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Incisional surgical site infection following cesarean section: A national retrospective cohort study

Khalid BM Saeed[a,c,*], Paul Corcoran[b], Richard A Greene[b,c]

[a] Department of Obstetrics and Gynaecology, University College Cork, Cork, Ireland
[b] National Perinatal Epidemiology Centre, Department of Obstetrics and Gynaecology, University College Cork, Cork, Ireland
[c] Cork University Maternity Hospital, Wilton, Cork, Ireland

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ABSTRACT

Objective: To determine the rate and associated risk factors for incisional surgical site infection following cesarean section in Ireland.
Study Design: This study was a retrospective population-based cohort study, conducted using the Hospital In-Patient Enquiry database (HIPE) for the period 2005–2016. All women who underwent cesarean section between 2005 and 2016 in Ireland were included. Potential risk factors for incisional surgical site infection were selected based on the existing literature and their availability within the HIPE database. The risk of incisional surgical site infection following cesarean section with exact Poisson 95% confidence intervals were reported. Multivariable Poisson regression included all potential risk factors simultaneously. Risk ratios are reported with their 95% confidence intervals and *P*-values.
Results: There were 802,182 deliveries during the study period, 219,859 of which (27.4%) were by cesarean section. There were 1396 cases of incisional surgical site infection, a risk of 0.63% (95% confidence interval: 0.60–0.67%). Public patients had approximately 20% higher risk and the risk was almost 40% higher among women aged over 35 years compared with those aged under 25 years. Most notable, related to the morbidities assessed, was the twofold increased risk of incisional surgical site infection associated with pre-existing diabetes and with urinary tract infection in pregnancy. Premature rupture of membranes, pyrexia during labour and postpartum haemorrhage each increased risk by 40–60%. Hematoma of a cesarean section wound remained by far the strongest risk factor for incisional surgical site infection.
Conclusion: Of all the risk factors we studied, hematoma had the strongest association with development of incisional surgical site infection. Of all women birthing by cesarean section in Ireland during 2005–2016, 25% had at least one of the risk factors identified by our study. Approximately 40% of the incisional surgical site infection cases came from this 25%. This might suggest that a universal approach to reducing risk of surgical site infection is warranted.

Introduction

Cesarean section (CS) has become one of the most commonly performed major surgeries worldwide, and the rate has been exponentially rising during the past three decades [1]. Globally, the CS rate increased from 12% to 21% in 2015 (16.1 million to 29.7 million) which represents an increasing trend of 75% in a 15-year period [2]. In a study by Betran and colleagues, almost one in five women, globally, would give birth by CS as the rate increased from 7% to 19% between 1990 and 2014 [3]. Countries worldwide have experienced a steady rise [4], with substantial variation between countries (0.6% to 58.9% in south Sudan and the Dominican Republic, respectively) and rates are reported to be lowest among poor, uneducated, and rural women [5]. In 1985, the multidisciplinary expert group at the WHO public health conference at Fortaleza, Brazil, recommends that CS rates higher than 10–15% are not justifiable [6]. In Ireland, the trend is similar to the global picture, with CS rates having increased by almost 200% between 1990 and 2016 (11%–32.7%) [7,8].

The term 'surgical site infection' (SSI) was introduced by The Surgical Wound Infection Task Force in 1992 [9]. It is defined as an infection affecting the wound (incisional) or the uterus (organ/space, once manipulated) occurring within 30 days of surgery [9]. SSIs remain a concern for patients and healthcare systems despite the

* Corresponding author at: Department of Obstetrics and Gynaecology, 5thfloor, CUMH, Wilton, Cork, Ireland.
E-mail addresses: dr.khalidballa@gmail.com, khalid.saeed@umail.ucc.ie (K.B. Saeed).

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advances in operative and perioperative care, and infection-control techniques [10]. According to the World Health Organization (WHO), SSIs are among the most common causes of healthcare-associated infections in Europe and the USA [11]. Developing SSI following CS has a substantial effect on the mother's health in the puerperium and imposes enormous demands on healthcare-system resources. In addition to the burden of infection on the mother, the cost to the health system is immense, as CS costs double that of vaginal delivery in terms of both care around the time of birth and post-operatively, including re-hospitalization and community care during the first 2 months [12].

