*The Economic and Social Review, Vol. 42, No. 4, Winter, 2011, pp. 383–406*

# Exploring Trends in the Rate of Caesarean Section in Ireland 1999-2007*

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*Abstract:* This paper explores levels and trends in the prevalence of Caesarean section delivery in Ireland between 1999 and 2007. Over this period the Caesarean section rate for singleton births in Ireland increased by over one quarter. Using data from the Irish National Perinatal Reporting System and the Hospital In-Patient Enquiry scheme we examine the contribution of maternal, delivery and clinical characteristics to the rise in the Caesarean section rate over the period. Analyses show small increases in the clinical indicators of risk for Caesarean section driven by significant change in maternal characteristics (age of mothers and number of previous deliveries) and possible changes in obstetric practice. Grouped logit models of risk of Caesarean by hospital and time period account for 55 per cent of the variation in the growth trend across hospitals. We discuss the possible contribution of changes in obstetric practice.

## I INTRODUCTION

A Caesarean section (CS) 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 CS should account for not

* The authors would like to gratefully acknowledge the assistance of the staff of the National Perinatal Reporting System Unit and the Hospital In-Patient Enquiry System of the Economic and Social Research Institute for making available the data used in this paper and assistance with clinical coding. Further information on both systems can be found at http://www.esri.ie/health_information. They are also grateful to three anonymous referees for helpful comments on an earlier draft of this paper. The usual disclaimer applies.
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less than 5 nor more than 15 per cent 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 per cent based on an examination of estimates of national CS rates and perinatal and maternal mortality rates from various countries.[1] In a recent publication the WHO *et al.* (2009) have stated that there is no empirical evidence for an optimum percentage or range of percentages. They state that "… the proposed upper limit of 15 per cent is not a target to be achieved but rather a threshold not to be exceeded". Despite the WHO recommendation and initiatives to curb the trend the CS rate in Ireland increased beyond the threshold in the mid-nineties. In 1993, the Department of Health and Children reported a CS rate of 13 per cent by 1999, the next year for which data was available, the rate had increased to 20.5 per cent of total births (HIPE & NPRS Unit ESRI, 2002). That represents a 57.2 per cent increase over a 7 year period and was even greater than that experienced in England which reported a 37.1 per cent increase in the CS rate over the same period (NHS Information Centre, 2009).

Studies have shown that CS increases risks for both mothers and babies when compared to spontaneous vaginal birth and the consensus tends to be that a lower CS 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 their CS rate (National Collaborating Centre for Women's and Children's Health, 2004). As well as clinical risks a CS is considerably more expensive than an uncomplicated vaginal delivery which has implications for health service provision.

The aim of this paper is to explore and if possible to explain the trend in the CS rate in Ireland using data from the National Perinatal Reporting System (NPRS) and the Hospital In-Patient Enquiry (HIPE) from 1999 to 2007. The paper is laid out as follows. The next section examines the relevant Irish and international literature on CS rates. This is followed by a discussion of the NPRS and HIPE data and methodology used for the paper in Sections III and IV. Section V is a descriptive analysis of the CS rate in Ireland between 1999 and 2007 that examines the factors deemed to influence the change in the CS rate by the literature. Using grouped logit models Section VI examines the factors leading to the increasing trend in the CS rate. Finally, in Section VII we summarise our findings, draw out some conclusions, and outline directions for future research.

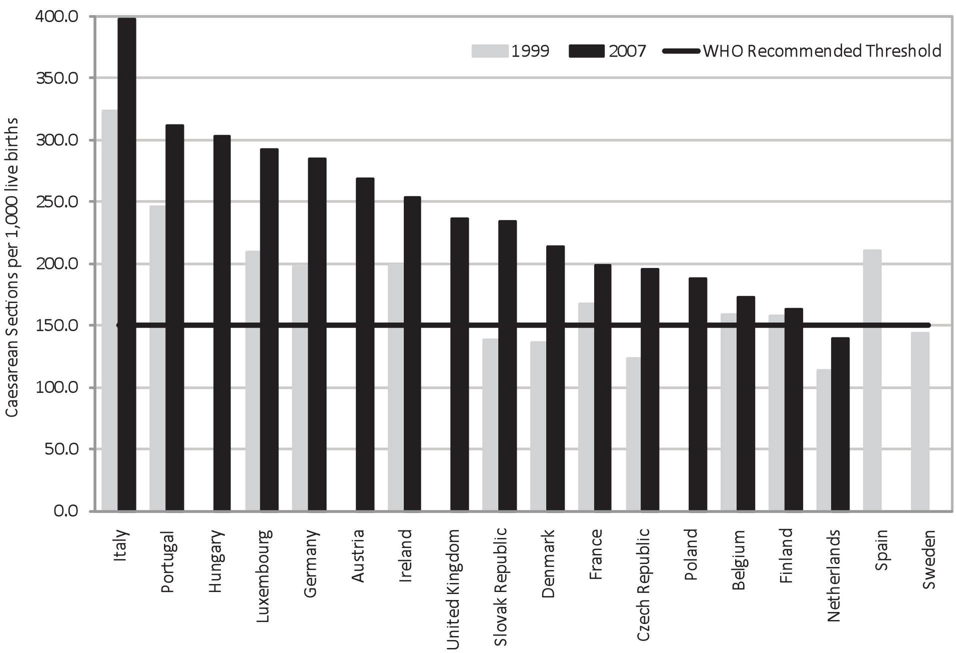
[1] In setting the acceptable levels it was deemed appropriate to select a conservative lower limit and a maximum that is slightly higher than the level reported in most developed countries, but less than the levels in those countries known to have excessive use of the procedure.

## II LITERATURE

We begin by examining CS rates across the EU-19 to see how Ireland compares to other countries and how this has changed between 1999 and 2007, the latest year for which data is available (Figure 1). There has been an increase in the number of CSs per 1,000 live births in all countries. Italy consistently had the highest number of CSs per 1,000 live births with a rate of 398.2 per 1,000 live births in 2007, over two and a half times the WHO recommended threshold. In 2007, only the Netherlands had a CS rate of less than the 15 per cent threshold recommended by the WHO, at 139.5 per 1,000 live births.

It is not only in Europe that CS rates continue to rise. Preliminary data for 2009 for the United States show that the CS rate rose for the twelfth consecutive year reaching 32.9 per cent or almost one-third of all births. This was the highest rate ever recorded there and reflects an increase of almost 60 per cent from its level of 20.7 per cent in 1996 (Martin *et al.*, 2009; Hamilton *et al.*, 2010).

