement/en/)

can effectively prevent maternal and perinatal mortality and morbidity. However, there is no evidence showing the benefits of caesarean delivery for women or infants who do not require the procedure. As with any surgery, caesarean sections are associated with short and long term risk which can extend many years beyond the current delivery and affect the health of the woman, her child, and future pregnancies. These risks are higher in women with limited access to comprehensive obstetric care. In recent years, governments and clinicians have expressed concern about the rise in the numbers of caesarean section births and the potential negative consequences for maternal and infant health. In addition, the international community has increasingly referenced the need to revisit the 1985 recommended rate."

World Health Organization

hrp

WHO Statement on Caesarean Section Rates

Every effort should be made to provide caesarean sections to women in need, rather than striving to achieve a specific rate

Executive summary

Since 1985, the international healthcare community has considered the ideal rate for caesarean sections to be between 10% and 15%. Since then, caesarean sections have become increasingly common in both developed and developing countries. When medically justified, a caesarean section can effectively prevent maternal and perinatal mortality and morbidity. However, there is no evidence showing the benefits of caesarean delivery for women or infants who do not require the procedure. As with any surgery, caesarean sections are associated with short and long term risk which can extend many years beyond the current delivery and affect the health of the woman, her child, and future pregnancies. These risks are higher in women with limited access to comprehensive obstetric care.

In recent years, governments and clinicians have expressed concern about the rise in the numbers of caesarean section births and the potential negative consequences for maternal and infant health. In addition, the international community has increasingly referenced the need to revisit the 1985 recommended rate.

Caesarean section rates at the population level

WHO conducted two studies: a systematic review of available studies that had sought to find the ideal caesarean rate within a given country or population, and a worldwide country-level analysis using the latest available data. Based on this available data, and using internationally accepted methods to assess the evidence with the most appropriate analytical techniques, WHO concludes:

1. Caesarean sections are effective in saving maternal and infant lives, but only when they are required for medically indicated reasons.
2. At population level, caesarean section rates higher than 10% are not associated with reductions in maternal and newborn mortality rates.
3. Caesarean sections can cause significant and sometimes permanent complications, disability or death particularly in settings that lack the facilities and/or capacity to properly conduct safe surgery and treat surgical complications. Caesarean sections should ideally only be undertaken when medically necessary.
4. Every effort should be made to provide caesarean sections to women in need, rather than striving to achieve a specific rate.
5. The effects of caesarean section rates on other outcomes, such as maternal and perinatal morbidity, paediatric outcomes, and psychological or social well-being are still unclear. More research is needed to understand the health effects of caesarean section on immediate and future outcomes.

Caesarean section rates at the hospital level and the need for a universal classification system

There is currently no internationally accepted classification system for caesarean section that would allow meaningful and relevant comparisons of CS rates across different facilities, cities or regions. Among the existing systems used to classify caesarean sections, the 10-group classification (also known as the 'Robson classification') has in recent years become widely used in many countries. In 2014, WHO conducted a systematic review of the experience of users with the Robson classification to assess the pros and cons of its adoption, implementation and interpretation, and to identify barriers, facilitators and potential adaptations or modifications.

WHO proposes the Robson classification system as a global standard for assessing, monitoring and comparing caesarean section rates within healthcare facilities over time, and between facilities. In order to assist healthcare facilities in adopting the Robson classification, WHO will develop guidelines for its use, implementation and interpretation, including standardization of terms and definitions.

1

Figure 8.1 The stand-alone *WHO Statement on caesarean section rates*, released in 2015.

The 'WHO recommended rate' has been so durable, so integral to the paradigm of birth, that it seems beyond question. Yet the paradox attendant to the WHO stance is that, over the life of the recommendation, the rate of CS has increased internationally.(Betran *et al*, 2016) A concerted and coordinated international effort to 'control' CS rates has been a stunning failure. Betran and colleagues (2016) in their WHO-sponsored international epidemiological review conclude that, "Caesarean section (CS) rates continue to evoke worldwide concern… the use of CS worldwide has increased to unprecedented levels." If there is 'concern' in the medical literature, there is outrage in some lay press with the rate of CS described as a surgical 'horror.'(**Figure 8.2**)

MEDICAL EXAMINER

How the C-Section Went From Last Resort to Overused

The history of the surgery is rife with horror, but today, 1 in 3 American babies are delivered via the procedure, twice what the World Health Organization recommends.

By REBECCA ONION

MAY 21, 2018 • 5:55 AM

Figure 8.2 Feature article in *Slate* magazine by Rebecca Onion. Accessible at: https://slate.com/technology/2018/05/how-the-c-section-went-from-last-resort-to-overused.html

For a procedure that is so common, and that causes such passionate community concern, there do not seem to be any evidence-based strategies that have been proven effective in reducing the rate of CS.(Khunpradit, 2011) Moreover, the underlying assertion – that 'good maternal and neonatal outcomes' are associated with a CS rate of between 10 and 15% - is rarely questioned. Is this article of faith actually justified?

The original WHO recommendation was based on data that were reliable and could be obtained from each country with precision: rates of maternal and

perinatal death.(PAHO, 1985) However death of mother or baby is, thankfully, an uncommon outcome and other adverse consequences of birth, both short term outcomes such as postpartum haemorrhage, maternal infection, and perinatal hypoxia and long term outcomes such as pelvic organ prolapse (POP) and urinary incontinence (UI), can never be ascertained accurately for most countries. Indeed the lifetime rate of surgery for POP and UI in developed countries is estimated to be 20% (Wu *et al*, 2014) and CS is known to be highly protective. This observation has led some authors to condemn target CS rates because of the adverse effects on the pelvic floor and continence.(Dietz and Campbell, 2016)

In this paper, we aimed to examine new data on CS and put them in an international perspective. We also set out to assess how increases in CS rates in Australia had correlated with rates of surgery for prolapse and incontinence.

