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Recent Trends in the Caesarean Section Rate in Ireland 1999-2006

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Abstract: This paper explores levels and trends in the prevalence of caesarean section delivery in Ireland between 1999 and 2006. Over this period the caesarean section rate in Ireland increased by almost one quarter. Using data from the Irish National Perinatal Reporting System we examine the contribution of maternal, birth/infant and hospital characteristics on the rise in the caesarean section rate over the period. International evidence suggests that earlier gestational age of child, older maternal age at birth, higher socio-economic status of mother and birth within a private hospital all increase the risk of caesarean section. Controlling for changes in the prevalence of these and other risk factors between 1999 and 2006 only explains half of the increase in the caesarean section rate amongst singleton delivery first time mothers. This suggests that changes in physician behaviour over the period may well play a significant role.

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I Introduction

A caesarean section is an operation in which the baby is born through an incision in the woman's abdomen and uterus. In 1997, UNICEF and the World Health Organisation (WHO) stated that caesarean sections should account for not less than 5 nor more than 15% of all births (UNICEF *et al.*, 1997). This was a restatement of the WHOs original recommendation published over 10 years earlier (WHO, 1985), in which it was stated that there were no additional health benefits associated with a rate above 10-15% based on an examination of estimates of national caesarean section rates and perinatal and maternal mortality rates from various countries.[1] Despite this recommendation and initiatives to curb the trend the caesarean section rate in Ireland increased beyond the WHO maximum in the mid-nineties. In 1993 the Department of Health and Children reported a caesarean section rate of 13%, by 1999, the next year for which data was available, the rate had increased to 20.5% of total births (HIPE & NPRS Unit ESRI, 2002). That represents a 57.2% increase over a 7 year period and was even greater than that experienced in the England which reported a 37.2 per increase in the caesarean section rate over the same period.

Studies have shown that caesarean section increases risks for both mothers and babies when compared to spontaneous vaginal birth and the consensus tends to be that a lower caesarean section rate is preferable. Research has identified sets of risk factors and many countries including the UK have developed clinical guidelines in an attempt to reduce the rate (National Collaborating Centre for Women's and Children's Health, 2004). As well as clinical risks a caesarean section is significantly more expensive than a vaginal delivery which has implications for health service provision.

The aim of this paper is to explain the trend in caesarean section rate in Ireland using data from the National Perinatal Reporting System (NPRS) from 1999 to 2006. The paper is laid out as follows. The next section examines the relevant Irish and international literature on caesarean section rates. This is followed by a discussion of

[1] In setting the acceptable levels it was deemed appropriate to select a conservative lower limit and a maximum that is slightly higher than the level reported in most developed countries, but less than the levels in those countries known to have excessive use of the procedure.

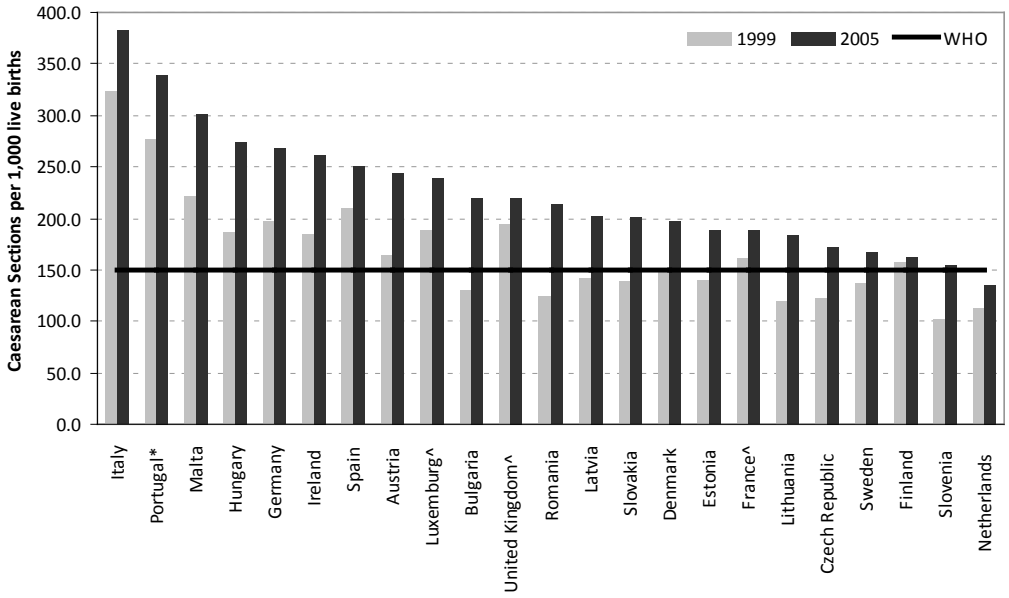
the NPRS data used for the paper in Section III. Section IV is a descriptive analysis of the caesarean section rate in Ireland between 1999 and 2006. It examines the factors deemed to influence the change in the caesarean section rate by the literature. Using logit models Section V examines the factors leading to the increasing trend in the caesarean section rate. Finally, in Section VI we summarise our findings, draw out some conclusions and outline directions for future research.

II Literature

We begin by examining caesarean section rates across the EU-27 to see how Ireland compares to other countries and how this has changed between 1999 and 2005. Figure 1 below illustrates the number of caesarean sections per 1,000 live births in the EU-27 in 1999 and 2005. There has been an increase in the number of caesarean sections per 1,000 live births in all countries. Italy consistently had the highest number of caesarean sections per 1,000 live births with a rate of 382.4 per 1,000 live births in 2005, over two and a half times the WHO upper limit. In 2005, only the Netherlands had a caesarean section rate of less than the 15% recommended by the WHO, at 135.1 per 1,000 live births.

It is not only in Europe that caesarean section rates continue to rise. In 2006 the caesarean section rate in the United States stood at 31.1% or almost one third of all births, this was the highest rate ever recorded in the United States (Martin *et al.*, 2009). This reflects a 50% increase from its level of 20.7% in 1996.

Figure 1: *Caesarean sections per 1,000 live births 1999 and 2005*



Source: WHO Regional Office for Europe 2009)
Notes: * 1999 data was unavailable for Portugal, data from 2000 is substituted
^ 2005 data was unavailable for Luxembourg, United Kingdom, and France, data from 2004 is substituted
Data were unavailable for Cyprus, Poland and Greece for both years.

As the caesarean section rate continues to rise, both in Ireland and internationally, it is important to highlight the impact such an invasive surgical procedure can have on the health outcomes of mothers and babies, including higher morbidity and mortality rates. In addition, caesarean section delivery has cost implications for health services as it is found to be significantly more expensive than spontaneous vaginal delivery.

