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ORIGINAL RESEARCH

Do rural and urban women experience differing rates of maternal rehospitalizations?

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ABSTRACT

Introduction: Conditions such as postpartum complications and mental disorders of new mothers contribute to a relatively large number of maternal rehospitalizations and even some deaths. Few studies have examined rural–urban differences in hospital readmissions, and none of them have addressed maternal readmissions. This research directly compares readmissions for patients who delivered in rural versus urban hospitals.

Methods: The data for this cross-sectional study were drawn from the 2011 California Healthcare Cost and Utilization Project. Readmission rates were reported to demonstrate rural–urban differences. Generalized estimating equation models were also used to estimate the likelihood of a new mother being readmitted over time.

Results: The 323 051 women who delivered with minor assistance and 158 851 women who delivered by cesarean section (C-section) were included in this study. Of those, seven maternal mortalities occurred after vaginal deliveries and 14 occurred after C-section procedures. Fewer than 1% (0.98% or 3171) women with normal deliveries were rehospitalized. The corresponding number for women delivering via C-section was 1.41% (2243). For both types of deliveries, women giving birth in a rural hospital were more likely to be readmitted.

Conclusions: This is the first study examining rural–urban differences in maternal readmissions. The results indicate the importance of monitoring and potentially improving the quality of maternal care, especially when the delivery involves a C-section. More studies investigating rural health disparities in women's health are clearly necessary.

Key words: cesarean section, maternal, readmission, rehospitalization, urban.

Introduction

Following the delivery of a child, women are vulnerable to a number of serious health risks (eg infections, depression)[1]. Because of these risks, new mothers in Asia, Africa, and some European countries remain in hospitals at least 1 week[2]. American mothers, on average, remain in hospital for only 2.6 days following delivery. This short stay following delivery has raised concerns that it may contribute to conditions such as postpartum complications and mental disorders that subsequently lead to rehospitalizations or even deaths[3-5].

Research indicates that post-partum problems resulting in hospitalization (ie rehospitalizations) result in considerable, potentially avoidable, spending by payers (insurance companies)[6]. Olsen et al. reported that the attributable total hospital cost of a surgical site infection after a cesarean section (C-section) was approximately $3529[7]. Qasim and Andrews also found that average cost per stay involving a C-section procedure was $5400 for a low-income patient but the readmission costs were $6600[8].

The *Patient Protection and Affordable Care Act* (PPACA), a federal health reform law, stresses that reducing hospital readmissions is an important strategy both for improving quality of care and to lowering the cost of care[9]. Several studies have examined rural–urban differences in hospital readmissions. Some of this work has shown that treatment in a rural hospital lowered the likelihood of hospital readmission[10,11]. However, older rural veterans seem more likely to have higher 30-day readmission rates than urban veterans, although a Congressional report suggests that rural–urban differences in readmissions do not exist[12,13]. Previous research has focused largely on readmissions in general. Only veterans' care has been subjected to closer scrutiny. None of this work investigated potential rural–urban differences in maternal readmissions. To begin to fill this knowledge gap, this study investigates the effects of rurality on the likelihood of maternal rehospitalizations, using the 2011 California Healthcare Cost and Utilization Project (HCUP).

This research has four objectives. These are to:

- describe the respective outcomes (ie rehospitalizations/readmissions) and individual characteristics of women with a normal delivery or a C-section
- compare the differences of individual characteristics between patients who were and who were not readmitted
- estimate the cumulative readmission rates within 7 days, 14 days, and 30 days for urban and rural hospitals
- identify how rural–urban factors may affect the likelihood of readmission, while controlling for covariates such as age and insurance plan. Proper assessment of geographic differences in readmissions and by two different delivery modes may be important for designing cost-effective interventions to reduce unnecessary readmissions.

Methods

Data source

The data of this cross-sectional study were drawn from the 2011 California HCUP. The HCUP, a national pool of all-payer hospital discharge data, is expected to provide empirical evidence of hospital readmission problems at the national level[14]. Unfortunately, only 15 out of the 50 states have continuously collected readmissions information. This research focuses on data from the state with the largest number of total discharges in the USA: California[15]. Therefore, this study focuses on maternal care in urban and rural hospitals in California.

