

Incidence, risk factors, and causes of maternal near-miss admitted to the intensive care unit in Yangzhou, China: A 5-year retrospective study

Ying Chen

Yangzhou University

Jiaoyang Shi

Dalian Medical College: Dalian Medical University

Yuting Zhu

Yangzhou University

Xiang Kong (✉ XKong@yzu.edu.cn)

Yangzhou University Medical Academy <https://orcid.org/0000-0003-3240-1290>

Yang Lu

Yangzhou University Medical Academy

Yanru Chu

Yangzhou University

Miskatul Mustafa Mishu

Yangzhou University Medical Academy

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Abstract

Background

The maternal near-miss (MNM) criterion formulated by the WHO can dynamically evaluate the obstetric quality and maternal health in medical institutions. The study aims to explore the incidence, risk factors, and causes of MNM cases admitted to the intensive care unit (ICU) within 5 years.

Methods

This study is a retrospective study. The data of MNM admitted to the ICU comes from the medical records of Subei People's Hospital in Yangzhou from 2015 to 2019. The study subjects meet at least one World Health Organization (WHO) criterion of MNM. The MNM who had not been admitted to the ICU in the same year served as the control group. We use descriptive analysis, Chi-Square test and Fisher's exact test for data analysis.

Results

151 women met the WHO criteria of MNM and there was one maternal death in 2016. The average maternal near-miss rate (MNMR) for ICU admission was 3.5 per 1,000LBs, and the average MNM morbidity was 0.36%. The average maternal mortality ratio (MMR) was 5 per 100,000LBs. The 5-year research period witnessed moderate growth in MNM admitted to the ICU. The region, referral, gravidity, prenatal examination, and mode of delivery were significantly related to the MNM admitted to the ICU ($p < 0.05$). Concerning neonatal characteristics, there is a significant difference in preterm birth rate and low Apgar scores at 1 min and 5 min ($p < 0.05$). The direct obstetric causes were the primary cause of MNM, regardless of the ICU admission. The leading direct obstetric causes of MNM admitted to the ICU were obstetric hemorrhage diseases (38.8%) following hypertension diseases (18.8%), while the leading indirect obstetric cause of MNM admitted to the ICU was heart-related diseases (7.2%). MNM for the ICU admission were mostly postpartum (96.9%), who underwent multiple interventions.

Conclusions

ICU is one of the most important endpoints of MNM management. In the context of "universal two-child", medical institutions should strengthen multidisciplinary joint treatment. In the future, it needs to be expanded to multi-center research to determine the criteria for MNM admitted to the ICU.

Background

Reducing maternal mortality (MD) is the primary issue of global concern. The global maternal mortality ratio (MMR) decreased from 385/10⁵ in 1990 to 216/10⁵ in 2015 [1]. Based on the goal of the Sustainable Development Strategy (SDG), the global MMR will be reduced to 70/10⁵ by 2030, and the total number of deaths will not exceed 250 million. Although there are regional and ethnic differences, the annual MMR of

any country cannot exceed $140/10^5$ [1–3].MMR is one of the vital indicators to measure the economic level, resource allocation, and maternal and child health status of a country or region.

Due to the development of modern medical technology, MMR, as the "tip of the iceberg", has a rare incidence, even in developing countries. It is impossible to monitor and evaluate the quality of obstetric care accurately [4]. Therefore, the World Health Organization (WHO) organized an expert group to review and revise the concept of maternal near-miss (MNM) in 2009, which clarify the diagnostic criteria from three aspects: clinical standards, laboratory tests, and disease management standards. MNM means that pregnant women who are on the verge of death within 42 days of pregnancy, childbirth, and postpartum are successfully rescued or continue to survive due to accidental factors [5]. MNM's condition changes are bidirectional[6]. It appears earlier than MD and has similar risk factors with MD. It can dynamically evaluate the obstetric quality of medical institutions and obtain more reliable and objective data to reduce severe morbidity and prevent death. Global unified diagnostic criteria are more conducive to guidance, tracking, and policymaking [7, 8].

