Research Article

Analysis of the Severe Maternal Outcomes between Resource-Poor and Resource-Rich Hospitals in China's Hunan Province from 2012 to 2018

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Background. This facility-based study analyzed the epidemiology and incidence of maternal near miss (MNM) and mortality by hospital level as part of Hunan Province's efforts to raise the quality of hospital care for women. *Methods.* We used data for MNM and mortality cases for 2012–2018 from 17 hospitals (12 resource-poor facilities, five resource-rich facilities) that receive referrals for obstetric complications in Hunan Province. Data were drawn from China's National Maternal Near Miss Surveillance System and collected using the World Health Organization near miss tool. We calculated the ratio of severe maternal outcomes (SMO) (i.e., MNM and maternal death (MD) cases), mortality index (MI), and MNM to mortality ratio (MNM : MD), and epidemiological factors, organ dysfunction, and maternal complications stratified by hospital level. The chi-square tests to examine differences between groups and total ratios and 95% CI were calculated. *Results.* There were 518 SMO cases (489 MNM and 29 MD) among 279407 live births (LBs) and 1299 SMO cases (1262 MNM and 37 MD) among 232386 LBs in resource-poor and resource-rich facilities. The total MNM ratio in resource-poor and resource-rich hospitals was 1.75 (95% CI: 1.60–1.91) and 5.43 (95% CI: 5.14–5.74) per 1000 LBs, respectively. There were differences in SMO cases between resource-poor and resource-rich hospitals in maternal age, education, parity, antenatal visits, and history of cesarean sections. In MNM cases, coagulation dysfunction was the main organ dysfunction (resource-poor hospitals: 59.10%; resource-rich hospitals: 79.32%), and the main maternal complications were obstetric hemorrhage (resource-poor hospitals: 71.98%) and hepatopathy (resource-rich hospitals: 69.49%). For MD cases, the main maternal complications were neurologic dysfunction (resource-poor hospitals: 41.38%) and coagulation dysfunction (resource-rich hospitals: 42.55%). Anemia was the main maternal complication for SMO cases in both resource-poor (69.69%) and resource-rich (68.59%) hospitals. *Conclusions.* MNM and MD are higher in resource-rich hospitals compared with resource-poor hospitals. The obstetric emergency capacity of resource-rich hospitals is higher than that of resource-poor hospitals. Future government policies should consider upgrading the obstetric emergency treatment capacity in resource-poor hospitals or to redistinguish the social functions of different medical institutions.

1. Background

The maternal mortality ratio (MMR) represents the number of maternal deaths per 100000 live births (LBs) and is a core indicator of a country's health and social development. Many countries have reported decreasing MMRs in the context of economic development and improved population health. The Global Burden of Disease study showed that over the last decade, the MMR fell by about 30% worldwide, from 288 in 2000 to 196 in 2015 [1]. Maternal mortality also declined by 8.9% per year between 1997 and 2014 in China, which has achieved Millennium Development Goal 5 (i.e., a 75% reduction of the MMR between 1990 and 2015) [2]. The MMR in China's Hunan Province declined by 45.24% between 2009 and 2014 [3]. Today, maternal death (MD) has become an extremely low probability event in the developed countries and parts of the developing countries, although severe maternal

morbidity or maternal near miss (MNM) cases remain major public health challenges for healthcare systems globally [4]. MNM is defined by the World Health Organization (WHO) as "a woman who nearly died but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy" [5–7]. The concept of MNM as developed by the WHO has been used to assess life-threatening conditions during pregnancy, labor, and puerperium to enable interventions to be focused on the chain of events leading to a woman's near miss or death [8, 9]. Prevention of MNM is now a major focus in countries with a low MMR, as it offers a means to improve the quality of maternal healthcare [10]. Assessment of pregnant women with severe maternal outcomes (SMO), which includes MNM and MD, may contribute to accelerating the reduction of morbidity and mortality [11]. The WHO recommends that countries should closely monitor SMO trends to identify preventable causes as well as system- and provider-related failures [12].

Progress has been made in reducing MD in Hunan Province [3]. However, there have been no official reports of SMO or MNM cases in Hunan Province. Additionally, regional disparities in maternal and child health persist in areas of China, particularly in hospitals, and no study has explored the incidence of SMO and MNM in different levels of medical institutions. However, evaluation of SMO is an important indicator that can help to improve quality of maternal care [13].

This study is aimed at comparing the incidence and epidemiological characteristics of SMO cases in selected resource-poor and resource-rich hospitals in Hunan Province, China, from January 1, 2012 to December 31, 2018. It is important to understand the incidence and epidemiology of SMO cases in different institutions to provide a basis for the government when developing policies concerning prevention of maternal deaths and improvement of obstetrical diagnosis and treatment across different levels of medical and health institutions.

