Original Article

Decreasing and Maintaining Low Maternal Mortality Rate and Near Miss in Kocaeli District

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ABSTRACT

Purpose: Every dying woman goes through a phase where her life could have been saved with effective and timely intervention. In this study, we aimed to report how the maternal mortality ratio (MMR) and maternal near-miss ratio (MNMR) were impressively reduced in Kocaeli between 2009 and 2014.

Methods: Patient files who delivered in Kocaeli between 2009-2017 were retrospectively reviewed. These data were obtained from Kocaeli Health Directorate, maternal deaths were determined by the Maternal Mortality Research Commission between 2009-2017, and the data were sorted according to three delay models.

Results: There were 192,815 deliveries assessed, 312 near miss cases and 32 death reported in 2009-2015 at Kocaeli. MNMR was 3.75 in 2010, it decreased significantly to 0.61 in 2015 (p=0.02). The MMR had decreased significantly from 32.9 in 2009 to 3.3 per 100,000 live births in 2014 in Kocaeli (p=0.007) whereas it was 15.2 in 2014 in Turkey.

Conclusion: A citywide organization and cooperation betwen all levels of health facilities, health care providers, together with education of practitioners, midwifes, obstetrics and gynecology specialists, weekly evaluation of citywide high risk pregnancies and providing 7/24 online consultation of high risk deliveries resulted in a significant decrease in MMR and MNMR.

Keywords: Maternal near-miss, maternal mortality, pregnancy

INTRODUCTION

Maternal mortality is a globally accepted indicator of the quality and accessibility of maternal healthcare services. Maternal death, though rare, represents the most critical complication associated with pregnancy. Despite global efforts, progress in reducing maternal mortality has been slow, particularly in Turkey. Each day, over 1,000 women die from pregnancy-related causes worldwide, with the majority of these deaths occurring in developing nations.[1] Maternal mortality remains a significant public health issue in low- and middle-income countries. Strengthened health systems and effective health services for women experiencing acute pregnancy-related complications are considered key factors in reducing maternal mortality.[2]

Every maternal death could potentially be prevented with effective and timely intervention. This situation was defined by the World Health Organization (WHO) in 2009 as a maternal near-miss: "A woman who nearly died but survived a complication that occurred during pregnancy, birth, or within 42 days of pregnancy termination".[3] Near-miss cases are more common than maternal deaths, offering important insights into the challenges and barriers within the healthcare system. Consequently, near-miss cases have emerged as a vital metric for assessing and enhancing maternal health services, especially in developing countries.

The objective of this study was to assess the impact on maternal mortality reduction of the emergency obstetric hemorrhage team, which was established for the first time in Kocaeli province in Turkey. This investigation focused on the influence of the team's establishment on the maternal mortality rate (MMR) and maternal near-miss rate (MNMR), highlighting the substantial reductions observed over time.

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METHODS

We conducted a retrospective study encompassing all women who met the WHO criteria for maternal near-miss or maternal death between 2009 and 2017 in Kocaeli. This retrospective study was initiated following the decision of the Ethics Committee of Kocaeli University. The WHO criteria were employed to identify cases of maternal near-miss (Table 1). Women exhibiting potentially life-threatening conditions were identified according to the WHO criteria (see Table 2).[4]

Data were obtained from the Kocaeli Health Directorate, with maternal deaths determined by the Maternal Mortality Research Commission between 2009-2017. The data were categorized according to the Three Delays Model. Phase 1 delay involves delays in deciding to seek appropriate medical care due to familial and community factors. Phase 2 delay occurs when timely access to an obstetric facility is hindered by multiple referrals or transfers between health facilities. Phase 3 delay involves delays in receiving appropriate and timely care within the healthcare facility.

According to the Kocaeli District Health Commission Circular, all members of the emergency obstetric team were authorized to conduct examinations, consultations, visits, and surgical operations across all district hospitals. Family practitioners, nurses, and midwives stationed at Family Health Care units, Mother and Child Health centers, and Obstetrics and Gynecology clinics underwent categorization into two groups. They were subjected to mandatory education sessions covering various aspects, including triage of high-risk pregnancies, obligatory notification of high-risk mothers, utilization of emergency call centers such as the "112 Emergency Call Center" protocols for patient transfer, predefined patient data and laboratory work-up requirements before or during patient transfer, management of delivery rooms including the use of partograms, fetal monitoring techniques employing ultrasound and hand doppler ultrasound, and cardiotocography, management of postpartum hemorrhage, timely maintenance of blood and blood products, and team management of obstetric emergencies. This educational program was implemented within the initial three months of 2009.

