Original Article

Predictors and Pathway of Maternal Near Miss: A Case–Control Study in a Tertiary Care Facility in Kolkata

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Abstract

Background: Use of maternal near-miss (MNM) cases as an adjunct has been advocated to understand the processes of obstetric care because they share similar pathways as maternal deaths. Identifying the predictors and care pathway is crucial to improve the quality of care and end preventable maternal deaths. **Materials and Methods:** This case–control study was conducted at a tertiary care facility in Kolkata from May 2019 to March 2020. Women admitted with complications during pregnancy, childbirth, or within 42 days of postpartum, who met the World Health Organization (WHO) near-miss criteria, were identified as cases, and equivalent age-group matched controls were recruited. Sample size of 60 cases and 60 controls was estimated, assuming a power of 80%, level of significance 0.05, and case–control ratio of 1. After obtaining approval from the institutional ethics committee and informed written consent from the participants, data was collected through face-to-face interview and review of records. Statistical analysis including care pathway analysis (using *three-delay* model) was performed using Statistical Package for Social Sciences version 16. **Results:** Joint family type (adjusted odds ratio [AOR] [CI] = 5.06 [1.48, 7.28]), lack of antenatal checkups (AOR [CI] = 7.85 [1.47, 12.09]), previous history of cesarean section (AOR [CI] = 3.94 [1.09, 14.33]), first delay in seeking care (AOR [CI] = 13.84 [3.62, 32.83]), and preexisting medical disorders (AOR [CI] = 11.03 [4.62, 22.80]) were identified as significant predictors of MNM in the adjusted model. Significant difference in the proportion of first and second delays in the care pathway was observed between cases and controls. **Conclusions:** Identification of risk factors of MNM and pattern of delays in the care pathway will help improving quality of obstetric care.

Keywords: Case–control study, delays, maternal mortality, maternal near miss, pathways

Introduction

Global estimates suggest that more than a quarter million women die every year during pregnancy, childbirth, and puerperium. Developing and low-middle income countries (LMICs), including India, disproportionately bear this burden.[1] Despite India's commitment toward ending preventable maternal deaths and reducing maternal mortality ratio (MMR), the country still accounts for 12% of all maternal deaths worldwide.[1,2] Additional efforts are needed to further accelerate the drop in MMR to meet the 2030 Sustainable Development Goal (SDG).

Maternal mortality, despite being a major public health issue, is infrequent nowadays owing to several public health initiatives that have been implemented nationwide to provide comprehensive obstetric care.[3] Estimates reveal that for every maternal mortality, many more women survive life-threatening situations (maternal near misses [MNMs]) during pregnancy, labor, or postpartum.[4-6] The use of an MNM approach to understand obstetric care processes has been advocated because it not only shares similar pathological, circumstantial, and care pathways as maternal deaths, but also allows researchers to interact with a larger number of cases who have survived, potentially providing insight into the challenges faced, quality

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of care received, and service delivery gaps.[6-8] The World Health Organization (WHO) has defined MNM as "women who nearly died but survived a complication that occurred during pregnancy, childbirth, or within 42 days of termination of pregnancy." The WHO near-miss criteria are based on potentially life-threatening pregnancy conditions, provision of critical interventions, and organ dysfunction.[6,9] Previous researches showed that MNM is a multifactorial condition triggered by patients' and provider-related characteristics, with previous history of cesarean section (C-section), preexisting medical disorders, induction of labor, lack of antenatal checkup (ANC), and delays as significant determinants.[10-13]

Delays in care pathway are assessed using Thaddeus's *three-delay model* that characterizes the factors contributing to severe maternal outcomes (MNM or maternal death).[14] The framework has been useful in understanding impediments along the care continuum as well as the circumstances surrounding access to emergency obstetric care (EmOC).[14-17] Identifying the predictors of MNM and delays in care pathway is helpful in informing policy decisions to enhance quality of care across continuum. Therefore, this study was aimed to determine the causes and predictors of MNM and identify the pattern of delays in obstetric care pathway.

