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

Peter BAGHURST,[1] Stephen ROBSON,[2] Georgia ANTONIOU,[3] Wendy SCHEIL[4] and Robert BRYCE[5]

[1]*School of Reproductive Medicine and Paediatrics, Faculty of Health Sciences, University of Adelaide, Adelaide, South Australia, Australia,* [2]*Department of Obstetrics and Gynaecology, Australian National University Medical School, Canberra, Australian Capital Territory, Australia,* [3]*Department of Orthopaedic Surgery, Women's and Children's Hospital,* [4]*Pregnancy Outcome Unit, South Australian Department of Health, and* [5]*Centre for Perinatal Care, Flinders Medical Centre, Adelaide, South Australia, Australia*

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.

Introduction

The proportion of babies born by caesarean section in Australia has increased from 18% in 1991 to 31.6% in 2010, a relative increase of 75% over that time period.[1] The reasons put forward to explain such an increase have included evolution in patterns of obstetric practice such as reluctance to manage complex vaginal births[2,3] and maternally requested caesarean sections.[4,5] At the same time, the proportion of instrumental deliveries have been static or decreased[1], suggesting some substitution of caesarean section for instrumental births. Few strategies seem to be effective in reducing the incidence of caesarean section, suggesting that causes other than patterns of clinical practice or patient demand may be influential.[6]

Over the same period that the incidence of caesarean section has been increasing, demographic characteristics within the population of women giving birth have also changed, in particular maternal age. One-third of women in Australia who gave birth to their first child in 1998 were aged 30 years or older; yet, by 2008, this proportion had increased to 42% and included 15% who were aged 35 years or over at the time of their first birth.[7] Smith and colleagues reported that 38% of the increased incidence of primary caesarean section in Scotland over the period 1980–2005 could be explained by the increase in age of women at first birth.[8] They estimated that the odds of caesarean section increased by about 1.5 for every five-year rise in maternal age. Similar recent studies from the United Kingdom[9] and Finland[10] have also reported that

Correspondence: Ass. Prof Stephen Robson, Centenary Hospital for Women and Children, PO Box 11, Woden, ACT 2606, Australia.
Email: Stephen.robson@anu.edu.au

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increasing maternal age in primiparous women is associated with an increasing rate of caesarean section. Caesarean delivery in a first labour has a powerful flow-on effect in subsequent births, since it is the largest determinant of the likelihood of caesarean section in subsequent pregnancies.[11,12] We sought to establish whether an association between maternal age at first birth and labour outcome exists in South Australia, and to what degree this could account for the observed increase in the incidence of caesarean section.

Materials and Methods

To examine the contribution of maternal age to the outcome of labour in first births, we examined births other than spontaneous vaginal births (SVB): that is, labour ending in any method of birth other than a spontaneous vaginal birth. This allowed for changes in obstetric practice over time, with substitution of caesarean section for many instrumental vaginal births, and also to account for the fact that factors other than pure dystocia might contribute to rates of caesarean section and instrumental birth. Thus, labours ending in either emergency caesarean section or instrumental birth were considered. Data for all first births in South Australia over the period 1991–2009 were obtained from the South Australian Pregnancy Outcome Statistics Unit, which maintains South Australia's perinatal statistics collection. Only first births were considered to exclude the obvious influence of previous birth outcomes.

Women who gave birth by prelabour (elective) caesarean section were excluded from the denominator used to calculate the incidence of non-SVB. Also excluded were multiple births, preterm and postterm births (<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 kg. Data were then extracted from the perinatal data set for analysis. Only variables that were consistently recorded across the entire study period were included. Regrettably, information about maternal obesity and BMI was only recorded in recent years so were unable to be included.

Logistic regression models, incorporating the potential confounders available in the data collection, were fitted using Stata, version 10.1 for Windows (StataCorp LP, College Station, TX, USA) and compared using standard statistical methods In the regression modelling, terms in maternal age were initially fitted using both natural splines and polynomials. Given that modelling with splines generated only marginal improvements in the fit achieved with a simple linear term in maternal age, the latter has been used for reporting here. Potential confounders included gestational age at birth, private versus public hospital status, racial background, diabetes (pre-existing and gestational), hypertension (pre-existing and pregnancy-induced), antepartum haemorrhage, use of induction and epidural analgesia/anaesthesia, gender and birthweight of the baby, and the advantage/disadvantage score from the Socio-Economic Indexes for Areas (SEIFA). The coding of categorical variables is shown in Tables 1 and 2. The modelling strategy involved firstly the fitting of a simple term in maternal age, ignoring all the potential confounders, and secondly, the fitting of maternal age together with all the potential confounders. These fits were compared with a smoothed fit to the observed data for each calendar year. The project received ethics approval from the South Australian Government Health Department, Human Research Ethics Committee.