China completed the Millennium Development Goals in 2015[9]. The "Healthy China 2030 " states that China's MMR should be reduced to $12/10^5$ in 2030[10]. After the implementation of the universal two-child policy in 2016, experts predict that the number of births will increase significantly in the next five years[11],which was estimated from 100,000 to more than 10 million each year[12]. The change in demographic structure will not only increase the number of older women, but also heighten the risk of pregnancy and the incidence of pregnant complications and comorbidities[12, 13].Obstetricians are facing greater challenges. The joint management of MNM by obstetrics and the intensive care unit (ICU) is a major measure for the rescue of emergency obstetrics. The incidence of MNM admitted to the ICU can be used as one of the important indicators to judge the severity[14]. A multicountry survey by WHO showed that the use of high-quality ICU is notably correlated with the decline in MMR[15].As a result, it is necessary to predict, identify, and manage the MNM admitted to the ICU to improve the risk prevention and control system.

So far, there is no report on monitoring MNM in Yangzhou. This study is a retrospective study, which aims to explore the incidence, risk factors and causes of MNM cases admitted to the ICU within 5 years, provide clinical experience and lessons for reducing the incidence of adverse maternal outcomes and standardize the process of maternal health care services.

Methods

Study design and area

This study is a retrospective study. The research location is the Subei People's Hospital of Yangzhou, Jiangsu Province, which is a tertiary general hospital integrating clinical, teaching, and scientific research in the field of obstetrics and gynecology. The GDP per capita and regional development of Jiangsu Province have reached the level of "medium-upper-class" developed countries[16]. The total population of

Yangzhou is 4.59 million and the birth rate is 9.87‰[17]. There are 116 hospital beds, 95 medical staff, and advanced equipment such as integrated obstetric beds, an obstetric central monitoring system, Doppler fetal heart rate monitor in the obstetric department. In 2016, the hospital became one of the Critical Maternal Emergency Centers for MNM in Yangzhou, which set up an emergency green channel for midwifery agencies in the region and established a multidisciplinary expert team to provide 24-hour emergency obstetric services.

Study period and participants

The participants included in this study were MNM who were admitted to the ICU at Subei People's Hospital from 2015 to 2019. The MNM who were not admitted to the ICU in the same year were used as the control group to compare the general demographic data, obstetrical data, and causes between the two groups.

When a participant met any of the clinical, laboratory, or management standards set by WHO, the researchers would add it to a standardized data table. The complete data could be available for review. Women admitted to the ICU not related to pregnancy (not during pregnancy or 42 days after the termination of pregnancy) were excluded.

Procedures for data collection

The data was collected from the patient's medical records by two researchers after unified training. The information obtained was only used to describe the characteristics of patients and analyze the data, so informed consent was not required. The ethics approval was provided by School of Nursing, Yangzhou University (Audit reference YZUHL2020014) on 1 March 2020. The contents of general demographic data and obstetric data include age, citizenship, region, referral, gravidity, parity, gestational week, prenatal examinations, previous cesarean section history, mode of delivery, mode of fertilization, hospitalization time, the timing of the ICU admission, length of stay in the ICU, neonatal sex, the birth of weight, Apgar score (1min, 5min) and neonatal outcome.

Medical diagnosis was coded under the International Classification of Diseases (ICD-10). When several complications coexist, only the major causes of admission to the ICU were considered. They were divided into direct obstetric causes and indirect obstetric causes. Direct obstetric causes included placenta previa, placental abruption, postpartum hemorrhage, uterine rupture, hemorrhagic shock, amniotic fluid embolism, pelvic hemorrhage, abdominal wall stroke, pregnancy-induced hypertension, acute fatty liver of pregnancy, intrahepatic cholestasis of pregnancy and Endometriosis; Indirect obstetric causes included infection, heart-related, kidney-related, endocrine system-related, respiratory system-related, liver-related, nervous system-related and epilepsy.