Thirty years of the World Health Organization's target caesarean section rate: time to move on

Stephen J Robson[1], Caroline M de Costa[2]

Summary

- It has been 30 years since the World Health Organization first recommended a "maximum" caesarean section (CS) rate of 15%.
- There are demographic differences across the 194 WHO member countries; recent analyses suggest the optimal global CS rate is almost 20%.
- Attempts to reduce CS rates in developed countries have not worked.
- The strongest predictor of caesarean delivery for the first birth of "low risk" women appears to be maternal age; a factor that continues to increase.
- Most women whose first baby is born by caesarean delivery will have all subsequent children by caesarean delivery.
- Outcomes that informed the WHO recommendation primarily relate to maternal and perinatal mortality, which are easy to measure.
- Longer term outcomes, such as pelvic organ prolapse and urinary incontinence, are closely related to mode of birth, and up to 20% of women will undergo surgery for these conditions. Pelvic floor surgery is typically undertaken for older women who are less fit for surgery.
- Serious complications such as placenta accreta occur with repeat caesarean deliveries, but the odds only reach statistical significance at the third or subsequent caesarean delivery. However, in Australia, parity is falling, and only 20% of women will have more than two births.
- We should aim to provide CS to women in need and to continue including women in the conversation about the benefits and disadvantages, both short and long term, of birth by caesarean delivery.

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Chapter 9

Summary and Conclusions

The proportion of Australian babies born by CS increased by almost 85% in the quarter century from 1991 to 2015, rising from 18% to 33.3%.(AIHW, 2015) Although the increase appears to have reached a plateau, with no significant change overall the last two years, such a fundamental disruption of the way women give birth has had a huge impact on the medical discourse in Australia:

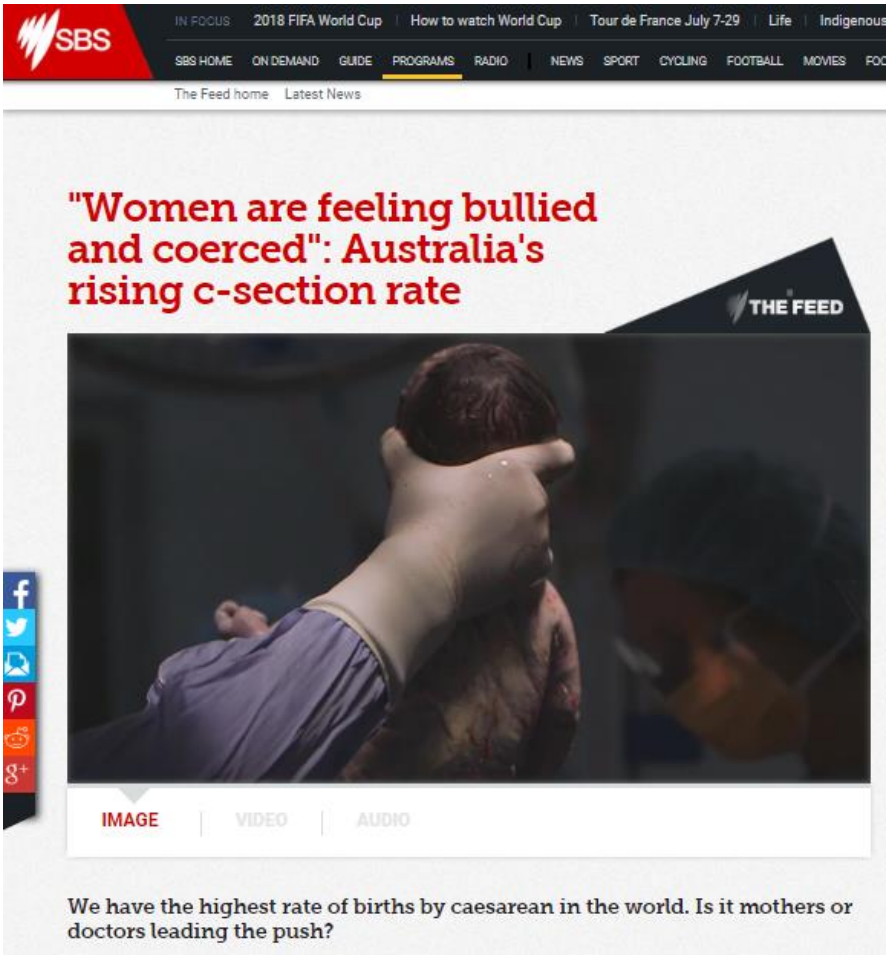
> "Historically, the introduction of caesarean section surgery was associated with an improvement in maternal and perinatal health outcomes. WHO has stated that no empirical evidence exists for an ideal caesarean rate, but 'what matters most is that all women who need caesarean sections actually receive them.' In areas with very high mortality rates, such as Africa, inadequate availability of caesarean section contributes to substantial maternal and perinatal morbidity and mortality. Conversely, in many developed countries, concerns exist about high rates of caesarean section, since increasing rates of this procedure show little evidence of leading to further improvement in perinatal outcomes. Caesarean section carries its own risks for maternal and infant morbidity and for subsequent pregnancies. At some point, these risks will outweigh the potential benefits associated with lowering the threshold at which the procedure becomes indicated. The skill needed to make a balanced clinical decision for an individual woman might well be greater than the skill required to actually undertake the procedure."(Roberts and Nippita, 2016)

…and the international discourse:

> "Despite the well-established morbidity, mortality, long-term effects, and unnecessary extra-cost burden associated with cesarean section delivery worldwide, its rate has grown exponentially. This has become a great topical challenge for the international healthcare community and individual countries. Estimated at three times the acceptable rate as defined by the World Health Organization in 1985, the continued upward

trend has been fueled by higher income countries. Some low- and middle-income countries have now taken the lead, and the factors contributing to this situation are poorly understood. The expansion of the private healthcare sector may be playing a significant role."(Beogo *et al*, 2017)

The sentiments expressed, relatively politely, in the medical literature are not quite so subtle in the lay press:



Accessible at:
https://www.sbs.com.au/news/thefeed/story/women-are-feeling-bullied-and-coerced-australias-rising-c-section-rate

"Hannah Dahlen from the Australian College of Midwives, says that although those factors are contributing to the rate rise in part, caesareans are not making changing maternal or infant mortality, and says the rate rise is unwarranted.

"'There's no doubt women are feeling bullied and coerced into caesareans. It can be very, very subtle, and it's about not giving them the full information, and moving them towards a direction you want to take," she said.

"'You can find a medical reason for anything," said Dahlen. "Whether or not it's a good medical reason is the question, and a lot of pseudo reasons are being used to argue women into C-sections.'"

The rate of CS in Australia, although now stable, remains more than twice that of the WHO-recommended 'limit' of 15%.(AIHW 2015; Gibbons *et al*, 2010) To put this rate in perspective, it is useful to look at data gathered by the Organisation for Economic Co-operation and Development (OECD), accessible at www.oecd.org. Australia's CS rate certainly is above the average for OECD countries (**Figure 9.1**), but using the WHO's crude yardstick indicators our maternal mortality (**Figure 9.2**) and neonatal mortality (**Figure 9.3**) rates compare favourably in international terms.

