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Risk adjustment for inter-hospital comparisons of caesarean section rates in Taipei municipal hospitals

Chun-Chyang Hsu [a], Guahn-Ren Shieh [b], Chuan-Song Wu [c], Hsi-che Shen [d,e], Chao-Hsiun Tang [e,*]

[a] *Department of Health, Taipei City Government, Taipei, Taiwan*
[b] *Department of Obstetrics and Gynecology, Taipei City Hospital, Zhong Xing Branch, Taipei, Taiwan*
[c] *Department of Otolaryngology, Taipei City Hospital, Zhong Xing Branch, Taipei, Taiwan*
[d] *Department of Emergency Medicine, Taipei City Hospital, Zhong Xing Branch, Taipei, Taiwan*
[e] *School of Health Care Administration, Taipei Medical University, 250 Wu Hsing Street, Taipei 110, Taiwan*

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Abstract

Background: This study sets out to determine whether adjustments for specific patient caesarean delivery risk factors have an affect on the assessment of performance rates among the municipal hospitals of Taipei City.
Methods: Analysis of National Health Insurance (NHI) claims data, linked with birth certificate data, was undertaken on a cohort of 27,693 live births in the six general hospitals of the Taipei Medical Hospital System (TMHS) between 1999 and 2001. Using multivariable logistic regression modeling of the risk factors independently associated with caesarean deliveries, an expected caesarean delivery rate was constructed for each of the hospitals. By contrasting observed rates with expected rates to quantify the magnitude of the deviation from average practice, a measurement similar to relative risk (RR) was also constructed for each hospital.
Results: The observed rates for two of the six hospitals examined fell within the expected 95% confidence interval (CI), two were above the expected upper limit, and two were below the expected lower limit. The RR ranking of Hospitals A (RR = 1.08, CI = 1.01–1.15) and C (RR = 1.01, CI = 1.00–1.03) improved from first to second, and third to fourth, whilst the RR of Hospitals B (RR = 1.09, CI = 1.05–1.14) and D (RR = 1.02, CI = 0.99–1.06) worsened from second to first, and fourth to third, respectively. The RR rankings of Hospitals E (RR = 0.92, CI = 0.88–0.96) and F (RR = 0.80, CI = 0.77–0.84) were the same as the observed rates.
Conclusions: Caesarean delivery rate profiles, or hospital comparisons without risk adjustment, may be methodologically biased and may lead to unfair judgments by healthcare purchasers.

Keywords: Risk-adjustment; Caesarean delivery; Taiwan

1. Introduction

Incidences of births in Taiwan which culminate in caesarean delivery are amongst the highest in the world, with the rates in Taiwan fluctuating between 32% and 34% from 2000 to 2003, at an average rate of 33.22% [1]. The Bureau of National Health Insurance (BNHI) has continually adopted the crude quarterly average rate, by region and/or hospital accreditation levels, to both monitor the behavior of healthcare delivery providers under the global budget payment system, and to make economic judgments as to the appropriateness of various practices [2]. This is, however, inherently unfair, given that a hospital may have a high caesarean delivery rate simply because it serves a higher-risk population, and not because of any variations in its adopted practices. With no adjustment for differences in the patient risks faced by any individual hospital, despite the appearance of providing unnecessary surgery, a hospital serving a high risk population may well be observing good practices.

* Corresponding author. Tel.: +886 2 23785339x3619; fax: +886 2 23789788.
E-mail address: chtang@tmu.edu.tw (C.-H. Tang).

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The need for case mix adjustment of the patient population was recognized by the American College of Obstetricians and Gynecologists (ACOG) in 2000, when it recommended that prior to comparing the caesarean delivery rates between hospitals, all caesarean delivery rates should be risk adjusted [3]. Although risk-adjusted caesarean delivery comparisons between hospitals within various regions has been proposed and discussed [4–8], such risk adjustment of caesarean delivery rates has been hampered in many areas or countries, largely as a result of the lack of adequate data sources.