Materials and Methods

Study design and setting

The facility-based case–control study was conducted from May 2019 to March 2020 among pregnant and postpartum women admitted in the maternity wards of a premier tertiary care teaching hospital in Kolkata, catering to patients from West Bengal as well as from the adjacent states.[18]

Selection criteria

Case

MNM: "Women attending the study facility, who nearly died, but survived a complication that occurred during pregnancy, childbirth, or within 42 days of termination of pregnancy" and fulfilled the WHO MNM criteria were recruited sequentially till the sample size was achieved.[6,19]

Control

A woman admitted in the same facility during pregnancy, childbirth, or within 42 days of delivery but not meeting any of the WHO near-miss criteria was selected. For each case, a control in the similar age group (<20 years, 20 to <35 years, ≥35 years) was selected in a 1:1 ratio. Lottery method was used in recruiting control if there was more than one available control on the day of data collection.

Exclusion criteria

Cases and controls unable or unwilling to give informed written consent and less than 18 years of age were excluded.

Sample size estimation

Based on previous findings by Abdel-Raheem *et al.* in 2017,[12] the proportion of cases exposed to delay was $p_1 = 0.55$ and the proportion of controls exposed to delay was $p_2 = 0.23$. Assuming a power of 80%, confidence level of 95%, and control to case ratio of one (1:1), the final sample size of near-miss cases (n) was estimated using the formula for difference in proportions:

$$n = \left(\frac{r+1}{r}\right)\frac{(\bar{p})(1-\bar{p})(Z_{\beta}+Z_{\alpha/2})^2}{(p_1-p_2)^2}$$

In the above-mentioned formula, n = sample size in the case group, r = ratio of controls to cases, = mean proportion of the population exposed, Z_{β} represents the desired power (it is 0.84 for 80% power), Z_{α} represents the desired level of statistical significance (at $\alpha = 0.05$, Z_{α} is 1.96), and $(p_1 - p_2)$ denotes the difference in proportions. Therefore, the minimum estimated sample size was 60 cases and 60 controls.

Study tools and technique

Cases were identified using the WHO near-miss criteria. Face-to-face interview along with review of medical records was conducted using predesigned pretested schedule adapted from available guidelines,[5,6] which included domains on a) *sociodemographic and background characteristics* (e.g., education, marital status, age at marriage, family type); b) *obstetric history* (e.g., ANC, history of C-section, gravida, parity); c) *medical history* from patient records (e.g., bed head tickets, maternal and child protection card, referral forms); and d) *delays in care pathway*. Open-ended questions were also asked to elicit probable reasons behind delays.

Operational definition

The *three-delay model* was used to measure *delays* at three separate levels.[10,12,20]

First delay

Delay in recognition of danger signs and decision-making at home to seek maternal health care. A first delay was considered if time taken at this level was more than 24 h.

Second delay

It is the time after decision-making to reach a health facility. A second delay was deemed if the time taken at this level was more than 60 min.

Third delay

Time taken in receiving appropriate management after reaching the health facility. A third delay was considered if the time taken at this stage was greater than 30 min.

Data analysis

Descriptive statistics were used to explain important explanatory variables in relation to the outcome variable (MNM). Odds ratio was calculated based on 95% confidence interval in the adjusted and unadjusted models. Binary logistic regression was performed to assess the relationship of outcome with exposure variables. Multivariable logistic (unconditional) regression analysis was performed by entering variables with a P value <0.25 at the same time to identify the predictors of MNM, while adjusting for other variables.[21,22] Hosmer–

Lemeshow test was used to ascertain model fitness. $P < 0.05$ was considered significant. The care-seeking journey was depicted using a pathway diagram based on statistical findings, and content analysis was used to highlight the reasons for delays. Statistical data were analyzed using the Statistical Package for the Social Sciences version 16.

Ethics

Institutional ethics committee approval was obtained from the study hospital before inception of the study. Informed written consent was obtained from all participants before each interview. Participants' privacy and confidentiality were ensured throughout the study process.

Results

Sociodemographic characteristics of mothers

A total of 120 participants (60 MNM cases and 60 controls) were interviewed, with a response rate of 100%. No significant difference was observed between cases and controls in terms of the socioeconomic class (according to modified BG Prasad's scale, 2020) and the education level of the mothers. Statistically significant difference was observed between cases and controls in terms of occupation, place of residence, and family type of the mothers [Table 1].