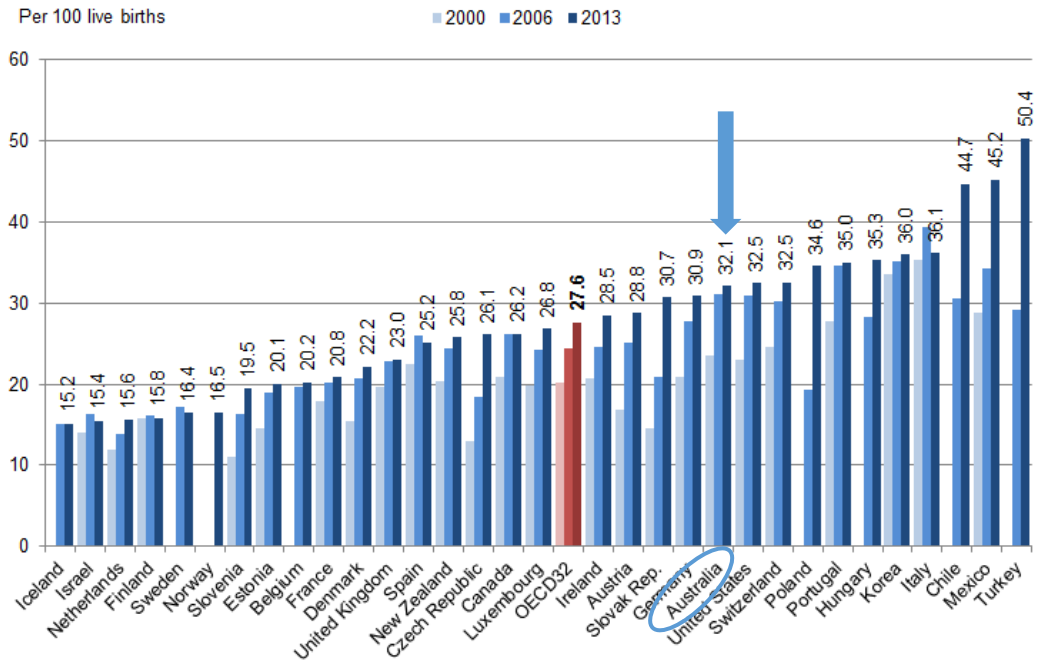


Figure 9.1 Comparison of trends in CS rates for OECD countries for years 2000, 2006, and 2013.
Open source: www.oecd.org

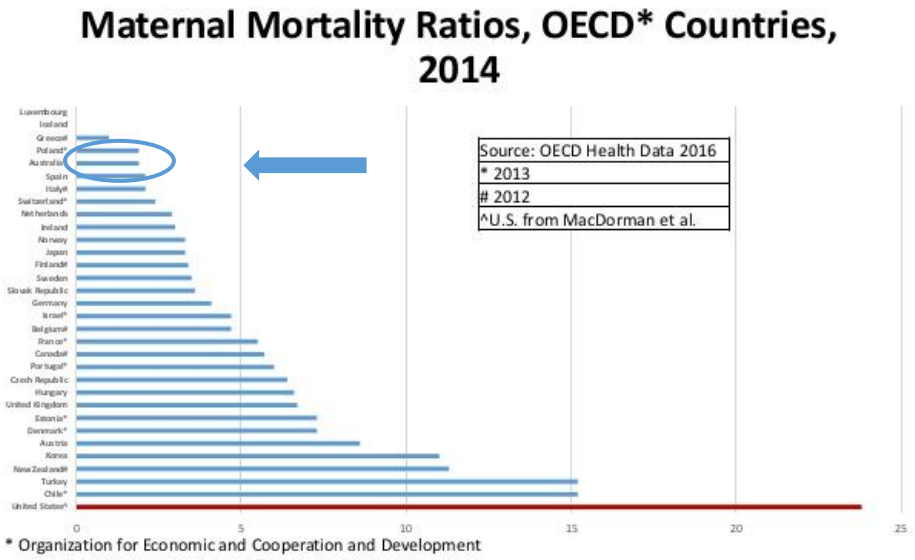


Figure 9.2 Comparison of maternal mortality ratios (MMRs) for OECD countries for the year 2014, with some data from 2013* and 2012#.
Open source: www.oecd.org

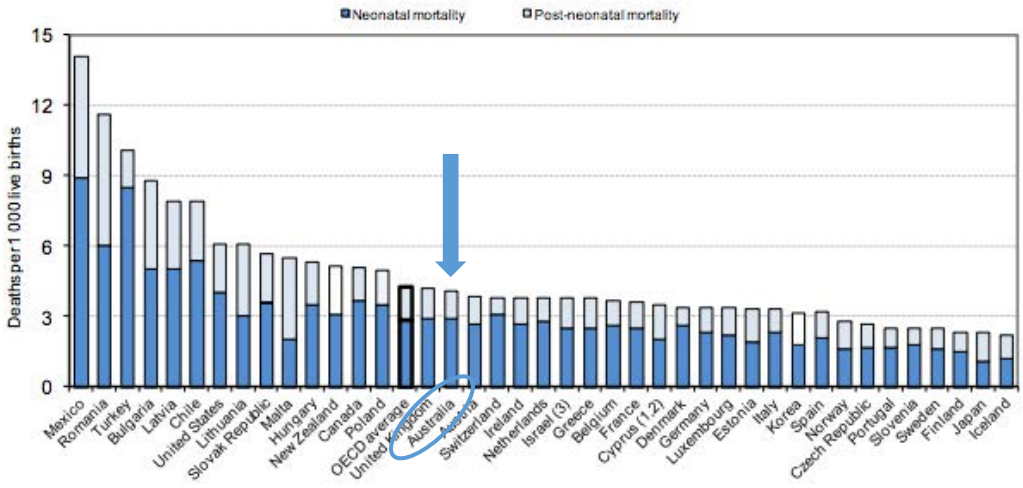


Figure 9.3 Comparison of neonatal and post-neonatal mortality rates for OECD countries for year 2012.
Open source: www.oecd.org

Caesarean section remains one of the commonest major surgical procedures in Australia, and across the world. Its significance is such that *The Lancet* Commission on Global Surgery has access to CS within two hours as the first 'bellwether' procedure in its first indicator, "access to timely surgery."(www.lancetglobalsurgery.org/indicators) Yet - at the same time - the World Health Organization continues to express concerns at the use of CS, with publications containing statements such as this:

