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Urbanization and the likelihood of a cesarean section

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ABSTRACT

Objective: This study examines the association between the likelihood of cesarean section (CS) and the degree of urbanization in Taiwan, exploring possible explanations for the difference.
Study design: The database used in this study was the Taiwan 2004 National Health Insurance Research Database. A total of 200,207 singleton deliveries fulfilled our criteria and were included in our study. The urbanization level of cities/towns where parturients resided at the time of delivery was stratified into seven categories. A multilevel logistic regression model was applied to examine the relative likelihood of CS by urbanization level after adjusting for parturient, physician and hospital characteristics.
Results: There was an upward trend in the CS rate with advancing urbanization level; the CS rates for urbanization level 1 (most urbanized) through 7 (least urbanized) were 33.7, 32.3, 30.4, 30.2 29.7, 29.5, and 28.6%, respectively. Compared with participants living at the highest urbanization level, the adjusted odds of a CS were 0.91 (95% CI = 0.85–0.98, $p = 0.014$), 0.84 (95% CI = 0.78–0.91, $p < 0.001$), 0.83 (95% CI = 0.68–0.88, $p < 0.001$), 0.79 (95% CI = 0.72–0.86, $p < 0.001$), and 0.70 (95% CI = 0.62–0.80, $p < 0.001$) times, respectively, for those living in cities/towns ranked from the third highest to the lowest levels of urbanization.
Conclusions: We conclude that higher urbanization levels were associated with higher odds of CS. Highly urbanized communities could therefore be targeted for policy intervention aimed at reducing the unnecessary CS rate.

1. Introduction

The steadily increasing global cesarean section (CS) rate has become a major concern in obstetrics and public health. Compared to vaginal deliveries (VDs), unnecessary cesarean deliveries increase maternal and neonatal morbidity and mortality risks, as well as adding to the costs of medical resources [1–3]. In order to reduce unnecessary CS, many researchers have attempted to identify factors associated with CS deliveries. Factors identified fall into several categories, including clinical (previous CS, dystocia, fetal distress, malpresentation, and breech presentation), parturient-related (age [4], parity [5], ethnicity [6], educational level [7], preferences [8], expectations [9]), obstetrician-related (practice styles [10], age [11], gender [11], delivery in daylight hours [12], convenience [12], fear of litigation [13], and type of birth attendants) and institutional factors (hospital size [14], teaching status [15], and ownership [15]).

In addition to the clinical and non-clinical factors above, Baicker et al. [16] and Lin and Xirasagar [15] have also demonstrated that there is significant geographic variation in the use of CS. Although numerous studies have reported associations between urbanization levels and the incidence of diabetes [17], breast cancer [18], allergic diseases [19], stroke [20] and asthma [21], almost none have attempted to explore possible relationships between the likelihood of CS and the degree of urbanization of the parturient's community. One survey-based study in Brazil reported that 20% of rural women were delivered by CS while more than 40% of urban women had a CS [22]. The profound demographic, infrastructure, land use and socio-economic transformations that accompany the urbanization process profoundly influence patterns of health care. In particular, urbanization may occur at a dramatic pace in less developed regions or countries. Therefore, lacking such knowledge may prevent policymakers and clinicians from developing effective strategies to reduce the incidence of unnecessary CS related to urban–rural differences.

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The purpose of this study was to examine the association between the likelihood of CS and the degree of urbanization of cities/counties in Taiwan and to explore possible explanations for the difference. Over the past five decades, Taiwan has experienced rapid socio-economic development, transitioning from an agriculturally based society to an increasingly industrial and commercial economy, a process that produced dramatic differences between rural and urban life. This provides a unique opportunity to explore the association between the degree of urbanization and the likelihood of CS. In addition, unlike prior studies which utilize a classic urban–rural dichotomy, this study stratifies cities/towns into seven urbanization classifications which allows us to more precisely discern the effect of urbanization on choice of delivery mode.

2. Methods

2.1. Database

The database used in this study was the Taiwan 2004 National Health Insurance Research Database (NHIRD), which covers about 98% of all patient encounters in Taiwan's population of over 23 million. Taiwan initiated the National Health Insurance (NHI) program in March 1995 to finance health care for all citizens of Taiwan. Taiwan's NHI has a unique combination of characteristics, including universal coverage, a single-payer payment system with the government as the sole insurer, comprehensive benefits and access to any medical institution of the patient's choice. The NHIRD database, one of the largest and most comprehensive population-based data sources currently available anywhere, includes a registry of contracted medical facilities, a registry of board-certified psychiatrists, a monthly claims summary for all in-patient claims, and details of all in-patient orders and expenditures on prescriptions dispensed at contracted pharmacies. This national database presents a unique opportunity to systematically explore the association between urbanization and delivery modes.