Table 1 Logistic regression analysis of term first births requiring instrumental assistance or emergency caesarean section in SA, 1991–2009

Predictor	Unadjusted odds ratio	*P*	Adjusted odds ratio	*P*
Gestation				
37 weeks	0.82	<0.001	0.94	0.06
38 weeks	0.85	<0.001	0.88	<0.001
39 weeks	0.89	<0.001	0.90	<0.001
40 weeks	1		1	
41 weeks	1.42	<0.001	1.18	<0.001
Hospital status				
Public	1		1	
Private	1.90	<0.001	1.19	<0.001
Race				
Aboriginal or TSI	0.68	<0.001	1.51	<0.001
Asian	1.06	0.023	1.40	<0.001
Caucasian	1		1	
Other	1.07	0.16	1.46	<0.001
Pre-existing hypertension	1.87	<0.001	1.22	0.002
Pre-existing diabetes	3.32	<0.001	2.46	<0.001
Pregnancy-induced hypertension	1.64	<0.001	1.31	<0.001
Gestational diabetes	1.62	<0.001	1.23	<0.001
Antepartum haemorrhage	1.09	0.015	1.15	0.001
Epidural analgesia or anaesthesia	4.98	<0.001	4.41	<0.001
Induction	2.00	<0.001	1.36	<0.001
Gender				
Male	1		1	
Female	0.79	<0.001	0.81	<0.001
Birthweight	1.0007	<0.001	1.0005	<0.001
Advantage score (SEIFA)				
Highest	1		1	
High	0.92	<0.001	1.14	<0.001
Middle	0.84	<0.001	1.14	<0.001
Low	0.82	<0.001	1.18	<0.001
Lowest	0.70	<0.001	1.25	<0.001
Non-SA resident	0.81	0.022	1.18	0.11
Maternal age (simple linear)	1.090	<0.001	1.083	<0.001

SEIFA, Socio-Economic Indexes For Area.
Elective CS, gestation <37 weeks or >41 weeks, birthweight <2000 g, and fetal deaths are all excluded.

Table 2 Logistic regression analysis of term first births by emergency caesarean section in SA 1991–2009

Predictor	Unadjusted odds ratio	*P*	Adjusted odds ratio	*P*
Gestation				
37 weeks	0.97	0.34	1.15	<0.001
38 weeks	0.92	<0.001	0.95	0.06
39 weeks	0.92	<0.001	0.96	0.043
40 weeks	1		1	
41 weeks	1.64	<0.001	1.26	<0.001
Hospital status				
Public	1		1	
Private	1.43	<0.001	0.996	0.8
Race				
Aboriginal or TSI	1.06	0.28	2.03	<0.001
Asian	1.04	0.17	1.28	<0.001
Caucasian	1		1	
Other	1.21	0.001	1.52	<0.001
Pre-existing Hypertension	1.88	<0.001	1.21	0.003
Pre-existing diabetes	4.31	<0.001	2.90	<0.001
Pregnancy-induced Hypertension	1.71	<0.001	1.31	<0.001
Gestational diabetes	1.78	<0.001	1.33	<0.001
Antepartum Haemorrhage	1.12	0.009	1.13	0.006
Epidural analgesia or anaesthesia	2.81	<0.001	2.31	<0.001
Induction	2.41	<0.001	1.76	<0.001
Gender				
Male	1		1	
Female	0.78	<0.001	0.83	<0.001
Birthweight	1.0007	<0.001	1.0006	<0.001
Advantage/disadvantage score (SEIFA)				
Highest	1		1	
High	0.92	0.001	1.06	0.03
Middle	0.90	<0.001	1.10	<0.001
Low	0.85	<0.001	1.08	0.002
Lowest	0.78	<0.001	1.15	<0.001
Non-SA resident	0.995	0.97	1.24	0.06
Maternal age (simple linear)	1.073	<0.001	1.069	<0.001

SEIFA, Socio-Economic Indexes For Area.
Elective CS, gestation <37 weeks or >41 weeks, birthweight <2000 g, and fetal deaths are all excluded.