> "The use of CS has increased dramatically worldwide in the last decades particularly in middle- and high-income countries, despite the lack of evidence supporting substantial maternal and perinatal benefits with CS rates higher than a certain threshold, and some studies showing a link between increasing CS rates and poorer outcomes. The reasons for this increase are multifactorial and not well-understood. Changes in maternal characteristics and professional practice styles, increasing malpractice pressure, as well as economic, organizational, social and cultural factors have all been implicated in this trend. Additional concerns and controversies surrounding CS include inequities in the use of the procedure, not only between countries but also within countries and the costs that unnecessary caesarean sections impose on financially stretched health systems."(Betran *et al*, 2016)

How is it possible for a surgical procedure that, in some instances, is taken as the foremost bellwether of the standard of health care in a country also be so maligned? For example, the catastrophic outcome of obstetric fistula is becoming less common as the rate of CS increases in low and middle income countries.(Wall, 2012) Indeed, the passage above raises many of the issues that have been addressed in these studies. Why has the rate of CS increased? What are the 'maternal characteristics' associated with CS? Are there links between caesarean birth and poorer outcomes? Are there 'social and cultural' factors at play? What costs do caesarean sections impose on financially stretched health systems? Using the results of the studies presented in this thesis it is possible to illuminate some of these questions and shed light on the answers.

9.1 The effect of age

More than two decades ago, in 1995, AIHW data reveal that less than 30% of first births occurred to women aged 30 years and older: today that figure is almost 50%. Over the same interval the rate of first births in women aged 35 years or more has more than doubled from just over 7% to almost 15%. These changes have been associated with an increase in the national overall CS rate from one birth in six to one in three. International studies have revealed a strong association between the age of all mothers and CS rates.(Jolly *et al*, 2000; Cleary-Goldman *et al*, 2005; Yogev *et al*, 2010; Wang *et al*, 2011; Kenny *et al,* 2013; Laopaiboon *et al*, 2014; Vaughan *et al*, 2014) Smith and colleagues (2008) reported that 38% of the increased incidence of primary CS in Scotland over the 25 year period from 1980 to 2005 could be explained by the increase in age of women having their first child. This association has led authors to conclude that, "older nulliparous women and their obstetricians should be the target of future efforts to control [caesarean section] rates."(Gareen *et al*, 2003)

To examine the contribution of maternal age at first birth, the first study in this thesis dealt with births other than spontaneous vaginal births (SVB) in South Australia. Data for all first births in South Australia over the period 1991 to 2009 were obtained from the South Australian Pregnancy Outcome Statistics Unit. Women who gave birth by pre-labour (elective) CS were excluded from the denominator used to calculate the incidence of non-SVB. Also excluded were multiple births, preterm and post-term births (less than 37^{+0} weeks at birth, or greater than 41 completed weeks, respectively), stillbirths, births in any presentation other than vertex at the start of labour (most commonly breech), and those where the birthweight was less than two kilograms.

Logistic regression models, incorporating the potential confounders available in the data collection, were fitted and compared using standard statistical methods. A total of almost 120000 first births following onset of labour were included, representing almost one third of all births over the study period. We found that the rate of CS rose proportionally more than instrumental delivery over the study period suggesting a substitution of caesarean section for instrumental vaginal births. The odds of emergency caesarean section were found to increase multiplicatively by approximately 1.069 (95% CI, 1.066-1.072) per year, or 1.39

per 5 years, a figure very close to that reported by Smith and colleagues from Scotland.(Smith *et al*, 2008). Overall, the data revealed that maternal age appeared to account for at least 75% of the relative increase in birth other than SVB observed over this time period. Thus, changes in maternal are important but do not account for the entire increase in CS rate.

9.2 The next birth after a caesarean section

The majority of women will have more than one child, not only in Australia but internationally. The most recent national data for Australia revealed the rate of CS in women having their first baby was 33.5%, and that for women having a subsequent child – but with no prior CS – was much lower at 10.4%.(AIHW, 2015) Importantly, of all births in women who had a previous CS, 84.6% were by CS; and, the single commonest indication for CS was a previous CS, accounting for 35.6% of all CS performed. It has long been recognised that for women whose first birth is caesarean, the most likely outcome is that all her subsequent births occur by CS. (Brennan DJ *et al*, 2009; Homer *et al*, 2011) Thus, an important area that influences the CS rate is decision- making about whether to try for vaginal birth after previous cesarean section.

While there exists the possibility that increasing the uptake of attempted VBAC could affect the overall rate of CS, population-level studies report a decline in the proportion of eligible women attempting VBAC. In Australia, this rate has fallen from about one half to one third over a decade, with a similar fall in the rate at which vaginal birth is achieved, from two thirds to one half.(Homer *et al*, 2011) Unfortunately, strategies designed to increase the uptake - and chance of success - of attempted VBAC seem to have little or no effect.(Catling-Paull *et al*, 2011; Khunpradit *et al*, 2011)

There appeared to be no published study directly addressing paternal – as opposed to *maternal* - influences on decision making regarding VBAC. The study described in this thesis aimed to determine whether maternal and paternal perception of risk for, and importance of, attempted VBAC was associated with an intention to attempt VBAC. Recruiting eligible couples from three hospitals - two metropolitan and one regional – we aimed to evaluate decision-making about VBAC with questionnaires completed (1) at the end of the second trimester, (2)

between 32 and 36 weeks, and (3) six weeks after the birth. A total of 75 couples completed the full set of questionnaires: in total 31 women (41%) ultimately attempted vaginal delivery, and 44 (59%) were delivered by planned CS. After adjusting for other variables such as maternal index birth complications and low paternal risk perception, a fall in paternal risk perception from second to third trimester was associated with an increase in the rate of VBAC attempts. This finding suggests that time spent providing information and education for fathers might increase the chance that a couple will attempt VBAC.

While the study is limited by the relatively small sample size, the couple's perception of risk of complications was clearly an important consideration. So, while a great deal of work has been undertaken examining the interventions that might increase the uptake rate of couples for attempted VBAC, none have revealed a strong influence.(Catling-Paull *et al*, 2011; Khunpradit *et al*, 2011) This study suggests that interventions that improve the paternal perceptions of risk during a pregnancy might increase the chance that a couple will attempt VBAC. This is certainly a very interesting pointer to a prospective trial.

