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## Postpartum hemorrhage: from insight to action

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# CHAPTER 6

## **NATIONWIDE CONFIDENTIAL ENQUIRIES INTO MATERNAL DEATHS BECAUSE OF OBSTETRIC HEMORRHAGE IN THE NETHERLANDS BETWEEN 2006 AND 2019**

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# ABSTRACT

## Introduction

Obstetric hemorrhage-related deaths are rare in high income countries. Yet, with increasing incidences of obstetric hemorrhage in these countries, it is of utmost importance to learn lessons from each obstetric hemorrhage-related death to improve maternity care. Our objective was to calculate the obstetric hemorrhage-related maternal mortality ratio (MMR), assess causes of obstetric hemorrhage-related deaths, and identify lessons learned.

## Material and Methods

Nationwide mixed-methods prospective case-series with confidential enquiries into maternal deaths due to obstetric hemorrhage in the Netherlands from January 1<sup>st</sup>, 2006 to December 31<sup>st</sup>, 2019.

## Results

The obstetric hemorrhage-related MMR in the Netherlands in 2006-2019 was 0.7 per 100 000 livebirths, and not statistically significantly different compared to the previous MMR of 1.0 per 100 000 livebirths in 1993-2005 (OR 0.70, 95% CI 0.38 to 1.30). Leading underlying cause of hemorrhage was retained placenta. Early recognition of persistent bleeding, prompt involvement of a senior clinician, and timely management tailored to the cause of hemorrhage with attention for coagulopathy were prominent lessons learned. Also, timely recourse to surgical interventions, including hysterectomy, in case other management options fail to stop bleeding came up as an important lesson in several obstetric hemorrhage-related deaths.

## Conclusions

The obstetric hemorrhage-related MMR in the Netherlands in 2006-2019 has not substantially changed compared to the MMR of the previous enquiry in 1993-2005. Although obstetric hemorrhage is commonly encountered by maternity care professionals, it is important to remain vigilant of possible adverse maternal outcome and act upon an ongoing bleeding following birth in a more timely and adequate manner. Our confidential enquiries still led to important lessons learned with clinical advice to professionals as how to improve maternity care and avoid maternal deaths. Drawing lessons from maternal deaths should remain a qualitative and moral imperative.

## INTRODUCTION

Successive improvements in maternity care during the 20<sup>th</sup> century have led to an impressive decline in the overall maternal mortality ratio (MMR) in high-income countries.<sup>1</sup> Nowadays, maternal deaths during pregnancy, childbirth and puerperium have become rare.<sup>2,3</sup> However, the declining death rates in recent decades are not to be taken for granted, and the deaths that do occur remain tragic and are often potentially preventable events.<sup>4</sup>

Despite a declining MMR in most high-income countries, the MMR in the United States of America paradoxically increased in recent years.<sup>5,6</sup> The MMR is an important indicator of the quality of maternity care<sup>7</sup>, but in addition to monitoring this quantitative indicator, it is also imperative to draw qualitative lessons from each maternal death. Confidential enquiries can help to define lessons learned and improve the quality of maternity care.<sup>8</sup> Such continuous efforts are necessary to succeed in the reduction of the MMR.<sup>9</sup> Hemorrhage after childbirth has been identified as one of the commonest causes of preventable pregnancy-related death.<sup>4</sup> While there had been a decrease in obstetric hemorrhage-related deaths, these deaths are on the rise again in some high-income countries.<sup>10</sup> A previous confidential enquiry into maternal deaths in the Netherlands showed an unchanged obstetric hemorrhage-related MMR between 1983-1992 and 1993-2005, indicating that the evaluation of maternity care and formulation of lessons learned may help to achieve a reduction in the obstetric hemorrhage-related MMR.<sup>11</sup> Thus, reviewing all obstetric hemorrhage-related maternal deaths remains crucial to improve the quality of maternity care<sup>12,13</sup>, particularly so in light of the increasing incidence of obstetric hemorrhage reported in multiple high-income countries, including the Netherlands.<sup>14,15</sup>

The purpose of this study was to systematically investigate all obstetric hemorrhage-related deaths in the Netherlands between 2006-2019 in order to examine the obstetric hemorrhage-related MMR within this time frame, assess causes of obstetric hemorrhage-related maternal deaths, and to identify substandard care factors related to those deaths in order to formulate lessons learned from confidential enquiries that may help to improve the quality of care.