The National Institute for Clinical Excellence (NICE) in the UK published a set of clinical guidelines for caesarean section in 2004. These guidelines are recommendations on the appropriate treatment and care of people with specific diseases and conditions within the NHS, in this case caesarean section. The guidelines are based on the best available evidence. As part of these guidelines they have summarised the effects of caesarean section compared with vaginal delivery for women (National Collaborating Centre for Women's and Children's Health, 2004), p18). They outline several conditions that are more likely to affect the mother after caesarean section compared with vaginal birth. These include abdominal pain, the need for further surgery, increased length of stay, hysterectomy, uterine rupture and maternal death amongst others.

In addition to the effects outlined by NICE, Sakala (2006) highlights a range of social and emotional harms of caesarean sections to mothers including poor birth experience, less early contact with baby, and poor overall mental health. Increased caesarean section rates are found to be associated with the increased postpartum use of antibiotics and greater severe maternal morbidity and mortality (Villar *et al.,* 2006).

A recent study found that delivery by caesarean section significantly increased the risk of having a hysterectomy, usually indicated by severe uterine haemorrhage, during the same clinical episode as the delivery of a foetus or infant, and this risk increased with the number of previous caesarean deliveries (Knight *et al.*, 2008).

As well as the increased risks for mothers there are notable increased risks from delivery by caesarean section for babies. Research from the UK shows that 35 of every 1,000 babies born by caesarean section have breathing problems just after the birth, compared with 5 of every 1000 babies after a vaginal birth (National Collaborating Centre for Women's and Children's Health, 2004).

As well as mild-to-severe respiratory problems Sakala (2006) also found an increase in the risk of accidental surgical cuts, non-establishment of breastfeeding and childhood and adulthood trauma among children born through caesarean. They conclude that 'without clear and well-supported justification for caesarean section or assisted vaginal birth, a spontaneous vaginal birth that minimizes use of interventions that may be injurious to mothers and babies is the safest way for women to give birth and babies to be born' (p5).

In the United States, MacDorman *et al.* (2006) found that for first time mothers (primiparous), infant mortality rates for 'no indicated risk' mothers were 56% higher for caesarean deliveries than those delivered vaginally. For mothers who had given birth before (multiparous), infant mortality rates for first caesarean deliveries were more than twice that for vaginal deliveries. When statistically adjusted for demographic and medical covariates the difference in neonatal mortality rates between caesarean and vaginal deliveries was only moderately reduced.

As well as clinical outcomes for mothers and babies the cost of the increasing number of caesarean sections is an issue that has been highlighted by a number of studies. In a systematic review of the economic aspects of alternative modes of delivery (1990-1999) Henderson *et al.* (2001) confirm that caesarean section is a more

costly mode of delivery than vaginal delivery. The cost of a caesarean delivery is related to the increased level of staffing required for a delivery of this type and an extended in-patient length of stay.

In an earlier report by the Audit Commission (1997) it was reported that a 1% rise in the caesarean section rate costs the NHS £5 million per year. A study of Scottish data in 2002 examined the economic costs of alternative modes of delivery during the first two months postpartum (Petrou and Glazener, 2002). This found that initial hospitalisation costs for caesarean section delivery were over twice those for spontaneous vaginal delivery. When other costs such as hospital readmissions, midwifery care, general practitioner care and health visitor support were accounted for caesarean deliveries were found to cost 1.8 times as much as spontaneous vaginal deliveries.

What factors influence the caesarean section rate and its increase over time?

International research literature suggests two main groups of reasons for the increasing rate of caesarean section over time across different countries. First, the clinical need for section may have increased, i.e. the clinical indicators may have become more prevalent over time. Across the literature there is significant consensus regarding the clinical indicators for caesarean section. The most frequently cited indicators are previous caesarean section, failure to progress (dystocia), fetal compromise and breech presentation (Taffel *et al.*, 1987); Anderson and Lomas, 1989); Henry *et al.*, 1995). In the National Sentinel Caesarean Section Audit in the UK, these four indicators together accounted for almost 70% of the caesarean section rate in England (Thomas and Paranjothy, 2001).[2] There has been little international research on how changes in these indicators over time are contributing to the increasing trend of caesarean section deliveries. Both Gregory *et al.* (1998) using US data, and Liu *et al.* (2004) using Canadian data highlight increases in caesarean deliveries for dystocia.

These clinical indicators can be seen as the proximate cause of caesarean section but the prevalence of these proximate causes may change as a result of change in trends in foetal and maternal characteristics. In particular, more multiple births,

[2] 'These data may need to be treated with caution because: there may be more than one indication to the decision to perform a caesarean section, and there may not be consistency in deciding the primary indication.' Thomas and Paranjothy (2001), p 20.

increasing maternal age, increasing maternal weight both before and during pregnancy and decreasing parity have been the focus of much research in this area and have been found to be a major contributing factor to trends in the clinical indicators for caesarean section (Joseph *et al.,* 2003). Higher maternal age increases the risk of hypertension, diabetes mellitus and other antenatal complications thus increasing the clinical need for section.

Changing maternal characteristics are themselves driven by wider social forces. The increasing age of mothers at birth reflects increasing educational and occupational attainment among women in the latter part of the 20th Century across a large number of countries leading to delayed fertility and smaller families (Blossfeld and Drobnic, 2001). Higher maternal weight reflects trends in diet and exercise across western industrial nations and increasing levels of obesity and overweight (International Obesity Taskforce, 2005).

The second group of reasons often cited for the increasing trend in caesarean section are changes in the preferences and behaviour of pregnant women and physicians. A growing tendency for women to request a caesarean section has been frequently put forward as a reason for recent trends in the caesarean section rate but evidence on the issue is sparse and that which does exist is mixed. A survey of obstetricians by Weaver *et al.,* 2007) asked for the three main reasons that they felt were responsible for the rising caesarean section rate. The survey found that maternal request was most frequently cited as the most important factor although the majority of respondents point out that they did not personally receive many requests for them. On the other hand, the national caesarean section audit in the UK (Thomas and Paranjothy, 2001) found that maternal request as reported by clinicians was a primary indication for only 7% of caesarean sections in the UK. Reviews of the literature by McCourt *et al.* (2007) and Gamble *et al.* (2007) found little evidence that women are requesting caesarean sections and concluded that maternal request is not a significant factor influencing caesarean section rates.