Infection morbidity has been reported as eight times greater after cesarean deliver when compared with vaginal delivery [13]. Current available literature quotes the SSI rate as between 3% and 15% [1]; older studies report it as high as 25% [14]. This variation could be due to differences in reporting methodologies, the duration of postnatal follow up and/or diagnostic criteria used [15]. In a recent four-country healthcare-associated infections (HCAIs) survey including the Republic of Ireland carried out in 2006, approximately 5% of patients in hospitals in Ireland have an HCAI, with SSIs accounting for one in seven of these infections, and nearly 5% of patients who had undergone a surgical procedure were found to have developed an SSI [16].

Many factors are reported to be associated with SSI post CS. Some factors are classified as host related or intrinsic, for example, age [17,18] and body mass index (BMI) [19–21]. Other factors are related to the antenatal period: limited antenatal visits [19], smoking [22,23], diabetes mellitus (presentational and gestational) [24,25], hypertensive disorders [21,25,26], and multiple gestations [25]. Intrapartum risk factors reported include emergency CS [21], prolonged labour duration [27], longer duration between rupture of membranes and operation [20,27,28], number of vaginal examinations [21], chorioamnionitis [23,26], duration of operation [29,19], operation by teaching service or non-consultant hospital doctor in training [21,30]. The surgical factors associated with development of SSI were reported to include use of subcutaneous drains, anaemia, and postoperative hematoma [22,26,30].

Materials and methods

This is a retrospective population-based cohort study which was conducted using the Hospital In-Patient Enquiry database (HIPE) for the period 2005–2016. The HIPE database is a computerized system designed to capture the administrative, demographic and clinical data on all inpatient discharges in all publicly funded hospitals in Ireland, and has been described in detail elsewhere [31,32]. Briefly, the HIPE is the only source of morbidity statistics available nationally for acute hospital services in Ireland. All acute public hospitals participate in HIPE, reporting on over 1.5 million records annually and cover approximately 98% of all childbirths [33], and is considered a robust source for public health related research [34].

The data include all women who gave birth by CS between 1 January 2005 and 31 December 2016 in Ireland. In January 2005, the HIPE system adopted the Tenth Revision, Australian Modification (ICD-10-AM) of the International Statistical Classification of Diseases and Related Health Problems [34]. Potential risk factors for incisional SSI were selected on the basis of the existing literature and their availability within the HIPE database. The factors examined included maternal characteristics (maternal age, patient insurance status), type of CS, morbidities (hypertensive disorders, diabetes, and urinary tract infection (UTI) in pregnancy), labour-related factors and postoperative factors. The ICD-10-AM diagnostic codes used to select these factors are detailed in supplementary Table 1.

Table 1
Characteristics of 219,859 cesarean deliveries, 2005–2016.

Characteristic	Category	n (%)
CS surgical site infection		1396 (0.6%)
Maternal age	<25 y	20,053 (9.1%)
	25–34 y	118,863 (54.1%)
	>35 y	80,943 (36.8%)
Insurance status	Private	69,100 (31.4%)
	Public	150,759 (68.6%)
CS type	Elective	110,900 (50.4%)
	Emergency	108,959 (49.6%)
Hypertensive disorder	No	199,728 (90.8%)
	Pre-existing	1452 (0.7%)
	Gestational	18,679 (8.5%)
Diabetes	No	206,888 (94.1%)
	Pre-existing	1813 (0.8%)
	Gestational	11,158 (5.1%)
Genitourinary infection in pregnancy		1486 (0.7%)
Premature rupture of membranes		9913 (4.5%)
Pyrexia during labour		5822 (2.6%)
Postpartum haemorrhage		13,190 (6.0%)
Haematoma of obstetric wound		708 (0.3%)

CS = cesarean section.

Statistical analysis

We report the risk of SSI following CS with exact Poisson 95% confidence intervals (CIs). We used Poisson regression to assess change in the annual risk of SSI over time and to assess differences in the risk of SSI between those with and without each of the potential risk factors. Multivariable Poisson regression included all potential risk factors simultaneously. Risk ratios are reported with their 95% CIs and *P*-values. The analyses were carried out using Statistical Package for the Social Sciences software (IBM, Armonk, NY, US) version 24, and Stata version 13.1. (Stata Corp, College Station, TX, US). Institutional Review Board approval was not needed as this study used publicly available anonymized data.