2. Methods

2.1. Aim.
This study is aimed at analyzing the differences in incidence and epidemiological characteristics of SMO cases between resource-poor and resource-rich hospitals in Hunan Province, China, from 2012 to 2018.

2.2. Research Design.
This study used a retrospective design based on data for Hunan Province collected from China's National Maternal Near Miss Surveillance System (NMNMSS) for 2012–2018. This study dynamically monitored the occurrence of SMO in different resources of medical institutions.

2.3. Setting.
Hunan Province is located in central China, has a population of 71.47 million people, and covers an area of $21.18 \, km^2$. This study included data for 12 resource-poor hospitals and five resource-rich hospitals. The 17 hospitals have been the maternal near miss surveillance hospitals of Hunan Province in China's National Maternal Near Miss Surveillance Program. Resource-rich medical institutions in China are considered better than resource-poor institutions in terms of the organization size, rate of use of obstetric beds, available human resources, and first aid and service capacity.

2.4. Participants' Characteristics.
The participants evaluated in this study were pregnant and postpartum women admitted to the obstetrics departments or intensive care units of the studied institutions, and those who died in hospital. We excluded pregnant women hospitalized in departments other than obstetrics and those with minor abdominal pain but no other obstetric complications. Women that required only embryo preservation (e.g., after in vitro fertilization procedures) and traditional Chinese medicine treatment were also excluded.

The study population included all women during pregnancy, childbirth, or within 42 days of termination of pregnancy regardless of age. Identification of MNM cases was based on the presence of 25 organ and system dysfunction criteria (cardiovascular, respiratory, renal, coagulation, hepatic, neurological, and uterine) via clinical-, laboratory-, and management-based parameters. We defined MNM cases as "a woman who nearly died but survived a complication that occurred during pregnancy, childbirth, or within 42 days of termination of pregnancy." MD was defined as "the death of a woman while pregnant, or within 42 days of the termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to, or aggravated by, the pregnancy or its management but not from accidental or incidental causes" [14].

2.5. Data Collection.
Data were drawn from China's NMNMSS for a 7-year period from January 1, 2012 to December 31, 2018. The NMNMSS was established in October 2010 and covers 17 health facilities in Hunan Province. The system is aimed at enumerating all MD and MNM cases based on the WHO near miss criteria. Data were collected through a review of all research objects from admission to the obstetrics and gynecology units to discharge. The 17 hospitals were selected by health administration departments of Hunan provincial to monitor causes of child and maternal mortality within the province. The NMNMSS sampling methods have been described in detail elsewhere [15]. Doctors responsible for patient care within each facility were trained to collect and record the main information for maternal cases admitted to the obstetrics departments from admission to discharge. The information collected included maternal sociodemographic characteristics, pregnancy termination conditions or complications, rescue measures and procedures, and maternal and perinatal outcomes during pregnancy, delivery, and postpartum. Collected data for women that met the inclusion criteria were entered into the NMNMSS. Quality assurance was ensured by county-, municipal-, and provincial-level maternal and child health hospital staff. If surveillance hospital errors exceed a predefined standard (e.g., if obstetric complications were

underreported by more than 5%, MD was underreported by more than 1%, or MNM was underreported by more than 5%), they reexamined all data in the process of quality checking.

The primary outcome indicators were SMO ratio, MNM ratio, MMR, and mortality index (MI). SMO cases included MNM and MD cases, and referred to a life-threatening condition (i.e., organ dysfunction or death). The SMO ratio is the number of MNM cases plus MD cases per 1000 LBs. The MNM ratio refers to the number of MNM cases per 1000 LBs. The MMR represents the number of MD cases per 100000 LBs. The MNM mortality ratio (MNM : MD) refers to the ratio of MNM to MD cases. Finally, the MI refers to the number of MD cases divided by the sum of MNM and MD expressed as a percentage (MI = MD/[MNM + MD]). The SMO and MNM ratios give an estimate of the amount of care and resources that would be needed in an area or facility. SMO ratio, MNM : MD, and MI are indicators for obstetric quality; the higher the MI and SMO ratios, more women with life-threatening conditions die (low quality of obstetric care). Conversely, the higher the MNM : MD, fewer women with life-threatening conditions die (better quality of obstetric care).