The Health Directorate formed a High-Risk Pregnancy Evaluation Commission that met weekly, a Maternal Mortality Commission that met monthly, and an Emergency Obstetric Coordination Team under the "112 Emergency" call centers. In addition, the Kocaeli University and Red Crescent blood banks, along with hospital transfusion units, provided daily updates to the health directorate regarding the availability of blood products, while intensive care units (ICUs) reported their bed capacities daily. Furthermore, various decrees were enacted to streamline patient transfers, mandating their coordination via the 112 ambulance system, ensuring patient stabilization prior to transfer, and organizing the allocation of blood products through the 112 emergency system.

All data presented here are provided by the authors: the director perinatologist of the Emergency Obstetric Team and the provincial health director. MMR is defined as the number of maternal deaths per 100,000 live births, and MNMR is defined
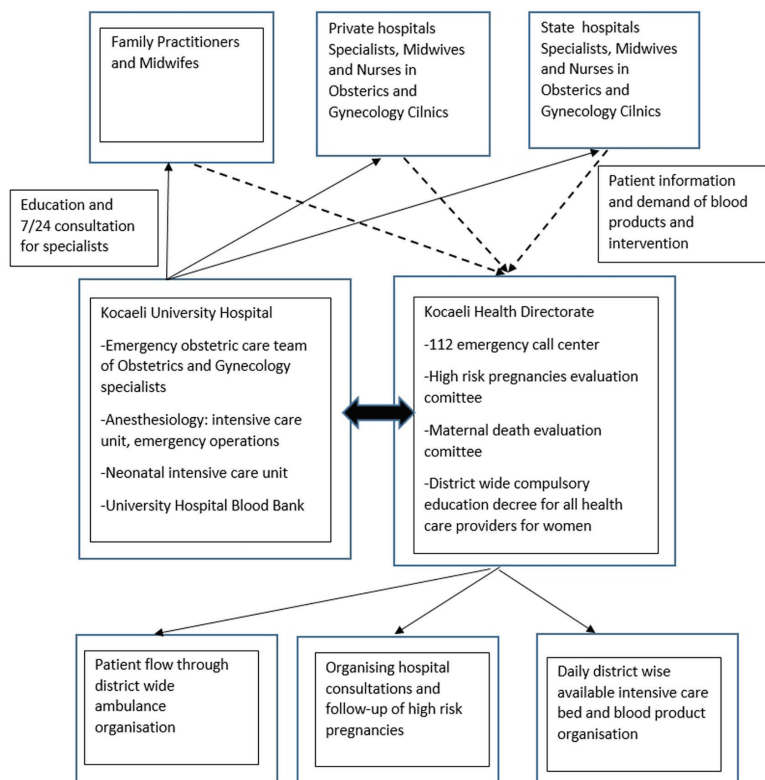

Figure 1. Organisation and work flow of maternal care in Kocaeli District

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Table 1. The World Healt Organization maternal near miss criteria		
Clinical criteria	**Laboratory-based criteria**	**Management-based criteria**
Shock	Severe hypoperfusion (lactate >5 mmol/L or >45 mg/dL)	Use of continuous vasoactive drugs
Cardiovascular arrest	Severe acidosis (pH <7.1)	Cardio-pulmonary resuscitation
Acute cyanosis	Severe hypoxemia (O_2 saturation <90% for ≥60 minutes or PAO_2/FiO_2<200)	Intubation and ventilation notrelated to anesthesia
Gasping	Severe acute azotemia (creatinine ≥300 μmol/mL or ≥3.5 mg/dL)	Dialysis for acute renal failure
Severe tachypnea (respiratory rate >40 breaths perminute) or severe bradypnea (respiratoryrate <6 breaths per minute)	Severe acute thrombocytopenia <50 000 platelets/mL	Massive transfusion of blood or red cells (≥5 units)
Oliguria non responsive to fluids or diuretics	Severe acute hyperbilirubinemia (bilirubin >100 μmol/L or >6.0 mg/dL)	Uterine hemorrhage or infection leading tohysterectomy
Failure to form clots		
Jaundice in the presence of preeclampsia		
Any loss of consciousness not medicallyinduced, lasting >12 hours		
Stroke		
Uncontrollable fit/status epilepticus		
Total paralysis		

Table 2. Potentially life-threatening conditions	
Women with severe complications	**Women undergoing critical interventions**
Severe postpartum haemorrhage Severe pre-eclampsia Eclampsia Sepsis or severe systemic infection Ruptured uterus Other complications associated with severe maternal outcome	Use of blood products Interventional radiology Laparotomy Admission to intensive care unit

as the number of maternal near-miss cases per 1,000 live births.