2.2. Study sample

The database provides one ICD-9-CM principal diagnosis code and up to four secondary diagnoses for each inpatient. Inpatient claims for all patients admitted to hospitals or obstetric and gynecology clinics for singleton deliveries between January 1, 2004 and December 31, 2004 were identified and included in this study. Ultimately, 200,207 singleton deliveries fulfilled our criteria and were included in our study.

2.3. Urbanization level

The level of urbanization of the cities/towns within which a parturient resided at the time of delivery was stratified into seven classifications (from 1 indicating the most urbanized to 7 indicating the least urbanized). This classification method was proposed by Liu et al. in Taiwan National Health Research Institute based on 2000 Taiwan census data [23] (Appendix A). This method has been widely adopted by prior studies [24,25]. All 359 cities/towns in Taiwan were stratified into the seven levels based upon a composite score obtained by calculating population density (people/km^2), population ratio of people with an educational level of college or above (%), ratio of people over 65 years (%), ratio of agriculture workers (%) and the number of physicians per 100,000 people. We believed that this classification method provides the most accurate reflection of the real scenario in terms of the urbanization levels of all 359 cities/towns in Taiwan to date.

2.4. Clinical indications for CS

This study adopted a hierarchy of mutually exclusive diagnoses devised by Lin and Xirasagar to account for the effects of maternal

Table 1
Deliveries in 2004 in Taiwan by urbanization level, delivery mode and control variables

Variable	Year 2004 ($N = 200,207$ deliveries)	
	Delivery mode *n* (row%)	
	Cesarean delivery	Vaginal delivery
Urbanization level		
1 (highest)	20,532 (33.7)	40,327 (66.3)
2	17,368 (32.3)	36,442 (67.7)
3	10,659 (30.4)	24,436 (69.6)
4	7,985 (30.2)	18,467 (69.8)
5	1,008 (29.7)	2,392 (70.3)
6	3,971 (29.5)	9,506 (70.5)
7 (lowest)	2,037 (28.6)	5,077 (71.4)
Patient characteristics		
Maternal age (years)		
<18	9,317 (21.3)	34,517 (78.7)
18–34	42,870 (32.2)	90,105 (67.8)
>34	11,373 (48.6)	12,025 (51.4)
Income-related insured amount		
0	20,086 (28.5)	50,505 (71.5)
NT$1–15,840	6,111 (34.6)	11,575 (65.4)
NT$15,841–25,000	20,392 (33.8)	39,951 (66.2)
≥NT$25,001	16,971 (32.9)	34,616 (67.1)
Presence of clinical indications		
Previous CS	19,133 (99.4)	114 (0.6)
Indisputable indications	32,076 (95.5)	1,496 (4.5)
Complications justifying CS	6,291 (37.5)	10,477 (62.5)
Pelvic floor/perineal injuries	5 (0.0)	20,049 (100.0)
Co-morbidities not ordinarily indications for cesarean	2,260 (24.7)	6,908 (75.3)
Maternal request CS	3,562 (100.0)	–
No complications	233 (0.2)	97,603 (99.8)
Geographic region		
Northern	30,088 (33.1)	60,711 (66.9)
Central	14,592 (28.1)	37,403 (71.9)
Southern	17,593 (33.3)	35,183 (66.7)
Eastern	1,287 (27.8)	3,350 (72.2)
Physician characteristics		
Physician gender		
Male	59,362 (31.9)	126,778 (68.1)
Female	4,198 (29.8)	9,869 (70.2)
Physician age		
<41	17,874 (30.4)	40,907 (69.6)
41–50	35,951 (31.9)	76,667 (68.1)
>50	9,735 (33.8)	19,073 (66.2)
Size of physician delivery service		
≤200	21,316 (32.7)	43,809 (67.3)
201–400	19,933 (31.8)	42,797 (68.2)
≥401	22,311 (30.8)	50,041 (69.2)
Hospital characteristics		
Hospital level		
Medical center	10,214 (34.0)	19,816 (66.0)
Regional hospital	15,866 (31.6)	34,379 (68.4)
District hospital	16,431 (30.7)	37,114 (69.3)
Ob/gyn clinic	21,049 (31.7)	45,338 (68.3)
Hospital ownership		
Public	7,224 (33.3)	14,452 (66.7)
Private not-for-profit	19,179 (32.2)	40,407 (67.8)
Private for-profit	37,157 (31.2)	81,788 (68.8)
Teaching status		
Yes	31,136 (32.3)	65,214 (67.7)
No	32,424 (31.2)	71,433 (68.8)

complications on the likelihood of a CS [15]. They classified all parturients into the following seven groups: women who had had previous CS (ICD-9-CM code 654.2), indisputable indications for CS including breech presentation (652.2 and 669.6), dystocia (653 and 660-662, excluding 661.3) and fetal distress (656.3), other antepartum or intra-partum complications potentially justifying a cesarean, complications reflecting pelvic floor/perineal/birth canal injury, other co-morbidities not ordinarily taken as indications for cesarean, maternal request, and no complications.