Changing physician behaviour in the form of obstetric practice could also play a role. After maternal request the second most important causal factor highlighted by the obstetricians surveyed in Weaver *et al.* (2007) for the rising caesarean section rate was litigation/defensive practice. The medico-legal environment was identified as a reason for rising caesarean section rates in the early 1980s in the United States when

Weekes (1983) highlighted the failure to carry out a caesarean section which results in disability as a major issue. Using Canadian data on primary caesarean section rates Joseph *et al.* (2003) found that the recent increases in the primary caesarean delivery rates can be attributed in part to changes in obstetric practice. Changes in obstetric practice included reductions in mid-pelvic forceps use, increases in the use of caesarean for breech presentation, labour induction, epidural anaesthesia, and obstetrician delivery. The authors point out that the changes in obstetric practice could be a response to changing maternal characteristics.

Using two national surveys conducted in France in 1981 and 1995 Guihard and Blondel (2001) assess the effects of the characteristics of mothers, babies and maternity units on caesarean section trends. Ninety five per cent of the increase from 10.7% to 15.3% over the period was accounted for by two groups: first-time mothers and those with a previous caesarean section. The proportion of first-time mothers remained stable but the caesarean section rate for this group increased and the proportion of those with a previous caesarean section increased while the rate of repeat caesarean section decreased. They highlight the importance of regulating the use of caesarean sections for first-time mothers.

Declercq *et al.* (2006), also raise the point that these increasing rates of primary caesarean, particularly among young first-time mothers, will have a profound influence on future caesarean rates by creating a large cohort of women for whom repeat caesarean will be the norm. They link this assertion to the increased restrictions placed on vaginal birth after caesarean by the American College of Obstetricians and Gynaecologists guidelines (ACOG, 2004).

In the case of Ireland, Farah *et al.* (2003) suggest six possible reasons for the increased caesarean section rates. These include, fear of malpractice litigation; increase use of electronic fetal monitoring with a high false positive detection of fetal hypoxia; increased expectation of the parents and past experience; decreased tolerance of possible bad outcomes; convenience both for the mother and physician; and damage to the pelvic floor with subsequent urinary and faecal incontinence. These are similar to those listed by Thomas and Paranjothy (2001) in the UK caesarean section audit and by other authors.

III Data and Methods

The main source of data on perinatal events in Ireland is the National Perinatal Reporting System (NPRS) collected and processed by the Economic and Social Research Institute (ESRI) since 1999. This contains information on all births in the Republic of Ireland. Births are registered and notified on a standard Birth Notification Form (BNF) which is completed where the birth takes place, either at the hospital or by the attending midwife. This study uses eight years of perinatal data from the NPRS[3] with an initial sample size of 480,610 births. For descriptive analyses, only births that took place within a hospital are included, that is, cases where 'place of birth' is recorded as 'domiciliary', 'born before arrival' and 'unknown' are excluded. Together these account for 0.6% of total births.[4] In addition, five 'mystery' births, for which the majority of variables are missing, are also excluded. The resulting sub-sample of all hospital births in Ireland between January 1 1999 and December 31 2006 is 477,544 births. Of the 477,544 births over this period caesarean deliveries accounted for 112,484 or 23.5%. The NPRS does not distinguish between elective and emergency caesarean sections so caesarean section in this paper refers to procedures carried out on both an elective and emergency basis.

Unfortunately clinical data on births is not available in the National Perinatal Reporting System in Ireland which means that it is not possible to identify the clinical indicators for caesarean sections using this data. The necessary morbidity data is however contained in the Hospital In-Patient Enquiry (HIPE) system.[5] We use the ICD-9-CM hierarchy of codes proposed by Anderson and Lomas (1989), tabulated by Taffel *et al.* (1987) and refined by Henry *et al.* (1995), following clinical record review, to identify the indications contributing to the caesarean section rate and examine how they have changed over time. The lack of information on number of

[3] The NPRS data set excludes all births where weight is under 500 grams. In the case of a multiple birth where one or more births from the set weighs under 500 grams, the birth/s weighing under 500 grams is/are removed from the national data set. Any birth/s weighing over 500 grams in the multiple birth set is/are retained in the national data set as a multiple birth/s.

[4] Domiciliary births are planned home births. The vast majority of these are attended by an independent midwife and are not associated with a hospital. Born before arrival indicates that an infant was delivered before arrival at hospital.

[5] There are two main differences between the HIPE and NPRS datasets when looking at births. The unit of measurement in NPRS is the birth, that is, there is one record for each baby born. In HIPE the unit of measurement is the discharge, that is, there is one record for each mother who delivered at least one baby. In addition, HIPE does not collect data from the two private maternity hospitals. For these reasons there are fewer records in HIPE than NPRS.

previous births ('parity') in HIPE also restricts our ability to distinguish between primary and repeat caesarean sections using this data.

In the next section we examine trends in caesarean section overall in Ireland and trends in factors that have been associated with the risk of experiencing a section. In V we then model the probability of caesarean section using logistic regression and the NPRS data for the year 1999 and 2006. We attempt to explain the change in the probability of section between these years represented by a dummy variable representing 2006 by addition of different predictor variables. The importance of previous caesarean and the absence of a variable for previous caesarean section in the NPRS data means that we only model first births (i.e. where parity=0). We also exclude multiple births for which the risk of section is substantially higher. As we will go onto show, the prevalence of multiple births has not increased over time and so their exclusion will not impact on the analyses.

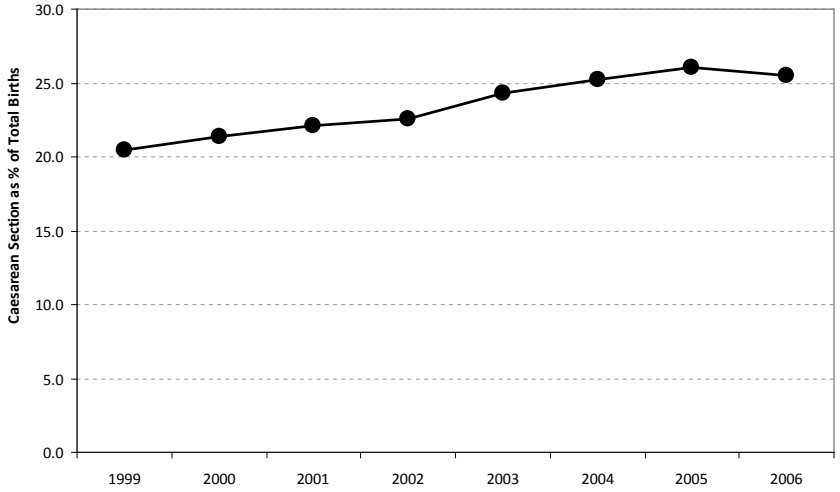
IV Profile of Caesarean Section in Ireland

The following section profiles births in Ireland from 1999 to 2006. We investigate factors that have been suggested in the literature to have led to an increase in the caesarean section rate: multiple births, maternal age, parity, birthweight, occupation/social class, day of week of birth, and hospital type.