Statistical Analysis

The data collected through the questionnaires were analyzed using IBM SPSS Statistics (version 25; IBM Corporation, Armonk, NY). Statistical significance was defined as p<0.05.

RESULTS

A total of 255,653 deliveries were assessed between 2009 and 2017 in Kocaeli, resulting in 312 near-miss cases and 41 deaths. The mean age of women was 28 (18-42) years, with a mean gestational week of 28 (9-39) weeks. In terms of maternal mortality, most (75%) occurred in the postpartum period, with 31% occurring between one week and 42 days postpartum, 29% within the first 48 hours, and 15% between 48 hours and one week. Maternal deaths were predominantly observed in the early postpartum period, with an average duration of 2.9 days (1-8), and those during the puerperal period averaged 18 (1-39) days.

In 2009, Turkey's MMR stood at 18.4 maternal deaths per 100,000 live births, while Kocaeli's MMR was significantly higher

at 34.7 (p=0.01). By 2014, Kocaeli's MMR had significantly (p=0.004) decreased to 3.3 per 100,000 live births, compared to the average rate in Turkey of 15.2 (Table 3).[5]

The measures implemented, including emergency obstetric intervention workflows and healthcare provider training, resulted in a significant decrease in delay models 2 and 3 within two years (Table 4). However, maternal deaths attributed to delay model 1 remained relatively unchanged throughout the study period.

From 2009 to 2017, 31.7% of maternal deaths were due to direct obstetric causes, and 43.9% were due to indirect causes in Kocaeli (Table 5). The causes of death of the 41 patients are detailed in Table 5.

The majority (95%) of pregnant women accessed prenatal care services, with 81% utilizing primary health clinics, 55% attending state hospitals, 34% visiting private hospitals, and 19% receiving care at tertiary hospitals. Furthermore, 77% of women underwent prenatal care visits more than four times, 13% received care two to three times, and 5% sought prenatal care only once.

Between 2010 and 2015, among the cohort of 312 near-miss cases, 134 patients received ICU treatment, while 32 patients underwent surgical interventions at the primary healthcare facility. These surgical procedures encompassed hypogastric artery ligation for 25 patients, hysterectomy for 6 patients, and uterine re-transplantation for 1 patient. Following this, 24 patients were referred to tertiary care centers, as outlined in Table 6.

The MNMR exhibited a significant (p=0.02) decline from 3.75 per 1000 live births in 2010 to 0.61 per 1000 live births in 2015. The correlation between the MMR and MNMR is delineated in Table 7.

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Table 3. Maternal mortality rate of Kocaeli and Turkey

Years	Number of live birth rate	Maternal deaths (n=41) n (%)	Direct causes	Maternal mortality rate per 100,000 live birth in Kocaeli	Maternal mortality rate per 100,000 live birth in Turkey
2009	25,876	9 (23.6)	6	34.7	18.4
2010	25,864	5 (13.1)	1	19.3	16.3
2011	25,770	3 (7.8)	1	11.6	15.9
2012	27,334	5 (13.1)	1	18.2	15.2
2013	27,521	5 (13.1)	0	18.1	15.8
2014	29,879	1 (2.6)	0	3.3	15.2
2015	30,901	4 (10.5)	1	12.9	14.7
2016	31,188	6 (15.7)	2	19.2	14.7
2017	31,320	3 (9)	1	9.5	17

Table 4. Analysis of maternal mortality according to delay models in Kocaeli

Year	Model 1 delay	Model 2 delay	Model 3 delay	Total
2009	2	4	3	9
2010	2	2	1	5
2011	2	1	0	3
2012	4	0	1	5
2013	4	1	0	5
2014	1	0	0	1
2015	3	0	1	4
2016	4	1	1	6
2017	2	0	1	3
Total	24	9	8	41