Interventions in the ICU include blood transfusion, mechanical ventilation, tracheal intubation, plasma exchange, and so on. If there was any doubt about the case of the missing data, we consulted the attending doctor. Through obstetrics delivery records, the annual delivery data was obtained. The data

collection period was from June 1, 2020, to July 31, 2020. The main researchers and experts regularly checked the completeness and consistency of the data and proposed amendments and improvements on the spot.

Outcome indicators

- Maternal near-miss ratio (MNMR): the number of maternal near-miss cases per 1000 live births.
- Maternal mortality ratio (MMR): the number of maternal mortality per 100,000 live births.
- MNM Morbidity %: the number of maternal near-miss cases /total number of maternal during the same period

Data analysis

Data was entered and organized by Microsoft Excel 2007. The analysis was performed by IBM SPSS statistics data editor version 26.0. Descriptive analysis was expressed by frequency and ratio, represented by N and % respectively. The cross table was used to explain whether there was a significant relationship between variables and adverse outcomes. Chi-Square test and Fisher's exact test were used to compare the two groups of categorical variables to assess the potential risk factors of MNM in the ICU admission. $p < 0.05$ was considered statistically significant during the study.

Result

Over the 5 years of the study (2015-2019), we enrolled information from 17946 women and 18346 live births (LBs) in the Subei People's Hospital. 151 women met the WHO criteria of maternal near-miss and there was one maternal death in 2016. They were divided into two groups (MNM to the ICU group and MNM not to the ICU group). The group of MNM not to the ICU was served as the control group. The average MMR for the hospital was 5 per 100,000 LBs. The average MNM morbidity for the ICU admission was 0.36% and MNMR was 3.5 per 1,000 LBs (Table 1). The period between 2015 and 2019 witnessed moderate growth in the number of MNM admitted to the ICU, and delivery quantity reached its highest point at 4319 in 2016 (Fig 1).

Demographic and obstetric characteristics of MNM to ICU

The demographic and obstetric characteristics of the two groups were compared (Table 2). The risk factors which were performed to be statistically significant were region, referral, gravidity, prenatal examination, and mode of delivery ($p < 0.05$). Overall, the percentage of women aged 35 or older was 21.5%. Approximately 65% of women came from rural areas. 41.5% were referred from other hospitals. 72.3% of pregnant women had more than one pregnancy. Irregular prenatal examination accounted for 29.8%. The rate of previous cesarean section history was 33.9%. Most MNM admitted to the ICU ended their pregnancy with cesarean section (92.3%) and had prolonged length of hospitalization (76.9%).

Compared with the two groups, the number of elderly age, rural area, referral, gravidity, parity, irregular prenatal examinations, previous cesarean section history, cesarean section and prolonged length of hospitalization in the ICU admission group were higher than that of the control group.

Neonatal characteristics of MNM to ICU

A total of 154 newborns (124 singletons and 15 twins) were born in the study (Table 3). Regarding neonatal characteristics, there is a significant difference in preterm birth rate (81.3% and 61.1%, respectively $p < 0.01$), low Apgar scores at 1 minute (21.9% and 2.2%, respectively $p < 0.01$) and low Apgar scores at 5 minute (6.3% and 0%, respectively $p = 0.02$).

Primary causes of MNM to ICU

Direct obstetric causes are the primary reasons for MNM, regardless of ICU admission (Table 4). The leading direct obstetric cause of MNM admitted to the ICU was obstetric hemorrhage disease (38.8%) following hypertension disease (18.8%). The leading indirect obstetric cause of MNM admitted to the ICU was heart-related diseases (7.2%). However, in the control group, the most common cause was obstetric hemorrhage disease (70.5%), following anemia (12.1%). The leading indirect obstetric cause was epilepsy (5.7%).