The caesarean section rate is defined here as the proportion of total births delivered by caesarean section.[6] Figure 1 shows how the caesarean section rate increased from 20.5% in 1999 to 25.5% or over one quarter of all births in 2006. This represents an increase of over 24% in eight years.

[6] Total births = ((live births + stillbirths) – (domiciliary + BBA + unknown + mystery))

Figure 1: *Caesarean sections as percentage of total births*



To what extent have the clinical indicators for caesarean section changed over time in Ireland? As stated in the last section HIPE data can be used to examine this issue. Since a number of clinical risk factors can exist simultaneously a method, which is suitable for application to Irish data, is needed to rank these. The method presented in Henry *et al.* (1995) assigns one indication for the caesarean section to each relevant case, with each indication taking precedence over all succeeding ones (previous caesarean, breech, dystocia, fetal distress, other), regardless of the order in which they were recorded in the dataset. Discharges with two or more of the relevant indication codes were assigned to one or other category according to this hierarchy.

Table 1 shows that having already had a caesarean section previously accounted for almost 27% of cases in 1999 rising to almost 32% in 2004. Table 1 also shows that this 2.4% increase between the periods can explain over 52% of the rise in total caesarean sections. The influence of previous caesarean section means that increases due to other clinical reasons are amplified in later years although medical practice is moving away from assuming a section at second and later births. Of those women who recorded a previous caesarean in 1999, 85% had a caesarean section; this decreased to 83.5% in 2004.

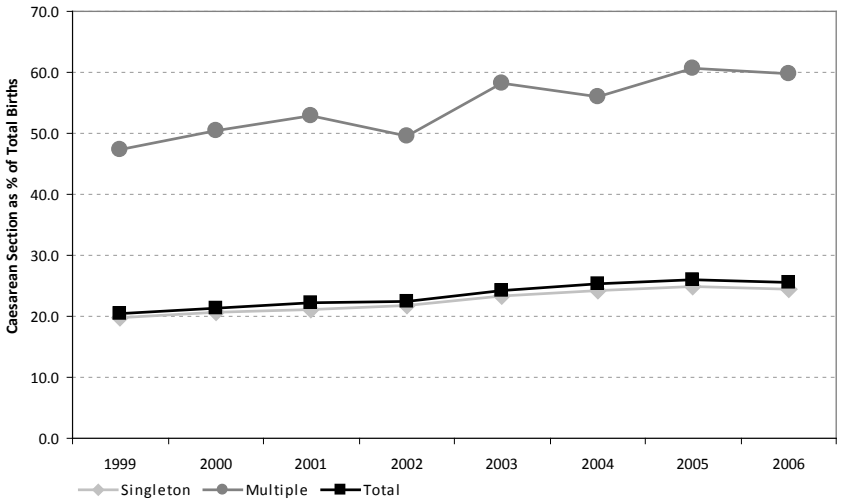
Table 1: *Increase in rates for selected complications, Ireland 1999-2004*

	1999		***2004***		***Change from 1999 to 2004***	
	Rate	*Per Cent Distribution*	*Rate*	*Per Cent Distribution*	*Rate*	*Per Cent Distribution*
Previous caesarean section	5.3	26.9	7.7	31.6	2.4	52.2
Breech	2.5	13.0	2.8	11.6	0.3	6.5
Dystocia	4.0	20.3	5.4	22.3	1.4	30.4
Fetal distress	1.3	6.4	0.8	3.3	-0.5	-10.9
Other	6.6	33.4	7.6	31.3	1.0	21.7
Total	**19.7**	**100.0**	**24.3**	**100.0**	**4.6**	**100.0**

After previous section, Table 1 shows that increases in the prevalence of dystocia (failure of the labour to progress) and 'other' reasons are the second third most common clinical indicators 'explaining' the increase in the caesarean section rate between 1999 and 2004. As stated above, trends in the prevalence of these clinical indicators may be driven by changes in the characteristics of mothers and pregnancies.

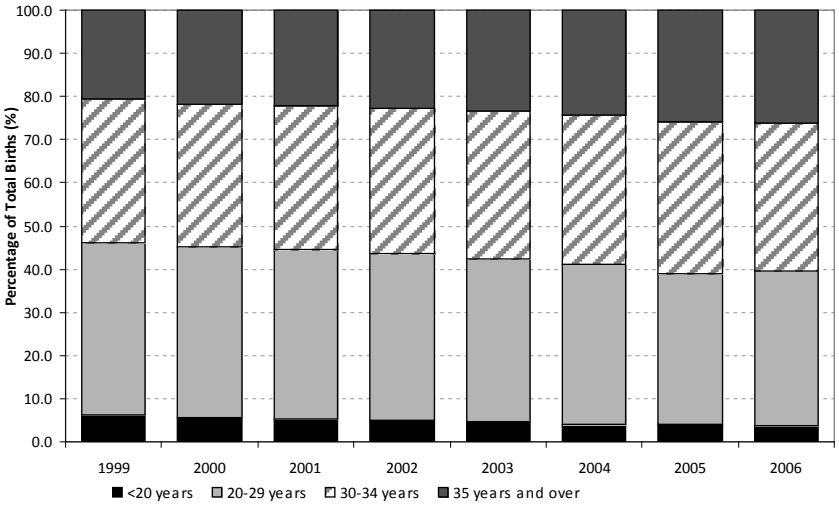
An increase in the proportion of multiple births has been suggested as a contributing factor to the increasing caesarean section rate. Multiple births accounted for 1,966 or 3.0% of the 65,392 hospital births in Ireland in 2006. This proportion has fluctuated very little over the 1999 to 2006 period, from a low of 2.6% in 2000 to a high of 3.2% in 2001. Given the increased complexity involved in multiple birth deliveries it is not surprising that the caesarean section rate for multiple births is almost 2.5 times that for singleton births in each of the eight years. In 2006 the caesarean section rate for singleton births was 24.4% and for multiple births was 59.8%. The caesarean section rates for both singleton and multiple births have increased by similar proportions over the period, by 23.8% and 26.1% respectively. This indicates that an increase in the number of multiple births or the increasing proportion of caesarean section for multiple births does not seem to explain the national trend (Figure 2).

