Title Page

Title: Shifting Paradigm in Cause of Maternal Mortality: A Pathway to Examine Obstetric Transition in West Bengal.

Sub Title: Causes of Maternal Mortality in West Bengal

Md Illias Kanchan Sk[1], Balram Paswan[1], Tapan Kumar Naskar[2]

1 Department of Population Policies and Programmes, International Institute for Population Sciences, Mumbai, India.

2 Department of Obstetrics and Gynecology, Medical College and Hospital, Kolkata, India.

Corresponding Author: Md Illias Kanchan Sk, Department of Population Policies and Programmes, International Institute for Population Sciences, Mumbai, India.
Email: illiaskanchan@gmail.com

Abstract

Introduction: Previously, studies have manifested high magnitude of maternal deaths attributed to obstetric haemorrhage in West Bengal. But in the recent decade, the state has marked a unique recognition for having highest maternal mortality caused due to eclampsia in the country and globe. This underscores the need of the study to determine the incidence of maternal mortality attributed to eclampsia and identify the confounding factors associated with eclamptic maternal deaths.

Data and Methods: The study adopted a retrospective facility-based maternal death review method. The study was conducted for all the maternal deaths occurred during January 2013 to December 2015 (N=437), in two tertiary level hospitals. Student's t-test was employed to compare incidence of eclampsia and meteorological parameters.

Results: Study found more than one-third of maternal deaths attributed to eclampsia. Majority of patients (about three-fourths) developed antepartum eclampsia. The incidence of eclampsia during the study period January 2013 to December 2015 was 1998 cases out of 78466 deliveries (2.55 cases per 100 deliveries). The result also confirmed a high level of case fatality rate (CFR-8.63 percent). Occurrence of eclamptic deaths was highest (n=61) in monsoon and post monsoon, followed by in summer (n=50) and lowest in winter (n=40). The seasonal difference in the occurrence of eclamptic deaths between winter and monsoon & post monsoon as well as summer and winter has been found to be statistically significant.

Conclusion: The study confirmed an excess risk of eclampsia, much higher compared to the previous studies which was the leading cause of maternal mortality in the study.

Keywords: Eclampsia, Maternal Mortality, Facility-based, West Bengal.

Introduction

The recent WHO estimation reports 303000 maternal deaths in 2015. The level of maternal mortality ratio in 2015 stood at 216 deaths per 100,000 live births (Alkema et al., 2016). Sub-Saharan Africa and South Asia share 90 percent of these deaths. India accounted for 45000 maternal deaths (15 percent) and ranked after Nigeria (58000 maternal deaths) concerning the global burden of maternal deaths (WHO, 2016). The India's special bulletin on maternal mortality published in 2018 estimates 130 maternal deaths per 100,000 live births (SRS, 2018). Over 80 percent of maternal deaths in India and elsewhere around the globe are the result of direct causes (Montgomer, Ram, Kumar and Jha, 2014). The single most common cause of maternal deaths is haemorrhage (25 percent). Other dominant direct causes are infection/sepsis (15 percent), eclampsia/high blood pressure (12 percent), unsafe abortion (13 percent) and obstructed labour/prolonged labour (8 percent) (McDougall, Campbell, and Graham, 2016;WHO, 2016). Indirect causes of maternal morality contribute to 20 percent of all maternal deaths (Ozimek and Kilpatrick, 2018; WHO, 2016; Das, Biswas and Mukherjee, 2014).

Our study region, West Bengal, a State of Eastern India, comprises of 24.9 million women in reproductive age group (15-49 years) which has 55 percent antenatal care coverage in the first trimester, 74 percent institutional delivery rate and 61 percent postnatal care coverage (ORGI, 2011; IIPS, 2016). The current Maternal Mortality Ratio (MMR) stands at 101 per 100,000 live births (SRS, 2018) and a substantial proportion (40-45 percent) of these maternal deaths are attributed to hypertensive disorders (HDs). Though the prime cause of maternal deaths is haemorrhage in the country and Globe but there are enough evidences which show an anomaly finding of having highest eclampsia related maternal deaths in West Bengal. (Ghosh et al., 2015; Das et al., 2014, Sarkar et al., 2013; Shrivastava, Nandy, Saha, Das, and Lahiri, 2011).

Eclampsia or hypertensive disorders (HDs) of pregnancy is a life-threatening complication to the women of reproductive age and their offspring, especially in the developing world (Cho et al., 2015; Ota, Ganchimeg, Mori, and Souza, 2014). The frequently cited statistics revealed that West Bengal is experiencing 10 to 30 times higher incidence and case fatality rate of eclampsia than what the developed nations are observing today (Das and Biswas, 2015; Sarkar et al., 2013). A recent estimate shows that the eclampsia accounted for 43.4 percent of total maternal deaths, with case fatality rate (CFR- the number of deaths per number of cases) of 8.1 percent (Das and Biswas, 2015). This estimation drives West Bengal into the home of highest

eclamptic maternal deaths in the country (Das and Biswas, 2015). The disproportionate high concentration of maternal deaths due to eclampsia in West Bengal was the prognosis of the lowest percentage (19.86%) of declining MMR among the various states of India (NICPD, 2015).