Figure 1: *Caesarean Sections Per 1,000 Live Births 1999 and 2007*




*Note*: For some countries data was not available for both years. No data was reported for Greece.
*Source*: OECD (2010).

CS can and does contribute to better outcomes for some births but the literature has highlighted the negative impact that such an invasive surgical procedure can have on the health outcomes of mothers and their babies and the considerable cost implications of an increasing number of CSs on health service provision.

The National Institute for Clinical Excellence (NICE) in the UK commissioned and published a set of clinical guidelines for CS 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 CS. The guidelines are based upon the best available evidence. As part of these guidelines they have summarised the effects of CS compared with vaginal delivery for women (National Collaborating Centre for Women's and Children's Health, 2004). They outline several conditions that are more likely to affect the mother after CS 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. These findings have been replicated in other countries (Sakala, 2006; Villar *et al.*, 2006; Knight *et al.*, 2008). Babies born by CS are seven times more likely to have breathing problems just after the birth compared with babies born vaginally (National Collaborating Centre for Women's and Children's Health, 2004).

As well as clinical outcomes for mothers and babies the cost of the increasing number of CSs is an issue that has been highlighted by a number of studies. The UK Audit Commission (1997) examined maternity services in England and Wales and reported that a 1 per cent rise in the CS 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 CS 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 CS was found to cost almost twice as much as spontaneous vaginal deliveries.

### 2.1 *What Factors Might Explain the CS Rate and Its Increase Over Time?*

The international research literature suggests three main groups of reasons for the increasing rate of CS over time across different countries.

*Clinical Indicators (including infant characteristics)*: The clinical need for CS 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 CS. The most frequently cited indicators are previous CS, abnormal labour (dystocia or failure to progress), fetal compromise/distress and breech presentation (Placek and Taffel, 1980; Taffel *et al.*, 1987; Anderson and Lomas, 1989; Henry *et al.*, 1995).[2] In the National Sentinel Caesarean Section Audit in the UK, these four indicators together accounted for almost 70 per cent of the CS rate in England (Thomas and Paranjothy, 2001).[3]

There has been little international research on how changes in these indicators over time are contributing to the increasing trend of CS deliveries. Both Gregory *et al.* (1998) using US data and Liu *et al.* (2004) using Canadian data highlight increases in CSs for dystocia, but other authors have found that the incidence of the main indicators has not increased over time (Shearer, 1993). Declercq *et al.* (2006) raise the point that the increasing rate of primary CS, particularly among young first-time mothers, will itself drive future growth in CS rates by creating a large cohort of women for whom repeat CS will be the norm. They link this assertion to the increased restrictions placed on vaginal birth after CS by the American College of Obstetricians and Gynaecologists guidelines (ACOG, 2006).

*Maternal Characteristics*: Clinical indicators can be seen as the proximate cause of CS but the prevalence of these indicators may change as a result of change in maternal characteristics. In particular, more multiple births, increasing maternal age, increasing maternal weight both before and during pregnancy and decreasing number of previous births (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 CS (Joseph *et al.*, 2003). Higher maternal age increases the risk of hypertension, diabetes mellitus and other antenatal complications thus increasing the clinical need for a CS.

Changing maternal characteristics are of course 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 (International Obesity Taskforce, 2005).

[2] "Dystocia is defined as abnormal labor that results from what have been categorised classically as abnormalities of the power (uterine contractions or maternal expulsive forces), the passenger (position, size, or presentation of the fetus), or the passage (pelvis or soft tissues)." ACOG (2003) p. 1446.

[3] "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.

*Delivery Characteristics*: If clinicians change the way they treat a given clinical situation this may influence CS rates even if the prevalence of that condition remains stable. The choice of CS over vaginal birth always requires an assessment of the clinical costs or benefits of each in any given situation and changing medical technology and practice has meant that CS has become less clinically problematic over time. *Ceteris paribus*, this has made CS more attractive as an option. For example in previous decades obstetricians and midwives were more likely to deliver breech births vaginally but changing clinical practice has made CS the dominant form of delivery (Placek *et al.*, 1980; Joseph *et al.*, 2003; Devane *et al.*, 2007).

Other changes in obstetric practice may also impact on the prevalence of CS, though not necessarily intentionally. An example of this is the increase in the prevalence of induction of labour and augmentation of a labour in process which many authors feel have had an impact on the CS rate. Induction has been reported as one of the fastest growing procedures in the United States; the rate more than doubled between 1990 and 2006 to 22.5 per cent of live births (MacDorman *et al.*, 2002; ACOG, 2009). The goal of labour induction is to artificially, by medication or other methods, stimulate uterine contractions so that pregnant women can deliver vaginally (ACOG, 2009). Induction of labour has been associated with an increased risk of a diagnosis of dystocia and CS (Boulvain *et al.*, 2001; Lowe, 2007). In particular, the CS rate is found to be higher in cases of elective (no evident complications) induction in first-time mothers (Seyb *et al.*, 1999; Dublin *et al.*, 2000; Cammu *et al.*, 2002; Lowe, 2007).

Using Canadian data on primary CS rates, Joseph *et al.* (2003) found that the recent increases in the primary CS 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 CS 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.

Non-clinical factors could also have a role in changing obstetric practice. In a survey of obstetricians that asked for the three main causes of the rise in CS rate, Weaver *et al.* (2007) found that litigation and defensive practice was the second most cited reason. The first most cited reason was maternal request, although the majority of respondents pointed out that they did not personally receive many requests for them. On the other hand, the national CS audit in the UK, Thomas and Paranjothy (2001) found that maternal request as reported by clinicians was a primary indication for only 7 per cent of CSs. Reviews of the literature by McCourt *et al.* (2007) and Gamble *et al.*

(2007) found little evidence that women are requesting CSs and concluded that maternal request is not a significant factor influencing CS rates.

Economic incentives may also influence the clinician's choice of delivery method. Recent data has shown that there is variation between the CS rates for public and private patients in public hospitals in Ireland.[4] This raises the issue of possible supplier induced demand, that is, if clinicians are compensated at a higher level for CSs. Tussing and Wojtowycz (1992) used the ratio of obstetricians to fertile females, the per capita output of gynecologic procedures and the ratio of the estimated area CS fee to the vaginal delivery fee to investigate the hypothesis of SID using data from the United States. The authors fail to find support in the data for the hypothesis that "obstetricians perform cesarean (sic) sections to enrich themselves from the additional fee income" (Tussing and Wojtowycz, 1992, p. 538).