Results

There were 802,182 deliveries during the 12-year study period, 219,859 of which (27.4%) were by CS. The CS number and rate increased from 14,185 (24.8%) in 2005 to 20,069 (32.1%) in 2016. This represents a 30% increase in the CS rate over 12 years (Fig. 1). This increase was wholly due to elective CS, which increased from 11.0% of all deliveries in 2005 to 18.1% in 2016, whereas each year, emergency CS accounted for 13.3–14.0% of all deliveries.

There were 1396 cases of SSI among the 219,859 CSs, a risk of 0.63% (95% CI: 0.60–0.67%), which is equivalent to one case in every 157 CSs. There was weak evidence that the risk of SSI increased

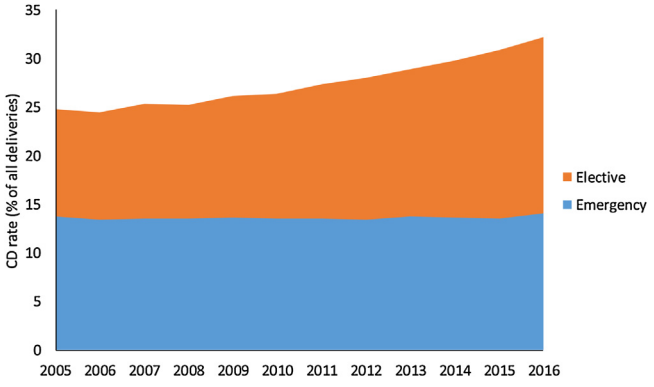

Fig. 1. Trend in cesarean delivery rate in Ireland, 2005–2016.

over the 12 years (annual risk ratio, RR = 1.02, 95% CI: 1.00–1.03, *P*-value = 0.041).

Characteristics of the 219,859 CSs are detailed in Table 1. More than half of the women were aged 25–34 years and more than one third were over 35 years. Almost 70% were public patients. Approximately 9% of the women had a hypertensive disorder, primarily gestational. A total of 6% of the women had a diabetes diagnosis and again, this was primarily gestational. A UTI diagnosis in pregnancy was recorded for less than 1% of the women. PROM and pyrexia during labour were recorded for 4.5% and 2.6%, respectively. A sum of 6% of women experienced PPH, whereas wound hematoma was recorded for just 0.3%. The median length of stay for the study period was five days. Length of stay did decrease over the time period, the median was five days for the years 2005–2010 but was four days for 2011–2016.

The risk of SSI was approximately 20% higher in women aged over 35 years compared with those aged less than 25 years, in public patients compared with private patients, and following emergency CS compared with elective (Table 2). Hypertensive disorders were associated with a greater than 50% increased risk, whether pre-existing or gestational. Diabetes was also associated with SSI, especially pre-existing diabetes which more than doubled the risk. The risk was three times higher among women with UTI in pregnancy. The ante-, intra- and postpartum complications, PROM, pyrexia and haemorrhage had similar effects on risk of SSI, whereas hematoma of obstetric wound greatly increased risk.

The multivariable analysis showed little attenuation in the strength of the associations between the risk factors and risk of SSI when considered together (Table 3). Risk of SSI was only slightly increased following emergency CS compared with elective. Public patients had approximately 20% higher risk and the risk was almost 40% higher among women aged over 35 years compared with those aged under 25 years. Most notable, related to the morbidities assessed, was the twofold increased risk of SSI associated with pre-existing diabetes and with UTI in pregnancy. PROM, pyrexia during labour and postpartum haemorrhage each increased risk by 40–60%. Hematoma of a cesarean section wound remained by far the strongest risk factor for SSI.

Comment

Our study found that one in every four pregnant women gave birth by CS, and the CS rate increased by 30% between 2005 and 2016. This is similar to the worldwide exponential upward trajectory of CS [1,3,4]. In their recently published article, Boerma and colleagues investigated the global use and disparities of CSs, concluding that almost 30 million births globally occurred by CS in 2015 [2]. In our population, elective CS was the major contributory factor to this rise in CSs, with just over 60% increase during the study period. A plausible explanation for this trend might be that elective cesarean is a repeated process; however, the emergent procedure is a non-recurring event.

We found the risk of CS SSI while an inpatient was 0.63% (1 in 157) and the data suggest that there was a small increase in the rate over the 12-year period. Previous studies have reported higher inpatient CS wound infection rates of 1.1% [35], 1.6% [36] and 1.4% [17]. These studies contrasted with ours in that they were prospective and some were undertaken by trained healthcare personnel whereas we relied on retrospective analysis of patient discharge data. When using post-discharge surveillance, the rate varies between 3–15% [1]. With some reports, the rate of SSI following CS was just over 25% [14]. Understandably, the rates are higher when post-discharge surveillance cases are included, as milder cases are captured while being treated in the community.