When a patient is admitted to a hospital for one or more conditions, a patient medical record is created with his/her demographic data. When this patient is discharged, a bill will be generated. This patient information becomes the basis of the HCUP databases[16]. State-level data organizations, hospital

associations, private data organizations, and the federal government collect discharge data from community hospitals and send these data to the Agency for Healthcare Research and Quality (AHRQ) for inclusion in the HCUP. Three components of the HCUP data set were used in this study: inpatient care data in the State Inpatient Database (SID), outpatient care data in the State Emergency Department Database (SEDD), and information in the State Ambulatory Surgery Database (SASD)[17].

This study used both single-level Clinical Classifications Software (CCS) codes for procedure and Medicare Severity Diagnosis Related Groups (MS-DRG) systems to identify the research sample. The single-level CCS was developed by AHRQ for aggregating cases into 285 mutually exclusive illnesses and 231 mutually exclusive procedures[18]. The DRGs developed by Yale University and the MS-DRGs, which were consolidated into 746 categories, were adopted for use of Medicare's Inpatient Prospective Payment System[19,20]. Both CCS and MS-DRG are diagnosis systems officially used by HCUP.

The research sample for this study included women admitted to inpatient departments, emergency departments, or ambulatory surgery units in 2011. Female patients without geographic information and primary procedure diagnoses were excluded. The remaining sample was divided into three groups:

- normal delivery (CCS-133, CCS-136, CCS-137; DRG-767, DRG-768, DRG-774, DRG-775)
- assisted delivery (CCS-135)
- C-section (CCS-134; DRG-765, DRG-766)[21,22].

Deliveries with complicating diagnoses were not included as those have a higher risk of readmissions and might bias the observed effects of rural–urban location in this study[23]. The sample size of the assisted delivery group with readmission records was too small (n=220) to produce convergence in the multivariate analysis. In addition, only three female patients having assisted delivery procedure were readmitted. This group was dropped from the database. The final study sample (n=481 902) included two groups: the normal delivery group and the C-section group.

Dependent variables: maternal rehospitalizations

In response to the increasing attention to the issue of readmissions, AHRQ compiled HCUP supplemental files to provide additional information for the analyses of 'revisits' readmissions[16]. Since each record in the HCUP represents one discharge abstract, the term 'revisit' implies two or more visits for health services for a particular patient. Any patient's first admission related to delivery and occurred between 1 January and 30 November was treated as the index admission. Any patient's admission to the same or different hospital that occurred within 30 days after the index admission was treated as a 30-day readmission.

If a patient passed away, was transferred to another facility on the same day, or was readmitted more than 30 days after the index admission, this patient was not considered as a 30-day readmitted case[17]. In short, the 30-day readmission rate is the number of readmissions that occurred within 30 days of the index admission divided by the number of total index admissions.

The second outcome variable of interest is to compare 7-day, 14-day, and 30-day readmission rates. The denominator for these rates was the total number of readmitted patients. In other words, the patients with only one admission record (ie their index/first admission) were excluded. The numerators were the numbers of patients readmitted within 7, 14, or 30 days after their previous discharge of delivery.

The third outcome variable in this study was a binary measure indicating whether this patient had been readmitted between 1 January and 30 November. One of the advantages using the HCUP is that the encrypted person identifier allows researchers to track all of each patient's admission records. A patient who was discharged alive and had only one admission record was defined as no readmission group (=0). If a patient was discharged alive and had any record of reasons for/causes

of readmission, this patient was defined as a readmitted case (=1).

Independent variables: hospital location and patient residence

The HCUP collects the ZIP codes of both hospitals and patients. Using the 2003 version of the Urban Influence Codes (UIC), every hospital was identified as a hospital in a rural (micropolitan areas or non-core) area, small metro (metropolitan with fewer than 1 million resident) area, or large metro (metropolitan with at least 1 million residents) area[18,24]. Likewise, individual patient ZIP codes were also classified into these three unique groups.