A more recent study from the United States has argued that an observed 13.5 per cent fall in fertility over the 1970-1982 period led clinicians to substitute from normal childbirth toward a more highly reimbursed alternative, CS. Using a nationally representative microdata set for this period, they show that there is a strong correlation between within-state declines in fertility and within-state increases in CS utilisation (Gruber and Owings, 1996).

### 2.2 *Irish Maternity System*

The maternity system offers several options to women giving birth in Ireland. Under the Maternity and Infancy Care Scheme, all women who are normally resident in Ireland are entitled to free maternity care irrespective of whether or not they have a medical card or private health insurance. In addition, women have the option to be a semi-private or private patient in a public hospital or a private patient in a private maternity hospital. Private status is paid for the majority of cases via the maternity clauses of medical insurance policies but out-of-pocket payments for private care are more common in maternal care than for treatment of medical conditions in Irish hospitals. Being a private patient in a public hospital means that you are the private patient of your chosen consultant and the consultant will endeavour to be at the delivery. In addition, after delivery you will be transferred to a private room if one is available. Other care options include Midwifery-Led Units, Community and Domino Midwives Schemes, and homebirth with

[4] In the Coombe in 2008, 32.2 per cent of births to private patients were CSs compared with 21.7 per cent for public and semi-private patients (Cullen, 2009). There is no adjustment for patient characteristics or risk profile.

independent midwives. The variety of care available varies across the country and each type of care will vary from hospital to hospital.[5]

## III DATA

The analysis uses nine years of data on singleton births in public hospitals from two Irish sources: the National Perinatal Reporting System (NPRS) and the Hospital In-Patient Enquiry (HIPE) scheme.[6]

### 3.1 *NPRS*

The main source of data on perinatal events in Ireland is the NPRS which contains information on all births in the Republic of Ireland and has been collected and processed by the Economic and Social Research Institute (ESRI) since 1999.[7] 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. Unfortunately, clinical data on births is not available in the NPRS which means that it is not possible to identify the clinical indicators for CS using this data, including whether the CS was carried out on an elective or emergency basis,. The NPRS sample employed for these analyses consists of 504,228 singleton public hospital births in Ireland between 1 January 1999 and 31 December 2007. Of the 504,228 births over this period CSs accounted for 112,672 (22.3 per cent).

### 3.2 *HIPE*

Much of the necessary clinical data is however contained in the HIPE data. HIPE contains administrative data (for example, admission and discharge dates, and medical card and public/private status), demographic data (sex, age) and clinical data on discharges from, and deaths in, acute hospitals in Ireland. The clinical data on discharges in 2007 were recorded in HIPE using *The International Statistical Classification of Diseases and Related Health Problems*, Tenth Revision, Australian Modification (ICD-10-AM) and the Australian Classification of Health Interventions

[5] From a more in-depth description of the options outlined here see www.hse.ie/eng/services/Find_a_Service/maternity/combinedcare.html and www.bump2babe.ie.

[6] Detailed information on the HIPE and NPRS data including *Annual Reports* are available from www.esri.ie/health_information

[7] 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.

(ACHI).[8] In total, 20 diagnosis (one principal and up to 19 additional) codes and, where applicable, 20 procedure (one principal and up to 19 additional) codes could be recorded for these discharges.[9] Between 1999 and 2007 there were 494,590 discharges from HIPE hospitals with a diagnosis of outcome of delivery (singleton).[10,11] It is only since the introduction of ICD-10-AM coding classification in 2005 that such a distinction between elective and emergency CS is available in the HIPE data and so it is not possible to include this variable in the analysis.

### 3.3 *Final Data*

Neither of the data sets alone contains all of the variables desirable for an examination of increasing CS rates nor is it currently possible to cross-match the data in order to do an individual level analysis using the necessary variables from each data set. To circumvent these issues we model trends in the probability of CS *at the level of the hospital*. Data from HIPE and NPRS are used to construct hospital level data for our variables of interest. To model trends these variables are constructed for each quarter from January 1999 to December 2007 yielding 36 periods per hospital. The combination of 20 hospitals with 36 periods produces 720 cases for analysis.

### 3.4 *Exclusions from the Model*

Due to data constraints a number of exclusions have been made for the modelling stage of the analysis. Firstly, data issues in two hospitals meant that eight periods were dropped from analysis leaving 712 hospital-periods. Second, due to the reconfiguration of maternity services in Cork in 2007 (HRID ESRI, 2009, p. 207), births from Cork hospitals have been excluded from the econometric analysis for the final 4 of the 36 periods. As a result of these exclusions, the number of cases aggregated to generate the hospital level variables which were included in the models was 496,547 for NPRS and 487,303 for HIPE.

[8] This coding classification scheme applied to discharges from 1 January 2005. Prior to the move to ICD-10-AM, The International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) was used. The move from ICD-9-CM to ICD-10-AM also entailed changes to coding guidelines (such as the definition of additional diagnoses). Consequently, the ICD-9-CM and ICD-10-AM coding schemes are not directly comparable. For a detailed discussion of updating the clinical coding classification in Ireland, see Murphy *et al.* (2004).

[9] The potential number of additional diagnosis and procedure codes captured by HIPE has increased from five (diagnoses) and three (procedures) prior to 2002 to nine (for both diagnoses and procedures) until 2005 when the number increased to 19 diagnosis and procedure codes.

[10] That is ICD-9-CM – V27.0 and V27.1 or ICD-10-AM – Z37.0 and Z37.1

[11] The small differences between the HIPE and NPRS deliveries can be accounted for mainly by uncoded cases in HIPE over the years.

## IV METHODOLOGY

The key question of interest can be described as:

$$Y_{jt} = \beta_0 + \beta_1 P_t + \beta_2 h_j + \beta_3 m_{jt} + \beta_4 d_{jt} + \beta_5 ci_{jt} + \varepsilon_{jt}$$

Where $Y_{jt}$ is the probability of CS in hospital *j* in period *t*. P is a linear trend parameterised as 36 time periods (yearly quarters identified by integers 1 to 36 across hospitals) between January 1999 and December 2007; h is a hospital fixed effect to correct for hospital specific factors; m represents a vector of *maternal characteristics*, d represents a vector of *delivery characteristics* and ci a vector of *clinical indicators* all measured as the proportion of all births with characteristics x in hospital *j* in period *t*; $\varepsilon_{jt}$ is a normally distributed error term.