2.5. Patient, physician and institution characteristics

Numerous studies have consistently documented the crucial role of non-clinical factors in the decision to have CS. The non-clinical factors included in this study consist of patient characteristics (age, income-related amount insured and geographic location at the time of delivery), physician (gender, age and annual size of delivery service) and institution (accreditation level, ownership and teaching status). Income-related amount insured was categorized as 0, NT$1–NT$15,840, NT$15,841–NT$25,000 and ≥NT$25,001. The reason for selecting NT$15,840 as a cutoff point is that this value is stipulated by government as the minimum wage for a full-time employee in Taiwan. Geographic location was categorized as northern, central, southern, and eastern Taiwan.

The hospital accreditation level classification was based on bed capacity and clinical service capabilities. In general, hospitals were classified as medical centers (minimum 500 beds), regional hospitals (minimum 250 beds), district hospitals (minimum 20 beds), and clinics (<10 beds). Ownership was

Table 2
CS Likelihood by urbanization level and control variables

Variable	2004 (N = 200,207 deliveries)						
	Urbanization level, n (CS rate, %)						
	1 (highest)	2	3	4	5	6	7 (lowest)
CS overall	60,859 (33.7)	5,3810 (32.3)	35,095 (30.4)	26,452 (30.2)	3,400 (29.7)	13,477 (29.5)	7,114 (28.6)
Patient characteristics							
Maternal age (years)							
<18	8,417 (22.7)	11,591 (21.6)	8,864 (20.5)	7,476 (20.6)	1,202 (20.1)	3,685 (21.3)	2,599 (36.5)
18–34	43,209 (32.7)	35,829 (32.7)	22,971 (31.6)	11,274 (31.7)	1,936 (33.4)	8,607 (30.5)	3,922 (55.1)
>34	9,233 (48.5)	6,390 (49.1)	3,260 (48.2)	2,475 (49.3)	262 (45.4)	1,185 (47.5)	593 (8.3)
Income-related insured amount							
0	17,380 (30.9)	19,070 (29.0)	13,732 (28.1)	10,438 (26.5)	1,534 (24.7)	5,041 (26.6)	3,096 (25.2)
NT$1–15,840	3,826 (38.0)	4,653 (35.9)	3,600 (33.2)	2,703 (32.3)	354 (33.9)	1,370 (33.1)	1,180 (29.5)
NT$15,841–25,000	16,287 (35.7)	1,8249 (34.2)	10,446 (31.5)	8,791 (33.0)	1,269 (33.3)	3,456 (32.5)	1,845 (32.3)
≥NT$25,001	23,366 (33.8)	11,838 (33.2)	7,317 (31.8)	4,520 (31.9)	243 (35.8)	3,610 (29.3)	693 (34.5)
Presence of clinical indications							
Previous CS	6,162 (99.4)	5,217 (99.6)	3,323 (99.5)	2,531 (99.4)	399 (99.0)	1,226 (99.4)	687 (98.5)
Indisputable indications	10,783 (95.2)	9,151 (96.4)	5,825 (97.1)	4,392 (93.8)	467 (96.8)	2,162 (95.7)	1,118 (91.2)
Complications justifying CS	5,526 (39.8)	4,640 (39.4)	2,554 (39.3)	2,048 (34.7)	267 (39.3)	1,253 (31.1)	623 (31.6)
Co-morbidities not ordinarily indications for cesarean	4,408 (41.8)	3,223 (42.8)	1,618 (39.7)	1,306 (42.8)	185 (29.2)	658 (42.9)	396 (31.6)
No complications	27,184 (0.3)	26,172 (0.6)	18,246 (0.3)	13,623 (0.6)	1,865 (0.1)	7,072 (0.2)	3,841 (0.5)
Geographic region							
Northern	40,462 (34.2)	23,743 (33.2)	12,865 (32.5)	6,366 (31.3)	567 (33.9)	6,133 (29.1)	663 (31.1)