DISCUSSION

The determinants underlying maternal mortality necessitate meticulous documentation and analysis. Utilizing maternal death reviews, establishing local committees dedicated to enhancing the quality of care, and implementing targeted interventions to augment healthcare providers' competencies are strategies proven to mitigate MMRs.[6]

Direct obstetric deaths stem from complications directly linked to pregnancy or its management, encompassing instances of incorrect treatments, omissions, and specific pregnancy-related complications such as hemorrhage and uterine rupture.[7] In contrast, indirect obstetric deaths arise from preexisting conditions, like diabetes or cardiac disease, or from new conditions that develop during pregnancy and are not directly related to it but are aggravated by the physiological effects of pregnancy. It is estimated that approximately 25% of maternal deaths are attributable to indirect obstetric causes.[8]

In developed nations, prevalent causes of maternal mortality comprise hemorrhage, thromboembolism, cardiac disease, sepsis, hypertensive disorders, and amniotic fluid embolism.[9] In Africa and Asia, hemorrhage accounts for 30.8% to 33.9% of maternal deaths, with hypertensive disorders following at 9.7%. Conversely, in high-income countries, hypertensive disorders are the foremost cause of maternal death (16.1%), followed by pulmonary embolism (14.9%).[10]

On a global scale, spanning from 2003 to 2009, hemorrhage constituted 27.1% of maternal fatalities, hypertensive disorders accounted for 14.0%, and sepsis contributed to 10.7% of the total maternal mortality.[11-13] Conversely, within the Kocaeli region during the period from 2009 to 2017, direct obstetric causes attributed to 31.7% of maternal deaths, while indirect obstetric causes were responsible for 43.9% (Table 5).

Measuring maternal near-miss cases can serve as a valuable indicator of the quality of care provided to pregnant women. The assessment of near-miss incidents yields more analyzable data than maternal deaths due to their higher frequency.[14] Souza et al.[15] reported that the overall maternal near-miss ratio was 8.3 per 1000 live births in a WHO study conducted in 29 developing countries. In a retrospective cohort study by Ozimek et al.,[16] out of 16,323 deliveries, 386 (2%) were screened positive for severe maternal morbidity. Upon detailed review, true severe maternal morbidity was identified in 150 (0.9%) deliveries. A multidisciplinary committee found that there was an opportunity for improvement in care in 66 (44%) of these cases.[16]

Several critical factors contribute to maternal survival during obstetric emergencies. These include the regularity of follow-up and registration of pregnant women, proximity to health facilities, presence of trained and qualified health workers during childbirth, availability of emergency obstetric care services, blood transfusion capabilities, and access to quality intensive care services. The Three-Delays model has been widely applied to identify and address preventable causes of maternal mortality and morbidity.

Between 2012 and 2015, prenatal care services were accessed by 95% of pregnant women. Among these, 81% sought care at primary health clinics, 55% at state hospitals, 34% at private hospitals, and 19% at tertiary hospitals. Throughout this timeframe, 77% of women attended prenatal care visits more than four times, 13% attended two to three times, and 5% attended only once.

Numerous studies have demonstrated that near-misses and maternal deaths are significantly higher among patients without registration and follow-up compared to those who receive consistent prenatal care. Regular prenatal follow-

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Table 5. Causes of maternal death in 2009-2017 in Kocaeli