This study takes advantage of a unique dataset, which merges birth certificate data with National Health Insurance (NHI) claims data, to determine whether adjustment for specific patient caesarean delivery risk factors has an effect on the assessment of performance rates between the municipal hospitals of Taipei City. We hypothesize that after adjusting for patient risk factors, the expected caesarean delivery rates may differ significantly from the crude rates within these hospitals, and that after such risk adjustment, some hospitals may have even higher rates. Adjusting for patient risks accommodates the public health authorities' concerns for the identification of hospitals whose caesarean delivery rates are significantly higher, or lower, than average practices within their hospital network, as a whole.

2. Materials and methods

This study took place in six general hospitals within the Taipei Municipal Hospital System (TMHS), a system under the administration of the Department of Health of the Taipei City Government. The hospital network essentially provides healthcare services for Taipei City's 2.6 million inhabitants and, amongst the noteworthy features of the TMHS, are its teaching hospitals whose major function is to improve the health of the local community. Doctors are employed under civil-servant status with their remuneration coming in the form of salaries; further monetary incentives are available in accordance with a similar volume-based formula.

This study takes as its sample live births ($n = 27{,}693$) delivered within the six general hospitals in the TMHS between 1999 and 2001, for whom birth certificate data and claims data from the NHI could be linked. The mother's date of birth, along with her unique personal identification number, provides the link between the birth certificate data and the NHI claims data.

The NHI claims data provides registries of all medical facilities contracting with the BNHI, complete with monthly claims summaries for all in-patient care, and contains information on all deliveries occurring within NHI-contracting hospitals and clinics, including the method of delivery and the ownership and teaching status of the hospital/clinic, as well as one principal and four secondary ICD-9-CM diagnostic codes.

The birth certificate dataset comprises of variables indicating maternal and paternal age and education, infant birth weight, sex and gestation age (in weeks), and the mother's details on multiple pregnancies, gravidity, marital status and county of residence. The potential-independent variables considered in this study were categorized as follows.

2.1. Clinical factors not necessarily indicative of caesarean delivery

These factors were defined as: (i) maternal and paternal ages (in years) at the time of the infant's birth; (ii) gestational period at birth (in weeks), recoded to reflect preterm ($\leq$35 weeks), term (36–40 weeks) and postdate (41 weeks or more) deliveries; (iii) multiple births; (iv) parity, coded as 0 and 1 or more; and (v) infant gender. Given that birth weight is closely correlated to gestational age, using both low birth weight and gestational age is redundant in most cases. Gestational age was selected for this study since it is a clinical estimate undertaken by physicians, whereas birth weight is only known after delivery. Insufficient or excessive fetal growth is further differentiated in this study in order to reflect the risk of intra-uterine growth retardation or macrosomia, given gestational age.

2.2. Clinical factors suggesting maternal or fetal risk

Clinical indicators for risk-adjustment were selected based upon clinical importance and the availability of data from the birth certificate and NHI claims file. Obstetric-related complications included malpresentation, antepartum hemorrhage, abruption placenta or placenta previa, previous caesarean section history, and preeclampsia or eclampsia. Pregnancy-related complications included diabetes mellitus, chronic/pregnancy associated hypertension, premature labor, polyhydramnios or oligohydramnios, and insufficient or excessive fetal growth.

Other complications, such as cardiac disease, cerebral occlusion-hemorrhage, infection of the amniotic cavity, genital herpes, syphilis and so forth, were combined into the category of 'other medical risks' since each of these individual complications were not present often enough to be statistically significant. Although dystocia and fetal distress are common indications for caesarean section (as proposed by Anderson and Lomas [9] and subsequently adopted by several other studies for the construction of maternal/fetal risk variables [4,10–12]) they were not considered in our model because of the lack of clinical criteria to define them [7]; thus it was felt that they may in fact reflect the quality of the care provided rather than the risk factors of the patients themselves.

Table 1 provides details of the labor and pregnancy complications at the time of labor and delivery, classified in accordance with the International Classification of Diseases, Ninth Revision (ICD-9).