Our study found that hypertension, diabetes, UTI in pregnancy, PROM, pyrexia in labour, PPH and hematoma were all associated with increased risk of infection. In our recently published case-control study of 3948 CSs [21], we have shown that in addition to hypertensive disorders, obesity, emergency CS, and multiple vaginal examinations were independent risk factors for SSI after CS. In a study by Tran et al., preeclampsia was shown to increase the risk of post-cesarean infection by a factor of two [26]. Similar findings were reported by Krieger and colleagues in a recent publication where in addition, hypertensive disorders of pregnancy and PROM were both independent risk factors for post-cesarean SSI [37].

In our study, diabetes was strongly associated with the risk of SSI, especially if it was pre-existing, when the risk was doubled. This is similar to the findings by Takoudes and colleagues, who

Table 2
Risk of surgical site infection after cesarean section stratified by potential risk factors.

Risk factor	Category	SSI, n	CS, n	Risk (%)	Risk ratio	(95% CI)	P-value
Maternal age	<25 y	116	20,053	0.58	1.00	(Reference)	
	25–34 y	717	118,863	0.60	1.04	(0.86–1.27)	0.676
	>35 y	563	80,943	0.70	1.20	(0.98–1.47)	0.071
Insurance status	Private	383	69,100	0.55	1.00	(Reference)	
	Public	1013	150,759	0.67	1.21	(1.08–1.36)	<0.001
CS type	Elective	623	110,900	0.56	1.00	(Reference)	
	Emergency	773	108,959	0.71	1.26	(1.14–1.40)	<0.001
Hypertensive disorder	No	1203	199,728	0.60	1.00	(Reference)	
	Pre-existing	15	1452	1.03	1.72	(1.03–2.85)	0.038
	Gestational	178	18,679	0.95	1.58	(1.35–1.85)	<0.001
Diabetes	No	1276	206,888	0.62	1.00	(Reference)	
	Pre-existing	25	1813	1.38	2.24	(1.50–3.32)	<0.001
	Gestational	95	11,158	0.85	1.38	(1.12–1.70)	0.002
Genitourinary infection in pregnancy	No	1369	218,373	0.63	1.00	(Reference)	
	Yes	27	1486	1.82	2.90	(1.98–4.24)	<0.001
Premature rupture of membranes	No	1290	209,946	0.61	1.00	(Reference)	
	Yes	106	9913	1.07	1.74	(1.43–2.12)	<0.001
Pyrexia during labour	No	1329	214,037	0.62	1.00	(Reference)	
	Yes	67	5822	1.15	1.85	(1.45–2.37)	<0.001
Postpartum hemorrhage	No	1265	206,669	0.61	1.00	(Reference)	
	Yes	131	13190	0.99	1.62	(1.36–1.94)	<0.001
Hematoma of obstetric wound	No	1358	219,151	0.62	1.00	(Reference)	
	Yes	38	708	5.37	8.66	(6.27–11.96)	<0.001

CS, cesarean section; CI: confidence interval; SSI: surgical site infection.

Table 3
Multivariable analysis of risk factors for surgical site infection after cesarean section.

Risk factor	Category	Risk ratio	(95% CI)	*P*-value
Maternal age	<25 y	1.00	(Reference)	
	25–34 y	1.13	(0.93–1.38)	0.232
	>35 y	1.37	(1.12–1.69)	0.003
Insurance status	Private	1.00	(Reference)	
	Public	1.22	(1.08–1.38)	0.002
CS type	Elective	1.00	(Reference)	
	Emergency	1.13	(1.01–1.27)	0.030
Hypertensive disorder	No	1.00	(Reference)	
	Pre-existing	1.42	(0.85–2.37)	0.181
	Gestational	1.47	(1.25–1.73)	<0.001
Diabetes	No	1.00	(Reference)	
	Pre-existing	2.05	(1.38–3.06)	<0.001
	Gestational	1.28	(1.04–1.59)	0.020
Genitourinary infection in pregnancy	No	1.00	(Reference)	
	Yes	2.41	(1.64–3.53)	<0.001
Premature rupture of membranes	No	1.00	(Reference)	
	Yes	1.59	(1.29–1.95)	<0.001
Pyrexia during labour	No	1.00	(Reference)	
	Yes	1.62	(1.26–2.08)	<0.001
Postpartum haemorrhage	No	1.00	(Reference)	
	Yes	1.42	(1.18–1.7)	<0.001
Hematoma of obstetric wound	No	1.00	(Reference)	
	Yes	7.76	(5.61–10.72)	<0.001