## **MATERIAL AND METHODS**

This was a nationwide mixed-methods prospective case-series in the Netherlands including all obstetric hemorrhage-related maternal deaths reported to the Dutch Audit Committee Maternal Mortality and Morbidity (Auditcomissie Maternal Sterfte en Morbiditeit, AMSM) between January 1<sup>st</sup>, 2006 and December 31<sup>st</sup>, 2019.

The AMSM is instituted by the Dutch Society of Obstetrics and Gynaecology (NVOG) and at present consists of eight consultant obstetricians, one obstetric anesthesiologist, one hospital-based midwife, and two residents in O&G.<sup>16</sup> The committee members are authorized by the NVOG to collect and analyze information about maternal deaths in the Netherlands that are reported to the AMSM by medical doctors, general practitioners, and midwives.<sup>16</sup> Since 2016, secure electronic reporting is made possible through the 'Netherlands Obstetric Surveillance System' (NethOSS), which is in line with the general Data Protection Regulation (GDPR). The NethOSS is a national surveillance system of severe maternal morbidity and mortality sending out a monthly email to allocated clinicians in each hospital with a maternity ward which includes a link for online registration. These clinicians are requested to report cases of severe maternal morbidity and mortality, or to declare 'nothing to report'. Once a maternal death has been reported to the AMSM, anonymized complete case file copies are requested to be uploaded to a secure online network that can only be accessed by the AMSM members. The case file copies consist of antenatal charts, surgery reports, radiology reports, laboratory and microbiology tests, autopsy reports, professional correspondence, and local audit reports. Through a confidential enquiry, the AMSM classifies the underlying cause of death according to the ICD-MM, systematically audits the provided care and assesses factors of substandard care and opportunities for improvement of care from which the AMSM formulates lessons learned for each death. The AMSM reports these findings back to the health care professionals in the field in an aggregated manner and directly to the involved caregivers if desired.

Maternal mortality is defined by the World Health Organization as the death of a woman during pregnancy, childbirth, or within 42 days after termination of pregnancy or childbirth.<sup>17</sup> The International Classification of Diseases-Maternal Mortality, tenth revision (ICD-MM), defined underlying cause of death as 'the disease or condition that initiated the morbid chain of events leading to death or circumstances of the accident or violence that produced a fatal injury'.<sup>17</sup> This definition brings into question where the morbid chain of events actually starts.

In the Netherlands, the chain of events is traced back to the primary event.<sup>18</sup> This implies that although a woman may have died due to excessive blood loss, the underlying cause of death might still be classified as preeclampsia, considering that preeclampsia was the primary event that led to clotting dysfunction and excessive obstetric hemorrhage.

### **Quantitative research**

Obstetric hemorrhage was defined as a pregnancy-related bleeding ( $\geq 1000\text{mL}$ ) following 24 weeks of gestation during pregnancy, childbirth, or up to 6 weeks postpartum. Since we were interested in all obstetric hemorrhage-related deaths, we chose to examine both those cases in which obstetric hemorrhage was classified by the AMSM as the underlying cause of death (defined as the initial event that initiated the chain of events ultimately leading to death), as well as cases where women died due to the complications of hemorrhage at any point in the chain of events, although the initial event starting the chain of events (underlying cause of death) was deemed otherwise by the AMSM. Identifying those cases where women died as a result of excessive bleeding in the chain of events, but the underlying cause of death was deemed otherwise, was done by PR, a resident who had no previous knowledge of these cases, and TA and JMS, both consultant obstetricians who have been members of AMSM for several years. Cases were independently examined and if there was a discrepancy between whether or not to include a woman, her case was brought up to a general AMSM meeting to reach a decision.

Furthermore, we classified 'obstetric hemorrhage' as the underlying cause of death in women who died due to excessive bleeding as a complication of cesarean section. This classification is in accordance with the classification system used by the ICD-MM<sup>17</sup>. In a previous report on maternal mortality in the Netherlands between 1993-2005, the underlying cause of death in a woman who died due to excessive hemorrhage as a complication of cesarean section was classified as 'complication of cesarean section'.<sup>11</sup> In order to pursue international uniformity regarding the classification of underlying cause of death, whilst still being able to compare our results to those presented for the Netherlands in the previous time frame of 1993-2005, we reclassified all deaths due to excessive bleeding as a complication of cesarean section for that previous time frame as 'obstetric hemorrhage' instead of 'complication of cesarean section'.<sup>11</sup>