9.3 Longer term effects of caesarean birth on children

Over recent years concerns have been raised about possible associations between CS and a number of adverse childhood health outcomes. (Cho *et al*, 2013; Allen *et al*, 2003; Souza *et al*, 2010; Lubiganon *et al*, 2010) There have been reports that children born by CS are at increased risk of respiratory illness in their first year of life (Souza *et al*, 2010; Bodner *et al*, 2011; Geller *et al*, 2009) and in later childhood (Thavagnanam *et al*, 2008; Kolokotroni *et al*, 2012), and relationships have also been described with diabetes and child overweight and obesity. (Huh *et al*, 2012; Li *et al*, 2013) However many factors influence child health beyond the mode of birth. An important limitation of many studies published to date has a lack of capacity to examine multiple physical and socio-emotional outcomes simultaneously across childhood, and thus account for the large number of potential confounding influences.

To address the limitations of studies published to date, the study described in this thesis used data from the birth cohort of the Longitudinal Study of Australian Children (LSAC). This rich dataset allowed a prospective examination across a

broad range of children's outcomes - from the first year of life until the age of nine years. The aim was to test whether children born by CS had higher rates of poor physical and socio-emotional outcomes compared to children born vaginally. After exclusion of children delivered in breech presentation, as one child of a multiple pregnancy, or where the method of birth could not be determined, a total of 4865 children were included in the final study group. A strength of this study was the use of the large prospective and population-representative sample available in LSAC, with a wide variety of measures across childhood available for study.

The proportion of children delivered by CS in the study was 28.2%: all the children in the study group were recruited in 2004 when the national rate of CS in Australia was 28.5%. We found that the children born by CS were more commonly delivered preterm, to have had low birthweight, and were more likely to have required intensive care or ventilator support. The families in the CS group were more likely to have been in the lowest quartile for socio-economic position, less likely to speak a language other than English at home, less likely to be a single-parent family, and less likely to have more children in the household. There were no differences between the two groups in the rates of overseas born parents, remote geographical location, or Indigenous status.

After analysis - accounting for birth factors, social vulnerability, maternal BMI, and breastfeeding - we found few differences in the long-term health and developmental outcomes of children delivered by CS compared to the children delivered vaginally. Children born by CS were more likely to have a medical condition in early childhood, and to use prescribed medication at at age six to seven years, but these findings were not present at other ages. An association between CS and increased child BMI at age eight to nine years was a relatively small effect, and it appeared to be mediated through maternal BMI rather than mode of birth. Women who are overweight and obese during pregnancy are more likely to undergo CS (Papachatzi *et al*, 2013), and maternal overweight and obesity are amongst the strongest risk factors for childhood obesity.(Williams *et al*, 2013; Chu *et al*, 2007) Intriguingly, children delivered by CS had better parent-reported global health at age two to three years, and higher on the prosocial scale at the beginning of school at age 6-7 years. Importantly, CS was not associated with any increase in the odds for asthma.

9.4 Are there other potentially preventable factors influencing the rate of caesarean section?

The factors thought to play a role in the increased rate of CS - increasing maternal age, particularly at the time of first birth (Baghurst *et al*, 2014; Smith *et al*, 2008; Essex *et al*, 2013; Klemetti *et al*, 2014), the increasing rate of overweight and obesity (Athukorala , 2010; Dodd *et al*, 2011), the fact that once a CS has been performed, the most likely mode of delivery in subsequent pregnancy is CS (Brennan *et al*, 2009; Homer *et al*, 2011; Karlstrom *et al*, 2011; Dahlen *et al*, 2013) – may or may not be amenable to change. Also, higher socio-economic status and possession of private health insurance are associated with higher rates of CS: thus, choice is likely to play a role.(Fairley *et al*, 2011; Wangel *et al*, 2012) As obvious as these factors seem to be, strategies aimed at reducing the rate of CS have had only modest success at best.(Khunpradit *et al*, 2011)

Taking these risk factors into account, it is likely that other influences exist and are affecting the rate of CS.(O'Leary *et al*, 2007) The aim of this study was to examine the importance of a range of pregnancy, birth, and family risk factors in predicting CS in Australia. Again, data were used from the LSAC in order to broaden evidence around CS in Australia. A number of pregnancy factors were associated with CS in the unadjusted models. Maternal smoking in pregnancy was associated with lower odds for CS. The use of any prescribed medication, medication for diabetes or hypertension, 'heartburn,' or indeed any other over-the-counter medications was associated with increased odds for CS. Importantly, maternal mental health problems, reported diabetes, and high blood pressure were also associated with increased odds of CS.

Perhaps unsurprisingly, two social factors were associated with increased odds for CS: higher annual household income; and, maternal age of 35 years or older. Yet other social factors were associated with lower odds of CS: maternal age less than 30 years; the child's father working in an unskilled occupation; a first language other than English; having two or more children in the household; fathers reporting a high educational level; and, the child's mother working in an unskilled occupation. Data from the fully adjusted model revealed caesarean birth was predicted by use of diabetes medication, use of heartburn medication, and

maternal mental health problems during pregnancy, maternal age greater than 35, and higher annual household income.

This study appears to be one of the first to examine the relationship between CS and a range of maternal and socio-economic factors simultaneously. Unexpectedly, the presence of maternal mental health problems during pregnancy increased the odds for CS: the strength of association was at least as strong as the association found between CS and maternal age over 35 years.

Mental health problems are common in Australia, affecting approximately one in five adults.(Slade *et al*, 2009) The findings build on evidence from Swedish population-based studies. One showed that hospital admission for mental health conditions in the five years prior to birth was associated with an increased risk of both elective and emergency CS.(Wangel *et al*, 2012) The other study reported that 'stress,' sleep difficulties, and 'worry' were all associated with an increased rate of emergency CS in first-time mothers.(Wangel *et al*, 2011)

It is quite possible that the presence of maternal mood disorders may be a surrogate for other predisposing factors, such as chronic medical conditions, social disadvantage, or stressful life events.(Wangel *et al*, 2011; McCourt *et al*, 2007) Whatever the association, detection in early pregnancy could potentially prompt appropriate evaluation of the pregnant woman and allow remedial management. It would seem useful to consider these effects using large-scale prospective research methods.

