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Secular trends in cesarean sections and risk factors in South Korea (2006–2015)

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Objective

This study aimed to investigate trends in the rate of cesarean sections (CSs) in South Korea from 2006 to 2015 and identify the risk factors associated with these changes.

Methods

Using the National Health Insurance Corporation dataset, all women who gave birth between 2006 and 2015 were included in the study. We investigated 1) the mode of delivery, 2) the complication rates during pregnancy (i.e., preeclampsia and placenta previa), and 3) pre-pregnancy factors (body mass index, hypertension [HTN], diabetes mellitus [DM], and other pre-existing medical conditions), and their trends during the study period.

Results

Over 10 years, the rate of CS increased from 36.3% in 2006 to 40.6% in 2015 (P<0.01). The rate of CS increased in primiparous women, women with multiple pregnancy, and women with preeclampsia. Maternal age and the incidence of placenta previa also increased. In contrast, the rate of vacuum deliveries and vaginal birth after CS decreased during the study period. The rate of women with pre-pregnancy obesity and DM increased, but the rate of women with pre-pregnancy HTN decreased.

Conclusion

The rate of CS in South Korea increased from 2006 to 2015. This trend may reflect changes in the rate of different risk factors. Identifying the causes of the increasing CS trend observed in this study will allow clinicians to monitor these factors and possibly reduce the rate of CS.

Keywords: Cesarean section; Trends; Risk factors

Introduction

Cesarean sections (CSs) are the most common major surgical procedure for women. There is no doubt that CS is a lifesaving procedure for mothers and babies. This procedure can prevent adverse pregnancy outcomes such as perinatal asphyxia, stillbirth, uterine rupture, or obstetric fistula [1]. However, an increase in the use of CS is worrisome in many ways. The World Health Organization (WHO) reported that the rate of CS is increasing and nearly doubled between 2000 (12.1%) and 2015 (21.1%) [2,3]. CSs are associated with not only higher economic burden than those by vaginal births but also with health burden such as the risk of uterine rupture, abnormal placentation, ectopic pregnancy, stillbirth,

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preterm birth, and altered immune systems and obesity in children born through a CS [4].

The CS rate in South Korea ranks fifth among 24 countries in the Organization for Economic Cooperation and Development [5]. The rate of CS in other East Asian countries is less by 10%, although women in these countries share similar pelvic cavity characteristics. There is no definite consensus on the optimal rate of CS. However, the WHO recommends a rate of CS of approximately 10–15% because the maternal and neonatal health risks outweigh the benefits beyond 15% [6].

Understanding the trends in the factors affecting cesarean deliveries may benefit from assessing the effects of both maternal and healthcare provider characteristics on the change in CS rates and assist in designing effective interventions to optimize the rate of CS. Therefore, we examined recent trends in CS and the related factors that influence its rate.

Materials and methods

1. Study data

Study data were collected by merging the Korea National Health Insurance (KNHI) claims database with the National Health Screening Examination (NHSE) data.

In South Korea, 97% of the population is required to enroll in the KNHI program. The remaining 3% of the population is covered by the medical aid program. Thus, using the KNHI claims dataset, which contains information on all claims, nearly all information about diseases and their treatment can be identified from this centralized database, with the exception of procedures not covered by insurance.

As part of the KNHI healthcare system, all insurance subscribers and dependents are invited to participate in a biannual NHSE free of charge. The NHSE consists of 2 components: a health interview and a health examination. Therefore, pre-pregnancy information contained in the NHSE was also used in this study.

2. Study population

Based on the KNHI claims dataset, we identified all women who delivered between January 1, 2006 and December 31, 2015 (dataset 1). Using dataset 1, the delivery mode, pregnancy outcomes, and pre-pregnancy diseases were identified based on the International Classification of Diseases, 10th Revision (ICD-10) codes.

Women were included in the analysis if they had an NHSE 1 to 2 years before their delivery (dataset 2). Pre-pregnancy characteristics were evaluated in dataset 2.

3. Measurements of outcomes and pre-pregnancy and pregnancy characteristics

The mode of delivery was identified using electronic data interchange (EDI) codes in the KNHI claims database using dataset 1.

Pregnancy characteristics and pre-pregnancy diseases were evaluated using dataset 1. Information on pregnancy characteristics including primiparity, multiple pregnancy, instrumental delivery, vaginal birth after CS (VBAC), placenta previa, and preeclampsia was collected using EDI codes and ICD-10 codes. Information on pre-pregnancy diseases including diabetes mellitus (DM; E10–E14), hypertension (HTN; I10–I15), renal diseases (N10–N08, N10–N16), and cardiovascular–pulmonary diseases (I20–I28, I60–I69), hypothyroidism (E02–E03), hyperthyroidism (E05), and systemic diseases (M30–M36) was retrieved based on the ICD-10 codes.