Clinical characteristics of MNM

Among potentially life-threatening conditions, severe obstetric hemorrhage (48.3%), severe preeclampsia (21.6%), and eclampsia (6.7%) were the major underlying causes. Also, 18.3% of MNM cases required critical intervention (laparotomy) due to pregnancy with abortive outcome (ectopic). In 11.6% of cases, coagulation/hematological dysfunction was diagnosed, of which six had disseminated intravascular coagulation disorder and one had hemolysis, elevated liver enzymes, and low platelet count (HELLP) syndrome. Cardiovascular dysfunction due to severe rheumatic and valvular heart disease was observed in 20% of cases.

Table 1: Sociodemographic characteristics of the study participants ($n=120$)

Variables	Cases ($n=60$)	Controls ($n=60$)	*P*
	No. (%)	No. (%)	
Age (completed years)			
<20	2 (3.3)	2 (3.3)	1.00
20 to <25	22 (36.7)	22 (36.7)	
25 to <35	33 (55.0)	33 (55.0)	
≥35	3 (5.0)	3 (5.0)	
Mean age (SD)	26.12 (4.48)	26.03 (4.18)	0.96#
Age range	19-39	19-37	
Religion			
Hindu	44 (73.3)	50 (83.4)	-
Muslim	16 (26.7)	8 (13.3)	
Christian	0 (0)	2 (3.3)	
Occupation			
Homemaker	55 (91.7)	47 (78.3)	**0.04***
Working mother	5 (8.3)	13 (21.7)	
Place of residence			
Rural	30 (50.0)	17 (28.3)	**0.01***
Urban	30 (50.0)	43 (71.7)	
Family type			
Nuclear	20 (33.3)	31 (51.7)	**0.04***
Joint	40 (66.7)	29 (48.3)	

SD=standard deviation. *Chi-square (χ^2) test was used for categorical variables. #Two independent-sample *t*-test (Mann-Whitney U); *P* values are significant at α=0.05

Maternal health-related characteristics

Presence of at least one preexisting medical condition was reported in 33 (55.0%) cases compared to seven (11.7%) controls. Among the cases, 23.4% had heart diseases (rheumatic heart diseases, valvulopathies) followed by hypertension (18.3%), diabetes mellitus (5.0%), anemia (3.3%), asthma (1.7%), seizure disorder (1.7%), and depressive disorder (1.7%). In contrast, hypertension, diabetes mellitus, and asthma were reported in 5%, 5%, and 1.7% of controls, respectively. It was also observed that more than one-fourth of cases (26.7%) had three or more pregnancies, whereas in controls, it was only one tenth. Majority (53.3%) of the cases and 40.0% of controls had previous history of C-section, and reportedly 16.7% of cases had history of abortion (spontaneous or induced) [Table 2].

Delays in care pathway

First delay (delay in decision-making to seek care)

Twenty-nine MNM cases and six controls had experienced *first delay*, with a statistically significant ($P < 0.01$) difference in proportion. It was observed that the median time to seek health care was also higher among cases (24 h) in contrast to controls (6 h). The most prominent reason among all the women who had experienced first delay was the inability to recognize the danger signs of obstetric complications (82.75% for cases and 66.6% for controls), followed by inability to find someone to care for children at home.

Second delay (delay in reaching health facility)

Among cases, 33.3% had experienced a *second delay* and there was a statistically significant difference in proportion ($P = 0.03$) when compared to controls (16.7%). Although there was difference in the mean duration between cases and controls, the median time taken to get referral was same (1 h) in both the groups. Longer travel times from house to a health-care facility, as well as a lack of knowledge regarding free public ambulance service were cited as factors for the second delay.

Third delay (delay in receiving care)

Out of six cases with multi-referral care pathway, only one had experienced a *third delay.* The reported reason behind the delay was unavailability of Rh-negative blood component for transfusion. However, it was observed that the mean time spent between arrival and the first examination for the cases was 24.04 ± 9.10 min and for the controls was 19 ± 8.42 min [Table 3].