We reviewed relevant NMNMSS data from January 1, 2012 to December 31, 2018. Next, we exported data from the NMNMSS to IBM SPSS version 20.0 for our analyses. In total, data of 1817 SMO cases from 541128 hospitalized pregnant women were used to analyze in this study. Frequency tables and crosstabulations by resource-poor and resource-rich hospitals were produced based on the collected demographic and clinical variables. All statistical tests were considered significant at $P < 0.05$. This study was approved by the Ethic Review Committee of Hunan Province Maternal and Children Health Care Hospital. The requirement for obtaining informed consent was waived because of the retrospective design of this study. This study was carried out in accordance with the principles of the Declaration of Helsinki. Hunan Province Maternal and Children Health Care Hospital is a comprehensive maternal and child care institution responsible for women's and children's healthcare in Hunan Province.

3. Results

3.1. Incidence of SMO. During the 7-year period, 541128 pregnant women were hospitalized in the 17 studied hospitals. There were 511793 LBs, which resulted in 1817 SMO cases. The total SMO ratio and 95% confidence interval (CI) in resource-poor hospitals was 1.85 (95% CI: 1.70–2.02) per 1000 LBs and in resource-rich hospitals was 5.59 (95% CI: 5.29–5.90) per 1000 LBs. There were 489 MNM cases and 29 MD cases in resource-poor hospitals, and 1262 MNM cases and 37 MD cases in resource-rich hospitals. The total MNM ratio was 1.75 (95% CI: 1.60–1.91) and 5.43 (95% CI: 5.14–5.74) per 1000 LBs in resource-poor and resource-rich hospitals, respectively. The total MMR was 10.38 (95% CI: 6.95–14.90) and 15.92 (95% CI: 11.51–21.95) per 100000 LBs in resource-

poor and resource-rich hospitals, respectively. In resource-poor hospitals, the total MI was 5.60% and the MNM ratio was 16.86. In resource-rich hospitals, the total MI was 2.85% and the MNM ratio was 34.11. A summary of deliveries and SMO and MNM indicators in resource-poor and resource-rich hospitals is presented in Table 1. We observed that the MNM ratio and MNM : MD in resource-poor hospitals declined from 2014 to 2018, whereas the MNM ratio, MNM : MD, and MMR in resource-rich hospitals fluctuated during the 7-year period (Figure 1).

3.2. Demographic Characteristics of Women with SMO. The majority (31.15%) of SMO cases in both resource-poor and resource-rich hospitals occurred among women aged 30–34 years. The highest proportion (48.76%) of cases was recorded as having a high school education. Only 2.20% of cases were not married at the time of the investigation, and nearly half was their second pregnancy. The antenatal visits of the cases of SMO grouped by resource-poor and resource-rich were 4–6 times (34.75%) and 7–9 times (40.88%) differently ($\chi^2 = 121.42$, $P = 0.104$). More SMO cases in resource-rich institutions had a history of cesarean section delivery. There was no difference in the marital status in SMO cases by hospital resource level ($\chi^2 = 2.65$, $P = 0.104$) (Table 2).

3.3. Termination of Pregnancy among Women with SMO. Most deliveries among women with SMO were at 37–42 gestational weeks in resource-poor (56.56%) and resource-rich (48.19%) hospitals. In total, 111 SMO cases (21.43%) in resource-poor hospitals and 36.26% SMO cases in resource-rich hospitals delivered low-birth-weight infants. Additionally, cesarean section was chosen in 61.39% SMO cases in resource-poor hospitals and 70.67% cases in resource-rich hospitals. Most SMO cases in resource-rich hospitals (94.30%) had delivered at provincial hospitals, and 87.26% SMO cases in resource-poor hospitals had delivered at county hospitals. The rate of LBs in resource-rich hospitals (92.38%) was higher than that in resource-poor hospitals (82.43%) (Table 3).

3.4. Organ Dysfunction and Maternal Complications. Coagulation dysfunction was reported in 1021 MNM cases (78.60%) in resource-rich hospitals and 297 MNM cases (57.34%) in resource-poor hospitals. The common organ dysfunction associated with MD was neurologic dysfunction (41.38%) in resource-poor hospitals and coagulation dysfunction (42.55%) in resource-rich hospitals. The highest MI was for neurologic dysfunction in resource-poor hospitals (2.32) and coagulation dysfunction in resource-rich hospitals (1.54). The most common maternal complications in resource-poor hospitals were hypertensive disorder in 18 MD cases and obstetric hemorrhage in 352 MNM cases. In resource-rich hospitals, the most common maternal complication was anemia (except unclassified diseases), which was found in 14 MD cases and 877 MNM cases. The highest MI associated with maternal complications was for hypertensive disorder (3.10) in

TABLE 1: Summary of deliveries, severe maternal outcomes, and near miss indicators in women admitted to resource-poor and resource-rich hospitals in Hunan Province from 2012 to 2018.