We calculated the obstetric hemorrhage-related MMR for the time frame 2006-2019, with and without those cases where women died due to excessive blood loss within the chain of events, but with an underlying cause of death deemed

otherwise. The number of livebirths in the Netherlands between 2006-2019 was obtained from Statistics Netherlands, which is the governmental authority that collects vital perinatal statistics.<sup>19</sup> Odds ratio's (OR) with 95% confidence intervals (CI) were calculated to compare the MMR due to obstetric hemorrhage with hemorrhage as underlying cause of death in the Netherlands between the time frames 1993-2005 and 2006-2019.<sup>11</sup> Maternal deaths were cross-checked with the maternal mortality data from Statistics Netherlands up to 2011. Thereafter, cross-check was no longer facilitated by Statistics Netherlands due to alleged privacy issues. However, to ensure completeness of reporting to AMSM, a cross-check with the TeMpOH-1 study (*Transfusion strategies in women during Major Obstetric Hemorrhage*) was performed. The TeMpOH-1 study was a nationwide retrospective cohort study into major obstetric hemorrhage, specifically in 61 hospitals in the Netherlands (71% of all the hospitals in the country at the time with a maternity ward), that collected data from women who received 4 units of packed red blood cells or any transfusion of fresh frozen plasma or platelets in addition to packed cells because of obstetric hemorrhage ( $\geq 1000\text{mL}$ ) between January 1, 2011 and January 1, 2013.<sup>20</sup> The numerator to calculate the obstetric hemorrhage-related MMR in the Netherlands in the time frame 2006-2019 also included women who died because of obstetric hemorrhage who were identified from the TeMpOH-1 study but were not reported to the AMSM. Statistical analyzes were performed with IBM SPSS Statistics (version 22.0, IBM Corp, Armon, NY, USA).

### **Qualitative research**

All obstetric hemorrhage-related deaths reported to the AMSM in 2006-2019 were critically reviewed by the entire AMSM in order to identify substandard care factors and formulate lessons learned. Each woman's care is thus systematically reviewed by all AMSM members and evaluated against relevant national guidelines.<sup>21-25</sup> Substandard care was defined as all factors that might have contributed to the chain of events leading to death.<sup>26</sup> Substandard care could be 1) patient related, 2) primary maternity care related (care provided by community midwives or general practitioners), or 3) secondary and tertiary care related (care provided by obstetricians or other medical doctors and hospital-based midwives). This classification system is in accordance with that of two previous national assessments of maternal mortality in the Netherlands.<sup>11,26</sup> Lessons learned were formulated from substandard care factors identified by the AMSM. De-identified case histories are given to illustrate specific lessons learned.

**Ethical approval**

Ethical approval for this study was waived, considering that the AMSM was mandated by the NVOG to collect and analyze maternal deaths, and that ethical approval is not required in the Netherlands for performing confidential enquiries with anonymized data. The TeMpOH-1 study was approved by the Ethical Committee of Leiden University Medical Center (P12.273; 31 January 2013) and by the institutional review board of each of the participating hospital. The TeMpOH-1 study was registered in the Netherlands Trial Register (Trial NL3909; 17 July 2013).



## RESULTS

A total of 27 obstetric hemorrhage-related maternal deaths were identified in the Netherlands between January 1, 2006 and December 31, 2019. Of these deaths, 24 (89%) were reported directly to the AMSM. The other 3 (11%) obstetric hemorrhage-related maternal deaths were identified after a cross-check with the TeMpOH-1. In 17 women (63%,  $N=17/27$ , including the 3 deaths that were identified from the TeMpOH-1), obstetric hemorrhage was considered as the underlying cause of death. Ten women (37%,  $N=10/27$ ) died due to the complications of obstetric hemorrhage within the chain of events with a different underlying cause of death.

The MMR of obstetric hemorrhage as underlying cause of death in the Netherlands between 2006-2019 was 0.7 per 100 000 live births (17/2.473.951) and was not statistically significantly different compared to the MMR of 1.0 per 100 000 live births (25/2.557.208) in the Netherlands in 1993-2005 (OR 0.70, 95% CI 0.38-1.30).<sup>26</sup> The overall obstetric hemorrhage-related MMR (including cases where women died because of hemorrhage in the chain of events but with a different underlying cause of death) in 2006-2019 was 1.1 per 100 000 live births (27/2.473.951).