Now the question can be raised that only knowing the level of eclampsia related maternal deaths is enough to avert further maternal deaths in the society. To reduce eclampsia-related maternal deaths, it is required to comprehend the underlying factors that contributed to the deaths. Previously studies in our selected region have contributed to examine the socio-economic confounders attributed to eclamptic-maternal deaths (Das and Biswas, 2015). But there is no sizeable literature available which shows the plausible association between several climatic factors and eclamptic maternal deaths. Therefore, this study has provided a unique dimension in the field of maternal and child health research by applying climatic factors to eclamptic maternal deaths in West Bengal. There are very few studies which examine the transition in the cause of maternal mortality by employing the concept of "obstetric transition" (Souza et al., 2014). The concept of "obstetric transition" was provided by WHO which refers to the shifting pattern in the cause of maternal mortality from direct obstetric causes to indirect causes (WHO, 2012). Looking at the anomaly scenario of having highest eclampsia related maternal deaths in West Bengal in contrast to the India and Globe, the study was also aimed to examine the trends in the causes of maternal mortality in global, national (India) and regional (West Bengal) levels over the last three decades.

Materials and Methods

Study Design

The study adopted a retrospective facility-based maternal death review method. It is the manifestation of a metacentric facility-based study conducted during January 2013 to December 2015, involving two major tertiary level healthcare referral centres in West Bengal located in eastern part of India. During this two-year study period, a total of 437cases of pregnancy and childbirth associated deaths were recorded. The study also captured the basic statistics of all 78466 pregnant women who were admitted to the labour ward of selected hospitals during the reference period, for the purpose of estimation of incidence of eclampsia, case fatality rate and contribution of eclampsia to total maternal deaths.

Study settings

Our selected health facilities namely Malda Medical College and Hospital (MMC&H) and Medical College and Hospital, Kolkata (KMC&H) are situated in the northern and southern part of West Bengal respectively. These hospitals drain the lion's share of complicated and high-risk patients from the neighboring townships and villages and also from other parts of India. The reference hospitals play as the major hubs for almost twenty-seven thousand deliveries annually (West Bengal Health Service, 2015 official website). MMC&H and KMC&H provide the services of blood bank with adequate blood component and antenatal care and impatient care to pregnant women of West Bengal residents. These facilities also provide a variety of health services that can efficiently and effectively manage several health requirements during the gestation period. Located approximately 3 kms away from the railway stations and within the city centres, the Malda and Kolkata Medical College and Hospitals have the advantage of connecting with most parts of the state through various types of mode of transport. These make it relatively easy for pregnant women in West Bengal to access various maternal care facilities during their gestation period. Hence, these selected hospitals can bring up the representative sample and effective picture to comprehend the contribution of eclampsia to maternal mortality in the community as a whole.

Materials

In this study, we used the hospital based records of all 437 women who died during antepartum, intrapartum or postpartum period, in the Department of Obstetrics and Gynecology of selected hospitals. The facility-based maternal death review form (FBMDR) were used to collect the details of these maternal deaths (MoHFW, 2005). We reviewed the individual case sheet of the women, death registers, referral letters, medical records, Bed Heat Tickets (BHTs) and previous antenatal care records to acquire the data related to our study. Data for several meteorological parameters was also obtained (mean monthly temperature, relative humidity, barometric pressure, amount of precipitation) from regional weather stations and has been cross-checked with other data available in the literature (print and electronic). We have also used various published literatures to examine the trends in the causes of maternal deaths.

Methods

The estimations of incidence, case fatality rate and maternal mortality attributed to eclampsia for the reference period were based on the following formulas-

1. Incidence Rate of Eclampsia (IR) $= \frac{m}{n} * 100$

Where, m = Total no of eclamptic patients

n = Total no. of delivery

2. Case Fatality Rate (CFR) $= \frac{p}{m} * 100$

Where, p = Total no of eclamptic deaths

m = Total no of eclamptic patients

3. Maternal Mortality attributed to Eclampsia$= \frac{p}{q} * 100$

Where, p = Total no of eclamptic deaths

q = Total no. of maternal deaths

Data analysis

Univariate analysis was applied to compute incidence and case fatality rate. The incidence of eclampsia and meteorological parameters among the four seasons were compared using student's t-test. The data was analysed using the statistical software STATA version 14.0. The differences were considered significant if $p<0.05$.

Ethical Considerations

The study protocol was submitted to the Institutional Ethical Review Board (IRB) of Malda and Kolkata Medical College and Hospitals, which reviewed it and gave approval. Further permission was also obtained from the competent authority of Ministry of Health and Family Welfare (MoHFW), Govt. of West Bengal. Confidentiality and anonymity of the subjects was upheld during data collection, storage, and analysis.

Results

Levels & trends of causes of maternal mortality in India & West Bengal

Table 1.a, 1.b and 1.c show the causes of maternal deaths in global, national and regional levels over the last three decades. Hemorrhage is ranked first as the cause of maternal deaths in all times, in India as well as in the world and it accounts for 27 and 25 percent respectively.

Studies accomplished in West Bengal reveal an anomaly finding in contrast to the Indian and global scenario, that eclampsia or hypertensive disorders of pregnancy is the leading cause of maternal deaths. It is found from our present study that among the underlying causes of death,

more than 80 percent of the maternal deaths were the result of direct obstetric causes and 16.4 percent were due to indirect obstetric causes. Eclampsia or hypertensive disorders of pregnancy contributed to more than one-third of deaths and was the leading cause of maternal mortality in the study.