9.5 Maternal-choice caesarean section and the need for data

Changes in the demographics of women do not entirely explain the increase in CS rates seen in Australia and elsewhere. However, the contribution of MCCS to overall CS rates is difficult to define with precision (Lavender *et al*, 2012): an estimate from Australia suggested that almost 17% of all elective caesarean sections may be MCCS.(Robson *et al*, 2009) It is no secret that CS where no unequivocal maternal or fetal indication exists remains a polarising subject. The Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) official guidance states that obstetricians may "agree to perform the caesarean section provided the patient is able to demonstrate an understanding of

the risks and benefits."(RANZCOG, 2017) Yet in the state of New South Wales, Health Department policy states that "maternal request on its own is not an indication for elective caesarean section."(NSW Health Department, 2012)

To date no randomised controlled trial has been undertaken comparing true MCCS – not surrogate procedures typically used, such as 'elective' CS - with intended VB and no such trials are listed on trial registries.(Lavender *et al*, 2012) In many such studies 'planned' CS is used as a surrogate for MCCS, serving to inflate the apparent risks by including CS performed in women with medical complications or other co-morbidities. Published comparative studies have provided either inconclusive or conflicting data of low quality.(NICE, 2011) MCCS remains a difficult subject for study because of the associated stigma and with jurisdictional prohibitions in public hospitals. This stigma affects recruitment strategies, and the 'ideal' trial would allow anonymity not only of the woman but also her obstetrician.

In an attempt to do just this, we performed a pragmatic patient-preference cohort study similar to that described in Crowther and colleagues (2012) study of VBAC choice and outcomes. Recruitment was attempted through private obstetric practices in Australia: women in their first uncomplicated pregnancy planning either MCCS or vaginal birth. Yet despite estimates of 10000 MCCS performed in Australia every year, and contact with 379 obstetricians offering private obstetric hospital care over a two-year period, only 64 women planning MCCS and 113 women planning VB ultimately were recruited. Although the group of women planning MCCS was older and more likely to have had a delay in achieving pregnancy, in all other respects the demographic characteristics of the group were similar. The two most commonly-reported reasons for requesting MCCS were concerns about 'risks to the baby' and avoidance of 'vaginal trauma' in the short- and long-term.

To compound the recruitment problems, only 57 women in the MCCS group and 101 in the control (planned VB) group completed the questionnaires through to eight weeks after the EDD. Of the women who reported wanting MCCS at recruitment, 81% ultimately were delivered by CS, two by emergency CS. Of the women who had planned VB 44% went on to have an unassisted vaginal birth, and 23 (23%) were delivered by CS. There were no significant differences in the

gestation at birth and birthweights, however maternal and neonatal complications were more common in the planned VB group. The women in the MCCS group by 'intention-to-treat' reported higher levels of satisfaction with the birth experience.

The study served to highlight the predicted difficulties in undertaking prospective research into MCCS. The disappointing number of women recruited to the study likely reflects concerns about stigma and intangibles, such as private health insurance cover, serving as a disincentive to participation. Obstetricians may well have been reluctant to participate in recruitment as well. Recruiting and retaining enough women to provide sufficient statistical power to establish true differences in adverse outcomes such as serious maternal morbidities as infection, thromboembolic complications, and maternal death would be impossible without a very large international study. The debate surrounding MCCS would be, in most other areas of clinical medicine, a clear prompt for a randomised trial. However, it seems unlikely and our experience with this pragmatic observational study suggests that definitive evidence to guide the 'debate' around MCCS my forever be unattainable.

9.6 The World Health Organization recommended rate of CS

During the performance of each of the five major studies described in this thesis, it became clear that the paradigm promoted by the WHO of a maximum CS rate of 15% was pervasive in the literature and had been for three decades.(WHO, 2009) Despite the clarification that "there is no empirical evidence for an optimum percentage or range of percentages," and the concession "What matters most is that all women who need caesarean sections actually receive them," the WHO 'target' rate stood.(Gibbons *et al*, 2010) Indeed, a new stand-alone policy statement was released, since, "the international community has increasingly referenced the need to revisit the 1985 recommended rate." The recommendation was framed by this passage:

> "There is no evidence showing the benefits of caesarean delivery for women or infants who do not require the procedure… caesarean sections are associated with short and long term health risk which can extend many years beyond the current delivery and affect the health of the woman, her

child, and future pregnancies. These risks are higher in women with limited access to comprehensive obstetric care."(WHO, 2015)

Yet the original 1985 consensus opinion was based on the observation that many countries with low perinatal mortality rates had rates of CS less than 10%.(WHO, 1985) The WHO has almost 200 member countries with widely varying resources and demographics and the recommendation is, unquestionably, old. A more recent review of international data, for example from the World Bank *World Development Indicators* (WDI) database and other reliable sources, provided a contemporary review of neonatal and maternal mortality among the WHO member countries.(Molina *et al*, 2015) Attempting to overcome the inherent differences, the authors adjusted for a large range of factors. They concluded that the optimal CS rate was approximately 19% at an international level: remarkably, the global CS rate was estimated to be 19.4%.

For women who have their first birth vaginally, the rate of CS for the next baby is around 7% (Chen *et al*, 2013) and so CS rates in the first pregnancy are the most influential determinant of caesarean section subsequently: age at first birth strongly influences the overall rate of CS for a country.(Brennan *et al*, 2009; Homer *et al*, 2011) Where the median age at first birth in a country is 20 years or less, the vast majority of those countries have CS rates below the WHO recommended rate of 15%. Conversely, countries with national CS rates greater than 15% overwhelmingly have an age at first birth of greater than 20 years. Even here in Australia, with our high rates of caesarean birth, the rate of CS in teenaged mothers has averaged 17.4% with no significant increase since 2005.

There is no doubt that the outcomes informing the WHO recommendation – maternal and neonatal death rates – are important. However, they also are very rare in developed countries. What the WHO does not take into account is long term consequences of vaginal birth such as pelvic organ prolapse (POP) and urinary incontinence (UI). Women in developed countries face a lifetime risk of about 20% of undergoing surgery for POP and UI.(Wu *et al*, 2014) Women who have had vaginal births have a tenfold higher risk of undergoing surgery for POP compared to women having exclusively caesarean births (Leijonhufvud *et al*, 2014), and this increases more than 20-fold if they have undergone a forceps delivery. Similarly, women who had only given birth by CS have about half the

rate of UI.(MacArthur *et al*, 2011; Gyhagen *et al*, 2013) This is not an insubstantial issue: POP and UI consign women to symptoms that are often miserable to endure, last for many years, interfere markedly with quality of life, and commonly lead to surgical treatments associated with rates of complications and re-operation much greater than an initial CS.

The feared long term consequence of CS is placenta accreta, a complication of pregnancy with an estimated incidence of about one in 10000 births in Australia, although this rate appears to be increasing.(Kamara *et al*, 2013) The rate of this placental complication begins to increase with the third or subsequent caesarean section.(Usta *et al*, 2005; Nisenblat *et al*, 2006; Silver *et al*, 2006) Parity is decreasing in Australia, however, and third or higher births occur only for about 20% of women now.