Maternal and pregnancy-related characteristics are presented in Table 1. Nine women (34%,  $N=9/27$ ) were booked as having a 'high-risk' pregnancy upon the first antenatal visit, with maternity care provided by an obstetrician. Eighteen women (66%,  $N=18/27$ ) started out with a 'low-risk' pregnancy with care provided by a primary care midwife. Of these 18 women, 10 (56%) were referred to obstetrician-led care during pregnancy, five (28%) during labor, and three (16%) following childbirth. Four women (15%,  $N=4/27$ ) were at home at the start of the lethal event, of whom two had already given birth and two had perimortem cesarean section. Out of the three women in total who underwent a perimortem cesarean section in this study (including the two women who were at home), two had obstetric hemorrhage prior to the cardiorespiratory arrest that led to a perimortem cesarean section. One had hemorrhage after perimortem cesarean section and successful resuscitation. All other women had hemorrhage following vaginal birth, or during or after cesarean section.

Causes of obstetric hemorrhage-related deaths are presented in Table 2 and subdivided into causes where obstetric hemorrhage was the underlying cause of death and causes where women died because of obstetric hemorrhage in the chain of events but with a different underlying cause of death. Commonest cause

for obstetric hemorrhage as underlying cause of death was retained placenta (N=5/17). Amniotic fluid embolism was the commonest cause in women with hemorrhage in the chain of events leading to death (N=6/10). Thirteen women (48%, N=13/27) had intrauterine balloon tamponade, 4 (15%, N=4/27) had uterine artery embolization, and 8 (30%, N=8/27) a hysterectomy. Sixteen out of 27 women (59%) died the same day, 9 (34%) within one week, and 2 (7%) within two weeks following hemorrhage.

Confidential enquiries were only available for the women reported to the AMSM (N=24). Assessment of maternity care identified substandard care factors in 18 women. In 6 women no substandard care factors were identified. Most of these substandard care factors were secondary or tertiary care related (Table 3), with the majority related to inadequate management (75%, N=18/24), or delayed diagnosis (42%, N=10/24). Lessons learned with regard to improving maternity care derived from these substandard care factors are in 'Box 1', along with de-identified case histories to illustrate specific situations.

**Table 1.** Maternal and pregnancy-related characteristics of women who died because of obstetric hemorrhage in the Netherlands between 2006-2019

	N=27	(%)
<b>Maternal age, years</b>		
20-29	6	(22)
30-39	18	(66)
≥40	3	(11)
<b>Body mass index, kg/m<sup>2</sup></b>		
18.5 to 24.9	11	(41)
25.0 to 29.9	3	(11)
≥30	5	(18)
Missing	8	(30)
<b>Ethnic background</b>		
Dutch native	15	(55)
European	1	(4)
African	4	(15)
Asian	4	(15)
Missing	3	(11)
<b>Parity</b>		
Nulliparous	12	(44)
Parous	15	(66)
<b>Initial antenatal care</b>		
Primary midwife-led care	18	(66)
Obstetrician-led care	9	(34)
<b>Multiple pregnancy</b>	0	(0)
<b>Prior cesarean section</b>	5	(18)
<b>Prior obstetric bleeding</b>	0	(0)
<b>Gestational age, weeks</b>		
24+0 to 31+6	1	(4)
32+0 to 36+6	5	(18)
≥37 weeks	21	(78)
<b>Mode of birth</b>		
Vaginal	6	(22)
Instrumental	10	(37)
Cesarean section	11	(41)
<i>Scheduled</i>	1	(9)
<i>Non-scheduled</i>	7	(64)
<i>Perimortem</i>	3	(27)

**Table 2.** Initial causes of obstetric hemorrhage-related deaths in the Netherlands between 2006-2019

	N (%) (N=17)	MMR (Live Births=2,473,951)
<b>Obstetric hemorrhage considered as the underlying cause of death</b>		
Uterine atony	3 (18)	0.12
Retained placenta	5 (29)	0.20
Remnant of placental tissue	3 (18)	0.12
Cesarean section related	4 (23)	0.16
Ruptured interstitial pregnancy	1 (6)	0.04
Spontaneous splenic rupture	1 (6)	0.04
	N (%) (N=10)	MMR (Live Births=2,473,951)
<b>Causes with obstetric hemorrhage in the chain of events leading to death</b>		
Amniotic fluid embolism	6 (60)	0.24
Pre-eclampsia	2 (20)	0.08
Septic shock	2 (20)	0.08

**Table 3.** Number of identified substandard care factors in the 24 obstetric hemorrhage-related maternal deaths that were reported to the AMSM in the Netherlands between 2006 and 2019\*