Figure 2: *Caesarean section rate for singleton and multiple births*



Maternal age has been found to have a significant effect on the probability of having a caesarean section in several international studies. It is clear from Figure 3 below that the age profile of women giving birth in Irish hospitals has changed significantly over the eight year period. There were a higher proportion of births to women in the older age groups in 2006 than there were in 1999. The proportion of births to women aged less than 20 years and 20 to 29 years decreased by 41.9% and 10.1% respectively. The proportion of births to women aged 30 to 34 years increased by 3.4%, and for women in the 35 years and over age group it increased by 26.8% over the eight years. The average age of women giving birth in Ireland increased from 30.1 years to 31.1 years between 1999 and 2006.

Figure 2: *Total births by mother's age group, 1999-2006*

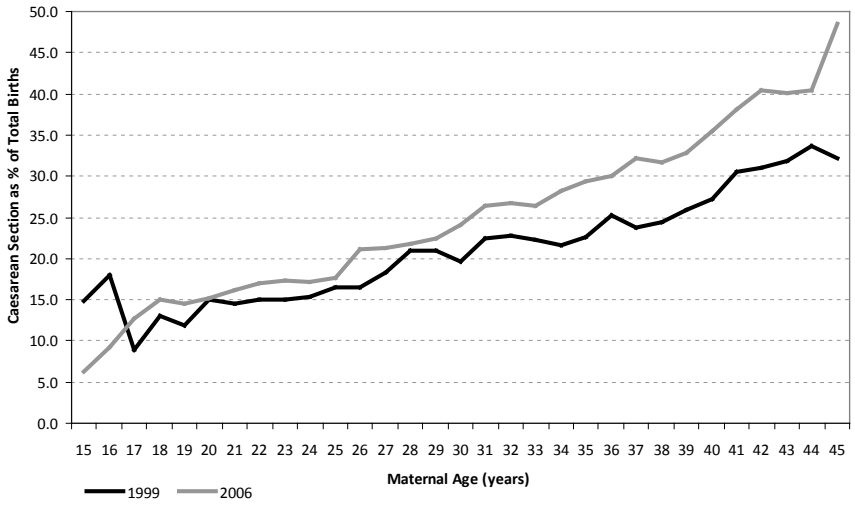


The caesarean section rate in 2006 was 25.5%, however this varied widely by maternal age as can be seen in Figure 3. It is clear that the caesarean section rate, in

general, increases with age and has increased over time. From 17 years of age onwards the caesarean section rates in 2006 are consistently higher than those in 1999. In 2006 the caesarean section rate surpassed 30% for births to women aged 36 years and over, this represented a significant shift from 1999 when the caesarean section rate did not reach this level until women reached 41 years and over.

Growth in the caesarean section rate was lowest for births to mothers aged 20 years and under at 11.6% and highest for births to mothers aged 35 years and over at 28.6%.

Figure 3: *Maternal age (years) by caesarean section rate (%), 1999 and 2006*[7]

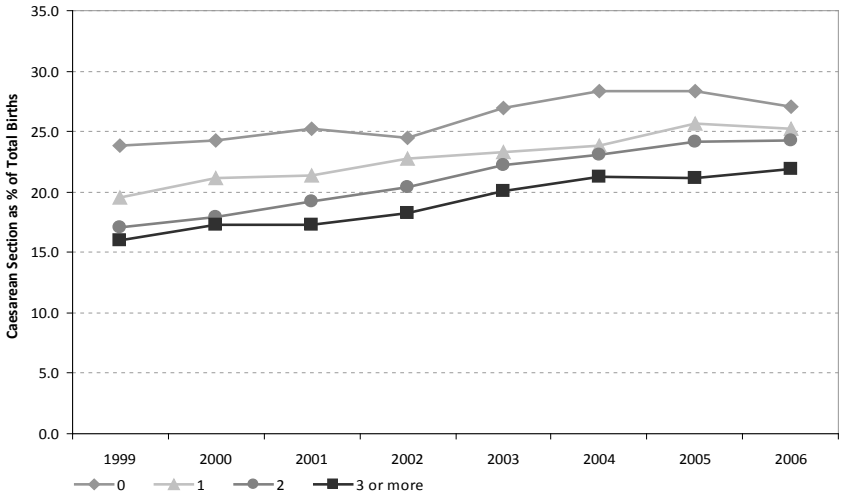


Maternal parity is defined as a woman's total number of previous live births and stillbirths. Falling maternal parity has been linked in the literature to an increasing caesarean section rate. In 2006, approximately 41% of births in Ireland were to first-time mothers, 32% to women with one previous birth, 17% to women with two previous births and the remainder to women with three or more previous births. The most significant change over the period was the 18.3% fall in the three or more category between 1999 and 2006. Average maternal parity fell from 1.12 to 1.05 between 1999 and 2006.

The caesarean section rate in Ireland varies by maternal parity group, as illustrated in Figure 4. The caesarean section rate is highest for first-time mothers and decreases with each subsequent parity group presented. In 2006, first-time mothers had a caesarean section rate of 27.0% compared to 21.9% for women with a parity of 3 or more.

[7] Only mothers aged between 15 and 45 are included in this chart.

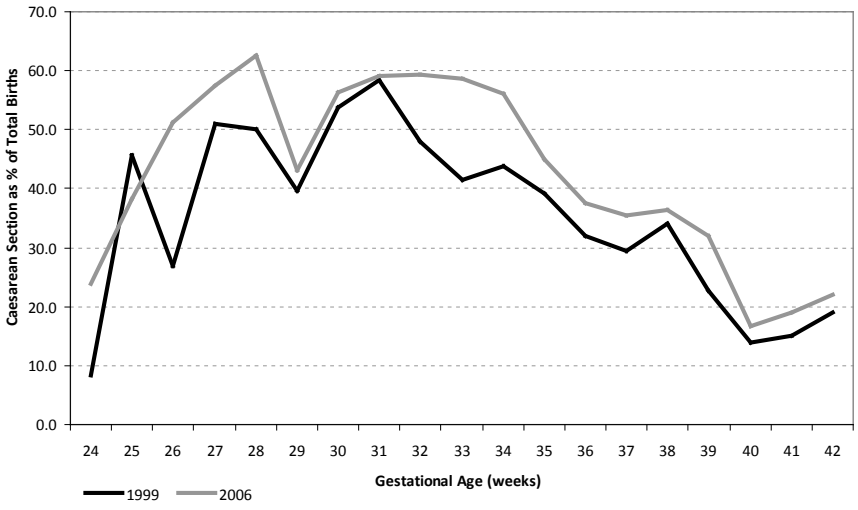
Figure 4: *Caesarean section rate by maternal parity group, 1999-2006*



In 1999, 87.8% of births in Ireland were born at term, that is between 37 and 41 weeks gestation. By 2006 this had increased to 90.4%. Pre-term births (<36 weeks) increased only slightly from 5.7% to 5.9% of total births. Post-term births (42 weeks or more) decreased from 6.5% of total births in 1999 to 3.7% in 2006.