Our dependent variable is an aggregate measure, i.e. the probability of CS in hospital j in period t between 1999 and 2007 and this has implications for the methodology that we use. Clearly, the use of grouped data means that the observations are not independent at the level of the hospital. There is a danger of the analysis producing low standard errors if we were to use analytical approaches that do not take this correlation into account (Moulton, 1986). Instead we use a grouped logit function and maximum likelihood estimation which explicitly recognises the grouped nature of the data. The logit function is defined as the grouped log odds ratio which can be written as:

$$\log\left(\frac{p_{jt}}{1-p_{jt}}\right)$$

Where $p_{jt}$ represents the number of CS divided by the number of births in hospital j in time period t. A full list of the variables and their construction used in the models is given in Table 1. The inclusion of the variable representing the time period (p) means that we control for the increasing trend in CS over the period of observation. To control for variation in this trend over hospitals, interactions between hospital and quarter are estimated. The use of the grouped estimator means that hospitals with a larger number of births contribute more to the overall odds of CS than smaller hospitals with contribution being proportional to the total number of births in the denominator of the log odds.

## V RECENT TRENDS IN CS DELIVERY IN IRELAND

The following section profiles hospital births in Ireland from 1999 to 2007. We examine trends in clinical indicators, maternal characteristics and delivery characteristics. The NPRS data (504,228 births) is used to examine

Table 1: *Variables Definitions and Summary Statistics*

| *S** | *Variable Name* | *Description* |
|---|---|---|
| *Hospital and Time* | | |
| – | Hospital | Dummy variable representing each hospital in the analysis |
| – | Period | Integer from 1 to 36 representing yearly quarters 1999 to 2007 |
| - | Hospital * Period | Interaction of hospital and quarter |
| *Maternal Characteristics* | | |
| N | Age 35-39 | % aged 35 to 39 |
| N | Age 40+ | % of mothers aged 40+ |
| N | First Time Mothers | % parity=0 |
| N | First Time Mothers*35+ | % parity=0 and age 35+ |
| H | Private | % births private insurance |
| *Delivery Characteristics* | | |
| H | Induction | % births medically or surgically induced |
| H | Augmentation | % births medically or surgically augmented |
| *Clinical Indicators* | | |
| H | Previous CS | % CS births where mother has uterine scare from previous CS |
| H | Breech | % CS births with breech presentation |
| H | Dystocia^ | % CS births dystocia (excluding high head at term and breech) |
| H | Distress | % CS births fetal distress (including cord prolapse) |
| H | Other^ | % CS births other causes |

*Notes:* * S indicates the source of the variable: N indicates the variable was calculated from aggregating NPRS data and H indicates the variable was calculated from aggregating HIPE data.

^ Dystocia includes “disproportion”, “obstructed labour”, “abnormality of forces of labour”, “long labour”, “malpresentation” and “failed induction of labour”.

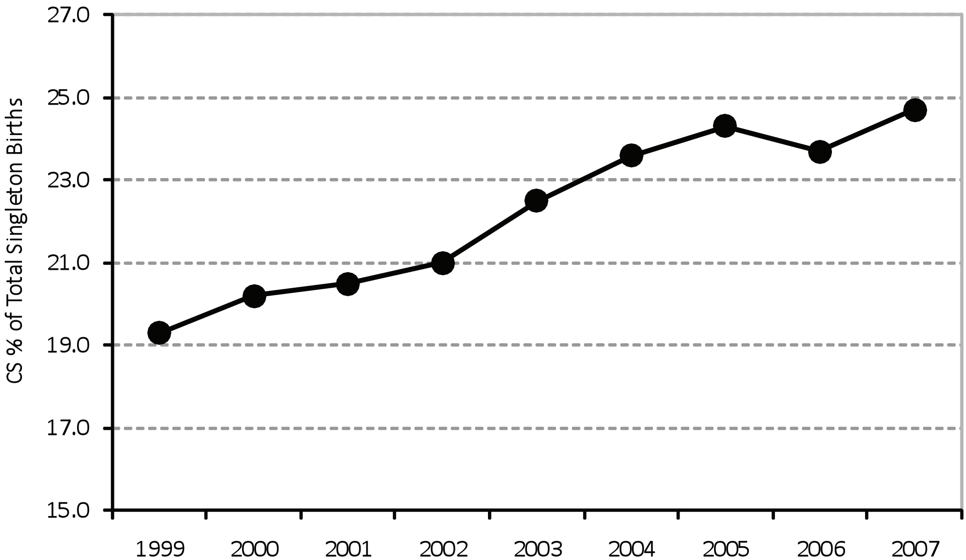
~ Other includes “Antepartum haemorrhage, abruptio placenta and previa placenta”, “insufficient or excessive fetal growth”, “genital herpes”, “diabetes mellitus in pregnancy, “hypertensive disorders”, “oligohydramnios”, “chorioamnionitis”, “malformation of fetal central nervous system”, and “congenital/ acquired abnormality of cervix or vagina”.

all but the clinical indicators and the public/private status of mothers upon their discharge from hospital, both of which are analysed using HIPE data (494,590 births).[12]

[12] Refers to the public/private status of the patient on discharge and not to the type of bed occupied. The medical card status of mothers is not included in the analysis as given the entitlement of women to free maternity services in Ireland it is not routinely collected in all hospitals.

The CS rate is defined here as the proportion of singleton births delivered by CS in public hospitals. Figure 2 shows how the CS rate for singleton deliveries increased from 19.3 per cent in 1999 to 24.7 per cent or over one quarter of total births in 2007. This represents an increase of 28.0 per cent in nine years.