Central	7,682 (29.9)	12,287 (28.5)	11,907 (26.5)	11,885 (28.6)	1,359 (27.2)	3,905 (27.9)	2,970 (26.9)
Southern	12,316 (34.8)	16,412 (34.1)	9,759 (32.6)	7,213 (32.3)	1,321 (30.2)	3,167 (31.9)	2,588 (30.6)
Eastern	399 (27.6)	1,368 (28.0)	564 (25.5)	988 (27.8)	153 (30.7)	272 (32.0)	893 (27.0)
Physician characteristics							
Physician gender							
Male	55,720 (34.0)	50,041 (32.4)	32,669 (30.5)	24,890 (30.4)	3,248 (29.7)	12,874 (29.5)	6,698 (28.7)
Female	5,139 (31.2)	3,769 (30.7)	2,426 (28.2)	1,562 (27.0)	152 (27.6)	603 (29.5)	416 (27.2)
Physician age							
<41	17,165 (32.5)	15,218 (30.7)	10,937 (29.1)	7,894 (28.8)	844 (30.8)	4,937 (28.8)	1,786 (27.3)
41–50	33,898 (33.6)	30,872 (32.3)	19,949 (30.8)	14,955 (30.6)	2,044 (28.5)	6,590 (30.9)	4,310 (29.7)
>50	9,796 (36.6)	7,720 (35.5)	4,209 (31.9)	3,603 (31.6)	512 (32.2)	1,950 (26.3)	1,018 (26.3)
Size of physician delivery service							
≤200	20,922 (35.4)	16,756 (33.2)	10,641 (31.1)	8,332 (30.2)	1,364 (28.0)	4,414 (30.5)	2,696 (29.2)
201–400	19,638 (33.6)	16,819 (32.5)	10,666 (29.9)	8,637 (30.6)	917 (32.2)	3,994 (29.5)	2,059 (27.1)
≥401	20,299 (32.2)	20,235 (31.3)	13,788 (30.2)	9,483 (29.8)	1,119 (29.6)	5,069 (28.5)	2,359 (29.3)
Hospital characteristics							
Teaching status							
Yes	32,442 (33.2)	26,412 (32.8)	13,505 (31.3)	12,508 (31.2)	1,503 (31.9)	6,920 (30.4)	3,060 (32.2)
No	28,417 (34.4)	27,398 (31.8)	21,590 (29.8)	13,944 (29.3)	1,897 (27.8)	6,557 (28.5)	4,054 (26.0)
Hospital level							
Medical center	14,651 (34.4)	8,012 (33.7)	3,912 (32.9)	2,118 (34.4)	197 (33.0)	723 (33.8)	417 (35.7)
Regional hospital	14,012 (31.1)	14,971 (32.3)	7,860 (31.4)	6,826 (31.1)	987 (32.9)	3,741 (30.9)	1,848 (32.6)
District hospital	13,915 (33.4)	14,456 (31.2)	9,310 (28.8)	7,992 (29.7)	838 (27.7)	4,790 (28.3)	2,244 (28.3)
Ob/gyn clinic	18,281 (35.5)	16,371 (32.5)	14,013 (30.1)	9,516 (29.0)	1,378 (28.0)	4,223 (28.8)	2,605 (25.0)

recorded as one of three types: public, private nonprofit and private for-profit.

2.6. Statistical analysis

The statistical package, Stata (STATA Corporation, Version 9.0), was used for all of the statistical analyses undertaken in this study. Parturient was the unit of analysis. Pearson chi-squared tests were used to assess the associations between the delivery mode (CS = 1, VD = 0) and urbanization level and other control variables. Thereafter, given the hierarchically structured data and the dichotomous outcome variable, a multilevel logistic regression model was applied to examine the relative likelihood of CS by urbanization level – after adjusting for the characteristics of parturient, physician and hospital – to account for possible dependence within cities/towns. A two-sided p-value of ≤ 0.05 was considered to be statistically significant.

3. Results

Table 1 summarizes the profile of sampled parturients according to delivery mode. Of the 200,207 singleton deliveries