	N
<b>Patient related</b>	
Delay in consulting a doctor	1
Refusing medical treatment	1
Communication difficulties	1
<b>Primary obstetric care related<sup>1</sup></b>	
Inadequate antenatal visit	1
Delay in referral to hospital	1
Delay in diagnosis	2
<b>Secondary or tertiary care related<sup>2</sup></b>	
Delay in diagnosis	10
Inadequate management	18
Communication difficulties between obstetricians and other specialists	2
Failure to stabilize before transport	2

\* Multiple substandard care factors could be identified per maternal death

<sup>1</sup> Care provided by community midwives and/or general practitioners

<sup>2</sup> Care provided by obstetricians and/or other medical specialists

**Box 1.** Lessons learned from the confidential enquiries of obstetric hemorrhage-related deaths reported to the AMSM in the Netherlands between 2006-2019

### **COMMUNICATION**

- Use a structured format of communication so that as little information as possible is lost, e.g. through the communication tool SBAR (Situation–Background–Assessment–Recommendation).
- Effective communication between members of a multidisciplinary team is essential during acute severe hemorrhage. Caregivers should inform each other of the current clinical situation and emphasize their findings that deserve prompt medical reaction.

*“A woman gave birth to her second child in the hospital and had a retained placenta. When she was transferred to the operating room, both the consultant obstetrician and anesthesiologist were not notified of the additional 1 liter blood loss before transportation and clinical signs of shock. After manual removal of the placenta, the woman deteriorated quickly, and blood products were not yet available considering that both clinicians in charge did not anticipate such a rapid decline. Despite swift recourse to invasive interventions to cease hemorrhage, she died from multiorgan failure the following week.”*

### **TRAINING**

- Multidisciplinary obstetric hemorrhage simulation training sessions, preferably on a local and national level, may help to ensure that clinical caregivers are appropriately trained for care during the course of bleeding, barriers in care are identified and cleared so that facilities are properly equipped to handle obstetric hemorrhage, and may improve communication and collaboration between multidisciplinary team members during acute and severe obstetric bleedings.

### **ANTENATAL CARE**

- Maternity caregivers should make an effort to overcome language barriers and invest time in creating health literacy (the ability to find, understand, and use information and services to inform health-related decisions and actions)<sup>27</sup> among women seeking care.
- Women who refuse transfusion of blood products should have pre-conception or antenatal counseling by experienced professionals, including the anesthesiologist and hematologist. Clinical caregivers must explain possible risks and consequences of refusing blood products, and a multidisciplinary plan should be in place to ensure optimal care during hemorrhage.

*“A non-native woman with poor Dutch and English skills who had recently moved to the Netherlands had a spontaneous onset of labor. Her midwife advised her by phone to come to the hospital. Because of the language barrier, the woman arrived at the wrong hospital (one without a maternity ward) and gave birth under guidance of an ER doctor. She had massive bleeding due to uterine atony and was transported to another hospital where an obstetrician and operating room stood prepared upon arrival. A peripartum hysterectomy was performed to cease bleeding. She died of a cardiac arrest on the ICU.”*

**PREVENTION & TIMELY RECOGNITION**

- Implement risk assessment tools to identify women at risk of obstetric hemorrhage, such as those proposed by the Safe Motherhood Initiative of the American College of Obstetricians and Gynecologists.<sup>28,29</sup> Women with an estimated high risk of obstetric hemorrhage should have venous access early during labor with blood sampling for hemoglobin testing and crossmatching. Emphasis should be on active management of the third stage of labor.
- Timely recognition of persistent bleeding is crucial to prevent a delay in referral and medical response. Keep track of total blood loss and be aware of clinical signs of hypovolemia, such as tachycardia and hypotension, which indicate that a woman may have lost more blood than expected. Hypotension is often a late sign and should be acted upon immediately.
- Implement obstetric warning scores for early detection of imminently deteriorating women to trigger prompt medical evaluation, especially during postoperative care. Be aware that the bleeding might be concealed, and be alerted by non-specific complaints. A reduced level of consciousness or collapse is a red flag.
- Immediate recourse to a manual removal of the placenta(l) (remnant) is warranted once a retained placenta is diagnosed or a placental remnant is suspected. Delay (especially >1 hour) can result in more blood loss. Close monitoring of vital signs is also essential as blood can accumulate in the uterus and may lead to abrupt deterioration of a woman.