Covariates: patient characteristics

This study investigated readmissions, while adjusting for eight covariates that have been shown to have a significant association with obstetric outcomes[25-28]. A patient's age at admission was a continuous variable. Race/ethnicity is categorized as 'non-Hispanic White', 'non-Hispanic African American', 'Hispanic', and 'others'. Expected primary payer was coded as 'Medicare' (ie both fee-for-service and managed care Medicare plans for disabled women), 'Medicaid' (ie both fee-for-service and managed care Medicaid patients), 'private insurance' (eg Blue Cross), 'self-pay' (ie uninsured), and 'others' (eg those with worker's compensation). One category of this measure, 'no charge', had was not observed based on inclusion criteria. A quartile classification of patient's estimated median household income from lowest (poorest) to highest (richest) quartile was also collected by HCUP.

The HCUP used chronic condition indicators to identify patients' chronic conditions (eg diabetes and mental illness) listed on their medical records[29]. Length of stay (LOS) is equal to the number of days between the admission date and the discharge date for each admission record. That means same-day stays are coded as 0. Both the number of chronic conditions and LOS were continuous variables. The former illustrates patients' health status and the latter illustrates how long they stayed in hospital immediately after giving birth (ie the index event).

Analyses

Descriptive analysis was conducted to determine the patient-level characteristics of patients with a normal delivery or a C-section in 2011. The binary analysis provided the individual differences between patients readmitted or not readmitted for each of these two groups. The accumulative readmission rates were also calculated based on the hospital location to demonstrate rural–urban differences.

Generalized estimating equation (GEE) models were then used to estimate the likelihood of being readmitted over time. Since patients might repeatedly go to the same hospital, GEE models are particularly useful by estimating the average response over the population (ie population-averaged effects) compared to a traditional logistic regression model. To meet the research purpose, the covariance structure was set as unstructured, the link function as logit, and family as binary. Data was imported into Statistical Analysis Software v9.3 (SAS; http://www.sas.com) based on the original format provided by the HCUP distributor. Then the data was transported into Stata v12.0 (http://www.stata.com). All analyses were conducted using Stata v12.0 and a p value of less than 0.05 was considered statistically significant.

Ethics approval

The use of data was approved by the Office of Research Compliance and Biosafety (Protocol # IRB-2013-0117) at Texas A&M University.

Results

The 323 051 women who delivered with minor assistance (normal delivery) and 158 851 women who delivered by C-section were included in this study. Of those, only 7 patients died after vaginal deliveries and 14 patients after C-section procedures. Next, 70.64% of women (228 198 cases) had

only one admission after vaginal delivery and 67.49% of women (107 206) after a C-section.

Less than 1% (0.98%) of women (3171 cases) with normal deliveries were readmitted within 30 days after the index admission and the corresponding number is 1.41% of women (2243 cases) with C-section deliveries. The majority of residents living in large-metro or small-metro areas gave birth in their local hospitals. Of rural women, 77.19% of rural women (6418 cases) were admitted to rural hospitals to deliver, 15.20% (1264 cases) to small-metro hospitals, and 7.61% (633 cases) to large-metro hospitals.

Table 1 presents the distribution of each individual characteristic for those women in either the normal delivery or C-section group. Chi-square tests were not conducted here since the large sample size results in significant *p* values throughout the analysis. The effect size was measured for the number of chronic conditions (effect size=0.30) and for the length of first stay (effect size=0.64). On average, women with C-section procedures were slightly older, non-Hispanic Black, more from large-metro areas, more admitted to large-metro hospitals, more covered by private insurance, having lower income, and had more chronic conditions and longer stays during the index admissions than women with normal delivery.