Information on pre-pregnancy characteristics including smoking status, obesity, fasting glucose, liver function tests (LFTs), and total cholesterol (TC) levels was collected using dataset 2. Smoking status was categorized into current smokers, past smokers, and never smokers. Health examinations included the measurement of body mass index (BMI) in kilograms per square meter. Obesity was defined as BMI ≥25 kg/m^2 [7]. All blood samples were obtained after a minimum fasting period of 8 hours. The levels of fasting glucose, aspartate aminotransferase (AST), alanine aminotransferase (ALT), and cholesterol were measured using enzymatic methods. A high fasting glucose level was defined as glucose ≥126 mg/L [8]. High LFTs were defined as AST and ALT levels >31 U/L [9]. High cholesterol was defined as cholesterol ≥200 mg/L [10].

4. Statistical analyses

The data are expressed as mean±standard deviation for continuous variables and as percentage for categorical variables.

Clinical and biochemical characteristics by delivery years were compared using analysis of variance (ANOVA) for differences in continuous variables and using the χ^2 test for categorical variables. Secular trends in the continuous and categorical variables were determined and compared across the years using ANOVA polynomial regression tests and chi-square Cochran-Armitage tests, respectively. All tests were 2-sided, and *P*<0.05 was considered to indicate statistical significance. Statistical analyses were performed using SAS for Windows, version 9.4 (SAS Inc., Cary, NC, USA).

Results

During the study period, 4,190,949 deliveries were recorded.

1. Trend in cesarean section from 2006 to 2015

The rate of CS increased from 36.3% in 2006 to 40.6% in 2015, but unchanged from 2006 to 2011, and with a continuous increase each year after 2011 (*P*<0.01) (Fig. 1).

2. Trend in pregnancy factors related to cesarean section

The secular changes in maternal characteristics and pregnancy factors related to CS are summarized in Table 1. The mean maternal age at delivery increased from 29.92 years in 2006 to 31.85 in 2015. Likewise, the proportion of mothers who had advanced age (≥35 years and ≥40 years) increased. There were no changes in the rate of underage (<20 years) mothers during the study period. The rate of primiparity and multiple pregnancy increased, and the rate of CS increased in these high-risk groups. The number of vacuum deliveries and VBACs decreased during the study period. The prevalence of placenta previa increased during the study period.

3. Trend in pre-pregnancy diseases

Table 2 shows the secular changes in the prevalence of

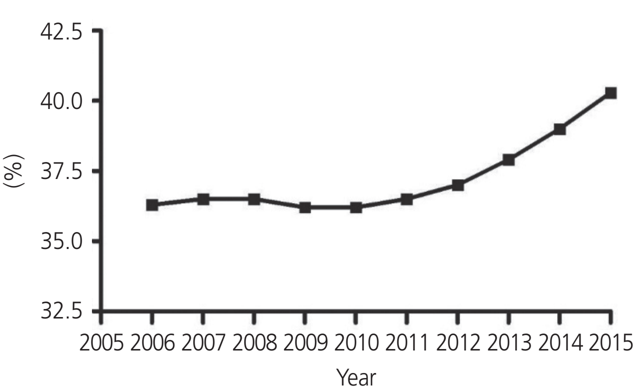

Fig. 1. Secular trends in the cesarean section rate between 2006 and 2015.

Table 1. Secular trends in maternal characteristics and pregnancy outcomes between 2006 and 2015