Clinical interventions of MNM to ICU

82 women were admitted to the ICU, whereas only 65 women met the WHO near-miss criterion. All of them underwent 217 clinical interventions in total (most of the women accepted more than one) (Table 5). These included blood transfusion (≥ 5 units red blood cells) (33.8%), continuous use of vasoactive drugs (23.1%), invasive blood pressure monitoring (21.5%), pressurized oxygen supply (49.2%), plasma replacement (3.1%), hysterectomy (13.8%), uterine backpack suture (6.2%), uterine artery embolization (7.7%), continuous renal replacement therapy (CRRT) (3.1%), endotracheal intubation (36.9%), deep/central venous catheterization (26.7%) and mechanically assisted sputum removal (38.7%). The timing of the ICU admission is mostly postpartum (96.9%).

Discussion

In the current study, the average MNMR for the ICU admission was 3.5 per 1,000 LBs and accounted for 0.36% when WHO criteria conducted by many obstetric experts were used. The finding was consistent with other developed countries and a recent systematic review that indicated a wide spread of the incidence of MNM for the ICU admission [18–21]. Although only a small percentage of women need to be admitted to the ICU for care, this population is increasing due to population growth and the introduction of new treatment models [22].

In 2016, China changed its fertility policy from "single two-child" to "universal two-child", which resulted in the concentrated release of accumulated fertility demand and an increase in the proportion of high-risk pregnant women [23]. The change in delivery volume is consistent with the results in this study. A

growing number of women are conceiving with assisted reproductive technology (ART), giving rise to a significantly increased risk of perinatal complications, blood transfusion, and ICU hospitalization [24]. Therefore, we strive to check at the source, pour attention into high-risk pregnant women, and provide the correct advice on the timing of pregnancy again, health care, and precautions during pregnancy.

With the progress of urbanization and the regional characteristics of Yangzhou, the rural population still occupies a considerable proportion. The migrant population with unstable income and lacking medical insurance has also increased overwhelmingly [25]. The government and health institutions should strengthen health education for the migrant population, raise awareness of self-health management, and gradually realize that migrant women enjoy the same health care services as the place where they immigrated. This solution can promote the conversion of a high-risk pregnancy to medium or low risk and effectively reduce the occurrence of MNM.

As expected, 41.5% of pregnant women transferred from other hospitals were admitted to the ICU in this study. These women are facing a higher risk of MNM due to the influence of transportation, referral distance, and primary care level [26, 27]. To resolve this contradiction, it is indispensable to establish a two-way cooperative relationship led by the Critical Maternal Emergency Center to ensure the coverage of all midwifery institutions, implement hierarchical referral treatment, and establish the shortest distance green treatment channel. For women with unstable conditions, experts from higher-level medical institutions can provide on-site treatment or telemedicine to guide the rescue.

Irregular prenatal examinations are one of the potential risk factors for MNM [28]. This study stated that the rate of irregular prenatal examinations in the ICU group was almost twice that of the control group, suggesting that regular examinations can prevent adverse pregnancy outcomes and reduce medical costs. It reached an agreement on the results of a retrospective study in Brazil [29]. With the help of the nation's free five-time prenatal examinations service for pregnant women, we will make full use of pregnant women's schools and communities to promote the benefits of regular examinations and help pregnant women understand its importance.

During the study period, the previous cesarean section rate was 33.9%. It was lower than the population-based prospective study in Italy, which found that repeated cesarean section was remarkably associated with postpartum hemorrhage and hysterectomy [14, 30]. The number of scarred uterus in China doubled from 2012 to 2016, 9.8% and 17.7% respectively [31]. The cesarean section rate in China was the highest among the nine Asian countries, especially the rate of cesarean sections without medical indications [32]. But for MNM admitted to the ICU, the cesarean section is an effective means to relieve adverse pregnancy outcomes [33]. So 92.3% of the delivery methods in this study were cesarean sections. Higher cesarean section rates and changes in fertility policies will lead to the diversification and complexity of diseases, which highlight the need for multidisciplinary treatment. Regular skills training and rescue drills for relevant health care personnel are also key measures.

This study found that the premature birth rate and low Apgar scores at both 1 and 5 minutes were significantly higher than those of MNM in the control group. A document reported that babies delivered by

mothers in the ICU have higher neonatal intubation rates, NICU transfer rates and lower Apgar scores [34]. This shows that the ICU health care personnel are facing huge challenges, not only need to pay attention to the physical condition of MNM, but the condition of newborns may also be critical and need to be dealt with in time.