Results

A total of 117 981 first births following labour were eligible for inclusion in the analysis of the study period 1991–2009, representing 32.8% of all South Australian births. Figure 1 shows that the proportion of dysfunctional labour was relatively stable in the early 1990s, and again from 2005 to 2009, with a rise of around 6% over the intervening period. The proportion of caesarean sections rose proportionally more than instrumental delivery over the study period (9.1% vs 5.6%, respectively) suggesting a substitution of caesarean section for instrumental vaginal births, at least until 2008 and 2009, when intrapartum caesarean sections declined slightly.(Fig. 2).

Figure 3 shows a rise in mean maternal age at first birth from 25.4 years in 1991, to 27.5 years in 2009. Associations between maternal age at first birth and the incidence of dysfunctional labour and emergency caesarean section are apparent in Figure 4. Logistic regression models taking into account many of the major risk factors known to be associated with birth other than SVB and emergency caesarean section are summarised in Tables 1 and 2. The models revealed that the odds of non-SVB increased multiplicatively by approximately 1.083 (95% CI, 1.080–1.086) for every year increase in maternal age or 1.49 for every 5 year increase. Similarly, 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.

Figure 5 presents a comparison of the ability of two statistical models to describe the pattern of change in dysfunctional labour from 1991 to 2009. The thick solid line displays the fitted values generated by a model containing only maternal age. Overall, maternal age predicted a 4.2% increase in dysfunctional labour from 1991 to 2009 (compared with the observed increase of 5.6%); and while it was not a good fit, it did at least capture 75% of the relative increase in birth other than SVB observed over this time period. The second model, containing other covariates and confounders of dysfunctional labour in addition to maternal age, fitted the observations only a little better. This suggested that additional unmeasured factors, which may have included changes in practice over time, have also played an important role.

Discussion

Our analysis showed an association between maternal age at first birth and labour outcome over the 19-year study period, which appeared to explain the majority of the increase in births other than SVB. This result was consistent with the study by Smith *et al.*, and strengthened the evidence that changes in the demographics of women giving birth for the first time make an important contribution to the changes in labour outcome.[8] A Finnish study comparing birth outcomes for primiparous women between 1991 and 2008 also reported similar findings.[10] In that study, the use of caesarean section in women aged 20–34 years was 17% in 1991, compared with 20% by 2008. However, over the same time period, for primiparous women aged 40 or older, the use of caesarean section actually fell slightly from 45% to 41%: the contribution was greater as the proportion of women in the older age group almost doubled during the 18-year study period. A study from the United Kingdom[9] reported that the use of intrapartum caesarean section increased sharply from 9.4% in women aged <20 to 30.3% in women aged 35 or more.

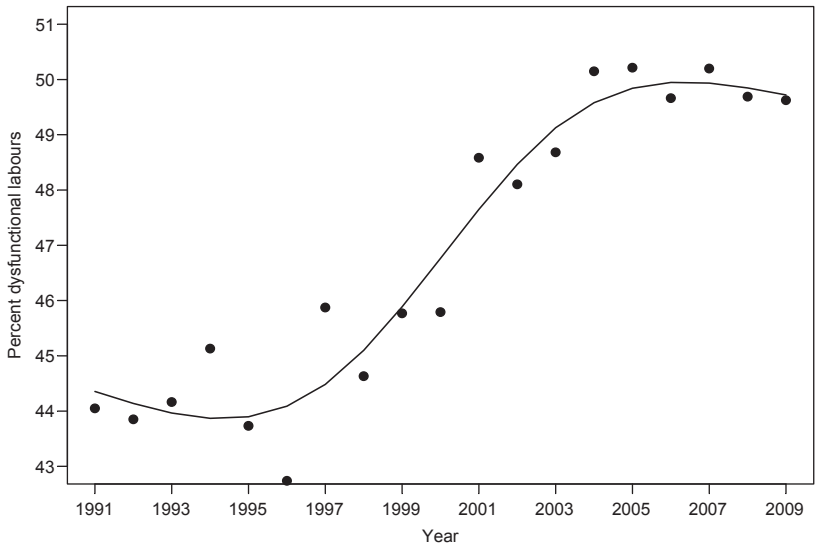

Figure 1 A plot showing the rising incidence, in South Australia, 1991–2009, of term first-birth labours requiring either instrument assistance or intrapartum caesarean section. The trend line was generated using natural splines.