Year	Cause of death	Direct or Indirect causes
2017	Systemic lupus erythamatosis	Indirect
2017	Mucopolysaccharidosis	Indirect
2017	Postpartum bleeding and disseminated intravascular coagulation	Direct
2016	Pulmonary embolism	Direct
2016	Acute pancreatitis	Indirect
2016	Gunshot wounds	Accidental
2016	Hemoperitoneum	Indirect
2016	Postpartum hemorrhage	Direct
2016	Brain tumour	Indirect
2015	Gastric cancer	Indirect
2015	Traffic accident	Accidental
2015	Congestive hearth failure	Indirect
2015	Massive pulmonary embolism	Direct
2014	Acute myeloid leukemia	Indirect
2013	Traffic accident	Accidental
2013	Traffic accident	Accidental
2013	Circulatory system disease	Indirect
2013	Aortic aneurysm and dissection	Indirect
2013	Acute myocard infarction	Indirect
2012	Postpartum hemorrhage	Direct
2012	Subarachnoid hemorrhage	Accidental
2012	Gunshot wounds	Accidental
2012	Chronic obstructive pulmonary disease	Indirect
2012	Jumping from high place	Accidental
2011	Preeclampsia	Direct
2011	Takayasu	Indirect
2011	Gunshot wounds	Accidental
2010	Cerebral venous thrombosis	Indirect
2010	Preeclampsia	Direct
2010	Pulmonary hypertension, CHF	Indirect
2010	Traffic accident	Accidental
2010	Mental illness and nervous system disease	Indirect
2009	Preeclampsia	Direct
2009	Venous thromboembolism	Direct
2009	Suicide	Indirect
2009	Postpartum bleeding	Direct
2009	Postpartum sepsis	Direct
2009	Peripartum bleeding	Direct
2009	Disseminated intravascular coagulation	Direct
2009	Pschizophrenia, house fire	Indirect
2009	Traffic accident	Accidental

Direct (31.7%), Indirect (43.9%), Accidental (24.4%). CHF: Congestive heart failure

Table 6. Maternal near miss cases evaluated and managed by the emergency obstetric care team 2010-2015

Year	Intensive care support	Surgical operation	Onsite consultation	Total
2010	33	17	47	97
2011	32	13	36	81
2012	27	8	19	54
2013	19	8	9	36
2014	12	7	6	25
2015	11	3	5	19
Total	134	56	122	312

Table 7. Change in MMR and MNMR over the years of Kocaeli

Years	Maternal deaths (n=41) n (%)	MMR per 100,000 live birth	Maternal near-miss cases per 1000 live birth
2009	9 (21.9)	34.7	
2010	5 (12.1)	19.3	3.75
2011	3 (7.3)	11.6	3.14
2012	5 (12.1)	18.2	1.97
2013	5 (12.1)	18.1	1.30
2014	1 (2.4)	3.3	0.83
2015	4 (9.7)	12.9	0.61
2016	6 (14.6)	19.2	
2017	3 (7.3)	9.5	

MMR: Maternal mortality ratio, MNMR: Maternal near miss ratio

up is crucial for differentiating between high- and low-risk patients, predicting complications, and planning interventions, all of which contribute to the reduction of severe maternal morbidities. The absence of regular prenatal follow-up remains a significant challenge in developing countries.[11,17,18]

Data from the United States Pregnancy Mortality Surveillance indicate that higher levels of education serve as protective factors against maternal mortality. Moreover, women who receive prenatal care have lower maternal death risks than those who do not receive any care.[19-21] Tunçalp et al.[22] reported that the prevalence rates for maternal near-miss varied between 0.6% and 14.98% based on disease-specific criteria. In Rwanda, the MMR decreased from 487 in 2010 to 210 in 2015, and facility-based deliveries increased from 69% in 2010 to 91% in 2015, likely due to the prohibition of traditional birth attendants and the availability of health insurance.[23]

In Turkey, the health system involves family practitioners recording new pregnancies in the Ministry of Health database, with monthly examinations and follow-up by family physicians. Between 2006 and 2015, primary health clinics actively reached out to newly pregnant women through home visits or telephone calls, providing immunizations. During this period, 26 social workers and 278 guidance specialists educated the public on prenatal and antenatal care, encouraging hospital deliveries among women aged 15-49 years, thereby improving the quality and quantity of follow-up care.

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The number of pregnant women transported to the hospital via emergency ambulance and healthcare clinic vehicles increased markedly. High-risk patients were referred to obstetricians specializing in their care, with access to a comprehensive range of specialized services. A case-control study of 77 maternal deaths at Birmingham University found that longer distances to the hospital were a significant predictor of maternal death.[9] Kocaeli, the largest city in Turkey's northwestern region, with a population of 1.75 million based on the 2015 census, has an extensive transportation network and qualified healthcare providers. The city is served by one university hospital, one training and research hospital, four state hospitals, and fifteen private hospitals.

In the United States, the mean MMR increased from 14.3 in 2005 to 17.2 in 2014, a rise attributed to increased immigration rates, cesarean delivery rates, and the prevalence of medical conditions.[24] Following the onset of the Syrian civil war, Turkey experienced a substantial influx of uncontrolled immigration, with Kocaeli, as an industrial city, having the highest migration rate. Consequently, the MMR in Kocaeli increased from 3.3 in 2015 to 13, and further to 19.2 in 2016.