The main obstetric causes of MNM admitted to the ICU were obstetric hemorrhage and hypertension. This finding is in line with the results of several studies conducted in France[21] and inconsistent with several studies in Brazil[35, 36]. Obstetric hemorrhage tends to easily have serious adverse effects on women's physical and mental health. On the one hand, the high rate of cesarean section leads to the invasive placenta [37], On the other hand, as a treatment center for MNM, the referral of obstetric patients from other hospitals to our hospital results in data bias. Obstetric medical workers should keep eyes on obstetric hemorrhage risk screening, carrying out key monitoring and dynamic management of pregnant women at risk of bleeding.

Our hospital uses prophylactic oxytocin for every parturient to reduce avoidable obstetric hemorrhage. Blood transfusion is an important emergency intervention. The availability of blood and the threshold of use is different in various regions [38]. Hence, ≥ 5 units of red blood cells as the inclusion criteria may not truly reflect the severity of MNM. This requires further research to determine the blood transfusion threshold that meets national characteristics. Hysterectomy is the most serious treatment for obstetric hemorrhage. The higher rate of hysterectomy is related to the delay in seeking medical services and referrals for pregnant women with severe obstetric hemorrhage. [22, 39]. However, in recent years, a reasonable choice of compression suture and uterine artery embolization has effectively reduced the rate of hysterectomy and improve maternal quality of life[37].

Affected by race, environment, and social economy, 5%-10% of pregnant women will develop hypertension [40]. In this study, 18.8% of MNM admitted to the ICU had hypertension. Study had pointed out that irregular prenatal examinations and low educational attainment were risk factors for hypertension[41]. Our hospital's recognition and treatment of hypertension are relatively complete. high-risk pregnant women with a family history of hypertension ought to be vigilant and screened as soon as possible. Meanwhile, the ability of health care personnel to judge and deal with complications needs to be enhanced.

Although obstetric causes are the main reason for MNM admitted to the ICU [42, 43], considering the development of reproductive medicine and other related medicine, perinatal complications and comorbidities tend to occur in women with underlying diseases, which make the treatments of indirect obstetric causes too complex and beyond the capacity of obstetricians [44]. The main indirect obstetric cause of MNM admitted to the ICU was heart-related diseases, while the control group is epilepsy .According to a national research studied in China, the incidence of MMR caused by heart-related diseases rose by 1.5 per 100,000 between 2013 and 2016[11]. As a tertiary general hospital, our hospital is able to provide comprehensive treatments and advanced intervention measures for women suffering those diseases and use multidisciplinary management to powerfully reduce MMR.

96.9% of MNM were admitted to the ICU after delivery. More than half of MNM spent less than three days in the ICU. Similar to other studies, China's first multi-center study showed that 92.26% of pregnant women were admitted to the ICU after delivery [45]. 87% of the ICU admissions in the United States occurred postpartum with an average length of 10 days for staying in hospital [19]. The difference in the length of the ICU stay implies that since our hospital has only a comprehensive ICU, most MNM admitted to the ICU only need continuous monitoring and do not necessarily need intensive care. In this case, establishing an obstetric intensive care unit may contribute to reducing the pressure on the ICU and providing specialist nursing for MNM.

During the 5-year study period, there was only one maternal death due to pregnancy complicated by heart failure. MMR is 5/10⁵. Compared with low-income and low-middle-income countries, this incidence reflects our hospital's good health service management and the availability of high-quality drugs and interventions [46]. Approximately 830 women die from preventable pregnancy-related diseases every day in the world, and 99% of MD occurs in developing countries [47, 48]. It is a valuable method for health care personnel to regularly audit and analyzes MNM admitted to the ICU.