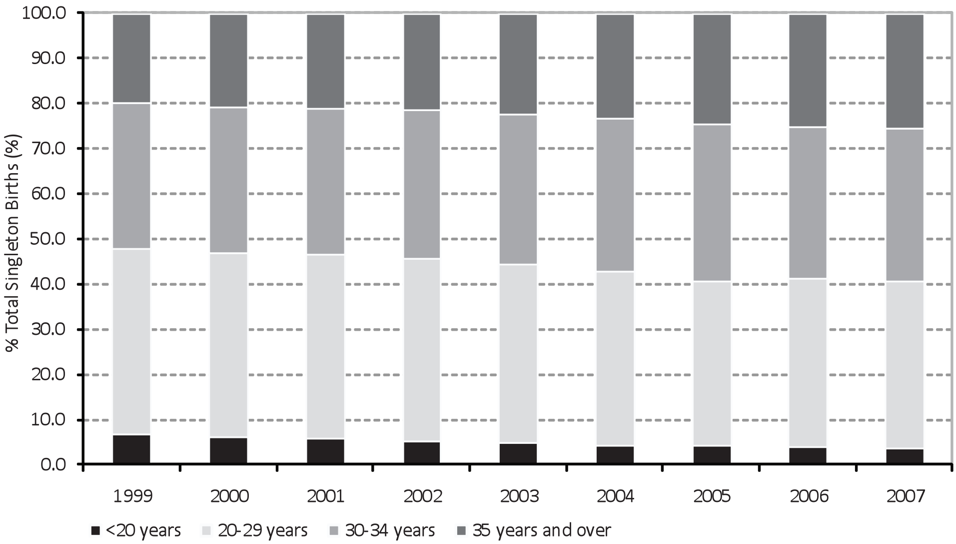
Figure 2: *Caesarean Sections as Percentage of Total Singleton Births in Public Hospitals, 1999-2007*




5.1 *Changing Maternal Characteristics and CS*

As previously discussed, a changing pattern of maternal characteristics could be one driver of changing CS rates in Ireland. Maternal age has been found to have a significant effect on the probability of having a CS in several international studies. It is clear from Figure 3 below that the age profile of women having singleton births in Irish public hospitals has changed significantly over the nine year period. There were a higher proportion of births to women in the older age groups in 2007 than there were in 1999. The proportion of births to women aged less than 20 years and 20 to 29 years decreased by 45.2 per cent and 10.5 per cent respectively. The proportion of births to women aged 30 to 34 years increased by 5.2 per cent, and for women in the 35 years and over age group it increased by 28.5 per cent over the nine years. The average age of women giving birth in Ireland increased from 29.9 years to 30.4 years between 1999 and 2007.

Figure 3: *Total Singleton Births by Maternal Age Group, 1999-2007*



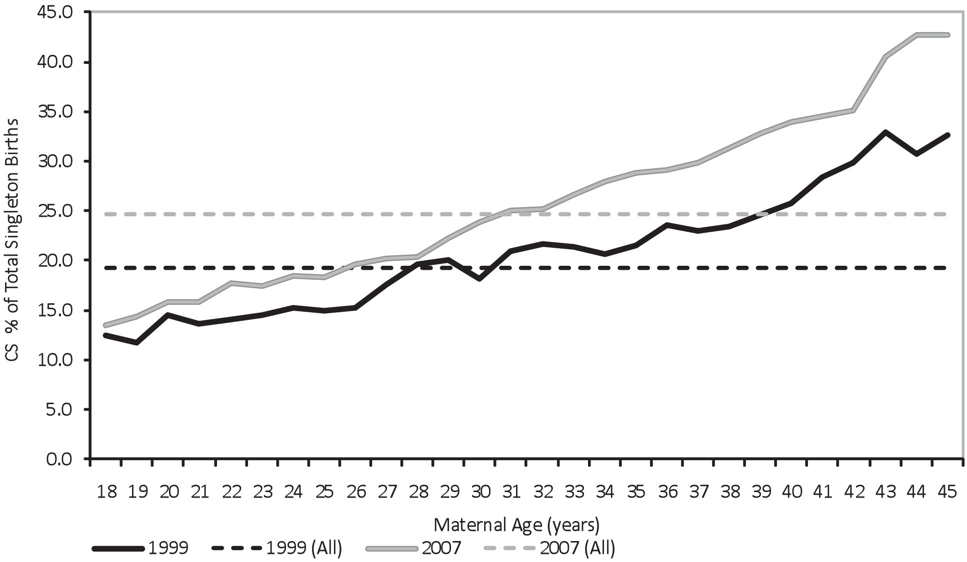

The CS rate for singleton births in public hospitals in 2007 was 24.7 per cent, however this varied widely by maternal age as can be seen in Figure 4. It is clear that the CS rate, in general, increases with age and has increased over time. From 18 years of age onwards the CS rates in 2007 are consistently higher than those in 1999. In 2007 the CS rate was over 28 per cent for births to women aged 35 years and over, this represented a significant shift from 1999 when the CS rate did not reach this level until women reached 41 years and over.

Growth in the CS rate between 1999 and 2007 was lowest for births to mothers aged less than 20 years (15.4 per cent) and highest for births to mothers aged 35 years and over (28.8 per cent).

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 CS rate. In 2007, approximately 42.1 per cent of births in Ireland were to first-time mothers, 31.7 per cent to women with one previous birth, 16.5 per cent 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 21.3 per cent fall in the three or more category between 1999 and 2007. Average maternal parity fell slightly from 1.13 to 1.08 between 1999 and 2007.

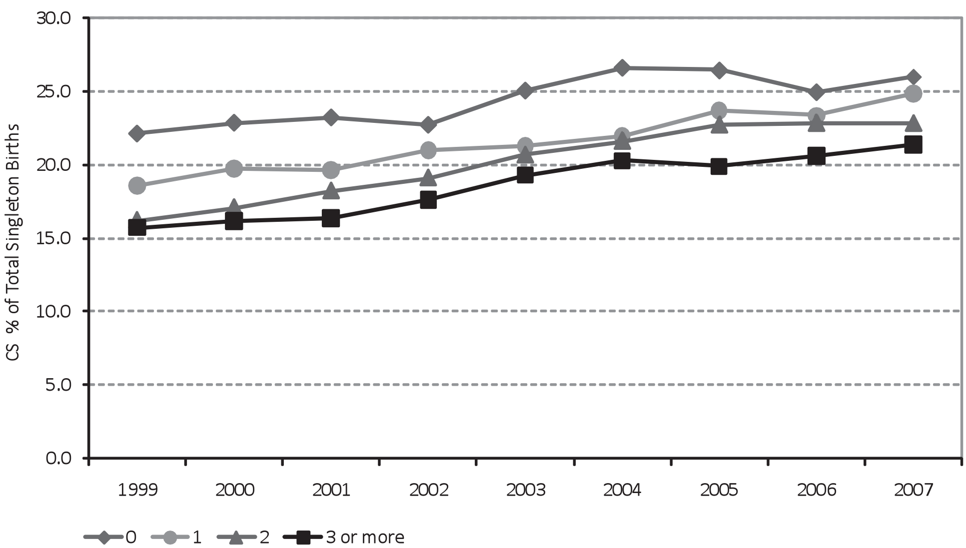
The CS rate in Ireland varies by maternal parity group, as illustrated in Figure 5. The CS rate is highest for first-time mothers and decreases with

Figure 4: *Maternal Age (Years) By Caesarean Section Rate (%), 1999 and 2007*




*Note:* Only mothers aged between 18 and 45 years are included in this chart.