Table: 1.a. Percent Distribution of Causes of Maternal Deaths in the Global Level by Six Different Sources

Causes	Year					
	1980*	**1992****	**2005^**	**2015^^**	**2018#**	**2019##**
Direct Causes						
Hemorrhage	20.0	25.0	34.0	23.0	48.8	23.0
Obstructed labour	9.2	13.0	11.0	2.0	2.3	4.0
Sepsis	9.7	15.0	21.0	4.0	7.0	3.0
Eclampsia	9.7	6.0	16.0	6.0	16.3	19.0
Abortion	12.9	33.3	18.0	3.0	9.3	3.0
Other Direct Causes	-	-	-	16.0	16.3	-
Indirect causes	11.9	-	-	24.6	-	-

Source: *Kassebaunm, et al, **WHO; ^Dikid et al.; ^^Hanson et al.; #Tesfaye et al.; ## Sageer et al.
[1]Other direct causes: Ectopic pregnancy, embolism, anaesthesia related.
[2]Indirect Causes: Malaria, Anaemia, heart diseases etc.

Table: 1.b. Percent Distribution of Causes of Maternal Deaths in National Level by Six Different Sources

Causes	Year					
	1980*	**1998^**	**2003^^**	**2005#**	**2013$**	**2019$$**
Direct Causes						
Eclampsia	10.5	8.3	4.6	12.0	5	8.9
Haemorrhage	14.0	29.6	37.7	25.0	37.9	14.4
Infections/ Sepsis	14.0	16.1	11.0	15.0	10.6	6.7
Unsafe abortions	11.4	8.9	8.0	13.0	8.0	-
Obstructed Labour & Rupture Uterus	-	9.5	4.8	8.0	4.8	5.5
Other Direct Causes[1]	19.0	-	-	8.0	33.7	7.8
Indirect Causes[2]	19.0	19.0	33.9	-		50.0

Source: *Rao, K.B; ^Sample Registration System; ^^Sample Registration System; #Pal; $MoHFW; $$Sreekumaru and Nair.
[1]Other direct causes: Ectopic pregnancy, embolism, anaesthesia related.
[2]Indirect Causes: Malaria, Anemias, heart diseases etc.

Table: 1.c. Percent Distribution of Causes of Maternal Deaths in Regional Level by Seven Different Sources

Causes	Year						
	2000*	**2005^**	**2011^^**	**2014#**	**2017##**	**2018&**	**Present Study**
Direct Causes							
Eclampsia	64.8	48.8	21.2	43.7	27.6	29.1	34.6

Haemorrhage	12.4	23.5	15.1	21.9	26.6	22.7	22.6
Infections/ Sepsis	-	2.1	-	13.4	9.5	10.9	9.8
Unsafe abortions	7.8	5.1	9.1	-	-	6.4	2.8
Obstructed Labour & Rupture Uterus	2	3.1	6.1	-	-	2.7	3.2
Other Direct Causes[1]	5.5	-	36.4	8.5	8.6	8.2	9.8
Indirect Causes[2]	7.5	-	12.1	12.5	9.5	16.4	16.3

Source: *Pal; ^ Biswas et al.; ^^Shrivastava et al; [#]Das;[##]Bhadra et al.; [&]Sk et al.
[1]Other direct causes: Ectopic pregnancy, embolism, anaesthesia related.
[2]Indirect Causes: Malaria, Anaemia, heart diseases etc.

Incidence of eclampsia, case fatality rate (CFR) of eclampsia and maternal mortality due to eclampsia

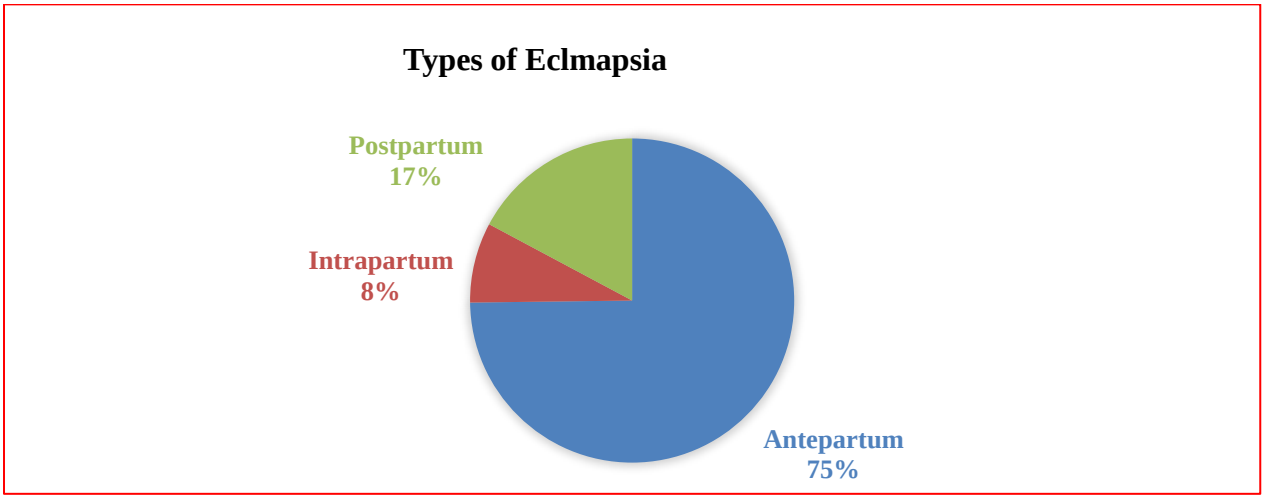
During the 3 year study period, a total of 78466 patients delivered at Malda and Kolkata Medical College and Hospital (Table 2). There were 1998 cases of eclampsia, yielding an overall incidence of 2.55 percent. The overall incidence of eclampsia was observed as 2.81 percent in Malda Hospital and 2.23 in Kolkata Hospital. In this period, the total number of maternal deaths were 437 out of which 151 (35 percent) were reported due to eclampsia at two selected hospitals. The overall contribution of eclampsia to total maternal deaths was 34.55 percent over a period of 3 years. The result also confirmed a high level of case fatality rate (CFR- 8.63 percent) in 2015, which included 8.50 percent CFR in Malda Hospital and 8.81 percent in Kolkata Hospital.