CS, cesarean section; CI: confidence interval.

concluded pre-gestational diabetes increased wound complications after CS by more than twofold, after adjusting for BMI, length of surgery, and previous CS [38]. In our case-control study, when controlled for other factors, diabetes did not convey increased risk following multivariable regression where cases and controls did not differ in relation to being diabetic or non-diabetics [21]. Similarly, the study by Olsen et al. reported no association between diabetes and SSI after regression analysis in their well-designed case-control study [30]. In a study by Martens and colleagues, they concluded diabetes was associated with an SSI [20]. However, other reports did not find this association in the risk of developing an SSI following CS [35,39].

Olsen et al. reported obesity, operation by the university teaching service and development of subcutaneous haematoma were independent risk factors for SSI [30]. After reviewing 60 wound infections following cesarean section in a previous case-control study, Emmons and colleagues found significant differences in the length of the first stage of labour, as well as rupture of membranes and number of vaginal examinations [40], however, UTIs were not associated with development of wound infections. In our study, less than 1% of the women were diagnosed during pregnancy to have a UTI. We believe this could be an underestimation, as HIPE data code for UTI when it is reported by the women during their first antenatal visit. Subsequent infection does not necessitate admission; or UTI diagnosed in the community might go unreported. Nonetheless, the risk of developing SSI was three times higher among women with UTI in pregnancy. So, the risk of developing an SSI in this population could be higher, and more stringent surveillance measures to capture the UTI diagnosed in the community might be needed.

In a well-designed multicentre study from England, blood loss was not associated with development of SSI, and authors concluded obesity, age < 20 years and operation performed by associate specialist or staff grade surgeons to be significant independent risk factors for SSI [41].

Of all the risk factors we studied, haematoma had by far the strongest association with development of SSI, perhaps expectedly, as stagnation of sera or blood might act as a medium for bacterial growth. It has only been previously reported by Olsen and colleagues [30] as an independent risk factor for SSI following CS.

Subcutaneous haematoma might act as a physical barrier preventing wound-edge approximation, healing, and vascular regeneration. In a Cochrane review by Anderson and Gates, no difference was noted in the risk of wound infection when subcutaneous fat was closed, yet there was reduction in the development of wound haematoma with subcutaneous fat closure compared with non-closure [42]. Lack of wider documentation that haematoma is a risk factor for SSI may be due to the fact that small haematomas can develop and be managed exclusively in the community [30].

Of all women birthing by CS in Ireland during 2005–2016, 25% had at least one of the risk factors identified in our study. Approximately 40% of the SSI cases came from this 25%. Therefore, most of the SSI cases (847 out of 1396, 60.7%) had none of the risk factors. This might suggest that these factors are not so strongly associated with risk of SSI that they could be considered useful in predicting infection. It may indicate that a universal approach to reducing risk of SSI is warranted.

An important limitation of HIPE data for this study is the absence of data on some potential risk factors for SSI, for example, maternal BMI and parity. Regarding the definition of SSI, the study included cases of incisional wound infection but data on whether the infection was superficial or deep was not available. Moreover, using HIPE data excludes women discharged from the hospital before SSI is diagnosed and we could not include patients readmitted with SSI because the HIPE data for such patients would not indicate whether they had a CS. However, to our knowledge, this is the largest cohort study to date investigating the incidence and risk factors of SSI following CS during an inpatient hospital admission. Another strength is that the data covers a 12-year period and includes more than 800,000 women. Moreover, the HIPE data set covers 98% of all childbirths in Ireland, and the data entry pertaining to demographic and clinical aspects during the hospitalization period is coded and entered by highly trained personnel [33].

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Dr Khalid BM Saeed is a PhD student in the Department of Obstetrics and Gynaecology, University College Cork, Ireland

(The theme of his thesis is surgical site infection following cesarean section). Currently Dr Khalid Saeed is a registrar at Cork University Maternity hospital.

Declaration of Competing Interest

The authors report no conflict of interest.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ejogrb.2019.07.020.

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