The proportion of births delivered by caesarean section has increased for almost every gestational age (Figure 5). The largest change in the proportion of births by caesarean section was in term births. There was a 25% increase in the proportion of term births delivered by caesarean section between 1999 and 2006.

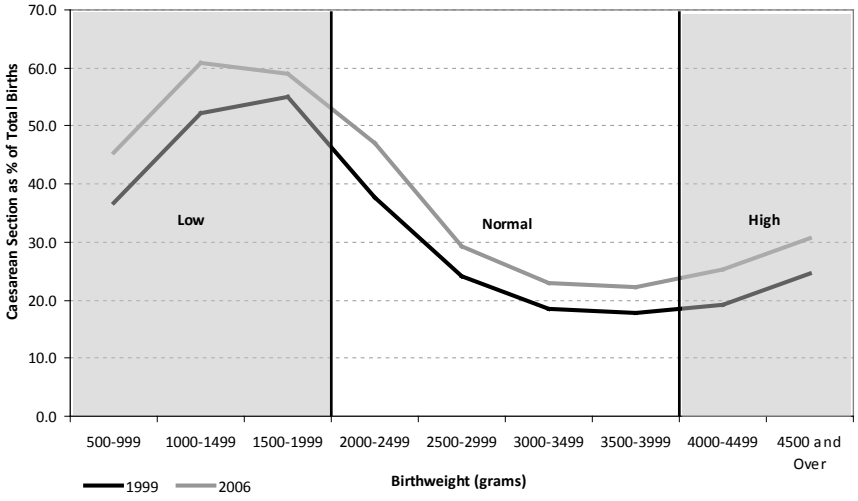
Figure 5: *Caesarean section rate by gestational age at delivery 1999 and 2006*



The proportion of births in each of the three weight categories (low, normal, high) remained relatively constant between 1999 and 2006. The caesarean section rate was highest in each year for low birthweight babies, that is, babies weighing less

than 2,500 grams. The caesarean section rate has increased for each of the birthweight categories over the period (see Figure 6). The high birth weight category, that is babies weighing 4,000 grams or more, experienced the highest rate of growth over the period when compared to the other birthweight categories at 30.7%. The caesarean section rate for low birthweight babies increased by 19.1% over the period and for normal birthweight babies it increased by 23.8%.

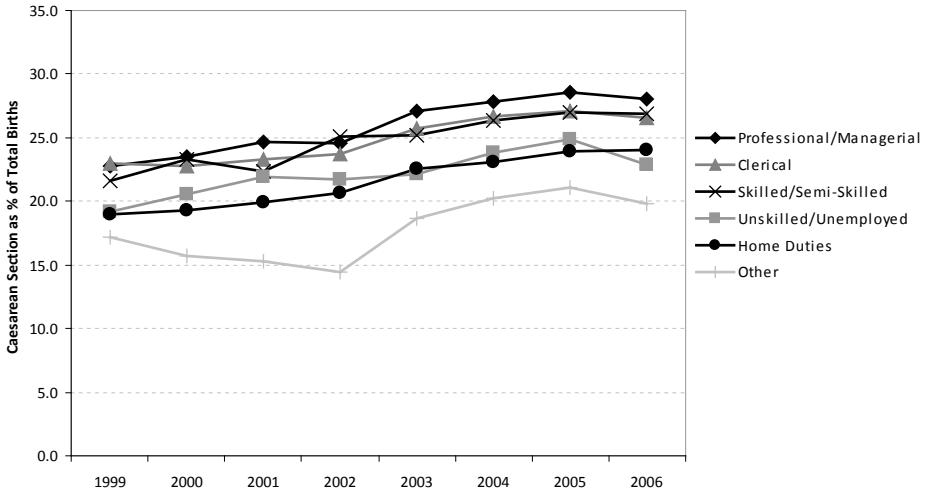
Figure 6: *Caesarean section rate by birthweight, 1999-2006*



It has been suggested that socioeconomic status may have an impact on the caesarean section rate. With the NPRS data we can look at both occupations and the private status of hospitals as socioeconomic indicators. Occupations recorded in NPRS are coded according to the Central Statistics Office system of socio-economic group classification. Since 1999 there have been significant changes in the occupations reported by women giving birth in Ireland. The most significant of these changes were a 39.1% increase in the professional/managerial category and a 41.3% decrease in the skilled/semi-skilled category over the period 1999 to 2006.

The caesarean section rate disaggregated by socioeconomic status is illustrated in Figure 7. Higher socioeconomic groups, that is, professional/managerial and clerical have the highest rates of caesarean section in the majority of years over the period. Professional/managerial have consistently had the highest caesarean section rates since 2003.

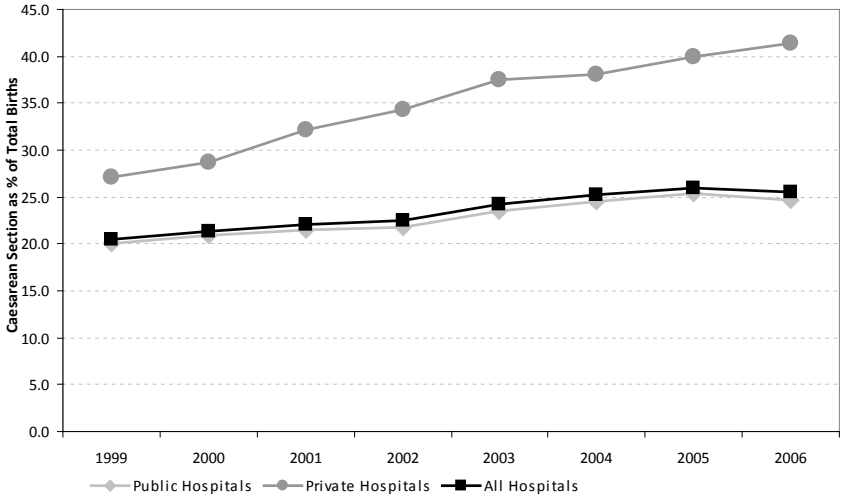
Figure 7: *Caesarean section rate by socioeconomic status, 1999-2006*



The NPRS collects data from two private hospitals in Ireland. The proportion of babies born in public and private hospitals has remained consistent over the period 1999-2006. On average 94% of hospital births take place in public hospitals, with approximately 5% in private hospitals each year.