Table 1
Obstetric and pregnancy risk factors

Risk factors	ICD-9-CM
Obstetric-related complications	
Malpresentation	652/761.7/763.0/763.1
Antepartum hemorrhage, abruptio placenta or placenta previa	641/762.0/762.1
Previous CS history	654.2
Preeclampsia or eclampsia	586.0/780.3
Pregnancy-related complications	
Polyhydramnios or oligohydramnios	657.0/658.0
Premature labor	644
Diabetes mellitus	648.0/648.8/775.0
Chronic/pregnancy associated hypertension	642/760.0/401–405
Insufficient or excessive fetal growth	656.5/656.6
Other medical risk	
Cardiac disease	648.5/648.6
Tuberculosis	647.3
Cervical incompetence	654.5
Congenital/acquired abnormality of cervix or vagina	654.6/654.7
Renal failure (disease)	646.2
Iso-immunisation with Rh antigen	656.1
Cerebral occlusion-hemorrhage	430/431/432/433/434
Infection of amniotic cavity	658.4
Malformation of fetal CNS/other known or suspected fetal abnormality	655.0/655.8/655.9
Anemia	648.2
Genital herpes	647.6
Syphilis	647.0

2.3. Non-clinical factors

Maternal and paternal education levels were based upon the level of formal education completed and categorized into two levels: senior high school or below, and college, university or above, in accordance with the education system in Taiwan. Mother's marital status was also considered.

The data were first analyzed to calculate the odds of caesarean delivery associated with all of the potential-independent variables. Stepwise logistic regressions were then carried out in order to develop a main effects model and to minimize the number of predictive variables within the formula; the variables were retained if they were significant predictors with a *P*-value of less than 0.05. Given that the sample dataset adopted for the current study provided a sufficiently large volume, it was extremely unlikely that any important variables would have been overlooked.

Using a formula developed from the regression coefficient, the above logistic model was applied to compare relative performance between hospitals; the adjusted odds ratios obtained from the logistic models and the corresponding 95% confidence intervals (95% CI) were reported.

Having first computed the predicted probability of caesarean delivery, the expected caesarean delivery risk was summarized into a single index for each woman. Thereafter, the expected rate for each individual hospital was assigned by averaging the predicted probability for all women delivering at the hospital. Finally, as proposed by Librero et al. [4], an index similar to the relative risk (RR) of caesarean delivery was constructed by means of dividing the observed rate by the expected rate to quantify the magnitude of behavior deviation from the average practice by each hospital. RR was significantly greater than 1 if caesarean deliveries were performed within the hospital more often than the average practice for the TMHS as a whole, and vice versa. The 95% confidence intervals were established to quantify the random error of RR by assuming a normal approximation to a binomial distribution.

All analyses were carried out using the SAS software program package, version 8.02 (SAS Institute, Inc., Cary, NC).

3. Results

The resultant dataset comprised of 27,693 births, of which 9350 were reported as caesarean deliveries, providing a crude caesarean delivery rate of 33.76% for all six hospitals. Table 2 provides details of the crude risk of caesarean delivery for each variable which could potentially predict the patient population risk.

Maternal/fetal complications, such as previous caesarean delivery, malpresentation, antepartum hemorrhage, abruption placenta or placenta previa, preeclampsia or eclampsia, insufficient or excessive fetal growth, and multiple births, were the strongest predictors of caesarean delivery, whilst chronic/pregnancy associated hypertension, polyhydramnios or oligohydramnios, premature labor, diabetes mellitus, preterm, led to only a modest increase in the level of risk. Multiparous women, and those women who had received education at senior high school level (or lower), were at a slightly higher risk of caesarean delivery, whilst the rates also increased steadily with increasing maternal and paternal age. Paternal education and the mother's marital status were not significant in predicting caesarean delivery rates. Hospitals were denoted by the letters A–F, and were ranked according to their observed caesarean delivery rates.

Details of the proportion of caesarean deliveries for the six hospitals, by selected risk factors are presented in Table 3, which shows that there are considerable variations in the distribution of the patient population risks for each of the hospitals, particularly for those patients with antepartum hemorrhage, abruption or placenta previa, preeclampsia or eclampsiadystocia, polyhydramnios or oligohydramnios, insufficient or excess fetal growth, and for mothers of more advanced age. The decision to undertake surgery on presentation of the risk factors also varied considerably across different hospitals.