*“An obese woman gave birth in hospital whilst intravenous access had not been established during labor. Following birth, the clinician in charge sutured multiple extensively bleeding vaginal lacerations. Total blood loss was estimated at 550mL despite signs of tachycardia and hypotension indicating that actual total blood loss might have been higher. Ten minutes later she collapsed and fundal expression revealed concealed hemorrhage loss inside the uterus. Vasoconstriction made it difficult to establish venous access at this point. The woman was taken to the operating room and hemoglobin level at that time was 3.22 g/dL (2.0 mmol/L). Bleeding was stopped with intrauterine balloon tamponade. Cardiorespiratory support was withdrawn when it became clear that she had lost all cortical functions.”*

### **COORDINATION & TIMELY MANAGEMENT**

- In case of persistent bleeding, a senior clinician must be notified and a massive obstetric hemorrhage protocol should be activated, while recording clinical events and parameters (volume of blood loss, vital signs, and administration of medication, fluids and/or blood products).
- At least one senior clinician must coordinate management of persistent bleeding and maintain situational awareness. Assigning this task to a clinician will provide leadership and direction to the team in an acute setting, while this clinician keeps an overview of the situation.
- Manage obstetric hemorrhage timely and appropriately with administration of uterotonics and tranexamic acid. Early fluid resuscitation is essential to maintain adequate circulating volume and tissue perfusion.
- Prompt access to uterotonic agents on the maternity ward and operating room is crucial and having an 'emergency' trolley with medications and (laminated) instruction cards for acute settings may prevent delay in adequate management.
- Resort to surgical interventions sooner rather than later when hemorrhage does not cease despite the administration of uterotonics and additional conservative interventions, such as uterine massage and bimanual compression of the uterus.
- Proceed to hysterectomy when other invasive interventions are unsuccessful. Resort to peripartum hysterectomy should be expedited when blood products are refused or when there has been a delay in diagnosis with a woman in extremis.

*"Following cesarean section because of breech presentation, a woman's hemoglobin level dropped and abdominal ultrasound examination revealed free fluid intra-abdominally. Transient postoperative bleeding was suspected and the woman was given blood products. Later that day her clinical condition deteriorated and she presented with abdominal swelling accompanied by oliguria. There was no senior clinician that coordinated care, and lack of leadership prevented exploratory laparotomy. The woman was transferred to the ICU where abdominal paracentesis revealed bloody ascites. She had a cardiac arrest and following resuscitation a laparotomy revealed 5L of hemorrhagic ascites without apparent bleeding focus. Due to progressive acute respiratory distress syndrome a transition to end-of-life care was decided."*

**BLOOD PRODUCTS & COAGULOPATHY**

- Repeat hemoglobin measurements during ongoing bleeding. One hemoglobin test result taken during the early phases of hemorrhage should neither be reassuring nor used to guide or withhold blood products when bleeding is ongoing.
- When bleeding is severe and ongoing, a massive transfusion protocol should be activated with an appropriate fixed-ratio (packed cells : plasma : platelets) transfusion strategy that may help to ensure timely correction of blood volume and coagulopathy.
- Coagulation must be monitored by observing clot formation and screening for coagulation parameters. Coagulation factors may be administered when coagulopathy is suspected or relevant changes in coagulation parameters are detected.
- Be aware of hemostatic impairment when bleeding is persistent or when there has been a delay in diagnosis. Timely recognition of coagulopathy may prevent delay in hemostatic interventions.

*“After removal of a placental remnant, the consultant-obstetrician noted excessive bleeding without clot formation and advised the anesthesiologist to administer packed cells that were not cross-matched and fresh frozen plasma. The anesthesiologist deemed otherwise based on a hemoglobin level of 9.18 g/dL (5.7 mmol/L) at induction of anesthesia with vital signs being within normal ranges following administration of phenylephrine IV. No blood products were administered, and a coagulation screening was initially not performed, despite the fact that the woman had already lost 4 liters of blood. Later, coagulation tests appeared abnormal. The obstetrician failed to control the bleeding, and cardiac arrest followed after intrauterine balloon tamponade with administration of sulprostone. A hysterectomy was performed after successful resuscitation. Loss of cortical functions and multiorgan failure led to cessation of medical support.”*



### **DISSEMINATED INTRAVASCULAR COAGULATION**

- Be vigilant of disseminated intravascular coagulation-related hemorrhage that may arise in women with amniotic fluid embolism, sepsis and preeclampsia. It is important to be aware and correct coagulopathy at an early stage during hemorrhage.
- Amniotic fluid embolism is a rare, life-threatening complication during or shortly after childbirth, characterized by an unexplained sudden (cardiovascular) collapse followed by disseminated intravascular coagulopathy if a woman survived the initial event. Timely consideration of the diagnosis with supportive therapy and rapid correction of coagulopathy is essential to avert adverse outcome.<sup>30</sup>