Table 3
CS Likelihood by urbanization level and control variables

Variable	2004 (N = 200,207 deliveries)						
	Urbanization level						
	1 (highest)	2	3	4	5	6	7 (lowest)
Crude odds ratio (crude OR, 95% CI)							
CS overall	1.00	0.94 (0.91–0.96)[a]	0.86 (0.83–0.88)[a]	0.85 (0.82–0.88)[a]	0.83 (0.77–0.89)[a]	0.82 (0.79–0.86)[a]	0.79 (0.75–0.83)[a]
Patient characteristics							
Maternal age (years)							
<18	1.00	0.94 (0.88–1.00)	0.88 (0.82–0.95)[a]	0.88 (0.82–0.95)[b]	0.86 (0.74–0.99)[c]	0.92 (0.84–1.01)	0.85 (0.76–0.95)[b]
18–34	1.00	1.00 (0.97–1.03)	0.95 (0.92–0.99)[b]	0.95 (0.92–0.99)[c]	1.03 (0.94–1.14)	0.90 (0.86–0.95)[a]	0.95 (0.88–1.02)
>34	1.00	1.02 (0.96–1.09)	0.99 (0.91–1.07)	1.03 (0.94–1.13)	0.88 (0.69–1.13)	0.96 (0.85–1.08)	0.96 (0.81–1.13)
Income-related insured amount							
0	1.00	0.91 (0.87–0.96)[a]	0.87 (0.83–0.92)[a]	0.81 (0.77–0.85)[a]	0.73 (0.65–0.83)[a]	0.81 (0.76–0.87)[a]	0.75 (0.69–0.82)[a]
NT$1–15,840	1.00	0.91 (0.84–0.99)[c]	0.81 (0.74–0.89)[a]	0.78 (0.70–0.86)[a]	0.84 (0.67–1.05)	0.81 (0.71–0.92)[b]	0.68 (0.59–0.79)[a]
NT$15,841–25,000	1.00	0.94 (0.90–0.98)[b]	0.83 (0.78–0.87)[a]	0.89 (0.84–0.94)[a]	0.90 (0.79–1.01)	0.87 (0.80–0.94)[a]	0.86 (0.78–0.95)[b]
≥NT$25,001	1.00	0.97 (0.93–1.02)	0.91 (0.86–0.97)[b]	0.92 (0.86–0.98)[c]	1.09 (0.84–1.42)	0.81 (0.75–0.88)[a]	1.03 (0.88–1.21)
Presence of clinical indications							
Previous CS	1.00	1.55 (0.91–2.64)	1.15 (0.66–2.03)	0.99 (0.55–1.77)	0.63 (0.22–1.77)	1.10 (0.49–2.46)	0.43 (0.21–0.86)[c]
Indisputable indications	1.00	1.32 (1.15–1.52)[a]	1.67 (1.40–1.99)	0.76 (0.65–0.88)[a]	1.51 (0.90–2.55)	1.13 (0.90–1.42)	0.52 (0.42–0.65)[a]
Complications justifying CS	1.00	0.99 (0.91–1.07)	0.98 (0.89–1.08)	0.80 (0.72–0.89)[a]	0.98 (0.76–1.26)	0.68 (0.60–0.78)[a]	0.70 (0.59–0.84)[a]
Co-morbidities not ordinarily indications for cesarean	1.00	1.04 (0.95–1.14)	0.92 (0.81–1.03)	1.04 (0.92–1.18)	0.57 (0.42–0.79)[a]	1.04 (0.88–1.23)	0.64 (0.52–0.80)[a]
No complications	1.00	1.62 (1.24–2.10)	0.86 (0.61–1.20)	1.76 (1.31–2.38)[a]	0.32 (0.08–1.28)	0.46 (0.25–0.86)[c]	1.39 (0.84–2.30)
Crude odds ratio (OR, 95% CI)							
Geographic region							
Northern	1.00	0.96 (0.93–0.99)[c]	0.93 (0.89–0.97)[a]	0.88 (0.83–0.93)[a]	0.99 (0.83–1.17)	0.79 (0.75–0.84)[a]	0.87 (0.74–1.02)