The caesarean delivery rates were adjusted by stepwise logistic regression analysis for the effects of the variables listed in Table 2 (with the exceptions of paternal education and marital status), thereby taking into consideration certain risk patients which could potentially alter a hospital's decision on caesarean delivery. The results of the logistic

Table 2
Crude risk of caesarean section delivery, by clinical and socio-demographic factors

Variable	Total no.	% of total	Crude odds ratio	95% CI
Malpresentation				
Yes	1694	6.12	59.23	46.17–75.99
No	25999	93.88	1.00	
Antepartum hemorrhage, abruptio placenta or placenta previa				
Yes	402	1.45	16.55	12.09–22.66
No	27291	98.55	1.00	
Previous CS history				
Yes	3762	13.58	104.23	86.17–126.09
No	23931	86.42	1.00	
Diabetes mellitus				
Yes	105	0.38	1.53	1.04–2.26
No	27588	99.62	1.00	
Preeclampsia or eclampsia				
Yes	197	0.71	6.92	4.94–9.68
No	27496	99.29	1.00	
Chronic/pregnancy associated hypertension				
Yes	93	0.34	2.98	1.97–4.51
No	27600	99.66	1.00	
Polyhydramnios or oligohydramnios				
Yes	36	0.13	2.75	1.42–5.33
No	27657	99.87	1.00	
Premature labor				
Yes	1360	4.91	1.42	1.27–1.59
No	26333	95.09	1.00	
Insufficient or excessive fetal growth				
Yes	171	0.62	4.65	3.35–6.46
No	27522	99.38	1.00	
Other medical risks				
Yes	123	0.44	2.14	1.50–3.05
No	27570	99.56	1.00	
Parity				
0	13401	48.39	1.00	
≥1	14292	51.61	1.10	1.05–1.15
Gestational age (weeks)				
≤35	935	3.38	1.52	1.33–1.73
36–40	24952	90.10	1.00	
≥41	1806	6.52	0.83	0.75–0.92
Infant gender				
Male	14649	52.90	1.09	1.04–1.15
Female	13044	47.10	1.00	
Multiple birth				
Yes	653	2.36	5.51	4.62–6.55
No	27040	97.64	1.00	
Paternal age				
≤29	6898	24.91	1.00	
30–34	11772	42.51	1.24	1.17–1.33
35–39	6835	24.68	1.58	1.47–1.70
≥40	2188	7.90	1.94	1.76–2.14
Paternal education				
Senior high school or below	14892	53.78	1.04	0.99–1.10
College, university or above	12801	46.22	1.00	
Maternal age				
≤29	13057	47.15	1.00	
30–34	10824	39.09	1.47	1.39–1.55
35–39	3381	12.21	2.13	1.97–2.30
≥40	431	1.56	2.94	2.43–3.57

Table 2 (*Continued*)

Variable	Total no.	% of total	Crude odds ratio	95% CI
Maternal education				
Senior high school or below	16006	57.80	1.09	1.03–1.14
College, university or above	11687	42.20	1.00	
Mother's marital status				
Married	26971	97.39	1.04	0.89–1.22
Unmarried	722	2.61	1.00	

regression analyses for the variables included within the final model are provided in Table 4.

With the exceptions of paternal age, paternal education, infant gender, and other medical risks, all of the other variables were retained within the final model. The likelihood ratio and Hosmer–Lemeshow test were both significant at $P < 0.0001$, indicating that the risk factors considered in this study were very significant in terms of

Table 3
Proportion of caesarean section deliveries, by hospital and selected risk factors