Characteristics	2006 (n=412,388)	2007 (n=454,582)	2008 (n=427,441)	2009 (n=407,106)	2010 (n=431,949)	2011 (n=431,570)	2012 (n=440,725)	2013 (n=395,706)	2014 (n=394,190)	2015 (n=395,292)	*P*-value
Age (yr)	29.92±3.79	30.12±3.80	30.39±3.92	30.59±3.91	30.87±3.83	31.04±3.89	31.25±3.88	31.49±3.93	31.67±3.96	31.85±3.99	<0.01
<20	0.66	0.41	0.40	0.37	0.36	0.42	0.39	0.42	0.39	0.35	<0.01
≥35	11.04	12.32	13.82	15.01	16.68	17.68	18.48	20.16	21.54	23.82	<0.01
≥40	1.06	1.11	1.30	1.54	1.75	2.03	2.21	2.43	2.64	2.79	<0.01
Primiparity	50.59	51.83	51.74	51.53	49.94	50.59	51.17	51.25	51.71	52.36	<0.01
CS in primiparity	35.42	35.83	36.04	36.09	36.41	36.85	37.79	39.27	40.77	42.55	<0.01
Multiple pregnancy	1.16	1.40	1.37	1.37	1.36	1.39	1.56	1.61	1.73	1.82	<0.01
V/D in multiple pregnancy	7.85	7.98	6.02	6.22	8.04	7.40	7.38	6.58	5.79	5.49	<0.01
Vacuum delivery	6.29	6.02	6.07	5.76	5.80	5.97	5.97	6.02	5.84	5.71	<0.01
VBAC	0.76	0.68	0.68	0.58	0.62	0.59	0.55	0.50	0.41	0.38	<0.01
Preeclampsia	2.04	2.06	1.93	1.93	2.01	1.90	2.04	1.86	1.86	1.96	<0.01
CS in preeclampsia	60.51	61.27	61.77	61.36	60.83	61.82	63.80	65.49	66.60	69.11	<0.01
Placenta previa	0.81	0.87	0.88	0.94	0.98	0.99	1.04	1.05	1.10	1.11	<0.01

Values are presented as mean±standard deviation or percentage.
CS, cesarean section; V/D, vaginal delivery; VBAC, vaginal birth after cesarean section.

maternal pre-pregnancy diseases. The prevalence of pre-pregnancy DM, cardiovascular-pulmonary disease, hyperthyroidism, and systemic disease was unchanged, but that of HTN and renal disease decreased during the study period. The prevalence of hypothyroidism increased.

4. Trend in pre-pregnancy factors related to cesarean section

The secular changes in pre-pregnancy risk factors related to CS were identified, as summarized in Table 3. The prevalence of pre-pregnancy obesity increased from 7.13% in 2006 to 10.67% in 2015. The prevalence of pre-pregnancy abnormal LFTs, high fasting glucose, and high TC also increased during the study period. The prevalence of pre-pregnancy smokers also increased.

Table 2. Secular trends in the prevalence of maternal pre-pregnancy comorbidities between 2006 and 2015

Characteristics	2006 (n=412,388)	2007 (n=454,582)	2008 (n=427,441)	2009 (n=407,106)	2010 (n=431,949)	2011 (n=431,570)	2012 (n=440,725)	2013 (n=395,706)	2014 (n=394,190)	2015 (n=395,292)	*P*-value
DM	1.12	1.05	0.99	0.94	0.98	1.03	1.06	1.09	1.09	1.11	<0.01
HTN	0.79	0.80	0.81	0.80	0.83	0.75	0.56	0.53	0.51	0.48	<0.01
Renal disease	1.98	1.92	1.91	1.83	1.88	1.81	1.76	1.77	1.57	1.60	<0.01
Cardio-vascular and pulmonary disease	0.53	0.56	0.57	0.54	0.58	0.58	0.56	0.55	0.53	0.52	<0.01
Hypothyroidism	2.28	2.48	2.76	2.91	3.07	3.02	3.13	3.15	3.04	3.22	<0.01
Hyperthyroidism	1.62	1.69	1.69	1.64	1.73	1.71	1.70	1.55	1.52	1.46	<0.01
Systemic disease	0.81	0.87	0.88	0.94	0.98	0.99	1.04	1.05	1.10	1.11	<0.01

Values are presented as percentage. Women were classified as having pre-pregnancy diseases if they were diagnosed with DM (E10–E14), HTN (I10–I15), renal diseases (N10–N08, N10–N16), cardiovascular and pulmonary diseases (I20–I28, I60–I69), and systemic diseases (M30–M36), based on the ICD-10 codes.
DM, diabetes mellitus; HTN, hypertension; ICD-10, International Classification of Diseases, 10th Revision.

Discussion

In this study, we evaluated secular trends in the rates of CS deliveries from 2006 to 2015 and their increase from 36.5% in 2007 to 40.3% in 2015. A previous study on changes in CS rate South Korea from 1982 to 2012 reported that the rate remained at 36% for the most recent 6 years of the study [11]. Our study evaluated 3 later years than that study and found that the rate increased significantly up to 40%. Increased maternal age, primiparity, pre-pregnancy obesity, multiple pregnancy, and placenta previa were contributing factors to the increase, while the rate of vacuum deliveries and VBACs decreased during the study period.