Within either the normal delivery or C-section delivery group, women were further divided into two subgroups: 'discharged alive but not readmitted', and 'discharged alive and then readmitted'. The χ^2 tests were conducted in each group of delivery comparing the distributions of readmitted and not readmitted patients. The effect size was calculated for the number of chronic conditions and the length of first stay. For women with a normal delivery, the effect sizes were 0.33 and 0.19, respectively. For women with a C-section procedure, the effect sizes were 0.45 and 0.23, respectively. For women with normal delivery (Table 2), those who were readmitted were much more likely to

- be African American (14.25>5.10%)
- have lived in rural areas (5.27%>1.81%)
- have gone to hospitals in small metro areas (28.96%≥23.54%)
- have public insurance plans (Medicare or Medicaid: 71.74%≥48.55%)
- have lower household income (37.20%≥29.57%).

Likewise, higher proportions of women readmitted to hospitals after the C-section delivery were non-Hispanic Blacks (16.32%≥6.19%), lived in small-metro areas (25.06%≥22.49%), received care in small-metro hospitals (23.53%≥21.91%), had public insurance plans (70.31%≥47.26%), had lower household income (38.69%≥29.75%), had more chronic conditions (1.24>0.62) and had longer lengths of first stay (4.53>3.57).

The cumulative readmission rates in patients with C-section delivery were higher than their normal delivery counterparts except in small-metro hospitals (Table 3). For example, the 30-day readmission rate in C-section patients from a large-metro hospital was 33.87% while it was 31.55% in patients with normal delivery. Regardless of delivery mode, patients giving birth in a rural hospital were more likely to be readmitted than in hospitals in metropolitan areas. The 7-day readmission rate of women with normal delivery in rural hospitals was 20.06% but it was only 12.20% of women in urban hospitals.

The GEE models for both delivery groups were employed to estimate the relationships between readmission likelihood and individual characteristics (Table 4). Since very few large-metro residents went to small-metro or rural hospitals for delivery, the variable of 'hospital location' was reclassified into two categories: 'large-metro area' and 'non-large-metro area'. When the response changes from 0 (not readmitted) to 1 (readmitted), the odds ratio was 1.35 (95% confidence interval 0.008–0.590) for women living in small-metro areas to be readmitted after their normal deliveries. Controversially, living in rural areas had protective effects for mothers with normal deliveries but adverse effects for mothers with C-section. The hospital location did not have a statistically significant impact on the likelihood of readmission.

Table 1: Characteristics of patients with maternal diagnoses, 2011 California Healthcare Cost and Utilization Project

Characteristic	Normal delivery (*N*=323 051)	C-section (*N*=158 851)	Total (*N*=481 902)
Age, years			
Mean and SD	27.95 ± 6.20	29.81 ± 6.26	28.56 ± 6.28
Range	9–57	9–55	9–57
Race/ethnicity, *n*(%)			
Non-Hispanic White	97 189 (31.82%)	47 787 (31.34%)	144 976 (31.66%)
Non-Hispanic Black	15 850 (5.19%)	9655 (6.33%)	25 505 (5.57%)
Hispanic	147 814 (48.39%)	72 530 (47.57%)	220 344 (48.12%)
Others	44 614 (14.61%)	22 506 (14.76%)	67 120 (14.66%)
Residence of patient, *n*(%)			
Large metro	239 653 (74.18%)	120 718 (75.99%)	360 371 (74.78%)
Small metro	77 430 (23.97%)	35 786 (22.53%)	113 216 (23.49%)
Rural	5968 (1.85%)	2347 (1.48%)	8315 (1.73%)
Hospital location, *n*(%)			
Large metro	238 440 (74.88%)	120 863 (76.90%)	359 303 (75.54%)
Small metro	75 132 (23.59%)	34 467 (21.93%)	109 599 (23.04%)
Rural	4872 (1.53%)	1847 (1.18%)	6719 (1.41%)
Payer, *n*(%)			
Medicare	838 (0.26%)	659 (0.41%)	1497 (0.31%)
Medicaid	156 718 (48.51%)	74 922 (47.17%)	231 640 (48.07%)
Private insurance	153 178 (47.42%)	77 422 (48.74%)	230 600 (47.85%)
Self-pay	5989 (1.85%)	2790 (1.76%)	8779 (1.82%)
Others	6317 (1.96%)	3052 (1.92%)	9369 (1.94%)
Median household income, *n*(%)			
Poorest	94 877 (29.65%)	47 008 (29.87%)	141 885 (29.72%)
Poor	85 792 (26.81%)	42 656 (27.11%)	128 448 (26.91%)
Wealthy	75 894 (23.71%)	36 660 (23.30%)	112 554 (23.58%)
Wealthiest	63 464 (19.83%)	31 040 (19.72%)	94 504 (19.80%)
No. of chronic conditions			
Mean and SD	0.35 ± 0.76	0.63 ± 1.07	0.44 ± 0.89
Range	0–11	0–16	0–16
Effect size			0.30
Length of first stay			
Mean and SD	2.13 ± 1.37	3.58 ± 2.87	2.61 ± 2.11
Range	0–117	0–119	0–119
Effect size			0.64