Risk factors	Hospital						Total
	A	B	C	D	E	F	
Total no. of births	1497	1996	17400	2901	1803	2096	27693
%CS	38.41	36.42	34.18	33.02	32.78	26.34	33.76
Malpresentation							
%	5.61	5.81	6.14	6.96	6.82	4.82	6.12
%CS	94.05	92.24	96.91	97.03	95.93	93.07	96.16
Antepartum hemorrhage, abruptio placenta or placenta previa							
%	2.67	1.40	1.33	0.93	1.55	2.24	1.45
%CS	95.00	92.86	88.36	81.48	85.71	91.49	89.05
Previous CS							
%	13.96	13.68	13.70	12.93	14.31	12.60	13.18
%CS	99.52	96.70	97.06	96.80	96.51	95.83	97.02
Diabetes mellitus							
%	0.53	0.35	0.39	0.03	0.67	0.43	0.38
%CS	75.00	85.71	36.76	100.00	25.00	55.56	43.81
Preeclampsia or eclampsia							
%	2.07	0.65	0.49	0.83	1.05	1.19	0.71
%CS	77.42	100.00	81.18	75.00	57.89	72.00	77.66
Chronic/pregnancy associated hypertension							
%	0.47	0.55	0.33	0.14	0.39	0.29	0.34
%CS	85.71	81.82	60.34	50.00	14.29	50.00	60.22
Polyhydramnios or oligohydramnios							
%	0.20	0.05	0.12	0.10	0.39	0.05	0.13
%CS	33.33	0.00	71.43	100.00	28.57	0.00	58.33
Premature labor							
%	4.88	4.16	5.58	2.52	3.33	4.77	4.91
%CS	49.32	49.40	40.99	32.88	40.00	42.00	41.54
Insufficient or excessive fetal growth							
%	1.20	0.15	0.47	0.79	1.33	1.00	0.62
%CS	27.78	100.00	79.27	86.96	50.00	71.43	70.18
Other medical risks							
%	1.20	0.20	0.39	0.41	0.50	0.62	0.44
%CS	83.33	25.00	43.28	66.67	22.22	69.23	52.03
Multiple births							
%	1.54	1.40	2.04	1.48	1.77	2.24	1.91
%CS	65.22	57.14	74.37	65.12	62.50	68.09	71.02
Maternal age ≥40							
%	2.47	1.10	1.63	1.10	1.16	1.67	1.56
%CS	62.16	31.82	54.58	46.88	42.86	60.00	53.36

Table 4
Adjusted risks of caesarean section delivery from logistic regression

Variable	Adjusted odds ratio	95% CI
Malpresentation		
Yes	119.97	93.00–154.77
No	1.00	
Antepartum hemorrhage, abruptio placenta or placenta previa		
Yes	41.70	29.96–58.04
No	1.00	
Previous CS		
Yes	252.59	207.24–307.88
No	1.00	
Diabetes mellitus		
Yes	1.97	1.20–3.24
No	1.00	
Preeclampsia or eclampsia		
Yes	13.19	9.16–19.01
No	1.00	
Chronic/pregnancy associated hypertension		
Yes	3.63	2.23–5.92
No	1.00	
Polyhydramnios or oligohydramnios		
Yes	2.65	1.17–5.98
No	1.00	
Premature labor		
Yes	0.82	0.68–0.99
No	1.00	
Insufficient or excessive fetal growth		
Yes	9.82	6.90–13.98
No	1.00	
Parity		
0	1.00	
≥1	0.36	0.33–0.39
Gestational age (weeks)		
≤35	0.84	0.67–1.05
36–40	1.00	
≥41	1.52	1.35–1.71
Multiple births		
Yes	8.67	7.03–10.68
No	1.00	
Maternal age		
≤29	1.00	
30–34	1.34	1.24–1.45
35–39	1.84	1.64–2.06
≥40	2.92	2.22–3.82
Maternal education		
Senior high school or below	1.13	1.06–1.22
College, university or above	1.00	

predicting the probability of caesarean delivery, but that the fit was imperfect. However, the number of concordant pairs was very high (*c*-statistic = 0.862), indicating that the predictive accuracy of the logistic model was good.

After controlling for all other variables within the model, the adjusted odds ratio for most of the obstetric- and pregnancy-related complications were of considerably greater magnitude when compared to the unadjusted risks, while those of polyhydramnios/oligohydramnios and maternal age were reduced. However, with the exceptions of postdates, premature labor and parity, the direction of the relationship between the caesarean delivery rate and all other variables remained the same.

The existence of previous caesarean delivery (OR = 252.59), malpresentation (OR = 119.97), antepartum hemorrhage, abruption placenta or placenta previa (OR = 41.70), preeclampsia or eclampsia (OR = 13.19), insufficient or excessive fetal growth (OR = 9.82) or multiple births (OR = 8.67) greatly increased the risk of caesarean delivery. Nulliparous women and those at postdate were no longer protective against caesarean delivery, but instead incurred increased risk; the likelihood of caesarean delivery was significantly lower for parous women (OR = 0.36) and higher for those women at postdate (OR = 1.52). Furthermore, the caesarean delivery rate increased significantly with the advancing age of the mother (OR = 1.34, 1.84, 2.92, for maternal ages 30–34, 35–39 and ≥40, respectively) and with the mother's lower education level (OR = 1.13).