There are some limitations to our research worth noting. First of all, given that this study was conducted in a single hospital, our results may not be generalized to primary and private hospitals. However, most MNM receives treatment in tertiary general hospitals, especially in middle-income and high-income areas. This bias will not have much impact on the result. Secondly, this study is a retrospective study with data from medical records. It is hoped that the occurrence of data loss can be minimized with the exploitation and development of tools for the automatic identification of MNM[38]. Finally, our use of WHO standards may underestimate the number of severe maternal morbidities. In the future ,research is needed to establish MNM standards suitable for our country or region.

To the best of our knowledge, this study is the first retrospective study of MNM admitted to the ICU in Yangzhou. The hospitals in this study have abundant experience in handling pregnancy complications and pay attention to the incidence, risk factors, and causes of MNM, which is helpful to promote the transformation from quantity to quality of obstetric health. Moreover, the 5-year study can objectively evaluate the impact of the "two-child policy" on MNM.

Conclusion

In this study, the average MNMR for admission to the ICU was 3.5/1000 LBs and the average morbidity was 0.36%. With the implementation of the "two-child policy", MNMR of the ICU admission is positively correlated with time. ICU is one of the most common endpoints in the management of MNM. The cooperation of the ICU, obstetrics, and other related departments to treat MNM can effectively reduce MMR. At present, there is a lack of consensus on the criteria for MNM admitted to the ICU. In-depth research and adequate monitoring can find deficiencies in obstetric services and offer a strong basis for policy formulation and improvement.

Abbreviations

ICU: Intensive care unit; MD:Maternal deaths; MMR:Maternal mortality ratio; MNMR:Maternal near-miss ratio; MNM:Maternal near miss; WHO:World Health Organization; LBs:live births; ART:assisted reproductive technology

Declarations

Availability of data and materials

The data in this research report is available for use with the permission of the corresponding author.

Ethics approval and consent to participate

The ethics approval to undertake this study was provided by School of Nursing, Yangzhou University (Audit reference YZUHL2020014) on 1 March 2020. The data were based on case records and were merely an assessment of the quality of clinical obstetric care in this study, so informed consent was not required.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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No funding was received for this study.

Authors' contributions

YC analyzed the data and written manuscript. JYS contributed significantly to collect the data and revise the manuscript. YTZ, YL, YRC and MMM were involved to interpret and revise the manuscript. XK supervised and guided the whole study. All authors read and approve the final manuscript, who were performed the study design.

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Tables

Table 1 ☐ Maternal statistic data cohort 2015 to 2019

Year	Total number of maternal	MNM cases	MNM to the ICU*	MNM Morbidity %	MNM to the ICU morbidity %
2015	3100	29	8	0.93	0.26
2016	4194	21	13	0.50	0.31
2017	3687	35	14	0.95	0.38
2018	3301	35	14	1.06	0.42
2019	3664	31	16	0.85	0.44
total	17946	151	65	0.86	0.36

Abbreviations: MNM maternal near miss ; ICU intensive care unit

*MNM to the ICU is defined as maternal near miss admitted to ICU]

Table 2: Demographic and obstetrical characteristics of women with maternal near-miss in two groups

Characteristics	MNM to the ICU		MNM not to the ICU		χ^2	P
	N	%	N	%		
Age						
<35	51	78.5	69	80.2	0.07	0.79
≥ 35	14	21.5	17	19.8		
Citizenship						
Local	49	75.4	66	76.7	0.04	0.85
Migrant	16	24.6	20	23.3		
Region						
Rural	42	64.6	41	47.7	4.29	0.04
Urban	23	35.4	45	52.3		
Referral						
No	38	58.5	69	80.2	8.50	<0.01
Yes	27	41.5	17	19.8		
Gravidity						
1	18	27.7	31	36.0	15.82	<0.01
2-5	46	70.8	38	44.2		
>5	1	1.5	17	19.8		
Parity						
0-1	25	38.5	44	51.2	2.41	0.12
≥ 2	40	61.5	42	48.8		
Prenatal examinations ^a						
Regular	33	70.2	67	85.9	4.51	0.03
Irregular	14	29.8	11	14.1		
Previous cesarean section history						
0	41	63.1	56	65.1	0.07	0.80
≥ 1	24	36.9	30	34.9		
Mode of delivery						
Cesarean delivery	60	92.3	63	73.3	8.90	<0.01