Resource-poor hospitals	Total	2012	2013	2014	2015	2016	2017	2018
All hospitalized pregnant women (number)	296985	37227	40216	43523	43536	47883	47529	37071
Live births (number)	279407	36095	38085	40600	41237	45250	44566	33574
Pregnancy complications (number)	124791	4638	12007	18285	20061	23705	23317	22778
Severe maternal outcome cases (number)	518	75	86	68	76	54	82	77
Maternal near miss cases (number)	489	71	83	65	72	50	76	72
Maternal death cases (number)	29	4	3	3	4	4	6	5
Overall near miss indicators								
Severe maternal outcome ratio (per 1000 live births) 95% CI	1.85 (1.70-2.02)	2.08	2.26	1.67	1.84	1.19	1.84	2.29
Maternal near miss ratio (per 1000 live births) 95% CI	1.75 (1.60-1.91)	1.97	2.18	1.60	1.75	1.10	1.71	2.14
Maternal mortality ratio (per 100000 live births) 95% CI	10.38 (6.95-14.90)	11.08	7.88	7.39	9.70	8.84	13.46	14.89
Maternal near miss mortality ratio (MNM : MD)	16.86	17.75	27.67	21.67	18.00	12.50	12.67	14.40
Mortality index (%)	5.60	5.33	3.49	4.41	5.26	7.41	7.32	6.49
Resource-rich hospitals	Total	2012	2013	2014	2015	2016	2017	2018
All hospitalized pregnant women (number)	244143	24659	26846	31675	35285	44175	43699	37804
Live births (number)	232386	24086	25604	30262	33684	42108	41383	35259
Pregnancy complications (number)	149997	4711	11426	19518	21912	29997	33091	29342
Severe maternal outcome cases (number)	1299	111	175	182	168	222	200	241
Maternal near miss cases (number)	1262	108	170	177	161	216	193	237
Maternal death cases (number)	37	3	5	5	7	6	7	4
Overall near miss indicators								
Severe maternal outcome ratio (per 1000 live births) 95% CI	5.59 (5.29-5.90)	4.61	6.83	6.01	4.99	5.27	4.83	6.84
Maternal near miss ratio (per 1000 live births) 95% CI	5.43 (5.14-5.74)	4.48	6.64	5.85	4.78	5.13	4.66	6.72
Maternal mortality ratio (per 100000 live births) 95% CI	15.92 (11.51-21.95)	12.46	19.53	16.52	20.78	14.25	16.92	11.34
Maternal near miss mortality ratio (MNM : MD)	34.11	36.00	34.00	35.40	23.00	36.00	27.57	59.25
Mortality index (%)	2.85	2.70	2.86	2.75	4.17	2.70	3.50	1.66

resource-poor hospitals and anemia (1.08) in resource-rich hospitals, excluding unclassified complications. These outcomes are shown in Table 4 and Figure 2.

4. Discussion

4.1. Severe Maternal Outcomes. The WHO has initiated a process of agreeing on a definition and developing a uniform set of identification criteria for MNM cases, with the intent of facilitating reviews of these cases to monitor and improve the quality of obstetric care [10]. Our study showed the prevalence of MNM was 0.175% among 296985 women attending 12 resource-poor health facilities and 0.543% among 244143 women attending five resource-rich health facilities in Hunan Province from 2012 to 2018. Other studies have reported MNM incidence rates from 0.4% to 1.6% [16–21]. A systematic review conducted in sub-Saharan Africa on the applicability of the WHO maternal near miss tool showed the median MNM ratio was 24.2 (95% CI: 12.4–35.8) per 1000 LBs, which ranged from 4.4 in a population-based study in South Africa to 198 in a rural private hospital in Nigeria [22]. The MNM incidence among hospitals in Ethiopia was 20.8% (9.1-38.8%), and a significant regional variation was observed with regard to MNM incidence and mortal-

ity index [23]. Overall, resource-rich hospitals in China's Hunan Province treat more MNM cases, but the incidence of MNM in this study was lower than that reported in most international studies.

MD constitutes the most obvious manifestation of severe morbidity related to pregnancy, childbirth, and puerperium. Our study showed the prevalence of MD was 10.38/100000 LBs (29 deaths) in the 12 resource-poor facilities and 15.92/100000 LBs (37 deaths) in the five resource-rich facilities. High maternal mortality was reported in the US, with rates from 16.0 to 17.8 per 100000 LBs between 2009 and 2016 [24]. In Turkey, the MMR was 15.4 deaths per 100000 LBs in 2012, compared with 13.7 in 2015 [25]. In sub-Saharan Africa, the MMR was 351 per 100000 LBs, which was similar to that in South Asia (336 per 100000 LBs) [26]. Over the past few decades, substantial progress has been made in safe motherhood, possibly attributable to delivery in hospital policies and prevention and treatment of postpartum hemorrhage programs, although regional inequality persists.