Pathway analysis showed that six cases and one control had multi-referral pathway *(Path 1)* involving more than one health

Table 2: Maternal health-related characteristics of the participants (*n*=120)

Variables	Cases (*n*=60)	Controls (*n*=60)	*P*
	No. (%)	No. (%)	
Age at marriage			
≤19 years	13 (21.7)	8 (13.3)	0.44
20-24 years	42 (70.0)	45 (75.0)	
≥25 years	5 (8.3)	7 (11.7)	
Age at first pregnancy			
≤19 years	4 (6.7)	2 (3.3)	0.64
20-24 years	47 (78.3)	47 (78.4)	
≥25 years	9 (15.0)	11 (18.3)	
Gravida			
1	24 (40.0)	21 (35.0)	**0.019**
2	20 (33.3)	33 (55.0)	
≥3	16 (26.7)	6 (10.0)	
Parity			
0	24 (40.0)	21 (35.0)	-
1	20 (33.3)	33 (55.0)	
2	10 (16.7)	6 (10.0)	
≥3	6 (10.0)	0 (0)	
ANC registration			
≤12 weeks	57 (95.0)	60 (100.0)	-
>12 weeks	3 (5.0)	0 (0)	
ANC visits			
≥4	44 (73.3)	56 (93.3)	0.003
<4	16 (26.7)	4 (6.7)	
Previous h/o abortion			
Yes	10 (16.7)	0 (0)	-
Preexisting diseases			
Yes	33 (55.0)	7 (11.7)	<0.001

ANC=antenatal checkup. Chi-square (χ^2) test was used for categorical variables; *P* values are significant at α=0.05

Table 3: Delays experienced by the participants (*n*=120)

Characteristics of delay	Cases (*n*=60)	Controls (*n*=60)	*P*
	No. (%)	No. (%)	
First delay			
No delay (<24 h)	31 (51.7)	54 (90.0)	**<0.01**
Experienced delay (≥24 h)	29 (48.3)	6 (10.0)	
Mean±SD (h)	26.3±18.1	12.1±12.3	
Second delay			
No delay (≤60 min)	40 (66.7)	50 (83.3)	**0.03**
Experienced delay (>60 min)	20 (33.3)	10 (16.7)	
Mean±SD (min)	76.6±43.7	59±36.6	
Third delay			
No delay (≤30 min)	59 (98.3)	60 (100.0)	0.31
Experienced delay (>30 min)	1 (1.7)	0 (0)	
Mean±SD (min)	24.4±9.1	19±8.42	

SD=standard deviation. Chi-square (χ^2) test was used for categorical variables; *P* values are significant at α=0.05

facility, namely, primary health centers (PHCs) and first referral units (FRUs). No significant difference was observed in median delays (first and second) between cases and controls having multi-referral path. Single referral pathway *(Path 2)* from FRUs was observed in majority (75.0%) of cases and nearly half (49.0%) of the controls. Statistically significant difference was obtained in the first delay median time between cases and controls having single referral pathway, as evident from the Mann–Whitney test ($U = 1081.5$, $z = -3.82$, $P < 0.001$). *Path 3* demonstrated that 15% cases and 50% controls were self-referred, seeking care directly at a tertiary facility, with no significant difference in median delays (first and second) between them [Figure 1].

Predictors of MNM

It was revealed that women living in joint families (adjusted odds ratio [AOR] = 5.06; 95% confidence interval [CI]: 1.48, 7.28), less than four ANCs (AOR = 7.85; 95% CI: 1.47, 12.09), previous history of C-section (AOR = 3.94; 95% CI: 1.09, 14.33), first delay in seeking care (AOR = 13.84; 95% CI: 3.62, 32.83), and history of preexisting medical disorders (AOR = 11.03; 95% CI: 4.62, 22.80) were significant predictors of MNM**.** Although residence in rural areas, higher gravida (≥3), and second delay had significant odds in the univariate model, they lost their statistical significance in the final multivariable regression model. Hosmer–Lemeshow test statistic showed that the multivariable prediction model was of good fit ($P = 0.51$), and the proportion of variance explained by the multivariable model ranged from 0.482 to 0.642 as demonstrated by Cox–Snell R^2 and Nagelkerke R^2, respectively [Table 4].