Table 5 shows, in descending order, the observed caesarean delivery rates, the expected rates generated by the previous model, and the RR. Expected rates ranged from 32.32% to 35.69%, whilst observed hospital rates varied from 26.34% to 38.41%. Of the six hospitals in the study, the observed rates of Hospitals C and D fell within the 95% confidence intervals of the expected rates. In terms of their RR ranking, comparing the observed rates with the expected rates, Hospital C improved from third to fourth place (RR = 1.01, CI = 1.00–1.03), whereas Hospital D worsened from fourth to third place (RR = 1.02, CI = 0.99–1.06).

Of the remaining hospitals, the observed rates of Hospitals A and B were above the upper limit of the expected confidence intervals, with the RR ranking of Hospital B deteriorating from second to first place (RR = 1.09, CI = 1.05–1.14) and that of Hospital A (RR = 1.08, CI = 1.01–1.15) improving from first to second place. Conversely, the rates for Hospitals E and F (RR = 0.92, CI = 0.88–0.96, and RR = 0.80, CI = 0.77–0.84, respectively) were below the lower limit of the expected confidence intervals, with their RR rankings remaining the same as the observed rate.

4. Discussion

In order to monitor the 'epidemic' caesarean delivery rate which exists in Taiwan – with a national average as high as 33.22% between 2000 and 2003 – the current practice used by the healthcare authorities, as a means of comparing the performance of different hospitals and providers, involves observed (unadjusted) caesarean delivery rates; however, not only is a comparison using the observed rates problematic, it is also misleading. A lower caesarean delivery rate within a given hospital will not necessarily indicate that the hospital

Table 5
Observed, expected and relative risk of caesarean section delivery

Rank	Hospital	Total No.	%	Observed caesarean delivery rates	Hospital	Expected caesarean delivery rates	Hospital	Relative risk	95% CI
1	A	1497	5.42	38.41	A	35.69 (33.53–37.85)	B	1.09	1.05–1.14
2	B	1996	7.21	36.42	E	35.54 (33.97–37.11)	A	1.08	1.01–1.15
3	C	17400	62.83	34.18	C	33.76 (33.27–34.25)	D	1.02	0.99–1.06
4	D	2901	10.48	33.02	B	33.45 (32.08–34.82)	C	1.01	1.00–1.03
5	E	1803	6.51	32.78	F	32.75 (31.38–34.12)	E	0.92	0.88–0.96
6	F	2096	7.57	26.34	D	32.32 (31.14–33.50)	F	0.80	0.77–0.84
Total		27693	100.00	33.76		33.76 (33.37–34.15)		1.00	0.99–1.01

is adopting better practices; it may simply reflect the hospital's provision of healthcare for a population with relatively lower risks. Conversely, in other hospitals where a higher proportion of caesarean deliveries are performed, this may simply be attributable to patient mixes with higher risks, rather than any adoption of inappropriate practices [6].

This study has shown that the indications leading to caesarean delivery differ considerably between hospitals; therefore, adjustment for the differences in risk factors for different patient mixes allows for more accurate and fairer comparison of caesarean delivery rates between all hospitals within the TMHS. This is evidenced by the absolute changes in the RR rankings of hospitals where the crude caesarean delivery rates were significantly higher than the expected rates. An additional contribution of the current study lies in its identification of those hospitals with significantly better-than-expected or worse-than-expected caesarean delivery rates, relative to other hospitals within the TMHS.

In specific terms, based upon a comparison with the average practices throughout the TMHS, the current study finds that the higher caesarean delivery rates found in Hospitals A and B truly reflect the general tendency within these hospitals to perform more caesarian surgeries than those undertaken in other hospitals, as opposed to any higher severity of patient mix.