*“A woman had labor induced and received epidural analgesia. Shortly after her membranes had ruptured spontaneously, she had a cardiovascular collapse and CPR was initiated. During resuscitation it turned out that she already had full dilation and a successful instrumental vaginal birth was performed. She then developed disseminated intravascular coagulopathy followed by persistent hemorrhage, which had not been anticipated. There was no overall assessment of blood loss and insufficient replacement of clear fluids soon after resuscitation. Correction of coagulopathy was not initiated. Bleeding ceased after intrauterine balloon tamponade and radiological uterine artery embolization. She did not recover and supportive care was withdrawn on the ICU.”*

### **REFERRAL TO (ANOTHER) HOSPITAL**

- Obstetric hemorrhage may occur after return of circulation following peri-mortem cesarean section. If an out-of-hospital resuscitation is successful, compress or close the uterus and abdomen before transportation to hospital.
- Stabilize hemodynamically unstable women before transport to another hospital.

*“A woman collapsed at home and was found in a puddle of blood by the medical response team on site. Perimortem cesarean section was performed during resuscitation followed by spontaneous circulation. The placenta was not removed and the uterus was not closed before transportation. Upon arrival at the hospital, the woman was pronounced dead due to complete exsanguination from uterine blood loss.”*

## DISCUSSION

The MMR of obstetric hemorrhage as underlying cause of death in the Netherlands was 0.7 per 100 000 live births in 2006-2019, which was similar to the MMR in 1993-2005.<sup>11</sup> The overall obstetric hemorrhage-related MMR (including women who died to hemorrhage in the chain of events, but with a different underlying cause of death) in 2006-2019 was 1.1 per 100 000 live births. Commonest cause of hemorrhage as the underlying cause of death was retained placenta. Amniotic fluid embolism was the commonest underlying cause with hemorrhage in the chain of events. Our confidential enquiries provide clear lessons learned with emphasis on timely recognition and management of persistent bleeding with attention for coagulation. These lessons learned have led to clear advice on how to improve maternity care in order to reduce the obstetric hemorrhage-related MMR in the Netherlands in the following years.

Main strength of this study was that we prospectively collected obstetric hemorrhage-related maternal deaths over a 14-year period through a national surveillance system. Furthermore, we adapted the definition of obstetric hemorrhage as underlying cause of death as proposed by the ICD-MM.<sup>17</sup> Using this uniform definition enabled us to compare our findings with other international studies on obstetric hemorrhage-related maternal deaths. Through systematic confidential enquiries based on actual medical records, we were able to identify improvable care factors and formulate lessons learned. Nevertheless, the ability of cross-checking with Statistics Netherlands stopped in 2012.<sup>19</sup> A cross-check with the TeMpOH-1 study revealed an additional 3 deaths due to obstetric hemorrhage between 2011-2013 that were not reported to the AMSM. This implies that the MMR of obstetric hemorrhage in the Netherlands in 2006-2019 is possibly higher and our findings are an underestimation of the actual problem. This affirms the importance of reliable national pregnancy-related mortality surveillance and thus we hope to reestablish the possibility to cross-check with Statistic Netherlands. Nevertheless, since 2016, NethOSS sends out a monthly email to allocated clinicians in all hospitals with a maternity ward in order to report cases of severe maternal morbidity and mortality, or to declare 'nothing to report'. This secure electronic way of reporting with the option to declare 'nothing to report' will help to ascertain validity of this registration system and will lead to a reliable national pregnancy-related mortality surveillance system in the Netherlands.

While the overall MMR in the Netherlands between 2006-2018 decreased by 50% compared to 1993-2005, the obstetric hemorrhage as underlying cause of death-related MMR remained relatively low and stable.<sup>26</sup> Nevertheless, our MMR 0.7 per