Central	1.00	0.93 (0.88–0.99)[c]	0.84 (0.79–0.90)[a]	0.94 (0.88–0.99)[c]	0.88 (0.77–0.99)[c]	0.91 (0.83–0.99)[c]	0.86 (0.78–0.95)[b]
Southern	1.00	0.97 (0.92–1.02)	0.91 (0.86–0.96)[a]	0.89 (0.84–0.95)[a]	0.81 (0.72–0.92)[a]	0.88 (0.81–0.96)[a]	0.83 (0.76–0.91)[a]
Eastern	1.00	1.02 (0.80–1.31)	0.90 (0.67–1.20)	1.01 (0.78–1.31)	1.17 (0.78–1.75)	1.24 (0.88–1.73)	0.97 (0.75–1.27)
Physician characteristics							
Physician gender							
Male	1.00	0.93 (0.91–0.96)	0.85 (0.83–0.88)	0.85 (0.82–0.88)	0.82 (0.76–0.89)	0.81 (0.78–0.85)	0.78 (0.74–0.83)
Female	1.00	0.98 (0.89–1.07)	0.87 (0.78–0.96)[b]	0.82 (0.72–0.93)[b]	0.84 (0.59–1.21)	0.93 (0.77–1.11)	0.82 (0.66–1.03)
Physician age							
<41	1.00	0.92 (0.88–0.97)[a]	0.85 (0.81–0.90)[a]	0.84 (0.79–0.89)[a]	0.93 (0.80–1.08)	0.84 (0.78–0.90)[a]	0.78 (0.70–0.87)[a]
41–50	1.00	0.85 (0.91–0.98)[a]	0.99 (0.85–0.91)[a]	0.87 (0.84–0.91)[a]	0.79 (0.72–0.87)[a]	0.89 (0.84–0.94)[a]	0.84 (0.78–0.90)[a]
>50	1.00	0.95 (0.89–1.01)	0.81 (0.75–0.88)[a]	0.80 (0.74–0.87)[a]	0.83 (0.68–0.99)[c]	0.62 (0.56–0.69)[a]	0.62 (0.54–0.72)[a]
Size of physician delivery service							
≤200	1.00	0.91 (0.87–0.95)[a]	0.82 (0.78–0.87)[a]	0.79 (0.75–0.84)[a]	0.71 (0.60.80)[a]	0.80 (0.75–0.86)[a]	0.75 (0.69–0.82)[a]
201–400	1.00	0.95 (0.91–0.99)[c]	0.84 (0.80–0.89)[a]	0.87 (0.83–0.92)[a]	0.94 (0.81–1.08)	0.83 (0.77–0.89)[a]	0.74 (0.66–0.81)[a]
≥401	1.00	0.96 (0.92–1.01)	0.91 (0.87–0.95)[a]	0.89 (0.85–0.94)[a]	0.89 (0.78–1.01)	0.84 (0.79–0.90)[a]	0.88 (0.80–0.96)[a]
Hospital characteristics							
Teaching status							
Yes	1.00	0.98 (0.95–1.02)	0.92 (0.88–0.96)[a]	0.91 (0.87–0.95)[a]	0.94 (0.85–1.06)	0.88 (0.83–0.93)[a]	0.96 (0.88–1.03)
No	1.00	0.89 (0.86–0.92)[a]	0.81 (0.78–0.84)[a]	0.79 (0.76–0.83)[a]	0.74 (0.67–0.82)[a]	0.76 (0.72–0.81)[a]	0.67 (0.62–0.72)[a]
Hospital level							
Medical center	1.00	0.97 (0.92–1.03)	0.93 (0.87–1.01)	1.00 (0.91–1.10)	0.94 (0.70–1.27)	0.97 (0.83–1.14)	1.06 (0.87–1.30)
Regional hospital	1.00	1.06 (1.00–1.11)[c]	1.02 (0.96–1.08)	1.00 (0.94–1.07)	1.09 (0.95–1.25)	0.99 (0.92–1.07)	1.07 (0.97–1.19)
District hospital	1.00	0.90 (0.86–0.95)[a]	0.81 (0.76–0.85)[a]	0.84 (0.79–0.89)[a]	0.76 (0.65–0.89)[a]	0.79 (0.73–0.85)[a]	0.79 (0.71–0.87)[a]
Ob/gyn clinic	1.00	0.88 (0.84–0.92)	0.78 (0.75–0.82)	0.74 (0.71–0.79)	0.71 (0.63–0.80)	0.74 (0.68–0.79)	0.61 (0.55–0.67)