Table 2. Incidence of eclampsia, case fatality rate and incidence of maternal mortality due to eclampsia in the studied hospitals, 2013-15.

Health Facility	Year	Total no. of delivery (n)	Total no of eclampsia (m)	Eclampsia deaths (p)	Incidence of eclampsia (=m/n%)	Case fatality rate (=p/m%)	Total no of maternal deaths (q)	Contribution of eclampsia to total maternal deaths (=p/q%)
MMC&H	2013	12937	387	31	2.99	8.01	80	38.75
	2014	14850	401	29	2.70	7.23	74	39.19
	2015	14874	412	35	2.77	8.50	88	39.77
	Overall	42661	1200	95	2.81	7.92	242	39.26
KMC&H	2013	11940	257	13	2.15	5.06	50	26.00
	2014	11704	246	17	2.10	6.91	65	26.15
	2015	12161	295	26	2.43	8.81	80	32.50

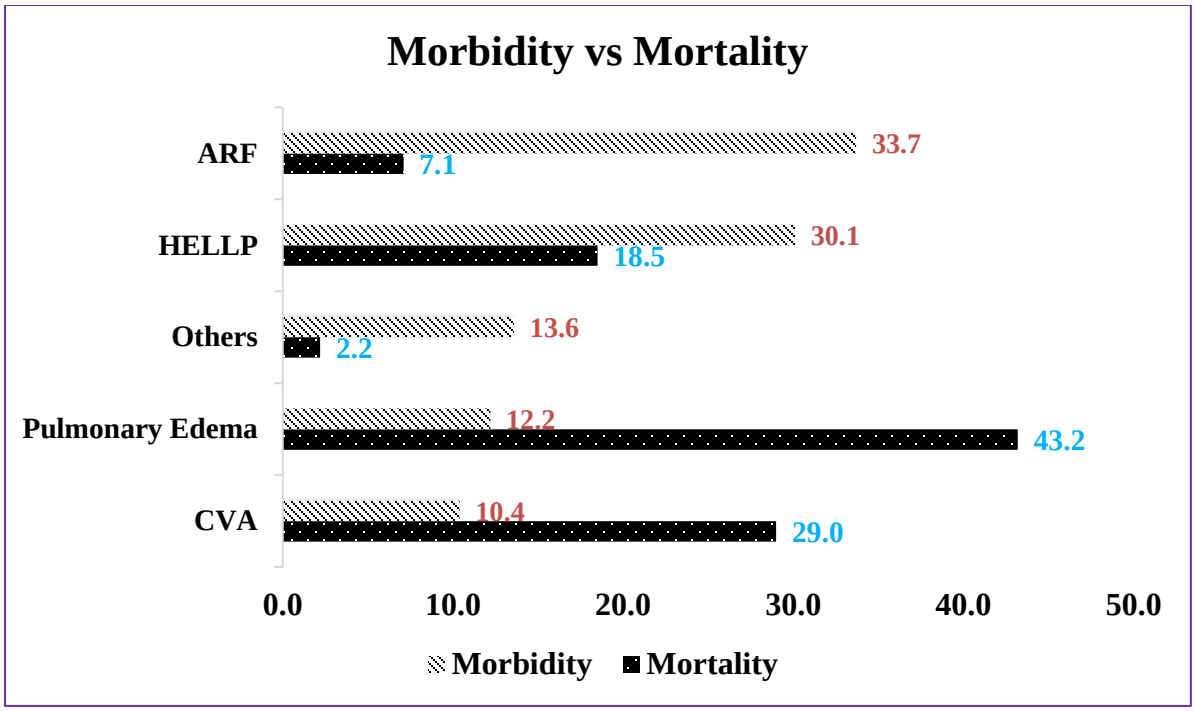
	Overall	35805	798	56	2.23	7.02	195	28.72
Total	2013	24877	644	44	2.59	6.83	130	33.85
	2014	26554	647	46	2.44	7.11	139	33.09
	2015	27035	707	61	2.62	8.63	168	36.31
	Overall	78466	1998	151	2.55	7.56	437	34.55

Figure 1. Types of Eclampsia in Eclamptic deceased women (n=151), 2013-2015.



Three-fourth (75 percent) of the patients were reported to suffer from antepartum eclampsia, 8 percent from intrapartum eclampsia and17 percent of maternal deaths were reported in those patients who developed eclampsia at the postpartum period (Figure 1).

Figure 2. Percent distribution of maternal morbidity associated with eclampsia (n= 1998) and mode of deaths in eclamptic deceased women (n=151), 2013-15



ARF= Acute Renal Failure; HELLP = Hemolysis, Elevated Liver enzymes, and Low platelet count; CVA = Cerebrovascular Accident

Out of the total eclamptic patients, one-third (n=637) cases were detected with acute renal failure in the emergency units of selected hospitals followed by HELLP (30 percent) (Hemolysis, Elevated Liver enzymes, and Low platelet count) (Figure 2). The maternal mortality due to pulmonary edema (43.2 percent) was found to be highest in eclamptic deceased women. The second commonest mode of death was CVA (Cerebrovascular Accident) and it accounted for 29 percent of all eclampsia-related maternal mortality.