In addition, this study has shown that whilst Hospital A ranked first in observed rate, after contrasting this with its expected rate, the performances of obstetricians within that hospital were better than those in Hospital B. On the other hand, although the observed caesarean delivery rate for Hospital C was found to be above the average rate within the TMHS as a whole, seemingly indicating that it was performing worse than hospitals D–F (whose rates were below the average caesarean delivery rate), the risk adjusted results indicate that the caesarean delivery rate for Hospital C was in fact no worse than we might have expected.

Finally, this study has also found that, relative to other hospitals within the TMHS, the lower caesarean delivery rates of Hospitals E and F simply reflected the differences in their clinical practices, as opposed to their provision of healthcare to low-risk patients. The differences in physician practices within these two hospitals may be worthy of lengthy study in order to establish optimum practice benchmarks for the TMHS as a whole. The current findings imply that when monitoring and comparing variations in hospital practices, potential confounding factors need to be taken into consideration for risk adjustment, so that unsound or biased judgments can be avoided.

The multivariable logistic regression modeling methodology adopted for this study has provided results consistent with the relationship established in many of the prior epidemiological studies on factors associated with caesarean delivery. Keeler et al. [8] reported a total of 24 variables which predicted the significant probability of caesarean delivery in four validated models, one each for previous caesarean delivery, breech presentation, nulliparity and 'others'. However, they found that risk adjustment did not significantly alter hospital ranking. The differences between their findings and those of the present study may be due to their exclusion of low-birth weight and multiple births.

Using a validated model to adjust the primary caesarean delivery rates, Bailit et al. [5] and Aron et al. [7] found wide-ranging predicted rates across hospitals, while in an attempt to identify regional hospitals with significantly better or worse than expected caesarean delivery rates, Glantz [6] reported 22 significant variables suitable for caesarean delivery rate adjustment. Adopting a logistic approach, Librero et al. [4] reported not only maternal/fetal risk factors, but also the interactions between such risk factors in predicting the risk of caesarean delivery.

Similar to the current findings, many of the prior studies have found that previous caesarean delivery [4,6,8], malpresentation [4–8], multiple gestation [4–7], eclampsia or preeclampsia [6,7] placenta previa or abruptio placenta [6,7] as well as other clinical indications (such as diabetes mellitus, insufficient or excessive fetal growth, hypertension, and so on) [4–8] were the strongest predictors of caesarean delivery risks, whilst maternal education [5], maternal age [4–8], postdates [5,7,8] and nulliparity [4,6,8], were also significant factors. However, following the risk adjustment of these earlier findings, the current study has revealed that several of the risk factors that were previously regarded as significant predictors of caesarean delivery, such as infant gender [6,8] and preterm [5] were no longer found to be significant factors.

In general terms, between various regions or countries, the factors associated with caesarean delivery are largely similar; however, due to differences in the data sources or the specific patient populations under examination, the odds ratios associated with each of the variables may well vary. Therefore, any given region must necessarily develop its own specific formula for adjusting caesarean delivery risk in order to assess and compare the hospitals within its region. By merging birth certificate and NHI claims data, this study represents the first attempt in Taiwan to calculate risk-adjusted caesarean delivery rates as a means of identifying those hospitals that are above or below the average practice within a healthcare system, such as the TMHS.

There are, however, several possible limitations which must be considered when interpreting the present findings, one of which is the possible biased information provided by the linked claims data. As compared with other hospitals within the TMHS, coders at certain hospitals may enter information inconsistently; there may, therefore, be systematic variations between hospitals in terms of the thoroughness of documenting clinical information. Thus, some of the variations in the clinical findings may simply reflect differences in the overall quality of the clinical documentation within a particular hospital. A second limitation is that the formula constructed for this study was based upon the average behavior observed throughout the TMHS; thus, it is impossible to extrapolate the results to other regions, or to the general healthcare system in Taiwan as a whole.

5. Conclusions

In the current healthcare environment in Taiwan, with disproportionately high caesarean delivery rates, the rates for cities/counties, regions, institutions and providers are currently compared using observed (unadjusted) rates, with the BNHI setting an arbitrary ceiling of around 32% on crude rates for hospital accreditation requirements, and hospitals being placed under strict periodic scrutiny. The present study has shown that hospital comparisons or profiles of caesarean delivery rates which do not take into account the risks arising from the composition of the patient population may be methodologically biased and could lead to unfair judgment on the part of healthcare purchasers.

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