[a] $p < 0.001$.
[b] $p < 0.01$.
[c] $p < 0.05$.

in the year 2004, 31.7% were performed by CS and 68.3% were VDs. The majority (30.4%) of parturients resided at the cities/towns situated at urbanization level 1. There was an upward trend in the CS rate with advancing urbanization level; the CS rates for the urbanization level 1 (most urbanized) through 7 (least urbanized) were 33.7, 32.3, 30.4, 30.2 29.7, 29.5, and 28.6%, respectively ($p < 0.001$). Table 1 also summarizes the distribution of characteristics of the attending physician, as well as hospital level, ownership, and teaching status of the healthcare institution by delivery mode. We found statistically significant relationships between the likelihood of a CS and parturient age, income-related amount insured, obstetric complications, geographic region, physician's gender, age, institutional level, ownership, and teaching status as demonstrated by Pearson Chi-squared test (all $p < 0.001$).

Tables 2 and 3 illustrate the crude relationship between urbanization level and CS likelihood, examined for the total sample, and separately for each segment of the sampled parturients, in terms of patient age, income-related amount insured, obstetric complications, geographic location, physician gender, age, and hospital level and teaching status. It shows that as compared to parturients living in the most urbanization areas, the respective odds ratios of a CS were 0.94, 0.86, 0.85, 0.83, 0.82 and 0.79 times, respectively, of those living in the cities/towns with the second highest level to the lowest level (7th level) of urbanization (all $p < 0.001$).

Table 4 describes the adjusted relationships between urbanization level and the likelihood of a CS by performing a multilevel logistic regression analysis. It showed that the odds ratios of a CS, for the most part, decreased with decreasing urbanization; as compared to participants living in the highest urbanization level, the adjusted odds of a CS were 0.91, 0.84, 0.83, 0.79, and 0.70 times, respectively, for those living in the cities/towns with the third highest level to the lowest level (7th level) of urbanization.

Our results also revealed that decisions about delivery were significantly influenced by physician age, gender, and the healthcare institution level and ownership. In particular, CSs were more likely to be performed in ob/gyn clinics compared to hospitals. The estimated variance of the city/town effect indicates that there is very little effect across cities/towns.

Table 4
CS Likelihood by urbanization level: adjusted CS odds by characteristics of patient, physician and hospital using multilevel logistic regression analysis

Variable	2004 (N = 200,207 deliveries)	
	OR, 95% CI	p-Value
Urbanization level		
1 (highest) (reference group)	1.00	
2	1.08 (0.83–1.07)	0.062
3	0.91 (0.85–0.98)	0.014
4	0.84 (0.78–0.91)	<0.001
5	0.83 (0.68–0.88)	<0.001
6	0.79 (0.72–0.86)	<0.001
7 (lowest)	0.70 (0.62–0.81)	<0.001
Patient characteristics		
Maternal age (years)		
<18	0.67 (0.63–0.70)	<0.001
18–34 (reference group)	1.00	
>34	1.75 (1.66–1.85)	<0.001
Income-related insured amount		
0 (reference group)	1.00	
NT$1–15,840	1.35 (1.26–1.45)	<0.001
NT$15,841–25,000	1.20 (1.14–1.26)	<0.001
≥NT$25,001	1.10 (1.05–1.16)	0.008
Presence of clinical indications		
Previous CS	959.67 (897.70–999.99)	<0.001
Indisputable indications	>999.99 (>999.99–999.99)	<0.001
Complications justifying CS	29.87 (28.33–31.51)	<0.001
Co-morbidities not ordinarily indications for cesarean	17.56 (16.44–18.75)	<0.001
No complications (reference group)	1.00	
Geographic region		
Northern (reference group)	1.00	
Central	0.75 (0.71–0.79)	<0.001
Southern	0.81 (0.77–0.86)	<0.001
Eastern	0.51 (0.45–0.58)	<0.001
Physician characteristics		
Physician gender		
Male	1.17 (1.09–1.26)	<0.001
Female (reference group)	1.00	
Physician age		
<41	0.85 (0.82–0.89)	<0.001
41–50 (reference group)	1.00	
>50	1.12 (1.06–1.19)	<0.001
Size of physician delivery service		
≤200 (reference group)	1.00	
201–400	0.96 (0.91–1.02)	0.148
≥401	0.85 (0.80–0.90)	<0.001
Hospital characteristics		
Hospital level		
Medical center	0.47 (0.43–0.52)	<0.001
Regional hospital	0.46 (0.43–0.50)	<0.001
District hospital	0.49 (0.46–0.52)	<0.001
Ob/gyn clinic (reference group)	1.00	
Hospital ownership		
Public	0.82 (0.76–0.89)	<0.001
Private not-for-profit	0.53 (0.49–0.57)	<0.001
Private for-profit (reference group)	1.00	
Random effect associated with city (variance ± S.E.)	0.7134 ± 0.2589	

4. Discussion

Countries with high CS rates have devoted attention to exploring factors contributing to the choice of CS, but to the best of our knowledge, no nationwide population-based study has yet been conducted to investigate the effects of urbanization level on delivery mode. In this study, urbanization was divided into seven stratifications based upon a composite score according to the following five dimensions: population density, the percentage of population with at least college level education, the ratio of people over 65 years old per 100,000 of the population, the proportion of agricultural workers per 100,000 people and the number of physicians per 100,000 people. We feel that this approach unequivocally represents differences between levels of urbanization within each region, and that, it provides an accurate reflection of the real scenario in terms of the urbanization levels in different cities/towns. As a result, our estimations should be more accurate than prior studies using a simple urban–rural dichotomy.