Figure 5: *Caesarean Section Rate by Maternal Parity Group, 1999-2007*



each subsequent parity group presented. In 2007, first-time mothers had a CS rate of 26.0 per cent compared to 21.4 per cent for women with a parity of 3 or more.

5.2 *Changing Patterns of Clinical Indicators and CS*

If the changing pattern of maternal characteristics examined above impacts on CS rates this is most likely through its impact on the prevalence of specific birth complications or the expectation of these complications. To examine whether the clinical progenitors of CS have increased over time we use the method outlined in (Anderson and Lomas, 1984; Henry *et al.*, 1995), where one broad indication for the CS is assigned to each relevant case, with each indication taking precedence over all succeeding ones (previous CS, breech, dystocia, fetal distress, other), regardless of the order in which they were recorded in the dataset.[13] Discharges with two or more of the relevant indication codes were assigned to one or other category according to this hierarchy.

Table 2 shows that having a prior CS accounted for over 27 per cent of cases in 1999 rising to 35.5 per cent in 2007. Table 2 also shows that this 3.5 percentage point increase between the periods can explain over 60 per cent of the rise in total CSs. The influence of prior CS means that increases due to other clinical reasons are amplified in later years although medical practice is moving away from assuming a CS at subsequent births. Of those women who recorded a previous CS in 1999, 84.6 per cent had a CS; this decreased to 83.2 per cent in 2007.

After previous CS, Table 2 shows that increases in the prevalence of dystocia (failure of the labour to progress) and "breech" are the second and third most common clinical indicators "explaining" the increase in the CS rate between 1999 and 2007. As stated above, trends in the prevalence of these clinical indicators may be driven by changes in the characteristics of mothers and pregnancies.

When Table 2 is disaggregated by the age of the mother it is evident that indicators for CS vary by age group. As would be expected the proportion of CS accounted for by "previous CS" increases with age while the proportion for all other indicators decreases with age. For example, in 2007 "previous CS" accounted for 3.0 per cent of CSs in those aged <20 years and for 39.4 per cent in those aged 35 years and over.

[13] The clinical coding for the conditions outlined in Henry *et al.* (1995) are in ICD-9 format. For the purpose of this paper these codes have been mapped to ICD-9-CM and ICD-10-AM. For this reason it has been necessary to make some minor adjustments to the codes presented in Henry *et al.* (1995) to make the codes in ICD-9-CM as comparable as possible to those in ICD-10-AM. See HRID ESRI (2008); and Murphy *et al.* (2004) for a discussion of the changes to clinical coding in Ireland in 2005.

Table 2: *Hierarchical Classification of Indications for Caesarean Section 1999 and 2007*[14]

| | *1999* | | *2007* | | *Change from 1999 to 2007* | |
|---|---|---|---|---|---|---|
| | *Rate* | *Per Cent Distribution* | *Rate* | *Per Cent Distribution* | *Rate* | *Per Cent Distribution* |
| Previous CS | 5.3 | 27.4 | 8.8 | 35.5 | 3.5 | 60.3 |
| Breech^ | 2.5 | 12.9 | 3.0 | 12.1 | 0.5 | 10.3 |
| Dystocia*^ | 4.8 | 25.0 | 5.9 | 23.8 | 1.1 | 19.0 |
| Fetal distress and cord prolapsed^ | 3.7 | 19.4 | 4.0 | 16.0 | 0.2 | 5.2 |
| Other~ | 1.7 | 9.0 | 1.7 | 6.8 | 0.0 | 1.7 |
| Remainder | 1.2 | 6.4 | 1.4 | 5.7 | 0.2 | 3.4 |
| Total | 19.3 | 100 | 24.8 | 100 | 5.5 | 100 |

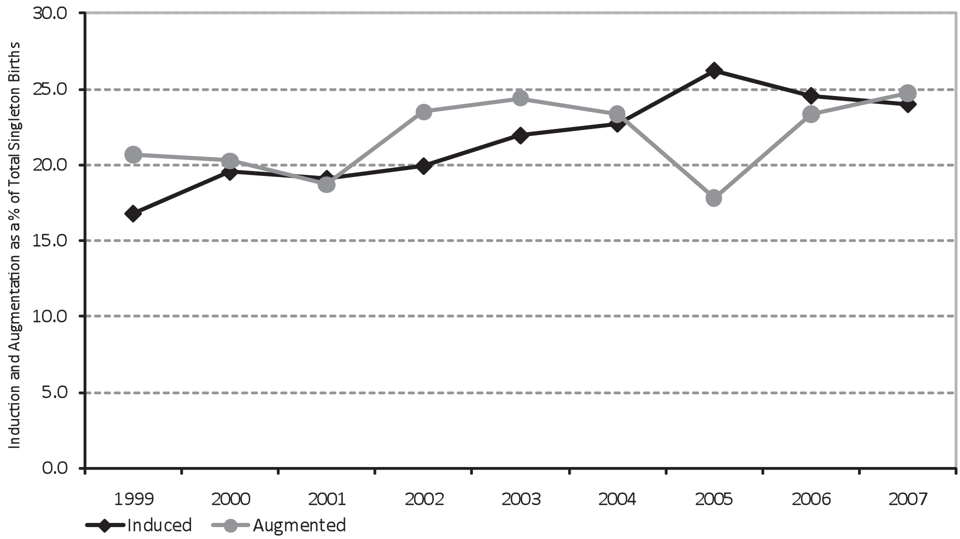
*Notes:* ^ There are minor changes from coding outlined in Henry *et al.* (1995) in order to make ICD-9-CM as comparable to ICD-10-AM as possible.
* Dystocia includes "disproportion", "obstructed labour", "abnormality of forces of labour", "long labour", "malpresentation" and "failed induction of labour".
~ Other includes "Antepartum haemorrhage, abruptio placenta and previa placenta", "insufficient or excessive fetal growth", "genital herpes", "diabetes mellitus in pregnancy, "hypertensive disorders", "oligohydramnios", "chorioamnionitis", "malformation of fetal central nervous system", and "congenital/acquired abnormality of cervix or vagina". In addition, Henry *et al.* (1995) "rhesus isoimmunisation" included in "remainder" rather than "other" due to difficulties with coding comparisons.