The caesarean section rate in private hospitals is consistently higher than that in public hospitals (Figure 8). Between 1999 and 2006 the caesarean section rate in public hospitals grew by 23.0% compared to 53.1% in private hospitals. However, as so few births take place in private hospitals this increase does little to explain the overall increasing national trend.

Figure 8: *Caesarean section rate by hospital type, 1999-2006*



This section has shown that the distribution of the characteristics of mothers and pregnancies have changed in Ireland from 1999 to 2006 and that these changes

may well have contributed to the increased rate of caesarean section over the period. In the next section we model the change in the probability of caesarean section between 1999 to 2006 and examine whether the change can be accounted for by trends in the factors just examined.

V Econometric Analysis of the Caesarean Section Trend

Following on from the bivariate analysis conducted in Section IV we now explore the factors that influence the probability of having a caesarean section and the change in the caesarean section rate over time. We use three logistic models to examine the influence of maternal characteristics, birth/infant characteristics and hospital characteristics. The first model examines the difference in the probability of the birth being a caesarean section in 2006 compared to 2009. The second model adds in maternal characteristics. The third and final model then adds birth/infant and hospital characteristics plus an interaction between year and the birth occurring within a private hospital. The rate of caesarean section rose substantially quicker in private hospitals compared to public and this is controlled for in the model. No other significant interactions were found. The third and final model is thus:

$$Y= \alpha+\beta 1Yr+\beta MC+\beta 3BC+\beta HC+INT$$

Where Yr: Year of birth 2006; MC: Mother's characteristics; BC: Birth/Infant characteristics; HC: Hospital characteristics; INT: Interaction between private hospital and year 2006. A full list of the variables and their construction used in the models is given in Table 2.

Table 2: *Variables definitions and summary statistics*

		1999 %	2006 %
Year	*(Reference category = 1999)*		
1999	=1 if year of birth is 1999	-	-
2006	=1 if year of birth is 2006	-	-
Maternal Characteristics			
Age	*(Reference category = 35 years and over)*		
< 20 years	=1 if aged <20 years	14.1	8.1
20-29 years	=1 if aged 20-29 years	51.9	47.5
30-34 years	=1 if aged 30-34 years	25.5	30.4
35 years and over	=1 if aged 35 years and over	8.6	14.0
Marital Status	*(Reference category = married)*		
Never married	=1 if never married	52.9	55.6
Married	=1 if married	46.6	43.6
Other	=1 if other	0.5	0.8
Occupation	*(Reference category = professional)*		
Professional	=1 if professional	25.1	29.2
Clerical	=1 if clerical	30.1	28.7
Skilled	=1 if is skilled	8.0	6.7
Unskilled	=1 if unskilled	17.0	18.6
Home duties	=1 if home duties	13.2	9.8
Other	=1 if other	6.6	7.1
Birth/Infant characteristics			
Day of week	*(Reference category = weekend)*		
Monday-Friday	=1 if Monday-Friday	76.7	75.8
Weekend	=1 if weekend	23.3	24.2
Gestational age at delivery	*(Reference category = 37-41 weeks)*		
<28 weeks	=1 if <28 weeks	0.4	0.4
28-36 weeks	=1 if 28-36 weeks	4.9	5.1
37-41 weeks	=1 if 37-41 weeks	86.2	89.5
42 weeks and over	=1 if 42 weeks and over	8.5	5.1
Birthweight	*(Reference category = 2,500-4,000 grams)*		
<2,500 grams	=1 if <2,500 grams	5.2	5.0
2,500-4,000 grams	=1 if 2,500-4,000 grams	81.5	82.2
4,000 grams and over	=1 if 4,000 grams and over	13.3	12.8
Gender	*(Reference category = female)*		
Male	=1 if male	52.0	51.7
Female (ref)	=1 if female	48.0	48.3
Hospital characteristics			
Public/Private Status	*(Reference category = public)*		
Public	=1 if public hospital	94.6	95.7
Private	=1 if private hospital	5.4	4.3
Size of Maternity Unit	*(Reference category = < 2,000 births)*		
< 2,000 births	=1 if <2,000 births	36.5	25.2
2,000-3,999 births	=1 if 2,000-3,999 births	14.0	30.2
4,000 births or over	=1 if 4,000 or over births	49.5	44.6

Our analysis strategy is to use the variables in the second and third models to 'explain' the effect of the dummy variable representing year. The extent to which the coefficient for this variable is reduced is used as a measure of the contribution of the factors in the model to trends in caesarean section between 1999 and 2006.

Table 3 shows that the results of the final specification of the model (as marginal effects) are in broad agreement with the literature in terms direction and scale of the effects. Almost all variables in the specification are statistically

significant. We will examine the results for each category of variables, that is, maternal characteristics, birth/infant characteristics and hospital characteristics.

Maternal age has the largest impact on the probability of having a caesarean section. First-time mothers aged less than 20 years age group are 16% less likely to have a caesarean section than those in the 35 and over age group. This is also true, to a lesser extent, for those in the 20 to 29 age group and 30 to 34 age group (15.2% and 8.2% respectively). Not being married has a significant negative impact on the probability of a caesarean section delivery. Women who have never been married are 8% less likely to have a caesarean section than married women. Maternal occupation is included as a proxy for social class. Each category with the exception of 'other' is significantly more likely to have a caesarean section than those in the 'professional' category. This result seems to contradict that found in the descriptive analysis, however, it may be that the worse underlying health status of other class groups is revealed once we control for the higher age at birth of professional and managerial mothers. Lower social class is associated with higher rates of perinatal mortality and low birth weight (Nolan and McGee, 1994) and we would expect that this would also translate into higher levels of risk factors for caesarean controlling for age.

All birth and infant characteristics included in the model have a significant impact on the probability of having a caesarean section. A first-time mother is 6% more likely to have a caesarean section if her baby is delivered on a weekday. This effect reflects medical practice rather than a day of the week effect with physicians unlikely to schedule elective or non-emergency caesarean sections for the weekend for staffing and resource reasons.

The gestational age of the baby at delivery also affects the caesarean section rate. Babies born at less than 28 weeks gestation are 8% less likely to be delivered by caesarean section than those babies born at term (37-41 weeks). Babies born between 28 and 32 weeks gestation or at 42 weeks or more are approximately 3% more likely to be delivered by caesarean section than those born at term. Similarly, low birthweight (<2,500 grams) babies are 23% more likely and high birthweight (>4,000 grams) babies are 10% more likely to be delivered by caesarean section than those in the normal birthweight (2,500-4,000 grams) category, the results are statistically significant. Finally, even controlling for the weight of the baby, male babies are 2.3% more likely to be delivered by caesarean section than female babies.