Indicators such as the MNM : MD and MI are also used to describe obstetric care. The MNM : MD represents the proportion of MNM cases that progressed to MD, with a higher ratio reflecting better quality of care [5]. In this study, the MNM : MD was 16.86 and 34.11 in resource-
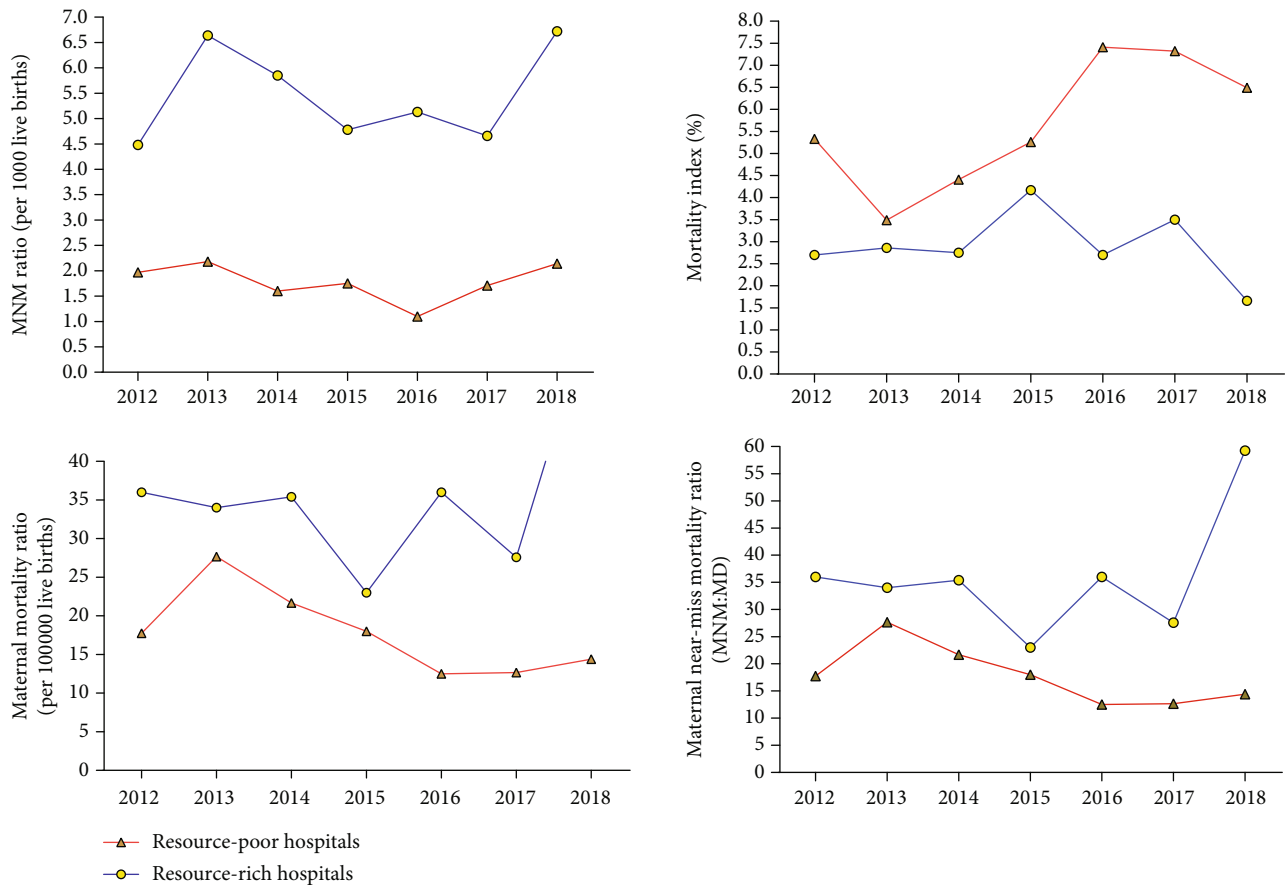
FIGURE 1: The time trend of MNM ratio, MI, maternal mortality, and MNM : MD in women admitted to resource-poor and resource-rich hospitals in Hunan Province from 2012 to 2018.

poor and resource-rich hospitals, respectively. Therefore, one MD occurred for every 17 MNM cases in resource-poor hospitals and for every 34 MNM cases in resource-rich hospitals. MNM cases are more likely to die in the nondeveloped and developing countries than in the developed countries. A study conducted in Somaliland and Tanzania using similar WHO criteria reported the MNM : MD was 6.7 [27, 28]. However, studies conducted in South Africa such as Nigeria, Tanzania, and Ghana and Pakistan reported near ratios ranging from 1.5 to 5 [21, 26, 29]. The ratios in our study were relatively high in the context of existing policies to promote maternal and child health.