Discussion

The study highlighted the sociodemographic, obstetric, and care pathway-related characteristics of the MNM cases and controls. Rural place of residence, joint family type, lack of ANC, previous history of C-section, history of preexisting diseases, and first delay (delay to seek health care) have been identified as significant predictors of MNM in the adjusted model. The delay in seeking care is often exacerbated by social and educational disadvantages. However, in this research, no significant association was observed between women's education and MNM, which is inconsistent with the findings of Mekango *et al*.[11] This finding, however, was in tandem with a study finding from Brazil.[23]

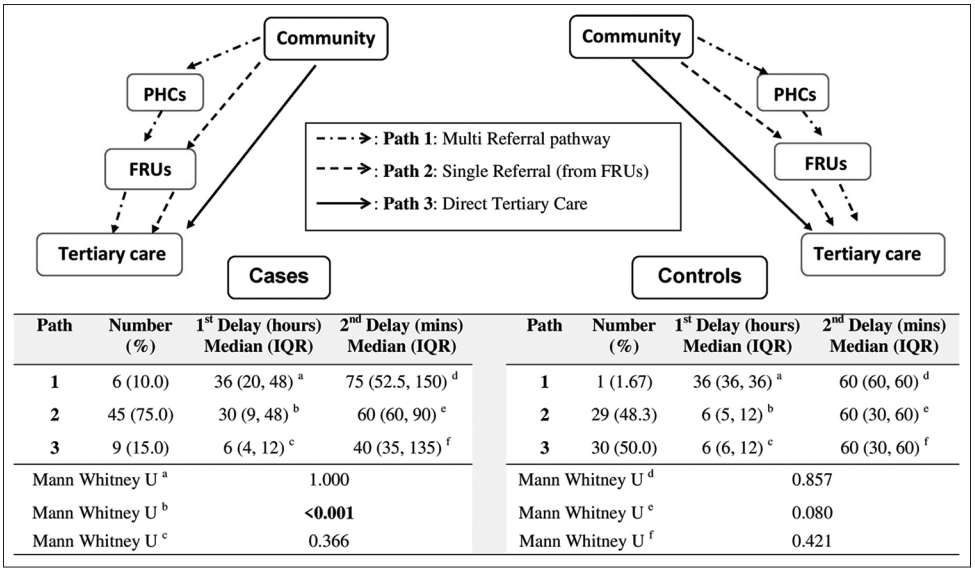
The lack of ANC visits was found to be significantly associated with MNM in this study, which is consistent with the findings from Ethiopia, Nigeria, Iraq, and India. This shows that adequate ANC prevents severe maternal outcomes and near miss.[10,24-26] Similar to a study finding from India, which showed early ANC registration was protective, the current research revealed that, ANC registration was delayed (>12 weeks) in 5% of near-miss cases, whereas all the controls were registered in their first trimester.[26] Potential rationale could be that ANC is an important point of contact for mothers to interact with health-care professionals regarding the danger signs of pregnancy and childbirth.

The study showed that women with a previous history of C-section carried higher risk of developing MNM. This

Table 4: Logistic regression analyses to identify the predictors of MNM (*n*=120)

Variables	Cases (*n*=60)	Controls (*n*=60)	Univariate		Multivariable	
			COR (CI)	*P*	AOR (CI)	*P*
Residence						
Urban	30	43	1		1	
Rural	30	17	2.52 (1.18, 5.38)	**0.01**	3.22 (0.84, 12.39)	0.08
Family type						
Nuclear	20	31	1		1	
Joint	40	29	2.13 (1.02, 4.47)	**0.04**	5.06 (1.48, 7.28)	**0.01**
ANC visits						
≥4 visits	44	56	1		1	
<4 visits	16	4	5.09 (1.58, 16.31)	**<0.01**	7.85 (1.47, 12.09)	**0.01**
Preexisting disease						
No	27	53	1		1	
Yes	33	7	9.25 (3.62, 23.64)	**<0.01**	11.03 (4.62, 22.80)	**<0.01**
History of C/S						
No	28	36	1		1	
Yes	32	24	1.71 (0.83, 3.53)	0.14	3.94 (1.09, 14.33)	**0.03**
Gravida						
<3	44	54	1		1	
≥3	16	6	3.27 (1.18, 9.06)	**0.02**	4.47 (0.82, 24.19)	0.08
First delay						
No delay	31	54	1		1	
Delayed	29	6	8.41 (3.15, 22.52)	**<0.01**	13.84 (3.62, 32.83)	**<0.01**
Second delay						
No delay	40	\50	1		1	
Delayed	20	10	2.50 (1.05, 5.94)	**0.03**	2.33 (0.53, 10.14)	0.26