Natural birth	5	7.7	23	26.7		
Mode of fertilization						
Natural	58	89.2	75	87.2	0.14	0.70
ART *	7	10.8	11	12.8		
Hospitalization time						
≤7	15	23.1	22	25.6	0.13	0.72
>7	50	76.9	64	74.4		

* ART is defined as assisted reproductive technology

^a The missing value of the prenatal examination is 26

Table 3 Neonatal characteristics of maternal near-miss in two groups

Neonatal characteristic	MNM to the ICU		MNM not to the ICU		χ^2	P
	N	%	N	%		
All live neonatal number	64	-	90	-		
Gestational age						
<37	52	81.3	55	61.1	7.15	<0.01
≥37	12	18.7	35	38.9		
Neonatal sex						
Male	30	46.9	41	45.6	0.03	0.87
Female	34	53.1	49	54.4		
Number of Neonatal						
Singletons	52	89.7	72	88.9	0.02	0.89
Twins	6	10.3	9	11.1		
Birth of weight						
<2500	3	25.0	1	2.9	-	0.05*
≥2500	9	75.0	34	97.1		
Apgar score at 1min						
<7	14	21.9	2	2.2	15.51	<0.01
≥7	50	78.1	88	97.8		
Apgar score at 5min						
<7	4	6.3	0	0	5.78	0.02
≥7	60	93.7	90	100.0		
Admission to Neonatal Department						
Yes	30	46.9	49	54.4	0.86	0.35
No	34	53.1	41	45.6		

*Fisher's exact test

Table 4 Causes of women with maternal near-miss in two groups

Cause*	MNM		MNM to the ICU		MNM not to the ICU	
	N		N	%	N	%
Direct obstetric cause	258		115	69.8	143	91.2
Obstetric hemorrhage disease	177		64	38.8	113	70.5
Abruptio placenta	7		5	3.0	2	1.3
Placenta praevia	32		7	4.2	25	15.8
Postpartum hemorrhage	96		28	17.0	68	43.2
Coagulation defects	11		10	6.0	1	0.6
Uterine atony	42		9	5.5	33	21.0
Placenta implantation	37		9	5.5	28	17.8
Soft birth canal lacerations/ hematoma	6		0	0	6	3.8
Ruptured uterus	4		1	0.6	3	1.8
Disseminated intravascular coagulation (DIC)	5		4	2.5	1	0.6
Hemorrhagic shock	26		14	8.5	12	7.5
Amniotic fluid embolism	4		3	1.8	1	0.6
Pelvic bleeding	2		1	0.6	1	0.6
Abdominal wall hematoma/ Abdominal apoplexy	1		1	0.6	0	0
Hypertension disease	39		31	18.8	8	5.0
Preeclampsia	15		12	7.4	3	1.9
Eclampsia	9		6	3.6	3	1.9
Chronic hypertension with preeclampsia	7		7	4.2	2	1.2
HELLP syndrome	3		3	1.8	0	0
Hypertensive crisis	3		3	1.8	0	0
Acute fatty liver during pregnancy	4		4	2.5	0	0
Intrahepatic cholestasis during pregnancy	8		5	3.0	3	1.7
Anemia	29		10	6.1	19	12.1
Endometriosis	1		1	0.6	0	0

Indirect obstetric cause	64	50	30.2	14	8.8
Infection	10	8	4.9	2	1.3
Epilepsy	10	1	0.6	9	5.7
Heart related	13	12	7.2	1	0.6
Cardiac insufficiency	4	4	2.4	0	0
Congenital heart disease	1	1	0.6	0	0
Heart failure	6	6	3.6	0	0
other	2	1	0.6	1	0.6
Endocrine related	1	1	0.6	0	0
Respiratory related	11	11	6.7	0	0
Respiratory failure	4	4	2.5	0	0
Acute pulmonary edema	5	5	3.0	0	0
Asthma	1	1	0.6	0	0
Acute respiratory distress syndrome (ARDS)	1	1	0.6	0	0
Renal related	7	6	3.6	1	0.6
Liver related	6	6	3.6	0	0
Nervous related	2	1	0.6	1	0.6
Other	4	4	2.5	0	0