Our findings revealed a MI of 5.6% in resource-poor hospitals and 2.85% in resource-rich hospitals, which was comparable to the 4.2% MI reported in previous studies conducted in China and Malaysia [19, 30]. A low MI (<5%) indicates better quality of care, with fewer women with severe conditions dying; in contrast, a high MI (>20%) indicates low-quality obstetric care for severe cases, in which more women with severe conditions die [5].

Based on our comparison of these four indicators, we concluded that resource-rich hospitals have a stronger medical treatment ability and better healthcare quality. We suggest upgrading the obstetric emergency treatment capacity in resource-poor hospitals or to redistinguish the social functions of different medical institutions, such as implementing graded diagnosis where resource-rich hospitals focus on treating MNM cases, and resource-poor hospitals focus on monitoring basic health indictors for pregnant women in rural areas and city communities based on the current medical resource and level of critical illness treatment. Results from our analysis may contribute to the development of the healthcare system in China.

4.2. Demographic Differences and Birth Outcomes. This study mainly compared women admitted to resource-poor hospitals with those admitted to resource-rich hospitals. Overall, the proportion of giving birth to a second child was highest in SMO cases. The phenomenon is due to the background of two-child policy opening and high cesarean section rate in China. The main differences found in the demographic comparisons were in the number of antenatal visits and history of cesarean section. SMO cases in resource-rich hospitals had more antenatal visits and a higher proportion of cesarean sections than SMO cases in resource-poor hospitals. In addition, 33.35% of all SMO cases were women with a history of cesarean section, which was less than the 58% reported in a study at a tertiary referral teaching hospital in the southeast of Iran

TABLE 2: Personal information for women with severe maternal outcomes at resource-poor and resource-rich hospitals in Hunan Province from 2012 to 2018.

Variables	Resource-poor hospitals		Resource-rich hospitals		χ^2	P
	N	%	N	%		
Mother's age (years)						
<20	17	3.28	13	1.00		
20-24	68	13.13	100	7.70		
25-29	149	28.76	405	31.18		
30-34	126	24.32	440	33.87	35.263	<0.001
35-39	80	15.44	222	17.09		
≥40	33	6.37	91	7.01		
Missing	45	8.69	28	2.16		
Mother's education						
None/primary school	30	5.79	21	1.62		
Middle school	187	36.10	117	9.01		
High school	249	48.07	637	49.04	318.1	<0.001
College or higher	34	6.56	504	38.80		
Missing	18	3.47	20	1.54		
Marital status						
Single, widowed, or divorced	16	3.09	24	1.85	2.65	0.104
Married	502	96.91	1275	98.15		
Parity						
0	181	34.94	544	41.88		
1	265	51.16	618	47.58	9.063	0.011
≥2	72	13.90	137	10.55		
Antenatal visits						
0	15	2.90	14	1.08		
1–3	87	16.80	116	8.93		
4–6	180	34.75	294	22.63		
7–9	125	24.13	531	40.88	121.42	<0.001
≥10	42	8.11	296	22.79		
Missing	68	13.13	48	3.70		
History of cesarean sections						
Yes	138	26.64	468	36.03	14.679	<0.001
No	380	73.36	831	63.97		

TABLE 3: Termination of pregnancy for cases with severe maternal outcomes at resource-poor and resource-rich hospitals in Hunan Province from 2012 to 2018.

Variables	Resource-poor hospitals		Resource-rich hospitals	
	N	%	N	%
Gestational age (weeks)				
<28	52	10.04	107	8.24
29-36	105	20.27	505	38.88
37-42	293	56.56	626	48.19
Missing	68	13.13	61	4.70
Birth weight (grams)				
<2500	111	21.43	471	36.26
2500-4000	298	57.53	744	57.27
≥4000	32	6.18	51	3.93
Missing	103	19.88	145	11.16
Mode of delivery/end of pregnancy				
Vaginal delivery	124	23.94	284	21.86
Cesarean section	318	61.39	918	70.67
Abortion/others	50	9.65	62	4.77
Missing	26	5.02	35	2.69
Place of delivery				
Provincial hospital	4	0.77	1225	94.30
County hospital	452	87.26	19	1.46
Township hospital/others	25	4.83	19	1.46
Missing	37	7.14	36	2.77
Total deliveries				
1	459	88.61	1136	87.45
≥2	26	5.02	111	8.55
Unknown/missing	33	6.37	52	4.00
Gender				
Female	244	47.10	645	49.65
Male	225	43.44	642	49.42
Unknown/missing	75	14.48	125	9.62
State of birth				
Live birth	427	82.43	1200	92.38
Stillbirth	44	8.49	112	8.62
Unknown/missing	73	14.09	100	7.70