9.7 Conclusion

All evidence suggests that an idealised and universal maximum target CS rate of 15% is too low, and the demographic profile of Australian women now makes such an achievement highly unlikely. It would also expose more women to a greater risk of surgery in later life. If our goal is to reduce the risk of CS to the minimal possible safe level, then population-level approaches to encouraging first pregnancy when women are young are most likely to achieve this. Women who do undergo CS can be reassured that the longterm health and developmental outcomes for their children are likely to be not different to those born vaginally. Should women and their partners wish to try for another child after a first CS, attention to engagement with the woman's partner – the baby's father – may increase the chance they will attempt VBAC. Rather than seeking to work to the goal of a 15% CS rate in Australia we should be aiming to provide CS to all women in need, and to include women themselves in the conversation about the benefits and disadvantages, both short and long term, of caesarean birth.

APPENDIX A

NICE GUIDELINES ON CAESAREAN SECTION: SUMMARY OF EFFECTS ON WOMEN'S HEALTH OF PLANNED CS.

ACCESIBLE AT: HTTPS://WWW.NICE.ORG.UK/GUIDANCE/CG132/CHAPTER/APPENDIX-C-PLANNED-CS-COMPARED-WITH-PLANNED-VAGINAL-BIRTH

Table 1 Summary effect on women's health of planned CS compared with planned vaginal birth for women with an uncomplicated pregnancy and no previous CS

Effects around the time of birth	Finding for planned CS	Finding for planned vaginal birth (including % unplanned CS in planned vaginal birth group)	Absolute effect	Relative effect (95% confidence interval)	Evidence quality and reference
Studies suggest may be reduced after a planned CS					
Perineal and abdominal pain during birth[i,l]	Median score 1.0	Median score 7.3 (10.3%)	6.3 lower	NC	Very low
Perineal and abdominal pain 3 days postpartum[i,l]	Median score 4.5	Median score 5.2 (10.3%)	0.7 lower	NC	Very low
Injury to vagina	0.0%	0.56% (14.7%)	6 fewer per 1000 (from 6 fewer to 2 fewer)	NC	Very low
Early postpartum haemorrhage	1.1%	6.0% (35%)	49 per 1000 (from 4 fewer to 56 fewer)	OR 0.23 (0.06 to 0.94)	Low
	3.9%	6.2% (8.3%)	23 fewer per 1000 (from 35 fewer to 6 fewer)	RR 0.06 (0.4 to 0.9)	Very low

Obstetric shock	0.006%	0.018% (8.2%)	12 fewer per 100,000 (from 17 fewer to 0.1 fewer)	RR 0.33 (0.11 to 0.99)	Very low
Studies suggest may be reduced after planned vaginal birth					
Length of hospital stay	3.2 days	2.6 days (35%)	0.6 days longer	Mean difference 1.58 (1.27 to 2.17)	Low
	3.96 days	2.56 days (8.2%)	1.4 days longer	Adjusted mean difference 1.47 (1.46 to 1.49)	Very low
Hysterectomy due to post-partum haemorrhage	0.03%	0.01% (8.2%)	14 more per 100,000 (from 3 more to 33 more)	RR 2.31 (1.30 to 4.09)	Very low
Cardiac arrest	0.19%	0.03% (8.2%)	15 more per 10,000 (from 11.5 more to 19.5 more)	RR 4.91 (3.95 to 6.11)	Very low
No difference found in studies					
Perineal and abdominal pain 4 months postpartum[si]	Median score 0.0	Median score 0.17 (10.3%)	0.17 lower	NC	Very low

Injury to bladder/ ureter	0.0%	0.14% (14.7%)	1 fewer per 1000 (from 2 fewer to 2 more)	NC	Very low
Injury to cervix	0.0%	0.28% (14.7%)	3 fewer per 1000 (from 3 fewer to 1 more)	NC	Very low
Iatrogenic surgical injury	0.00%	0.07% (14.7%)	7 fewer per 10,000 (from 10 fewer to 30 more)	NC	Very low
Pulmonary embolism	0.00%	0.003% (14.7%)	2 fewer per 10,000 (from 2 fewer to 40 more)	NC	Very low
Wound infection	0.01%	0.00% (35%)	1 more per 10,000	p = 1.0	Low
	1.5%	0.9% (8.3%)	6 more per 1000 (from 1 fewer to 19 more)	RR 1.7 (0.9 to 3.2)	Very low
Intraoperative trauma	0.1%	0.3% (8.3%)	1 fewer per 1000 (from 3 fewer to 7 more)	RR 0.5 (0.1 to 3.5)	Very low
Uterine rupture	0.02%	0.03% (8.2%)	13 fewer per 100,000 (from 22 fewer to 2.2 more)	RR 0.51 (0.25 to 1.07)	Very low

Assisted ventilation or intubation	0.01%	0.005% (8.2%)	7 more per 100,000 (from 0 fewer to 22 more)	RR 2.21 (0.99 to 4.90)	Very low
Acute renal failure	0.004%	0.001% (8.2%)	2 more per 100,000 (from 9 fewer to 13 more)	RR 2.17 (0.58 to 8.14)	Very low
Conflicting findings from studies					
Maternal death	9/737 (cases/ controls)	49/9133 (cases/controls) (Of maternal deaths occurring in the planned vaginal birth group 13/49 (26.5%) were women who gave birth by unplanned CS)	NC	OR 2.28 (1.11 to 4.65)	Very low
	0.00%	0.00% (14.7)	No difference (no events)	NC	Very low
	0.00%	0.002% (8.2%)	1.8 fewer per 10,000 (from 2 fewer to 6 more)	NC	Very low
Deep vein thrombosis	0.00%	0.03% (14.7%)	0.7 fewer per 1000 (from 0.2 fewer to 4 more)	NC	Very low

	0.06%	0.03% (8.2%)	32 more per 100,000 (from 14 more to 59 more	RR 2.20 (1.51 to 3.20)	Very low
Blood transfusion	1.7%	1.9% (35%)	2 fewer per 1000 (from 14 fewer to 34 more)	OR 0.87 (0.27 to 2.78)	Low
	0.3%	0.3% (14.7%)	0 fewer per 1000 (from 2 fewer to 5 more)	RR 0.89 (0.20 to 3.99)	Very low
	0.3%	0.4% (8.3%)	1 fewer per 1000 (from 2 fewer to 5 more)	RR 0.7 (0.2 to 2.7)	Very low
	0.02%	0.07% (8.2%)	41 fewer per 100,000 (from 53 fewer to 23 fewer)	RR 0.20 (0.20 to 0.64)	Very low
Infection – wound and postpartum	1.1%	0.8% (14.7%)	3 more per 1000 (from 2 fewer to 11 more)	RR 1.36 (0.75 to 2.4)	Very low
	0.6%	0.21% (8.2%)	390 more per 100,000 (from 323 more to 464 more)	RR 2.85 (2.52 to 3.21)	Very low