ANC=antenatal checkup, AOR=adjusted odds ratio, CI=confidence interval, COR=crude odds ratio, C/S=cesarean section, MNM=maternal near miss. *P*-values are significant at α=0.05



Path	Number (%)	1st Delay (hours) Median (IQR)	2nd Delay (mins) Median (IQR)
1	6 (10.0)	36 (20, 48) [a]	75 (52.5, 150) [d]
2	45 (75.0)	30 (9, 48) [b]	60 (60, 90) [e]
3	9 (15.0)	6 (4, 12) [c]	40 (35, 135) [f]
Mann Whitney U [a]		1.000	
Mann Whitney U [b]		**<0.001**	
Mann Whitney U [c]		0.366	

Path	Number (%)	1st Delay (hours) Median (IQR)	2nd Delay (mins) Median (IQR)
1	1 (1.67)	36 (36, 36) [a]	60 (60, 60) [d]
2	29 (48.3)	6 (5, 12) [b]	60 (30, 60) [e]
3	30 (50.0)	6 (6, 12) [c]	60 (30, 60) [f]
Mann Whitney U [d]		0.857	
Mann Whitney U [e]		0.080	
Mann Whitney U [f]		0.421	

Figure 1: Pathways of care taken by MNM cases (*n* = 60) and controls (*n* = 60) till they reached the tertiary care facility. MNM = maternal near miss

finding is coherent with the findings of a global survey as well as from northern Ethiopia, southern Ethiopia, Nigeria, and Brazil.[10,13,23,24,27] To minimize potential health risks associated with C-section, it should not be performed unless medically indicated and has to be reduced to the WHO-recommended threshold of 5%–15%.[28] It was also observed that women with higher gravida (≥3) have higher odds of developing MNM, which is similar to the study findings of Kumar *et al*.[26] Concordant with previous findings, this research also showed that mothers with a

history of a preexisting medical condition had higher odds of developing MNM.[10]

Obstetric hemorrhage (48.3%) was the commonest cause of MNM, followed by hypertensive disorders (28.3%) in pregnancy (preeclampsia, eclampsia), contrary to the findings from Kerala, India, where 40.6% had severe preeclampsia, 21.8% had abruptio placenta, and 12.5% had severe sepsis as the underlying cause of MNM.[29] However, the finding was coherent with findings from Ethiopia.[30] In terms of organ dysfunction, our study findings were dissimilar to those of another study from India, where hematological/coagulation system dysfunction was the most common (71.8%) followed by respiratory, hepatic, and renal dysfunction.[29] In our study, the first delay was significantly associated with MNM, which is inconsistent with another finding from West Bengal, India, where both first and second delays were significant predictors.[26] However, significant difference in proportion was observed between cases and controls in terms of experiencing first and second delays. First, second, and third delays were identified among 48.3%, 33.3%, and 1.7% MNM cases, respectively, compared to 18.8%, 40.6%, and 21.8% near-miss cases, respectively, reported in a previous research conducted in India.[29] This indicates that insignificant delay in receiving adequate and appropriate treatment might have prevented fatal maternal outcome. Similar to our findings, relatively low frequency of third delay and its lack of association with near-miss events was reported in a previous research.[31]

Strengths and limitations

Despite adopting stringent WHO near-miss criteria and a three-delay model, the study had some limitations. Purposive research area selection and study design bias may have influenced the conclusions of this study. As the study was limited to a tertiary public health-care facility, it may not reflect the pattern of delays among MNM cases admitted in private health-care facilities. Recall bias and social desirability bias might have been present as information was gathered retrospectively.

Conclusion

The study using near-miss approach provides an opportunity to gain insights about maternal health-care processes directly from the women who have survived. Underlying causes of MNM and delays need to be addressed in this context. Empowering women and their family members to make informed decision to seek timely care, extending preventive health services for early detection of underlying disease, strengthening referral linkages, ensuring operational readiness at a facility level, and optimizing existing obstetric care services is the way forward.

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Conflicts of interest

There are no conflicts of interest.

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