C-section, cesarean section. SD, standard deviation

Discussion

This study used the 2011 California HCUP data with its very large number of hospital discharges to compare readmission rates of women with a normal delivery or with C-section delivery procedures, while considering the geographic areas of hospitals and patients. The research findings suggested that childbirth in these areas is a relatively safe event with only a 0.98% readmission rate for the normal delivery group and 1.41% for the C-section group.

Table 2: Comparisons of characteristics between patients with and without maternal readmission, 2011 California Healthcare Cost and Utilization Project

Characteristic	Normal delivery			C-section		
	Not readmitted (*n*=319 873)	Readmitted (*n*=3171)	*p* value	Not readmitted (*n*=156 594)	Readmitted (*n*=2243)	*p* value
Residence of Patient, *n*(%)			<0.001			<0.001
Large metro	237 570 (74.27)	2076 (65.47)		119 106 (76.06)	1602 (71.42)	
Small metro	76 502 (23.92)	928 (29.27)		35 221 (22.49)	562 (25.06)	
Rural	5801 (1.81)	167 (5.27)		2267 (1.45)	79 (3.52)	
Hospital location, *n*(%)			<0.001			<0.001
Large metro	236 347 (74.96)	2086 (66.60)		119 218 (76.95)	1634 (73.37)	
Small metro	74 225 (23.54)	907 (28.96)		33 941 (21.91)	524 (23.53)	
Rural	4733 (1.50)	139 (4.44)		1777 (1.15)	69 (3.10)	
Age, years			0.047			0.157
Mean and SD	27.97 ± 6.19	25.53 ± 6.04		29.84 ± 6.25	27.79 ± 6.39	
Range	9–57	9–49		9–55	9–52	
Race/ethnicity, *n*(%)			<0.001			<0.001
Non-Hispanic White	96 134 (31.78)	1052 (35.10)		47 021 (31.29)	760 (34.94)	
Non-Hispanic Black	15 423 (5.10)	427 (14.25)		9299 (6.19)	355 (16.32)	
Hispanic	146 467 (48.42)	1344 (44.84)		71 618 (47.65)	911 (41.89)	
Others	44 439 (14.69)	174 (5.81)		22 352 (14.87)	149 (6.85)	
Payer, *n*(%)			<0.001			<0.001
Medicare	796 (0.25)	41 (1.29)		605 (0.39)	54 (2.41)	
Medicaid	154 479 (48.30)	2234 (70.45)		73 391 (46.87)	1523 (67.90)	
Private insurance	154 400 (47.65)	777 (24.50)		76.836 (49.07)	580 (67.90)	
Self-pay	5948 (1.86)	41 (1.29)		2762 (1.76)	28 (1.25)	
Others	6239 (1.95)	78 (2.46)		2994 (1.91)	58 (2.59)	
Median household income, *n*(%)			<0.001			<0.001
Poorest	93 718 (29.57)	1159 (37.20)		46 144 (29.75)	859 (38.69)	
Poor	84 824 (26.77)	964 (30.94)		41 988 (27.07)	667 (30.05)	
Wealthy	75 247 (23.74)	644 (20.67)		36 202 (23.34)	454 (20.45)	
Wealthiest	63 115 (19.92)	349 (11.20)		30 797 (19.85)	240 (10.81)	
No. of chronic Conditions			<0.001			<0.001
Mean and SD	0.35 ± 0.76	0.66 ± 1.08		0.62 ± 1.06	1.24 ± 1.65	
Range	0–11	0–10		0–13	0–16	
Effect size			0.33			0.45
Length of first stay			<0.001			<0.001
Mean and SD	2.12 ± 1.35	2.47 ± 2.26		3.57 ± 2.82	4.53 ± 5.17	
Range	0–117	0–44		0–117	0–44	
Effect size			0.19			0.23