[31]. Although previous cesarean delivery is not considered a risk factor for SMO or adverse perinatal outcomes, there could be differences between study groups in terms of healthcare-seeking behavior, referral mechanisms, intrapartum monitoring, and clinical decision-making [32]. Considering that resource-poor hospitals are located in rural areas and resource-rich hospitals are located in urban areas, there were fewer antenatal visits for pregnant women living in rural areas. This may be related to health awareness. It may be necessary to improve maternal health knowledge and focus on behavior change in low-resource and limited literacy settings, which may contribute to reductions in maternal mortality [33].

Among the 1817 SMO cases in this study, 51% cases delivered at 37–42 gestational weeks, 68% cases delivered by cesarean section, and 88% of women were giving birth for the first time. Most newborns were LBs and term infants. Several studies have shown that the presence of MNM in women is strongly associated with the occurrence of adverse perinatal outcomes, such as stillbirth, preterm birth, low birth weight, and early neonatal mortality [34–37]. However, studies that quantified the effect of MNM on adverse perinatal outcomes are scarce in China. We intend to explore this issue in a further study.

4.3. Clinical Disorders. Hypertensive disorders and neurologic dysfunction were responsible for most MD cases in resource-poor hospitals, whereas anemia and coagulation

TABLE 4: Organ dysfunction and maternal complications for cases with severe maternal outcomes at resource-poor and resource-rich hospitals in Hunan Province from 2012 to 2018.

Organ dysfunction	Resource-poor hospitals				Resource-rich hospitals			
	Maternal near miss ($N = 489$%)	Maternal deaths ($N = 29$%)	Severe maternal outcome ($N = 518$%)	Mortality index	Maternal near miss ($N = 1262$%)	Maternal deaths ($N = 47$%)%	Severe maternal outcome ($N = 1299$%)	Mortality index
Cardiovascular dysfunction	221 (49.19)	6 (20.69)	227 (43.82)	1.16	233 (18.46)	13 (27.66)	246 (18.94)	1.00
Respiratory dysfunction	37 (7.57)	7 (24.14)	44 (8.49)	1.35	90 (7.13)	8 (17.02)	98 (7.54)	0.62
Renal dysfunction	19 (3.89)	4 (13.79)	23 (4.44)	0.77	27 (2.14)	1 (2.13)	28 (2.16)	0.08
Coagulation dysfunction	289 (59.10)	8 (27.59)	297 (57.34)	1.54	1001 (79.32)	20 (42.55)	1021 (78.60)	1.54
Hepatic dysfunction	6 (1.23)	4 (13.79)	10 (1.93)	0.77	27 (2.14)	1 (2.13)	28 (2.16)	0.08
Neurologic dysfunction	89 (18.20)	12 (41.38)	101 (19.50)	2.32	120 (9.51)	8 (17.02)	128 (9.85)	0.62
Uterine dysfunction	82 (16.77)	1 (3.45)	83 (16.02)	0.19	172 (13.63)	0 (0.00)	171 (13.16)	0.00
Maternal complications								
Obstetric hemorrhage	352 (71.98)	3 (10.34)	355 (68.53)	0.52	864 (68.46)	7 (14.89)	871 (67.05)	0.54
Pregnancy-related infections	42 (8.59)	2 (6.90)	44 (8.49)	0.34	109 (8.64)	4 (8.51)	113 (8.70)	0.31
Hypertensive disorder	146 (29.86)	18 (62.07)	164 (31.66)	3.10	290 (22.98)	11 (23.40)	302 (23.25)	0.85
Heart disease	12 (2.45)	4 (13.79)	13 (2.51)	0.69	58 (4.60)	5 (10.64)	63 (4.85)	0.38
Embolism disease	14 (2.86)	5 (17.24)	16 (3.09)	0.86	19 (1.51)	7 (14.89)	23 (1.77)	0.54
Hepatopathy	23 (4.70)	3 (10.34)	26 (5.02)	0.52	59 (4.68)	3 (6.38)	62 (4.77)	0.23
Anemia	350 (71.57)	11 (37.93)	361 (69.69)	1.89	877 (69.49)	14 (29.79)	891 (68.59)	1.08
Diabetes mellitus	37 (7.57)	0 (0.00)	37 (7.14)	0.00	202 (16.01)	6 (12.77)	208 (16.01)	0.46
Nephropathy	7 (1.43)	3 (10.34)	10 (1.93)	0.52	31 (2.46)	0 (0.00)	30 (2.31)	0.00
Pulmonary disease	2 (0.41)	0 (0.00)	2 (0.39)	0.00	28 (2.22)	3 (6.38)	31 (2.39)	0.23
With other diseases	275 (56.24)	14 (48.28)	289 (55.79)	2.41	746 (59.11)	25 (53.19)	783 (62.66)	1.92