The final group of variables included in the model were those related to hospital characteristics. The NPRS hospitals were divided into public and private.[8] Women were 6% more likely to deliver by caesarean section in a private hospital than a public hospital. There was also found to be a smaller probability of having a caesarean section in a hospital in which there are more than 2,000 births per year. This reflects the different practices of the large teaching hospitals in Ireland which consistently report lower levels of caesarean section. The significant positive effect of the interaction between the private hospital and the year variables underlines the steeper upward trend in section in private hospitals compared to public.

Our central interest here is the extent to which our analysis 'explains' the effect of the dummy variable representing 2006 relative to the reference year of 1999. The year trend variable remains positive and significant in all three specifications but the coefficient decreases from 0.0291 in specification 1 to 0.0134 in specification 3. This implies that 54% of the change in the caesarean section rate between 1999 and 2006 can be explained by the variables included in the final model.

[8] The NPRS database does not record if the mothers care for the birth has been arranged privately rather than through the public hospital system. 'Private' in our analyses applies purely to the location of the birth with data from two private maternity hospitals included in the analyses.

Table 3: *Factors associated with caesarean section*

	Specification 1		Specification 2		Specification 3	
	Marginal Effects	***t-statistic***	***Marginal Effects***	***t-statistic***	***Marginal Effects***	***t-statistic***
Year						
1999 (ref)			–	–	–	–
2006	0.0291	7.42	0.0156	3.69	0.0134	3.05
Maternal Characteristics						
Age						
< 20 years			-0.1670	-30.24	-0.1670	-30.25
20-29 years			-0.1530	-24.56	-0.1520	-24.50
30-34 years			-0.0827	-14.90	-0.0825	-14.86
35 years and over (ref)			–	–	–	–
Marital Status						
Never married			-0.0393	-8.17	-0.0395	-8.20
Married (ref)			–	–	–	–
Other			0.0350	1.42	0.0348	1.42
Occupation						
Professional (ref)			–	–	–	–
Clerical			0.0211	3.80	0.0213	3.84
Skilled			0.0372	4.35	0.0370	4.33
Unskilled			0.0133	1.94	0.0134	1.95
Home duties			0.0281	3.40	0.0281	3.40
Other			-0.0073	-0.72	-0.0071	-0.69
Birth/Infant characteristics						
Day of week						
Monday-Friday			0.0581	12.88	0.0580	12.86
Weekend (ref)			–	–	–	–
Gestational age at delivery						
<28 weeks			-0.0808	-3.47	-0.0808	-3.47
28-36 weeks			0.0315	2.71	0.0314	2.70
37-41 weeks (ref)			–	–	–	–
42 weeks and over			0.0263	3.05	0.0262	3.04
Birthweight						
<2,500 grams			0.2310	16.05	0.2310	16.06
2,500-4,000 grams (ref)			–	–	–	–
4,000 grams and over			0.1060	15.84	0.1060	15.84
Gender						
Male			0.0237	5.83	0.0237	5.83
Female (ref)			–	–	–	–
Hospital characteristics						
Public/Private Status						
Public (ref)			–	–	–	–
Private			0.0784	7.29	0.0590	4.14
Size of Maternity Unit						
< 2,000 births (ref)			–	–	–	–
2,000-3,999 births			-0.0132	-2.30	-0.0127	-2.20
4000 births or over			-0.0203	-4.04	-0.0201	-4.00
Interaction term						
2006 * Private					0.0344	1.90
Observations	**47,843**		**45,167**		**45,167**	

VI Discussion

The caesarean section rate in Ireland has increased by over 25% in the eight year period from 1999 to 2006. The rate is now over ten% higher than that recommended by the WHO and is amongst the highest in Europe. Given the significant affect caesarean sections have on mothers and their babies and the cost implications for health service providers it is important to investigate the factors which are driving the rate in Ireland higher.

Our analysis has confirmed that many of the international trends are also true for Ireland. Women are having fewer children and they are having them later in life leading to a large increase in the proportion of women giving birth over the age of 35. Older age of mother is associated with a higher risk of a number of complications that can contribute to the risk of caesarean and this has clearly been a substantial contributor to increases in the Irish rate. The caesarean rate has increased for mothers of all ages but the highest rate of increase has been for mothers aged 35 or over where rates have increased by almost 30%. This may be because of the clinical indicators for this group have worsened but it is likely that the high rate of increase reflects changing behaviour on the part of the mother and/or physician.

Although births in private hospitals in Ireland make up a small proportion of the total it is clear that these births carry a significantly higher and increasing risk of occurring by caesarean compared to births in public hospitals. This risk does not reflect the composition of mother or birth characteristics in private hospitals as we control for these in the model. It also cannot reflect worse clinical indicators since these hospitals deal with a more affluent group of mothers and would not take births which were seen to carry a higher risk of complications.[9] Given this it seems likely that the higher rate in these hospitals reflects either higher levels of maternal request for caesarean or different obstetric practice.

After adjusting for a large number of maternal, child and hospital characteristics we have managed to explain roughly half of the change in the caesarean section rate over the period 1999 to 2006. It is therefore clear that the increase in the caesarean section rate over time observed in Ireland cannot be

[9] Because of their size private hospitals in Ireland cannot have the same level of facilities and specialist personal that the large maternity hospitals carry so they are significantly more risk averse.

explained solely on the basis of these characteristics. Other compositional factors may be important. We have not controlled directly for clinical indicators in this analysis as these variables are not available for use in the NPRS. However, separate analysis of clinical indications in the HIPE data suggests that these factors cannot have contributed much to the increasing trend. Integration of the HIPE and NPRS data sets would allow us to control for clinical indications, whether the woman has had a previous caesarean section and if the caesarean section was an emergency or elective (all of which are included in HIPE) but at the present time such integration is not possible. Changes in other obstetric practices which cannot be measured as yet may also have played a minor role. The small but significant contribution of failure for the labour to progress (dystocia) in the analysis of clinical indicators may suggest that factors such as increased use of epidural aesthesia may have played a role (Thorp *et al.* 1989). Changes in practices such as this and changing technology (such as increasing use of sensors for foetal hypoxia) may explain some of the 46% left unexplained in our model. It seems likely however that much of the unexplained component are changes in physician behaviour of different kinds. Future research should look for ways to examine this empirically in the Irish context.

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