The rise in the rate of CS is a worldwide phenomenon. A multinational survey of the CS rates by the WHO reported an overall mean of 26.4% [12], and a recent global analysis of 150 countries reported a 12.4% increase in the rate of CS, with an average annual rate of increase of 4.4% over the past decades [13]. The trend in CS in Hong Kong, whose population shares similar pelvic sizes as that in our population, demonstrated a 10% increase during a 20-year study period, resulting in CS rates up to 24–25% [14]. European countries including Norway and England also showed moderate increases of 15.4% and 24.1%, respectively [15]. Our study found a significantly increasing rate over the study period, almost 3 times higher than that in 2015 when compared to the WHO-recommended CS rate. Herein, we explored the factors contributing to the increase in the rates of CS.

Table 3. Secular trends in maternal pre-pregnancy factors between 2006 and 2015

Characteristics	2006 (n=57,690)	2007 (n=73,822)	2008 (n=72,884)	2009 (n=78,468)	2010 (n=90,100)	2011 (n=92,802)	2012 (n=99,639)	2013 (n=89,093)	2014 (n=90,094)	2015 (n=93,315)	*P*-value
Obesity	7.13	7.03	7.34	7.74	8.42	8.76	9.09	9.29	9.87	10.67	<0.01
High AST	0.80	0.68	0.66	0.74	0.87	0.88	0.93	0.97	1.03	1.07	<0.01
High ALT	1.30	0.97	1.00	1.22	1.37	1.45	1.47	1.52	1.69	1.71	<0.01
High fasting glucose	0.13	0.12	0.12	0.14	0.17	0.17	0.18	0.20	0.25	0.23	<0.01
High TC	2.33	2.26	2.36	2.50	2.86	3.10	3.15	3.23	3.62	3.84	<0.01
Current smoking	3.77	4.20	4.47	4.31	4.88	5.38	5.80	5.77	5.93	5.44	<0.01

Values are presented as percentage. Obesity was defined as BMI ≥25 kg/m^2. High LFTs were defined as AST and ALT levels of >31 U/L. High fasting glucose levels were defined as a glucose level of ≥126 mg/L. High cholesterol was defined as a cholesterol level of ≥200 mg/L.
AST, aspartate aminotransferase; ALT, alanine aminotransferase; TC, total cholesterol; BMI, body mass index; LFT, liver function test.

One important finding to consider is the increase in the rate of primary CS. This can lead to another CS in the future because VBACs have been decreasing as shown in our results. The risk of uterine rupture increases with VBAC attempts, and this catastrophic event may lead to litigation problems. In addition, the incidence of placenta previa was increased in our population. Placenta previa might be the cause for the rise in rates of CS, or the increased the rates of CS might be the cause of placenta previa. The risk of placenta previa in subsequent pregnancies increases with the number of previous cesarean deliveries [16,17]. Increased maternal age, *in vitro* fertilization, and previous myomectomy are also directly linked to the risk of placenta previa [18,19].

One cause of increased primary CS is maternal request without indication. A previous survey conducted in Korea showed that 6–7% of CS were preformed upon maternal request without indication [11,20]. The increase in women's dissatisfaction with long labor and vaginal delivery and fear of emergency CS in the middle of labor due to arrest of labor or failure to progress have resulted in lower obstetrician thresholds for CS deliveries. The decrease in operative deliveries using forceps or vacuum was another consequence observed in our population. As operative delivery is associated with pelvic floor injuries and acute perinatal injuries, obstetricians tend to perform CS instead of using forceps or vacuum. The society has generally become far less tolerant of poor outcomes, and a trend has been toward placing blame either on the individual or on the system involved. This condition, and the fear of litigation, makes clinicians reluctant to resist maternal requests.

The most pressing social issue in South Korea is the low birth rate, which was only 0.98 in 2018 [21]. The main reasons contributing to this situation are women balancing careers with having children, the high cost of raising children, lifestyle choices regarding marriage, gender equity values, and higher education levels of women [22]; people avoid getting married and having many babies. This social phenomenon results in increased nulliparity and maternal aging. Consistent with previous findings, maternal aging, multiple pregnancy, and pre-pregnancy obesity were associated with increased rates of CS in this study [23].