Resource-poor hospitals MNM (%)	Resource-rich hospitals MNM (%)	Organ dysfunction	Resource-poor hospitals NNM (%)	Resource-rich hospitals NNM (%)
49.19	18.46	Cardiovascular dysfunction	20.69	27.66
7.57	7.13	Respiratory dysfunction	24.14	17.02
3.89	2.14	Renal dysfunction	13.79	2.13
59.1	79.32	Coagulation dysfunction	27.59	42.55
1.23	2.14	Hepatic dysfunction	13.79	2.13
18.2	9.51	Neurologic dysfunction	41.38	17.02
16.77	13.63	Uterine dysfunction	3.45	0
		Morbidity conditions		
71.98	68.46	Obstetric hemorrhage	10.34	14.89
8.59	8.64	Pregnancy related infections	6.9	8.51
29.86	22.98	Hypertensive disorder	62.07	23.4
2.45	4.6	Heart disease	13.79	10.64
2.86	1.51	Embolism disease	17.24	14.89
4.7	4.68	Hepatopathy	10.34	6.38
71.57	69.49	Anemia	37.9	29.79
7.57	16.01	Diabetes mellitus	0	12.77
1.43	2.46	Nephropathy	10.34	0
0.41	2.22	Pulmonary disease	0	6.38
56.24	59.11	With other diseases	48.2	53.19

FIGURE 2: The proportion of organ dysfunction and maternal complications for MNM and MD cases at resource-poor and resource-rich hospitals in Hunan Province from 2012 to 2018.

dysfunction were most common in MD cases in resource-rich hospitals. However, for MNM cases, anemia and coagulation dysfunction were the leading cause of death in both resource-poor and resource-rich hospitals. We found the major causes of SMO were anemia, hypertensive disorder, and obstetric hemorrhage. Hypertensive disorder and cardiovascular dysfunction were the most frequent conditions among MNM cases in Alborz Province of Iran, where medical resources are undeveloped [38]. In the setting of the present study, hypertensive disorders related to MNM cases in resource-poor hospitals and anemia in resource-rich hospitals need more attention to prevent SMO cases in Hunan Province. Anemia in pregnancy is associated with severe maternal morbidity and is an indirect cause of MD across pregnant populations in both low- and high-income settings [39]. The high prevalence of anemia also contributed to adverse outcomes in women with prenatal hemorrhage. It is therefore crucial to optimize maternal iron status to improve maternal outcomes [40]. Postpartum hemorrhage was less common in the present study compared with other studies, which may be because of the high coverage of essential medical interventions to prevent this condition.

5. Limitations

We applied the unified WHO maternal near miss criteria in different-sized hospitals, which might have resulted in information bias because of differences in diagnostic capabilities and standards. Second, we used facility-based sampling, which could have introduced referral bias. Third, some related risk factors associated with MNM such as prepregnancy body mass index, diseases before pregnancy, and family history were not collected in this study.

6. Conclusions

The study shows higher ratios of MNM and MD cases in resource-rich hospitals compared with resource-poor hospitals. The obstetric emergency capacity of resource-rich hospitals is higher than that of resource-poor hospitals. Our findings suggest future government policies should consider upgrading the obstetric emergency treatment capacity in resource-poor hospitals or to redistinguish the social functions of different medical institutions.

Abbreviations

SMO: Severe maternal outcomes
MNM: Maternal near miss
MD: Maternal deaths
MI: Mortality index
MNM : MD: The ratio of maternal near miss to mortality
LBs: Live births
NMNMSS: China's National Maternal Near Miss Surveillance System
WHO: World Health Organization
CI: Confidence intervals
MMR: Maternal mortality ratio.

Data Availability

The datasets used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no competing interests.

Authors' Contributions

XLL was primarily responsible for conceiving the project and writing the paper. ZMJ was responsible for modifying the paper. WAH, XDH, and KFJ were responsible for carrying out data collection and analysis of the manuscript. LZY was responsible for reviewing the manuscript. Xiong Lili and Zeng Mengjun were the coauthors.

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