### 5.3 *Changing Delivery Characteristics and CS*

It was suggested in Section II that the use of induction and augmentation may also have contributed to the rise in CS in recent years. They have certainly become more common as shown by Figure 6. The proportion of deliveries with an induction procedure rose from 16.8 per cent in 1999 to 24.0 per cent in 2007 and with an augmentation procedure increased from 20.7 per cent in 1999 to 24.7 per cent in 2007.

[14] *Previous CS – ICD-9-CM*: 654.2 – *ICD-10-AM*: O34.2, O75.7
*Breech – ICD-9-CM*: 652.1^, 652.2 - ICD-10-AM: O32.1, O64.1
*Dystocia – ICD-9-CM*: 653, 652 (ex. 652.5)^, 660, 659.0, 659.1, 661 (ex. 661.3), 662
*ICD-10-AM*: O32, O33, O61, O62 (ex. O62.3), O63, O64, O66
*Fetal distress and cord prolapsed – ICD-9-CM*: 656.3, 659.7^, 656.8^, 656.9^, 663.0 *ICD-10-AM*: O68, O69.0
*Other~ – ICD-9-CM*: 641, 656.5, 656.6, 647.6, 054, 648.0, 648.8, 642, 658.0, 658.4, 655.0, 654.6, 654.7, 665.0, 665.1
*ICD-10-AM*: O44, O45, O46, O365, O366, O98.3, A60, O24, O10, O11, O13, O14, O15, O16, O41.0, O41.1, O35.0, O34.4, O34.6, O71.0, O71.1
*Remainder – ICD-9-CM*: All else *ICD-10-AM*: All else

Figure 6: *Prevalence of Induction and Augmentation, 1999-2007*




## VI ECONOMETRIC ANALYSIS OF THE CAESAREAN SECTION TREND

In the previous section we reviewed trends across a number of different factors which could be seen to be associated with CS in Ireland. To examine the independent role of different factors and control for the distribution of both singleton births and CS across public hospitals we use the methodology outlined in Section III and estimate the probability of CS across the period from January 1999 to December 2007 using a grouped logit model and maximum likelihood estimation. We first fit a base model estimating coefficients for the period between January 1999 and December 2007, dummy variables for each of 20 hospitals and the hospital specific trend in CS (the interaction of hospital dummy and period). We then fit five additional models to examine the impact of specific factors on probability of CS. To examine trend effects in clinical indicator variables, i.e. change in the slopes of these effects with time, we fit interactions between each and a year dummy. After fitting all the variables we will be in a position to assess the extent to which we can statistically account for the CS trend between 1999 and 2007.

We are estimating grouped logit models and both our dependent and independent variables (except period and hospital) are aggregates. This has implications for the interpretation of the coefficients produced. In a standard, individual level logit model, the results represent the change in the odds of dependent variable Y for each individual with characteristic X. In the grouped logit on the other hand, the odds represent the mean change in odds for all individuals in the sample with a 1 per cent change in independent predictor X within the aggregate units.

Table 3 gives the odds ratios for a set of models with levels of significance. For ease of presentation we do not show the main period effect or hospital/period interactions, individual hospital parameters or interactions of hospital with quarter (38 terms).[15] The base model estimates have also been omitted. Model 1 fits variables representing the proportion of mothers aged 35-39 and 40+ (older mothers), the proportion of first births and the proportion of first births to older mothers. Higher proportions of older mothers are associated with increased odds of CS in Model 1, though only the 35-39 term is significant. The 35-39 term is rendered insignificant by the entry of the variable representing the proportion of previous caesareans in Model 4. Births to first-time mothers are associated with an increase in risk but this term not significant in most of the models. The proportion of older first-time mothers is associated with an almost threefold increase in the odds of CS. Model 2 adds in the term for the proportion of births to women with private medical insurance. This is highly significant and positive on the odds of CS. Moreover, the inclusion of the term reduces the magnitude of the terms for the proportion of older mothers considerably.

Our earlier discussion had suggested that induction and augmentation in particular, may have contributed to increasing CS rates. Model 3 adds in induction and augmentation and shows that just augmentation has a significant impact on CS probability decreasing the odds.

The variables entered up to this point can be viewed as the “distal’ influences on CS rates. Models 4 and 5 on the other hand show the results for the clinical indicators which are the proximate or immediate factors leading to CS. Model 4 shows the effect for proportion of women with a previous CS. This is clearly a powerful predictor increasing the odds by 26.16. Model 5 shows the coefficients for a number of clinical indictors. Model 5 shows that other risk factors for CS are also important. Breech and dystocia are both associated with a greater odds of CS (12.7 and 1.4 respectively), as is “fetal distress (including cord prolapse)’ (1.1) and “other’ (1.7). Here we simply use the proportion of births with a principal indicator, as per the Henry *et al.* (1995) hierarchy, of each characteristic within each hospital period. As expected, the introduction of previous CS in Model 4 and the clinical risk factors in Model 5 moderates the effect of the other, more distal factors added in earlier models but has a particularly interesting effect on the variable representing the

[15] Variables representing season of birth were tested but proved to have no significant effect and were thus omitted from the final models.