*one woman could have experienced more than one cause

Table 5 Clinical interventions of MNM admitted to the ICU

Clinical interventions	N	%
ICU admission	65	43.0%
Timing of the ICU admission		
Antepartum	2	3.1
Postpartum	63	96.9
Length of stay in the ICU		
1-3	35	53.8
≥ 4	30	46.2
Blood transfusion (≥ 5 units red blood cells)	22	33.8
Continuous use of vasoactive drugs	15	23.1
Noninvasive assisted ventilation	34	52.3
Invasive blood pressure monitoring	14	21.5
Pressurized oxygen supply	32	49.2
Plasma replacement	2	3.1
Hysterectomy	9	13.8
Uterine backpack suture	4	6.2
Uterine artery embolization	5	7.7
Continuous renal replacement therapy	2	3.1
Endotracheal intubation	24	36.9
Deep/Central venous catheterization	18	26.7
Mechanically assisted sputum removal	25	38.7

Figures

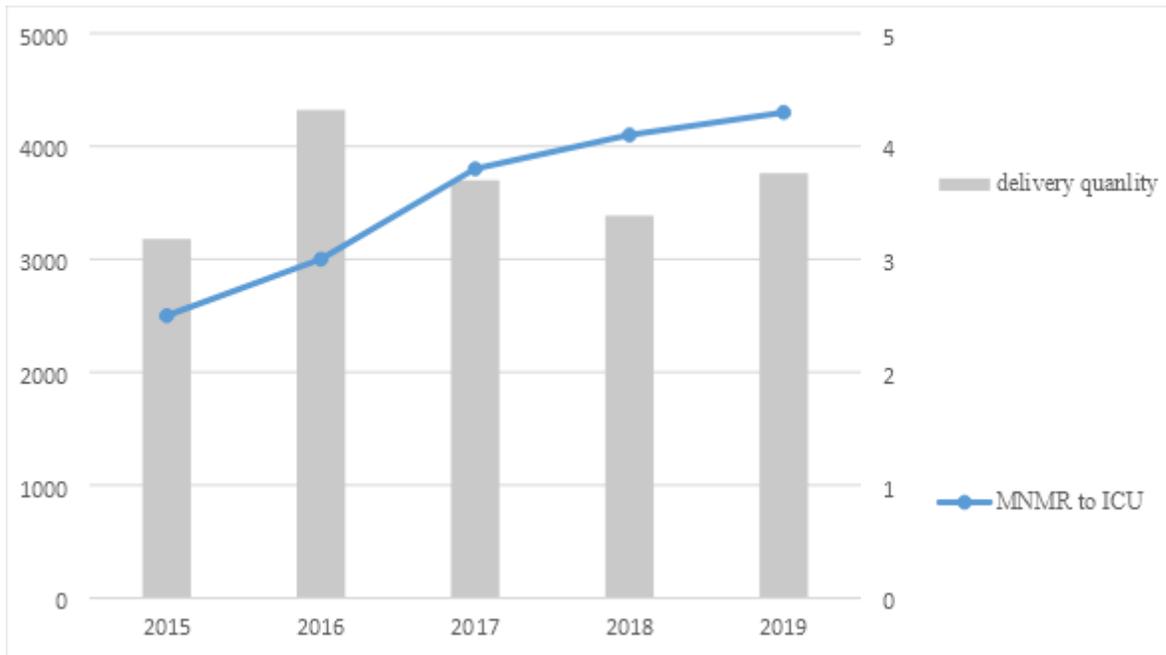


Figure 1

Change trend of delivery volume and MNMR* admission to ICU from 2015 to 2019. *MNMR is defined as the number of maternal near miss cases per 1000 live births