A large number of valuable studies have speculated about the reasons involved in the choice of delivery mode. Such commentary in both the medical literature and popular media have suggested that non-clinical factors are of as much importance as clinical factors [22,13] Consistently, our study found that one non-clinical factor, urbanization level, was a major contributory factor associated with the mode of childbirth for parturients in Taiwan. We found that a parturient residing at the time of delivery in a less urbanized community would be less likely to undergo a CS; the odds ratios of a CS were 0.91, 0.84, 0.83, 0.79, and 0.70 times, respectively, for those living in the areas with the third-highest to lowest (7th) urbanization level compared to parturients living in the highest urbanization level. Our findings are similar to those of a study in Brazil which reported that more than twice as many urban women chose CS delivery as women in rural areas [22].

One possible explanation for such differences is that lower fertility rates accompany higher levels of urbanization. Although urban populations are steadily growing (through migration) in most Chinese communities, numerous studies have demonstrated that fertility rates in rural areas are much higher [26,27]. The lower fertility raises the stakes for parturients living in urbanized places, focusing more attention on the safety of the baby and the baby's future fate. To date, most Chinese parturients still believe that CS can improve birth outcome and is a safer method to delivery a baby compared with VD. As a result, parturients living in more urbanized places had a greater tendency to deliver surgically even in the absence of clinical need than those living in less urbanized areas.

In addition, the lower fertility rates in urban areas may create financial incentive for physicians to substitute cesarean childbirth for normal delivery. Under the Taiwan NHI, the reimbursed amount for CS is about two times as high for CS as for vaginal delivery in 2004. Therefore, based on induced-demand model, the financial incentive may drive physicians in urban areas to perform more CSs in order to compensate the loss of their practice income as a result of lower fertility rates. One study by Gruber and Owings has also reported that the decrease in fertility leads to the increase in highly reimbursed alternative, CS, based on the analysis of data from US National Hospital Discharge Survey [28].

Another possible explanation for rural–urban difference in the likelihood of CS is that parturients living in more urbanized areas may intend to select certain auspicious dates for delivery to improve their baby's fate. Choosing an astrologically auspicious birth time to best match the child's "eight characters" appears to be a special innovation happening in traditional Chinese culture. Most Chinese believe that choosing a lucky day and time for childbearing will bring good fortune and change the baby's fate to a better one. Studies have reported that choosing a lucky time for baby is one of the major reasons for elective CS in Taiwan [9,29,30].

This study suffers from three inherent limitations. Firstly, some information such as mother's socioeconomic characteristics, birth weight and parity, which play important roles for the choice of delivery type, are not available from the NHIR dataset. Secondly, our study did not permit us to precisely determine the causal relationships between delivery mode and level of urbanization. Although one-year cross-sectional data does provide a detailed picture of these causal relationships, they can only be definitively determined with a design using longitudinal data. Thirdly, area-level measures of urbanization concerns ecological fallacy, which might inflate estimates of individual-level associations. Sampled subjects might engage in contexts other than those determined by the communities in which their deliveries took place.

5. Policy implications

Despite these limitations, this is the first population-based study to demonstrate the relationship between urbanization and delivery mode. We conclude that higher level of urbanization was associated with higher odds of CS. The results of this study should be of assistance to policymakers and obstetricians alike in terms of facilitating the effective allocation of medical resources when providing delivery services to parturients in communities with different levels of urbanization. In addition, communities with higher levels of urbanization could be a major target for policy intervention in order to effectively reduce the unnecessary CS rate. Since the National Health Insurance System has recently been suffering a financial deficit, ways to reduce unnecessary medical expenditures and allocate medical resources effectively have become the first priority. The high Caesarean Section rate, which contributes to high medical expenditures, has been targeted for decrease. Based on the results of this study, the bureau of National Health Insurance can first target communities with higher levels of urbanization, in order to effectively reduce the unnecessary CS rate and resulting medical expenditures. In other words, reducing the CS rate in urbanized areas can both reduce medical expenditures and improve the health of neonates and their mothers.

Appendix A. Description and criteria of the seven levels of urbanization in Taiwan

Level	Criteria				
	Order of population density (people/km^2)	Order of the proportion of people with college educational levels or above (%)	Order of the proportion of elderly people over 65 years (%)	Order of the proportion of agricultural workers (%)	Order of the number of physicians per 100,000 people
1	1	1	5	7	1
2	2	2	6	6	2
3	3	3	7	5	4
4	4	4	3	4	3
5	6	5	1	2	7
6	7	7	2	1	5
7	5	6	4	3	6

Note: This table was modified from a study by Liu et al. [23]. Level 1, Most urbanized; Level 7, least urbanized.

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