Seasonal variations of eclamptic deaths

Occurrence of eclamptic deaths was highest (n=61) in monsoon and post monsoon (July to Oct), followed by in summer (n=50) (March to June) and was lowest in winter (n=40) (Nov to Feb) for the study period (2013-2015) (Figure 3). The difference of occurrence of eclamptic deaths between winter and monsoon & post monsoon as well as summer and winter is statistically significant ($p<0.05$) but it is insignificant ($p=0.554$) when summer and monsoon &post monsoon were compared (Table 3 & 4). It was also observed that humidity ($p<0.000$) was significantly varied between winter and monsoon & post monsoon.

Figure 3. Comparison of eclamptic deaths in various season (n=151)

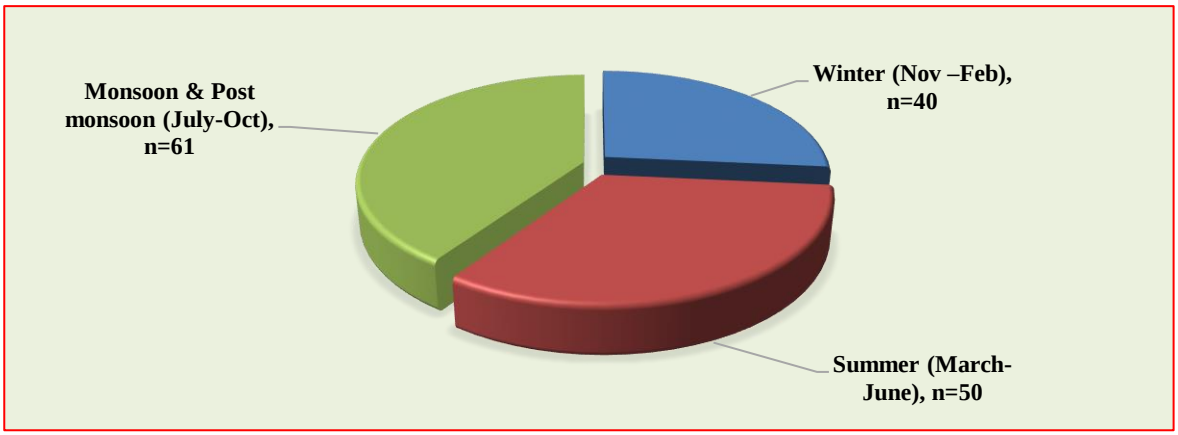


Table 3. Various weather parameters in winter, summer and monsoon and post monsoon season, West Bengal, 2013-2015.

Seasons	Mean temp. (◦C)	Mean relative Humidity (%)	Average rain fall (mm)	Mean sea level pressure (hPa*)
Winter	20.21	66.20	13.34	1013.64
Summer	30.21	57.52	104.33	1003.73
Monsoon	27.91	85.66	271.92	1002.45

*Hectopascal Pressure Unit

Table 4.p values showing the seasonal comparison

Parameters	Winter: Summer	Winter: Monsoon post monsoon	Summer: Monsoon & post monsoon
Occurrence of eclamptic death.	p=0.016	p=0.011	p=0.713
Mean temperature	p=0.000	p=0.000	p=0.002
Mean relative humidity	p=0.056	p=0.000	p=0.000
Average rainfall	p=0.041	p=0.000	p=0.007
Mean sea level pressure.	p=0.000	p=0.000	p=0.504

*p<0.05, **p<0.01, ***p<0.001.

Discussion

Our study presents an excess risk of maternal mortality caused by hypertensive disorders that is much higher than anticipated when we compared with other studies conducted in the national and global levels. The present study reported about 1998 cases of eclampsia, yielding an overall incidence of 2.55 percent. The estimated incidence rate of eclampsia in the present study is almost double to that of the national level estimates (Yaliwal, Jaju, and Vanishree, 2011; Abdullah, Shaikh, and Jamro, 2010), whereas economically advanced nations like UK and USA are witnessing the incidence of only 0.049 percent to 0.043 percent respectively (Kuljit, Shrivastav, Rahatgaonkar, and Bhosale, 2014). Compared to different Global and Indian studies where CFR of eclampsia varied from 2.74 percent to 4.96 percent, we recognized a very high case fatality rate of 8.63 percent in 2015 (Nobis and Hajong, 2016; Ali et al. 2015; Ghosh et al., 2015; Das and Biswas, 2014; Sarkar et al., 2013; Ronsmans and Campbell, 2011). In this study, more than one-third of maternal deaths were attributed to eclampsia. This result confirms a high burden of maternal deaths caused by eclampsia reflecting an alarming situation which requires urgent cogitation and improvement. The above findings corroborate and add to previous studies conducted in West Bengal (Ghosh et al. 2015; Giordano et al., 2014; Das and Biswas, 2014). This finding is entirely anomalous to the studies available in different parts of India as well as in the globe.

In line with other studies, this study also manifest that majority of patients (about three-fourths) developed antepartum eclampsia (Babbar, Armo, and Murthy, 2015; Sarkar et al., 2013; Afroj, 2012). An overwhelming majority of maternal deaths in the antepartum eclamptic patients may be explained by the late referral, irregular ANC and transfer of moribund patients just before death to the studied hospitals. The antepartum eclampsia is mainly detected in the late second, and early third trimester of pregnancy, as the irregular AN care existing these gestational ages lead preeclampsia to severe frailty in the study population (Ghosh et al., 2015; Sarkar et al., 2013).