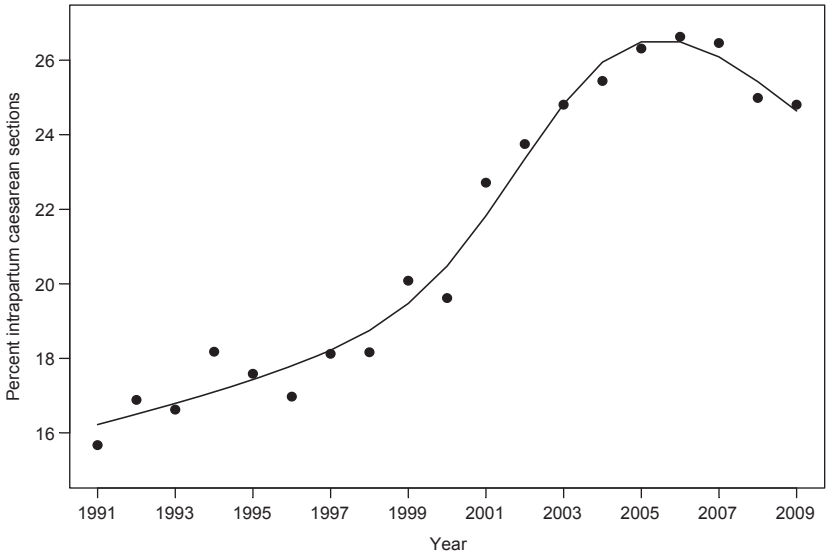

Figure 2 A plot showing the rising incidence in South Australia, 1991–2009, of term first-birth labours ending with intrapartum caesarean section only. The trend line was generated using natural splines.

Recent studies have provided a possible explanation for the mechanism underlying the effect of age on the progress of labour. The contractile function of myometrial muscle *in vivo* has been shown to be adversely affected by an increasing length of time between menarche and first birth, and hence maternal age at first labour. When uterine muscle biopsies, harvested at the time of elective caesarean section, were tested for contractility in response to potassium they found that spontaneous contractile activity decreased with increased maternal age.[8]

An important potential weakness of the study was our inability to adjust for the effect of obesity, as data regarding maternal obesity were only available for births in the last two years of the study period: there is evidence that maternal obesity is also associated with the outcome of labour.[13,14] 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 61% of Australian adults aged 18 years and over were either overweight or obese in 2007–2008.[15] A similar *in vivo* relationship to that of increasing maternal age has been demonstrated between maternal obesity and uterine contraction.[16–18]

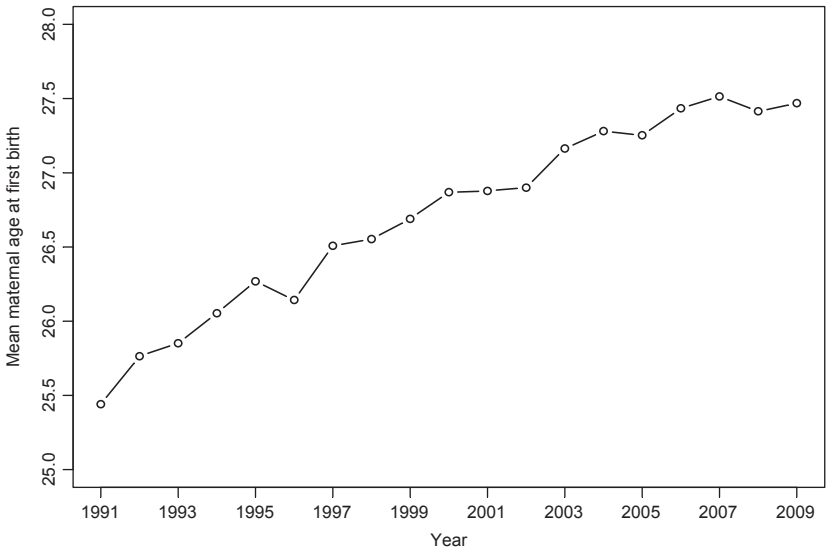

Figure 3 A plot of mean maternal age in South Australia, 1991–versus calendar year for term singleton first births. (Births by elective section, or for which the birthweight was <2000 g were not included).