The third delay in addressing maternal mortality is attributed to untrained healthcare professionals, diagnostic inadequacies, urgent blood transfusion requirements, and overburdened ICUs in tertiary institutions. Many of these limitations can be mitigated through comprehensive training for healthcare workers and the implementation of surveillance and control systems to enhance care quality. In Malaysia, the national MMR decreased by 94%, from 530 per 100,000 live births in 1950 to 28 per 100,000 live births in 2009. This significant reduction was largely due to the introduction of competency-based training and the deployment of midwives to rural areas, as well as improvements in the healthcare delivery system.[25]

In 2013, the Intensive Care National Audit and Research Center Case Mix Program reported the development of the first validated early warning scoring system for pregnant women. This system has proven to be a highly effective tool for the early identification of women at increased risk of mortality. Obstetric early warning systems, which are based on the identification of predetermined abnormal values in vital signs or laboratory parameters, have been proposed as a potential strategy to reduce maternal morbidity and mortality by enabling a rapid and effective medical response.[26] A prospective observational study of over 1000 deliveries reported that the early warning charting system had a positive predictive value of 53.8% and a negative predictive value of 96.9% for the identification of maternal morbidity.[27,28]

The Turkish Gynecology and Obstetrics Society (TGOS) has played a pivotal role in educating obstetricians, gynecologists, and midwives on the management of obstetric emergencies and the additional risks posed by underlying medical conditions. Furthermore, TGOS has provided training for clinical staff in surgical procedures and the management of postpartum hemorrhage.

In Turkey, the Emergency Obstetric Intervention Programme (EOI), implemented in 2009, has been the most effective organization for reducing maternal mortality. The EOI Programme aims to decrease the MMR by providing qualified prenatal and postnatal care. Similarly, the Mother Care Country Projects, conducted between 1989 and 1993 in Bolivia, Guatemala, Indonesia, and Nigeria, emphasized two crucial aspects of reducing maternal and perinatal mortality: ensuring referral facilities and training midwifery and obstetrics staff; and involving women and their families in recognizing danger signs and mobilizing for referral.[29] These projects demonstrated improvements in referral systems and a reduction in perinatal mortality.

A 2014 study published by the WHO highlighted significant advancements made by the Acute Emergency Obstetrics Team in providing pregnant women with accessible obstetric care facilities, managed by qualified healthcare personnel.[8] The TGOS conducted a comprehensive analysis of the causes of maternal and fetal mortality and morbidity in Turkey, formulating new strategies aimed at reducing mortality, morbidity, and cesarean rates.

In 2009, the establishment of a postpartum hemorrhage team in Kocaeli marked a pioneering effort. Comprising three academicians equipped to handle various scenarios, this team commenced operations to effectively address postpartum hemorrhage. As a result, the MNMR decreased substantially from 3.75 in 2010 to 0.61 in 2015. The model, initially implemented in Kocaeli, was subsequently adopted in all cities of Turkey.

The TGOS conducted educational sessions to enhance the management of obstetric emergencies, particularly focusing on postpartum hemorrhage. These sessions provided training to 308 obstetricians, covering blood transfusion criteria and surgical procedures. Furthermore, 620 midwives received education on various topics including postpartum hemorrhage management, external fetal monitoring techniques, partogram use, nutritional guidelines, exercise during pregnancy, and methods for inducing labor.

CONCLUSION

The initiatives implemented since 2009 have resulted in the recognition of near-miss cases and have enhanced the skills of healthcare professionals in managing these cases. In addition, the establishment of postpartum bleeding teams in every province has ensured prompt, appropriate, and precise interventions for all near-miss cases, which has significantly contributed to a notable reduction in both the MMR and the MNMR.

Footnote

Ethics Committee Approval: This retrospective study was initiated following the decision of the Ethics Committee of Kocaeli University.

Informed Consent: Retrospective study.

Authorship Contributions

Surgical and Medical Practices: Y.C., Y.D., Concept: Y.C., Y.D., Design: Y.C., E.Y., Data Collection or Processing: E.Y., Ş.Y.K.,

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Analysis or Interpretation: E.Y., M.S.M., Literature Search: M.S.M., Writing: Y.C., Ş.Y.K.

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