There has been a gradual increase in the mean age of pregnant women in Korea. Older maternal age leads to a further rise in the CS rate. Maternal aging is a consequence of women's higher education level, followed by marriage at an older age. Increased maternal age poses higher obstetric complications because these women have more chronic diseases such as diabetes and HTN before and during pregnancy. The rate of preeclampsia was slightly decreased during 10 years, but a higher rate of CS in preeclamptic patients was observed. One possible explanation for the decrease in preeclampsia is the introduction of voucher programs for maternal health care covered by KNHI since 2008, and this program has allowed easier access to facility antenatal care and reduced the financial burden of low-income pregnant women [24]. Maternal aging also results in an increased failure to progress due to a contracted pelvis [25]. Women with contracted pelvis are likely to pass their pelvic dimensions to their own offspring. This phenomenon implies that the application of life-saving CS can evolutionarily increase the rates of contracted pelvises [26]. These factors related to aging lead to increased rates of CS. Several previous statistics in many countries showed the link between older maternal age and the increased rates of CS [27].

Our results showed a 50% increase in the frequency in multiple pregnancy and decreased numbers of vaginal deliveries in multiple pregnancy. The evolution of infertility therapy is one of the main reasons for the increase in multiple pregnancy. In Korea, the Ministry of Health and Welfare has established regulations on the number of embryo transfers regarding maternal age and status of embryos such that no more than 3 cleavage-stage embryos or 2 blastocysts can be transferred even after the age of 35. This has had a direct influence on adverse obstetrical outcomes including increase in the rate of CS deliveries. There are more chances of malpresentation in multiple pregnancy and even without malpresentation, and doctors tend to perform CS instead of vaginal delivery.

Several pre-pregnancy factors were associated with increased rates of CS deliveries. Pre-pregnancy obesity was one important factor that increased the rate of CS. There has been a rapid rise in maternal pregnancy BMIs in the past decades, and the prevalence of adult obesity in South Korea increased from 29.7% in 2009 to 32.4% in 2015 due to increase in childhood obesity and human microbiome issues, in agreement with our results [28,29]. Obesity is a well-known factor that contributes to adverse maternal and neonatal outcomes [30]. Associated factors that lead to CS are chronic diseases of the mother, macrosomia due to uncontrolled blood glucose levels, excess intra-abdominal adipose tissue causing obstructed labor, and induction agent intolerance due to large body volumes [31-33].

Despite the decreasing trend in smoking among people worldwide, our results showed that smoking prevalence among Korean women increased [34]. Changes in gender role, higher education, and social norms are contributing factors for the increase in smoking trend among women. Other than this factor, abnormal liver function and higher fasting glucose levels appear to be associated with the risk of CS. These factors may increase the rate of CS because they are strongly associated with comorbidities. However, the relationship between these factors and CS should be investigated in the future.

Several interventions have been implemented to reduce unnecessary CS, but their effectiveness was limited. However, counseling low-risk primipara mothers who favor CS on the risk of CS and educating them on optimal gestational weight gain and the importance of controlling body weight before pregnancy may help to prevent unnecessary CS. In low-risk pregnancies, women who want a primary CS should be counseled on the increased risks of perinatal mortality and morbidity resulting from CS. They include higher blood loss, infection rates, thromboembolism, and adjacent organ injuries in mothers and respiratory problems and mortality in babies [35,36]. One previous study conducted in China reported that attendance in a prenatal education course significantly reduced the rate of maternal CS requests [37]. Education on labor and normal delivery, the benefit of babies born vaginally, the perinatal risk of CS, pain management during labor, and the supporting roles of the husband or parents by skilled obstetricians, and maternal unit nurses or midwives may help to lower the number of CS as noted in this study.

This population-based cohort study reports trends in the rate of CS deliveries in South Korea over 10 recent years. However, the study had several limitations. First, social factors such as educational background, socioeconomic status, labor force participation, and publicity of the hospital, which are known to be associated with CS rates, were not considered. Second, the results of our study are not completely generalizable because our health insurance system is different from those in other countries and the population enrolled was East Asian. Third, the indications for primary CS were not described and may not be accurate because insurance does not cover the CS on maternal request.

We observed increasing trends in the rates of CS over the recent decade. Maternal aging, increased primiparity, increased pre-pregnancy obesity, increased placenta previa, increased multiple pregnancy, and decreased vacuum deliveries and VBACs were major factors associated with the increased rates of CS. CS should be undertaken when medically necessary, and informed consent should include short-term and long-term effects of CS for the sake of the mother and the baby. Efforts should focus on providing CS to the appropriate women at the right time. In addition, public health programs to lower the rate of CS should be established, and multidisciplinary discussion should be performed in the future, whether national health insurance will cover "CS upon maternal request."

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Ethical approval

This study was approved by the Institutional Review Board (IRB) of the Korea University Medical Center (IRB No. 2019GR0256).

Patient consent

All the information that was provided for the study had been de-identified; therefore, we were unable to obtain informed consents from the participants.

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