Hysterectomy	0.6%	0.1% (35%)	5 more per 1000	p = 0.13	Low
	0.1%	0.01% (14.7%)	1 more per 1000 (from 0 more to 5 more)	RR 9.09 (1.36 to 60.33)	Very low
	0.06%	0.02% (8.2%)	41 more per 100,000 (from 23.6 more to 68 more)	RR 3.60 (2.44 to 5.31)	Very low
Anaesthetic complications	0.4%	0.3% (14.7%)	1 more per 1000 (from 2 fewer to 11 more)	RR 1.24 (0.34 to 4.59)	Very low
	0.53%	0.21% (8.2%)	319 more per 100,000 (from 257 more to 389 more)	RR 2.5 (2.22 to 2.86)	Very low
CS, caesarean section; OR, odds ratio; RR, relative risk; NC, not calculable					
[a] score/10, higher scores indicate higher pain levels					

Table 2 Summary effect on babies' health of planned CS compared with planned vaginal birth for women with an uncomplicated pregnancy and no previous CS

Effects around the time of birth	Finding for planned CS	Finding for planned vaginal birth (including % unplanned CS in vaginal birth group	Absolute effect	Relative effect (95% confidence interval)	Evidence quality and reference
Studies suggest may be reduced after planned vaginal birth					
NICU admission	13.9%	6.3% (35%)	76 more per 1000 (from 31 more to 134 more)	RR 2.20 (1.4 to 3.18)	Low
No difference found in studies					
Hypoxic-ischaemic Encephalopathy (CNS depression, seizures, pH < 7)	0.2%	0.2% (14.7%)	0 fewer per 1000 (from 2 fewer to 5 more)	RR 0.81 (0.22 to 3.00)	Very low
Intracranial haemorrhage	0.00%	0.01% (14.7%)	0.2 fewer per 1000 (from 0.4 fewer to 3 more)	NC	Very low
Neonatal respiratory morbidity	12.0%	11.5% (14.7%)	5 more per 1000 (from 14 fewer to 27 more)	RR 1.04 (0.88 to 1.23)	Very low
Conflicting findings from studies					
Neonatal mortality	0.0%	0.1% (14.7%)	1 fewer per 1000 live births (from 1 fewer to 2 more)	NC	Very low
	0.17%	0.07% (7.9%)	1 more per 1000 live births (from 1 more to 2 more)	RR 2.4 (2.20 to 2.65)	Very low

Apgar score at 5 mins < 7	0.0%	0.5% (14.7%)	5 fewer per 1000 (from 5 fewer to 1 fewer)	NC	Very low
	0.6%	1.2% (35%)	6 fewer per 1000 (from 9 fewer to 157 more)	RR 0.44 (0.07 to 2.51)	Very low
CS, caesarean section; NICU, neonatal intensive care unit; CNS, central nervous system; RR, relative risk; NC, not calculable					

APPENDIX B

DATA COLLECTION FOR THE LONGITUDINAL STUDY OF AUSTRALIAN CHILDREN

Core measures	**Socio-demographic information** *Household - details on all members* **Family** Family structure (parents'marital status, presence/absence of parent, Step-parent, age and other details of siblings, adoption/foster status) Children's sex and ages Parental sex and ages Family transitions — nature, timing, number Mobility **Parents'work** Work status (full-time/part-time, casual/permanent/temporary) Occupation Work history Work conditions, hours Family-friendly practices/flexibility **Parents' income** Earnings (gross/net/personal/household) Income support (amounts and types) Total income bracket Financial stress **Parents' (other) human capital** Education Ethnic background Country of birth Ethnic identity Language (including English proficiency) Religious identity **Child functioning** Behavioural (externalising, hyperactivity, etc) Emotional (internalising, anxiety, etc) Temperament Self regulation, empathy Motor/physical development Social competence **Characteristics of home** Location (region/physical environment) Type/condition of dwelling Overcrowding Cleanliness/orderliness **Community** Availability and use of parks, other amenities Involvement in local groups Perception of community safety Neighbourhood (trust, knowledge and involvement) Services Access/use/satisfaction with services (libraries,maternal an child health clinics, hospitals, family/community centres, pre-schools, child care, legal, counselling etc) **Other**

	Consent for biological measures, data linkage
Family functioning	**Parenting cognitions and practices (intact & separated parents)** Beliefs and goals Discipline practices Consistency, monitoring Involvement of self and other parent in various domains Agreement/conflict between parents about parenting Parenting self-efficacy Parenting stress/coping Attitudes and expectations about: Education Work Cultural issues Gender roles Parental role stress Work and family balance Stressful life events Parenting education **Relationships** Parents' marital relationship / co-parental relationship Family cohesion Sibling relationships Parent-child relationship Child's friends/ peer groups **Social supports** Wider family Other social support
Educational	**Child 4 years** Language and cognitive development Readiness to learn Pre-literacy activities Participation in preschool/kinder programs Use of libraries / books, at-home reading Children's out-of-home activities Parent attitudes and expectations about education Language stimulation Carer/teacher — child relationship Family-centre relationship, involvement Teacher characteristics Characteristics of school/preschool Child-staff ratio Group sizes Ethos, climate
Health	**Overall health** Illness, disability (type/duration) Immunisation Biological measures Height Weight Diet Motor/physical development, coordination **Child 0 years** Gestation and birth Birth weight Birth length Feeding (breast/bottle) Full-term/premature

	Child 4 years Gestation and birth cognitive measures Biological measure: girth Obesity: diet, physical activity/sport/TV/computer **Parental health** Overall health Illness, disability (type/duration) Maternal stress (in pregnancy, post-natal) Substance use Lifestyle (healthy)
Child care	**Child care / Preschool/kindergarten** Availability/access issues Current use — time, hours etc Current cost, affordability Age at entry Current type (includes multiple) Changes/adjustment to transition Characteristics of centre and program Child-staff ratio Group sizes Quality indicators (eg accreditation) **Parents** Satisfaction with care Preferences Reasons for use **Relationships** Carer/teacher—child relationship Family—centre relationship, involvement

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