The highest number of eclamptic deaths were observed in monsoon and post monsoon season (n=61), followed by summer (n=50) and lowest in winter (n=40). This is similar to other studies conducted in Mumbai and the other parts of world also corroborate our finding (Subramaniam, 2007; Westerterp, Plasqui, and Goris, 2005). But whether these metrological factors have any link with case fatality of eclampsia is a matter of contention and requires

research. Several hypotheses had been put forward to clarify this association. Humidity may be one such and study found it differs significantly ($p<0.000$) between winter and monsoon and post-monsoon seasons. The justification may be conferred to extreme humidity. The metrological division classifies West Bengal into the extreme humid region in the country, and this may explain the high eclamptic deaths in this region (Verburg et al., 2018; Trogstad, Eskild, Magnus, Samuelsen, & Nesheim, 2001).

The study found that the Eclampsia or hypertensive disorders of pregnancy (34.5 percent) was found as the leading cause of maternal death in the study followed by hemorrhage (23.7 percent) (Das, Biswas, and Mukherjee, 2014; Shrivastava, Nandy, Saha, Das, and Lahiri, 2011; Das and Biswas, 2015; Ghosh et al., 2015). This study shows an anomaly finding in contrast to Indian and global scenario which reflects that eclampsia is the most common cause of maternal deaths. Studies conducted in different parts of India and even in the global level have shown that hemorrhage is the most common cause of maternal mortality iron (Ozimek and Kilpatrick, 2018; WHO, 2016; Das, Biswas, and Mukherjee, 2014; Paul, Sen, Kar, and Mohapatra, 2013; Paul, Mohapatra,and Kar, 2011). Earlier studies have shown that obstetric hemorrhage was the major contributor to maternal mortality at all levels of health care units in West Bengal, but recently there is a paradigm shift in the pattern of maternal mortality.

It can be stated that the study did not find any obstetric transition (shifting from direct obstetric causes of maternal mortality to indirect causes) in the study region (Souza et al., 2014). But the study has manifested a shift in the causes of maternal mortality from hemorrhage to eclampsia in West Bengal. Significant reduction in maternal deaths from hemorrhage probably are due to the better management to prevent bleeding in tertiary health care units by the availability of oxytocin, methylergometrine, prostaglandin and timely surgical interventions. Detection of eclampsia is possible in late second trimester or early third trimester (Park, Shim, and Cha, 2015; Gillon, Pels, Dadelszen, MacDonell, and Magee, 2014). Low reporting of ANC cheak-up during second trimester may be accounted to high prevalence of eclampsia in West Bengal (IIPS, 2016).

However, the limitation of the study is in the utilization the hospital records which questions the data quality along with the incomplete entries. We also relied on the accuracy of health professional's assessment and documentation concerning the causes of deaths which can be considered as a limitation. Nevertheless, the study has made a significant contribution to

highlighting the shifting paradigm in attributing eclampsia as a concerned cause of maternal mortality in West Bengal. This study appeals further research to establish the plausible association between several climatic factors and case fatality so that we can comprehend the pathophysiology and disease-aggravating factors of eclampsia better.

It can safely be concluded that the incidence of eclampsia among pregnant women in West Bengal was observed to be on the higher side as reported in Indian settings and was the leading cause of maternal mortality in the study. The study does not manifest obstetric transition in the cause of maternal mortality in West Bengal but highlights a paradigm shift from hemorrhage to eclampsia. The monsoon and post-monsoon seasons witnessed the highest case fatality due to eclampsia, and it demands further research to establish the plausible association of several climatic factors. Finally, we can conclude by emphasizing that the hypertensive disorders of pregnancy or eclampsia can be averted by establishing separate 'eclampsia units' at lower levels of health facilities. Main thrust should also be on ensuring regular and proper antenatal care particularly during late second or early third trimester to avert maternal mortality from eclampsia.

References

Abdullah, A., Shaikh, A. A., & Jamro, B. (2010). Maternal and perinatal outcome associated with eclampsia in a teaching hospital, Sukkur. *Rawal Med J*, *35*, 23-26.

Afroj, S. (2012). Maternal and Foetal Outcome of Eclampsia in Mymensingh Medical College Hospital. *Journal of Shaheed Suhrawardy Medical College*, *1*(1), 14-17.

Ali MA, Babitha MC, Lokeshchandra HC, Kavya SD, Maheen Z, Madhuri RS. (2015). A Study of changing trends of maternal mortality at the tertiary care centre, MMC & RI Mysore, India. *Int J Reprod Contracept Obstet Gynecol*, 4(1):239-42.

Alkema, L., Chou, D., Hogan, D., Zhang, S., Moller, A. B., Gemmill, A. ... & Say, L. (2016). Global, regional, and national levels and trends in maternal mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Maternal Mortality Estimation Inter-Agency Group. *The Lancet*, *387*(10017), 462-474.

Babbar, K., Armo, M., & Murthy, M. (2015). Burden of eclampsia: a persisting problem in the developing countries. *International Journal of Reproduction, Contraception, Obstetrics and Gynecology*, *4*(4), 1029-1033.

Bhadra, B., Choudhury, R. R., Sarkar, D., & Sarkar, S. (2017). An epidemiological study of mortality among mothers admitted in a rural tertiary hospital of West Bengal. *Journal of family medicine and primary care*, *6*(2), 270.