SD, standard deviation

Consistent with other studies[4,30,31], the authors found that the readmission rate after the C-section procedure was slightly higher than that observed for the normal delivery group. Policy-makers may wish to consider efforts to target hospitals with higher readmission rates after C-section by a means of payment or incentive policy[32]. Prior studies have suggested that administration of perioperative antibiotics is helpful to reduce the rate of delivery infectious complications, the key reason for readmission[33,34].

Table 3: Cumulative readmission rates among patients with readmissions, 2011 California Healthcare Cost and Utilization Project

Delivery	Large metro, *n*(%)	Small metro, *n*(%)	Rural, *n*(%)	Total, *n*(%)
Normal delivery (*N*)	6706	2916	334	9856
7-day	806 (12.20%)	365 (12.52%)	67 (20.06%)	1238 (12.56%)
14-day	1321 (19.99%)	570 (19.55%)	87 (26.05%)	1978 (20.07%)
30-day	2086 (31.56%)	907 (31.11%)	139 (41.62%)	3132 (31.78%)
Cesarean section (*N*)	4824	1768	153	6743
7-day	629 (13.04%)	190 (10.75%)	34 (22.22%)	853 (12.65%)
14-day	994 (20.60%)	307 (17.37%)	47 (29.01%)	1348 (19.99%)
30-day	1634 (33.87%)	524 (29.65%)	69 (42.59%)	2227 (33.02%)

Table 4: Generalized estimating equation estimates about associations of readmission likelihood with individual characteristics, 2011 California Healthcare Cost and Utilization Project

Reference group	Normal delivery		C-section	
	Estimate (95% CI)	*p* value	Estimate (95% CI)	*p* value
Residence (large metro)				
Small metro	0.299 (0.008, 0.590)	0.044	0.236 (–0.092, 0.565)	0.159
Rural	–0.949 (0.625, 1.273)	0.000	0.764 (0.380, 1.147)	0.000
Hospital location (small-metro, rural)				
Large metro	0.132 (–0.159, 0.423)	0.374	0.271 (–0.060, 0.603)	0.108
Age, years	–0.045 (–0.052, –0.038)	0.000	–0.033 (–0.041, –0.025)	0.000
Race/ethnicity (Non-Hispanic White)				
Non-Hispanic Black	0.488 (0.361, 0.615)	0.000	0.333 (0.188, 0.477)	.000
Hispanic	–0.514 (–0.609, –0.418)	0.000	–0.584 (–0.698, –0.469)	.000
Others	–0.776 (–0.942, –0.610)	0.000	–0.650 (–0.834, –0.466)	.000
Payer (Medicare)				
Medicaid	–0.808 (–1.152, –0.464)	0.000	–.837 (–1.142, –0.527)	0.000
Private insurance	–1.732 (–2.082, –1.382)	0.000	–1.769 (–0.2079, –1.457)	0.000
Self-pay	–1.335 (–1.813, –0.856)	0.000	–1.231 (–1.727, –0.734)	0.000
Others	–1.075 (–1.495, –0.656)	0.000	–0.954 (–1.355, –0.552)	0.000
Median household income (poorest)				
Poor	0.140 (0.049, 0.230)	0.003	0.015 (–0.092, 0.122)	0.787
Wealthy	0.010 (–0.097, 0.117)	0.860	–0.075 (–0.201, 0.051)	0.246
Wealthiest	–0.112 (–0.254, 0.030)	0.121	–0.331 (–0.496, –0.166)	0.000
No of chronic conditions	0.339 (0.307, 0.371)	0.000	0.317 (0.290, 0.345)	0.000
Length of first stay	0.048 (0.037, 0.059)	0.000	0.038 (0.031, 0.045)	0.000