100 000 live births was comparable to the obstetric hemorrhage-related MMR of France (0.9 in 2013-2015)<sup>31</sup>, Spain (0.82 in 1999-2015)<sup>32</sup>, and the United Kingdom (which varied between 0.34-0.78 in the time frame 2009-2017).<sup>33</sup> The United States (1.74 in 2016-2017)<sup>10</sup> and Italy (1.92 in 2006-2012)<sup>34</sup> reported obstetric hemorrhage-related MMRs that were considerably higher. It is also of note that the United Kingdom and France reported maternal deaths due to uterine rupture, uterine inversion, placental abruption, placenta previa and abnormally invasive placenta, all causes that are associated with severe obstetric hemorrhage, while none of the deaths in the Netherlands were related to one of these causes.<sup>31,33</sup> It is difficult to point out a clear explanation for this difference, and it would require comparisons with near miss cases. However, this finding emphasizes to remain vigilant of possible adverse outcome in all obstetric hemorrhage causes. The majority of our lessons learned are similar to those contained in the annual reports of 'Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK (MBRRACE-UK)', a national program of work investigating maternal deaths in the United Kingdom and Ireland.<sup>33,35,36</sup> These MBRRACE-UK reports also stress the importance of early recognition of bleeding and activating a massive obstetric hemorrhage protocol with one clinician taking a 'helicopter view' to coordinate all aspects of care, while clear communication within the whole team is crucial and invasive interventions should be applied sooner rather than later.<sup>33,35,36</sup> Furthermore, a report from nine maternal mortality review committees in the United States with data ranging from 2008-2017 identified similar improvable care factors (i.e. delay in diagnosis, inadequate management, and lack of coordination or communication) and stated that 70% of these obstetric hemorrhage-related deaths were preventable.<sup>30</sup> It indicates that multiple high-income countries are facing similar problems and may learn from each other's recommendations in order to save women's lives during obstetric hemorrhage.

Our lessons learned create awareness and provide clinical caregivers tools to improve maternity care during obstetric hemorrhage. Timely recognition and management of hemorrhage and vigilance for concealed hemorrhage and the development of coagulopathy remains of utmost importance. Appointing a clinical care coordinator is essential as several women died due to a lack of coordination and absence of a clear plan. As 19/29 women died with their uterus preserved, a decision to perform a hysterectomy may be taken more readily, especially in women in extremis or refusing blood products. Caregivers need to be aware of the risk of severe obstetric hemorrhage with amniotic fluid embolism, sepsis and preeclampsia and correct coagulopathy promptly. Considering that 66% of the women started out with a 'low-risk' pregnancy without risk factors should

assert clinical caregivers to remain vigilant of possible severe hemorrhage, and stimulate an active management of the third stage of labor. Finally, we endorse multidisciplinary team training, both at a local and national level, to be prepared for obstetric hemorrhage and improve communication and collaboration between caregivers during acute settings.

Our findings show that there are still multiple opportunities to improve maternity care during the course of obstetric hemorrhage in order to avert maternal deaths. This should encourage performing confidential enquiries in other countries to evaluate maternity care and identify improvable care factors that may avoid maternal deaths because of obstetric hemorrhage. It has been acknowledged that a comprehensive maternal mortality surveillance system with confidential enquiries and the engagement of community participation so that lessons learned are widely disseminated lead to a reduction in maternal deaths.<sup>8</sup> The United Kingdom has demonstrated commitment to reviewing maternal deaths and formulating lessons learned through the MBRRACE-UK program.<sup>33</sup> This program provides a framework for how national surveillance of maternal deaths may be applied in order to improve quality of maternity care.<sup>33</sup> We applaud the efforts to implement a similar program in the United States, i.e. 'Enhancing Reviews and Surveillance to Eliminate Maternal Mortality' (ERASE MM) with standardized collection of data on maternal deaths through the 'Maternal Mortality Review Information Application' (MMRIA).<sup>37</sup> Maternal deaths because of obstetric hemorrhage are rare in the Netherlands, and general lessons learned for specific obstetric-related maternal deaths are not yet reported back to clinical caregivers. Implementing a recurring (e.g. 5-year) cycle in which data on maternal deaths due to obstetric hemorrhage are shared and trended over time allows for more robust comparisons and evaluation of previously formulated lessons learned that may be published among clinical caregivers. Implementing a recurring obstetric hemorrhage-related theme-based cycle with confidential enquiries into deaths to repeatedly evaluate maternity care and formulate lessons learned should be encouraged across all settings.

## CONCLUSION

The obstetric hemorrhage-related MMR remained relatively low and stable in the Netherlands between the time frames 1993–2005 and 2006–2019. Nevertheless, it remains imperative to evaluate maternity care during obstetric hemorrhage in order to learn and avoid maternal deaths. Our lessons learned that were identified from confidential enquiries have led to clear advice on how to improve maternity care in order to reduce the obstetric hemorrhage MMR in the Netherlands in the following years. Implementing a recurring obstetric hemorrhage-related theme-based cycle of confidential enquiries into maternal deaths to repeatedly evaluate maternity care and formulate lessons learned should be encouraged across all settings.

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