Biswas, A. B., Das, D. K., Misra, R., Roy, R. N., Ghosh, D., & Mitra, K. (2005). Availability and use of emergency obstetric care services in four districts of West Bengal, India. *Journal of health, Population and Nutrition*, 266-274.

Cho, G. J., Kim, L. Y., Min, K. J., Sung, Y. N., Hong, S. C., Oh, M. J. ... & Kim, H. J. (2015). Prior cesarean section is associated with increased preeclampsia risk in a subsequent pregnancy. *BMC pregnancy and childbirth*, *15*(1), 24.

Das, R. (2014). Maternal mortality at a teaching hospital of rural India: a retrospective study. *Age*, *19*(79), 30-85.

Das, R. Biswas, S. & Mukherjee, A. (2014). Maternal mortality at a Teaching Hospital of Rural India: A retrospective study. Age, 19(79), 30-85.

Das, R., & Biswas, S. (2015). Eclapmsia: The major cause of maternal mortality in Eastern India. *Ethiopian journal of health sciences*, *25*(2), 111-116.

Dikid, T., Gupta, M., Kaur, M., Goel, S., Aggarwal, A. K., & Caravotta, J. (2013). Maternal and perinatal death inquiry and response project implementation review in India. *The Journal of Obstetrics and Gynecology of India*, *63*(2), 101-107.

Ghosh, U., Maity, D., Santra, d., Koley, A., Khan, H. & Roy, A. (2015). Maternal death due to eclampsia in various seasons in a tertiary centre in eastern part of India: a three year retrospective study. *Online Journal of Health and Allied Sciences*, *14*(1).

Gillon, T. E., Pels, A., von Dadelszen, P., MacDonell, K., & Magee, L. A. (2014). Hypertensive disorders of pregnancy: a systematic review of international clinical practice guidelines. *PloS one*, *9*(12), e113715.

Giordano, J. C., Parpinelli, M. A., Cecatti, J. G., Haddad, S. M., Costa, M. L., Surita, F. G., ... & Sousa, M. H. (2014). The burden of eclampsia: results from a multicenter study on surveillance of severe maternal morbidity in Brazil. *PLoS One*, *9*(5), e97401.

Hanson, C., Cox, J., Mbaruku, G., Manzi, F., Gabrysch, S., Schellenberg, D. ... & Schellenberg, J. (2015). Maternal mortality and distance to facility-based obstetric care in rural southern Tanzania: a secondary analysis of cross-sectional census data in 226 000 households. *The Lancet Global Health*, *3*(7), e387-e395.

International Institute for Population Sciences (IIPS) & ORC MACRO. (2016). National Family Health Survey (NFHS-4), 2015-16: India. Mumbai, India: IIPS; 2016.

Kassebaum, N. J., Bertozzi-Villa, A., Coggeshall, M. S., Shackelford, K. A., Steiner, C., Heuton, K. R., ... & Templin, T. (2014). Global, regional, and national levels and causes of maternal mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet, 384(9947), 980-1004.

Kuljit K, Shrivastav RD, Rahatgaonkar V, Bhosale UT. (2014). Study of Fetal and Maternal Outcome in Eclampsia. International *Journal of Recent Trends in Science and Technology*, 11(1), 42-4.

Ministry of Health and Family Welfare, Government of India (2013). Maternal and Newborn Health Toolkit. 2013. Maternal Health Division, Government of India. http://nhsrcindia.org/sites/default/files/Maternal%20%20Newborn%20Health%20Toolkit.pdf

McDougall, L., Campbell, O. M., & Graham, W. (2016). Maternal Health: An executive summary for the Lancet's series. *Lancet*, *388*(10556), 1-8.

Ministry of Health and Family Welfare (MoHFW), Government of India. (2005). Janani Suraksha Yojna: guidelines for implementation (Internet). New Delhi, India: Ministry of Health and Family Welfare; 2005. Available from: http://www.mohfw.nic.in/NRHM/RCH/guidelines/JSY_guidelines_09_06.pdf.

Montgomery, A. L., Ram, U., Kumar, R., Jha, P., & Million Death Study Collaborators. (2014). Maternal mortality in India: causes and healthcare service use based on a nationally representative survey. *PloS one*, *9*(1), e83331.

National Institute of Public Cooperation and Child Development. (2015). An Analysis of Levels and Trends in Maternal Health and Maternal Mortality Ratio in India. New Delhi: National Institute of Public Cooperation and Child Development; 2015. Available at: http://nipccd.nic.in/reports/mhmm.pdf.

Nobis, P. N., & Hajong, A. (2016). Eclampsia in India through the decades. *The Journal of Obstetrics and Gynecology of India*, *66*(1), 172-176.

Office of the Registrar General & Census Commissioner, India (ORGI), Provisional Population Totals Paper 2 of India & States/UTs.

Ota, E., Ganchimeg, T., Mori, R., & Souza, J. P. (2014). Risk factors of pre-eclampsia/eclampsia and its adverse outcomes in low-and middle-income countries: a WHO secondary analysis. *PloS one*, 9(3), e91198.

Ozimek, J. A., & Kilpatrick, S. J. (2018). Maternal Mortality in the Twenty-First Century. *Obstetrics and gynecology clinics of North America, 45(2), 175-186.*

Pal, A. (2005). Review of changing trends in maternal mortality in a rural medical college in West Bengal. *J Obstet Gynaecol India, 55*, 521-528.