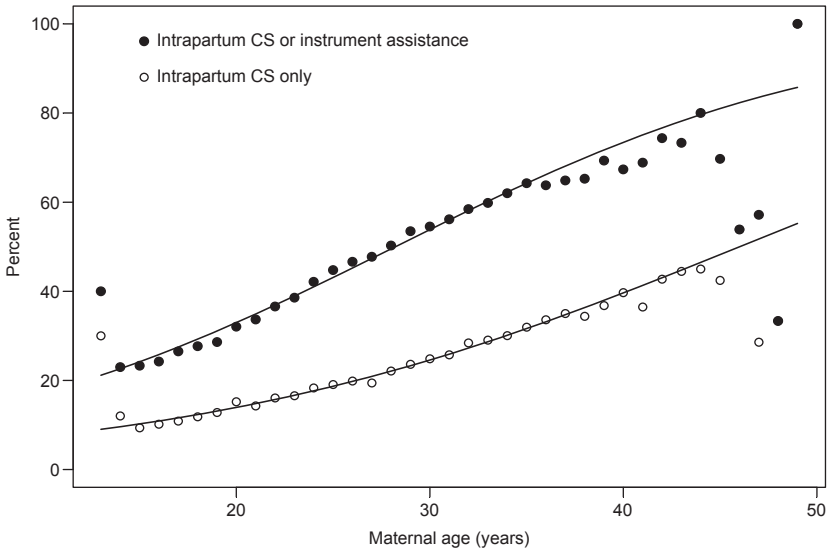

Figure 4 Plots showing the dependence on maternal age of the incidence of (1) term first-birth labours requiring either instrument assistance or intrapartum caesarean section (solid circles); and (2) term first-birth labours ending with intrapartum caesarean section (open circles).

While changes in maternal characteristics appear to have contributed to the increase in caesarean section rates over the study period, there are obviously other influential factors as well, including the influence of elective caesarean section and an increase in induction of labour. Experience in vaginal breech delivery[19], instrumental deliveries from high station or rotational forceps deliveries[20] have also reduced over the period of the study, likely influencing practice.

A study from New South Wales[21] concluded that maternal age could account for at most 21% of the increase in elective and intrapartum caesarean sections among first-time mothers over the period 1994–2010, which is well below our estimate of 75% of the increase in dysfunctional labour. We considered both instrumental deliveries and caesarean sections as appropriate surrogates for dysfunctional labour, whereas the approach adopted in that study was conservative in that it would have attributed to maternal age only that proportion of the increase in intrapartum caesarean sections that could not be explained by the other risk factors used in their modelling. The risk factors they used were not revealed

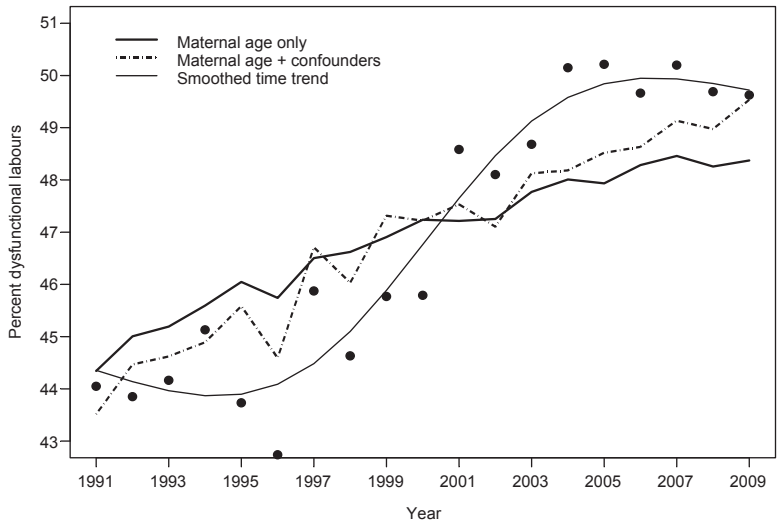

Figure 5 A comparison of three models fitted to the incidence (%) of dysfunctional labour in term first births for the period 1991–2009. The thin black line shows the smoothed trend line fitted to the observed annual incidence; the thick black line shows the fitted incidence generated by a model in which the only predictor was maternal age; and the broken line shows the fitted values for a model containing terms in maternal age and other risk factors, as listed in Tables 1 and 2.

but if any of those risk factors were correlated with, or confounded with maternal age, which is extremely likely, then any apparent effect attributable to maternal age would have been substantially diminished.

Our analysis suggested that advancing maternal age at first birth does not, on its own, completely account for the rising incidence of non-SVB in South Australia during the two decades until 2009, but it did reveal that the majority of that increase might be associated with increasing maternal age at first birth. This information has important implications for counselling women, both before and during pregnancy, regarding the implications of their age on labour outcomes. It should also assist in planning for provision of maternity services, because these results suggest that maternal age at first birth is an important contributor to births other than SVB, and hence, the primary caesarean section rate.

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