CI, confidence interval. C-section, cesarean section

This study indicated that, in general, women discharged from rural hospitals had higher readmission rates than metropolitan hospitals. Several factors may contribute to this finding such as inadequate family support after delivery, poor quality of hospital care, and disease burden of mothers in rural areas[35,36]. In addition, fewer newborns and more elders in rural areas than in urban areas make the recruitment of obstetrics and gynecology doctors and related professionals

difficult[37]. The ratio of obstetricians to residents is 35 per 1000 in urban counties but only 2 per 1000 in rural counties[38]. Rural hospitals may provide unstable prenatal and postpartum services because of their small numbers of patients[39-41]. Prior research noted that rural hospitals heavily depend on nurse practitioners and other mid-level health professionals[42]. Therefore, strengthening the knowledge and skills of this group of rural providers is important. Public health interventions such as strengthening the capacity of the obstetric workforce, the safety of delivery procedures, and education about self-care before and after delivery in rural areas are also imperative.

This study adds new findings to the literature that women with a normal delivery in small metro hospitals may be at significantly higher risk of maternal rehospitalizations controlling other individual characteristics. However, the location of a hospital is not related to the readmission likelihood for women with C-section procedures. Corresponding to the literature regarding patients' choices of hospital[43], the present study found that 15.20% of rural populations went to hospitals in small-metro areas and 7.61% to large-metro hospitals for delivery. Rural patients' traveling to small-metro or large-metro hospitals for delivery indicates inadequate access to quality care in their local facilities[44]. More studies to address rural health disparities in obstetric services are necessary.

There are several limitations in this secondary data analysis. First, the data drawn from medical charts might be biased due to recording or transcription errors. For instance, some patients' procedure CCS were coded as 'C-section' while their diagnosis CCS was coded as 'normal delivery'. Researchers are not able to access the original report and had to adopt the valid procedure CCS codes only. Second, this data only contains community hospital discharges in California in 2011. As defined by the American Hospital Association, community hospitals include non-federal, short-term, general and other specialty hospitals but exclude veteran, Department of Defense, Native American, long-term, psychiatric, tuberculosis, and alcohol/chemical dependency treatment hospitals[17]. Critical access hospitals, which serve in rural areas, are not required to report the discharge data to the HCUP. However, there is no direct evidence about how many critical access hospitals in California did not provide the report. Another study pointed out that rural patients may be referred to urban hospitals since critical access hospitals are required to have an average LOS of less than 96 hours[45]. Twenty-two percent of the rural patients in this study received care in urban hospitals which means critical access hospitals were not their providers. Third, this study took into account of all-cause, all-area, and all-payer readmissions. The benefit of this approach is to prevent providers from changing the diagnosis code on purpose, since a hospital could pay high penalties due to readmissions[32]. Future studies to compare different causes of readmissions in rural and urban hospitals are recommended. Finally, the multivariate analyses of this study have been adjusted for personal characteristics. Nevertheless, characteristics of healthcare providers such as hospital bed size, hospital ownership, and the experience of obstetrics and gynecology doctors are not collected into this data. Future research should include more organizational characteristics.

Conclusions

The research findings show the real performance of hospitals in one state. California has above-average performance in terms of six maternal health indicators[46]. Thus the rate of maternal readmission might be higher for other states. It is imperative to address geographic differences in maternal rehospitalizations as well as to improve data collection. Studies about vulnerable mothers in rural areas are recommended to identify their access and utilization of obstetric services.

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