Park, H., Shim, S., & Cha, D. (2015). Combined screening for early detection of pre-eclampsia. *International Journal of Molecular Sciences*, *16*(8), 17952-17974.

Paul, B., Mohapatra, B., & Kar, K. (2011). Maternal deaths in a tertiary health care centre of Odisha: an in-depth study supplemented by verbal autopsy. Indian journal of community medicine, 36(3), 213.

Paul, B., Sen, M., Kar, K., & Mohapatra, B. (2013). Facility based maternal death review: learning from maternal deaths in a teaching hospital of Eastern India. Int J Biomed Res, 4, 12-20.

Prakash, A., Swain, S., & Seth, A. (1991). Maternal mortality in India: current status and strategies for reduction. *Indian pediatrics*, *28*(12), 1395-400.

Rao, K. B. Report of the Maternal Mortality Committee of FOGSI 1982. Fed. Obst. Gyn. Soc. Ind. Bombay.

Ronsmans, C., & Campbell, O. (2011). Quantifying the fall in mortality associated with interventions related to hypertensive diseases of pregnancy. *BMC public health*, *11*(3), S8.

Sageer, R., Kongnyuy, E., Adebimpe, W. O., Omosehin, O., Ogunsola, E. A., & Sanni, B. (2019). Causes and contributory factors of maternal mortality: evidence from maternal and perinatal death surveillance and response in Ogun state, Southwest Nigeria. *BMC pregnancy and childbirth*, *19*(1), 63.

Sample Registration System (SRS). (2018). Office of Registrar General, India. Special bulletin on maternal mortality in India (2014-16).

Sample Registration System. (1998). Office of the registrar general, India.

Sample registration system. (2003). Office of the registrar general, India.

Sarkar, M., Basak, S., Mondal, S. K., Das, S., Roy, D., Mandal, J., ... & Das, S. K. (2013). Maternal mortality associated with eclampsia in an indian medical college: a four year retrospective study. *Journal of Medicine and Medical Sciences*, *4*(10), 394-398.

Shrivastava, P. R. A. B. H. A., Nandy, S. A. S. W. A. T. I., Saha, I. N. D. R. A. N. I. L., Das, D. K., & Lahiri, S. K. (2011). Deaths amongst women of reproductive age group in the gynaecology and obstetrics department of a tertiary care hospital of Eastern India. *Safety Science Monitor,* 15(3), 1-5.

Sk, M. I. K., Chattopadhyay, A., Anand, A., Naskar, T. K., & Chakraborty, S. (2018). Analyzing the etiology behind mortality associated with antepartum, intrapartum, and post-partum cases in a tertiary care teaching hospital of West Bengal. *Journal of the Turkish German Gynecological Association*, *19*(2), 65.

Souza, J. P., Tunçalp, Ö., Vogel, J. P., Bohren, M., Widmer, M., Oladapo, O. T., ... & Temmerman, M. (2014). Obstetric transition: the pathway towards ending preventable maternal deaths. BJOG: An *International Journal of Obstetrics & Gynaecology*, 121, 1-4.

Sreekumaru U, Nair S. (2019). Trends in Causes of Maternal Mortality in a Tertiary Care Centre in Kerala after Introduction of CRMD and Quality Standards Programme. JMSCR Vol, 07, Issue, 01, p579-585, January.

Subramaniam, V. (2007). Seasonal variation in the incidence of preeclampsia and eclampsia in tropical climatic conditions. *BMC women's health*, 7(1), 18.

Tesfaye, G., Loxton, D., Chojenta, C., Assefa, N., & Smith, R. (2018). Magnitude, trends and causes of maternal mortality among reproductive aged women in Kersa health and demographic surveillance system, eastern Ethiopia. *BMC women's health*, *18*(1), 198.

Trogstad, L. I., Eskild, A., Magnus, P., Samuelsen, S. O., & Nesheim, B. I. (2001). Changing paternity and time since last pregnancy; the impact on pre-eclampsia risk. A study of 547 238 women with and without previous pre-eclampsia. *International journal of epidemiology*, *30*(6), 1317-1322.

Verburg, P. E., Dekker, G. A., Tucker, G., Scheil, W., Erwich, J. J. H., & Roberts, C. T. (2018). Seasonality of hypertensive disorders of pregnancy–A South Australian population study. *Pregnancy hypertension*, *12*, 118-123.

Westerterp, K. R., Plasqui, G., & Goris, A. H. (2005). Water loss as a function of energy intake, physical activity and season. *British journal of nutrition*, *93*(2), 199-203.

WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division. (2016). Trends in maternal mortality: 1990 to 2015: estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division. Geneva, Switzerland: World Health Organization; 2015. Available from: http://apps.who.int/iris/bitstream/handle/10665/194254/9789241565141_eng.pdf;jsessionid=6E186501EC864EC6A3019A72554201BA?sequence=1

WHO, UNICEF, UNFPA, World Bank. (2012). Trends in maternal mortality: 1990 to 2010. https://www.who.int/reproductivehealth/publications/monitoring/9789241503631/en/.

World Health Organization. (1992). International statistical classification of diseases and related health problems: 10th revision (ICD-10). *http://www. who. int/classifications/apps/icd/icd*.

Yaliwal, R. G., Jaju, P. B., & Vanishree, M. (2011). Eclampsia and perinatal outcome: a retrospective study in a teaching hospital. *J Clin Diagn Res*, *5*(5), 1056-1059.