Table 3: *Grouped Logit Model of Caesarean Section by Hospital and Period*

| | *Model 1* | | *Model 2* | | *Model 3* | | *Model 4* | | *Model 5* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Odds* | *Sig.* | *Odds* | *Sig.* | *Odds* | *Sig.* | *Odds* | *Sig.* | *Odds* | *Sig.* |
| *Maternal Characteristics* | | | | | | | | | | |
| Age 35-39 Years | 1.82 | ** | 1.66 | * | 1.63 | * | 1.18 | n.s. | 1.24 | n.s. |
| Age 40+ Years | 2.21 | n.s. | 1.77 | n.s. | 1.67 | n.s. | 1.09 | n.s. | 1.03 | n.s. |
| First birth | 0.94 | n.s. | 0.97 | n.s. | 0.99 | n.s. | 1.34 | * | 1.30 | n.s. |
| First birth + aged 35+ Years | 2.63 | * | 2.22 | n.s. | 2.09 | n.s. | 3.56 | ** | 2.63 | * |
| Private patient | | | 1.41 | *** | 1.39 | *** | 0.98 | n.s. | 0.80 | * |
| *Delivery Characteristics* | | | | | | | | | | |
| Induction | | | | | 1.10 | n.s. | 1.03 | n.s. | 0.96 | n.s. |
| Augmentation | | | | | 0.93 | * | 0.86 | *** | 0.83 | *** |
| *Clinical Indicators* | | | | | | | | | | |
| Previous CS | | | | | | | 26.16 | *** | 26.83 | *** |
| Breech presentation | | | | | | | | | 12.69 | *** |
| Dystocia | | | | | | | | | 1.37 | *** |
| Fetal distress (including cord prolapse) | | | | | | | | | 1.12 | n.s. |
| Other | | | | | | | | | 1.70 | * |
| LL | –264,101 | | –264,096 | | –264,093 | | –264,025 | | –264,008 | |
| N (Individual Level) | 511,695 | | 511,695 | | 511,695 | | 511,695 | | 511,695 | |
| N (Hospital/Periods) | 712 | | 712 | | 712 | | 712 | | 712 | |
| LR | 6,115 | | 6,126 | | 6,132 | | 6,267 | | 6,302 | |
| Pseudo $R^2$ | 0.0114 | | 0.0115 | | 0.0115 | | 0.0117 | | 0.0118 | |

*** p<0.01, ** p<0.05, * p<0.1
*Sig. = Significance*

proportion of private patients which now becomes significant and negative on the overall odds of CS. This would suggest that the effect of a greater proportion of private status women on the odds of CS is mediated, almost entirely, by the proportion with the different clinical indicators, the implication being that women with more clinical indicators for CS are more likely to have private medical insurance. Given that we have controlled for the age of the mother this should not be a consequence of selection on mother's demographic characteristics. Instead, it suggests that women with clinical indicators for CS are more likely to opt for private care.

The results above show that the prevalence of specific clinical indicators may have contributed to growth in CS rates over time. Our discussion in

Section II suggested that changing obstetric practice relative to these clinical indicators may also contribute to the CS trend if clinicians become more likely to use CS when faced with a particular indicator. To test for this we fitted interactions between year and each clinical indicator to Model 5. No specific trend was detected for any of the clinical indicators except for the variable representing the proportion of births with indications of dystocia. Here there was a significant and steady growth in the slope coefficient for dystocia between 1999 and 2007.

It is clear that a number of variables in the analysis are associated with a higher probability of CS but we have still to assess their impact on the overall trend in CS between 1999 and 2007. The extent to which the variables in the six models account for the hospital specific growth coefficients is taken as a measure of their value in explaining the overall trend. Table 4, shows that when entered together in Model 5, the variables account for 55 per cent of the hospital trend coefficients. Although all of the variables contribute to this conclusion, the largest contribution is made by Model 4, the model containing the proportion of women who have previously had a CS. Although not shown, the addition of the interaction effect of year and the clinical indicators increased the proportion of the hospital variance explained to 60 per cent.

Table 4: *Reduction in Hospital Specific Time Trend in CS by Addition of Variables*

| | *Base Model* | *Model 1* | *Model 2* | *Model 3* | *Model 4* | *Model 5* |
|---|---|---|---|---|---|---|
| *% Change* | *0%* | *8%* | *30%* | *38%* | *55%* | *55%* |

## VII DISCUSSION

The CS rate for singleton births in public hospitals in Ireland has increased by over 28 per cent in the nine-year period from 1999 to 2007. The rate is now over 10 per cent higher than the threshold "recommended" by the WHO and is amongst the highest in Europe. Given the significant effect CS has 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.

Analysis of the literature suggested three main processes may explain recent CS trends: first, the changing pattern of clinical indicators, perhaps driven partially by the second – the changing distribution of maternal characteristics. The third process was the changing distribution of delivery characteristics driven by changing obstetric practice for both clinical and non-clinical reasons.

Table 4, Model 1 shows that changing maternal characteristics clearly play a role. Controlling for the proportion of older mothers across hospitals and across periods within hospitals explains 8 per cent of the trend in CS between 1999 and 2007. However, most of the effect of changing maternal characteristics appears to be mediated by the impact this has on the prevalence of clinical indicators since controlling for the latter decreases the effect of maternal characteristics to zero. If we put aside for the moment the influence of previous CS as a driver of the increasing probability of CS, it is clear that the prevalence of some clinical indicators of CS have increased between 1999 and 2007 but not by the level necessary to explain the overall change in CS rate in Irish hospitals. Some of the additional growth in CS is explained by the non-linearity in the effect of the clinical indicators and particularly dystocia with time. Not only were the rates of clinical indicators for CS increasing between 1999 and 2007, their influence on the probability of CS also increased.

Although changing delivery characteristics such as use of induction and augmentation in Irish hospitals had appeared to be a possible factor for the rise in CS rates in the descriptive analyses, our models suggest that they are not significant factors in the overall rise in CS. Controlling for maternal characteristics, the prevalence of induction is insignificant and its effect on the odds of CS approaches zero whilst the prevalence of augmentation actually has a significant negative effect on hospital CS levels.

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 CS and this has clearly been a substantial contributor to increases in the Irish rate. The CS rate has increased for mothers of all ages but the highest rate of increase has been for mothers aged 35 years and over where rates have increased by almost 30 per cent. Our model showed that a 1 per cent rise in the proportion of first-time mothers aged 35+ in Irish hospitals was associated with an almost threefold increase in the risk of CS for each birth.

Together, changes in maternal characteristics, delivery characteristics and clinical indicators explain 55 per cent of the increase in CS between 1999 and 2007 in our models. It is unclear what factors explain the remainder of the trend over the same period. Complication rates with CS have fallen over time so the disincentive to use CS has decreased. This may well have changed the balance in clinical decision making toward the use of CS particularly if the threat of litigation because of not intervening and using CS has increased or if clinicians have become more sensitive to the possibility. Unfortunately, the use of aggregated data in this paper limits the extent to which the interaction between factors influencing CS can be explored. If possible, future research in the Irish context should use individual level data to examine factors associated with CS and the relationship between maternal characteristics, clinical indicators and CS in particular.

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