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## Obstetric hemorrhage: improving care by collaborating across borders

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## Chapter 5

# **Binational confidential enquiry of maternal deaths due to postpartum hemorrhage in France and the Netherlands: lessons learned through the perspective of a different context of care**

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## Abstract

**Objectives:** To learn lessons for maternity care by scrutinizing postpartum hemorrhage management (PPH) in cases of PPH-related maternal deaths in France/the Netherlands.

**Methods:** In this binational Confidential Enquiry into Maternal Deaths (CEMD), 14 PPH-related maternal deaths were reviewed by six experts from the French/Dutch national maternal death review committees regarding cause and preventability of death, clinical care and healthcare organization. Improvable care factors and lessons learned were identified. CEMD practices and PPH-guidelines in France/the Netherlands were compared in the process.

**Results:** For France, new insights were primarily related to organization of healthcare, with lessons learned focusing on medical leadership and implementation of (surgical) checklists. For the Netherlands, insights were mainly related to clinical care, emphasizing hemostatic surgery earlier in the course of PPH and reducing third stage of labor by prompter manual removal of the placenta. Experts recommended extending PPH-guidelines with specific guidance for women refusing blood products and systematic evaluation of risk factors. The quality of CEMD was presumed to benefit from enhanced case finding, also through non-obstetric sources, and electronic reporting of maternal deaths to reduce the administrative burden.

**Conclusion:** A binational CEMD revealed opportunities for improvement of care beyond lessons learned at the national level.

## Introduction

Where maternal deaths and severe acute morbidities have generally been reducing in high-income countries, the incidence of postpartum hemorrhage (PPH) has paradoxically been on the rise in many settings. The literature reports the importance of cross-border collaborations to study and reduce the burden of PPH and comparing incidence and management of PPH between countries might be a way to identify shortfalls in PPH care.[1-2]

Maternal mortality (MM) due to PPH is still largely preventable and case fatality rate of PPH can be considered an indicator of the quality of obstetric care.[3] The PPH-related maternal mortality ratio in France has decreased over the last decade, but remains high compared to the United Kingdom and the Netherlands.[4-7] However, the increasing incidence of PPH in the Netherlands indicates that also in that country continuous efforts are needed to improve PPH-related care.[8, 9]

Following this line of thought, we designed a binational confidential enquiry into maternal deaths (CEMD) for France and the Netherlands, which have conducted national CEMDs since 1995 and 1981 respectively.[10, 11] Since obstetric care differs to some extent between these two countries, we hypothesized that additional lessons learned, beyond those already identified by the French and the Dutch committees, might emerge from a binational review of PPH-related maternal deaths. Reviewing cases through a different “contextualist” framework by experts from two different care contexts, may give rise to new perspectives.

Our primary objective was to learn lessons for maternity care in both countries by scrutinizing management of PPH in individual cases of PPH-related deaths. Secondary objectives were to (a) compare conclusions on cause and preventability of death of our binational CEMD with those from the French/Dutch national expert committee on maternal mortality (b) compare national PPH-guidelines while reviewing such cases, and (c) compare CEMD practices between both countries in the process.

## Methods

We organized a binational review of PPH-related maternal deaths reported to the Dutch Audit Committee Maternal Mortality and Morbidity (Auditcomissie Maternale

Sterfte en Morbiditeit, AMSM) and the French National Confidential Enquiry on Maternal Mortality (ENCMM).

The French national expert committee on maternal mortality (CNEMM) and AMSM were each represented by three experts; the French committee by two obstetrician-gynecologists and one anesthesiologist from CNEMM and the Dutch by three obstetrician-gynecologists from AMSM, two from tertiary academic centers and one from a secondary level teaching institution.

PdV was present during one meeting of both AMSM and CNEMM in order to (A) be trained in performing CEMD, (B) observe differences in CEMD practices, and (C) have the appropriate background knowledge to be able to organize this binational CEMD.

### **Study-population**

In total, 14 cases of PPH-related maternal deaths were selected (PdV,TvdA, CDT). For each country, five cases of PPH by atony and two cases of PPH by cesarean surgical trauma were selected consecutively since these etiologies are among the main causes of severe PPH. [12] The number of cases was pragmatically determined by PdV, TvdA and CDT based on the number of cases available for each country. French cases were selected among maternal deaths that happened in 2013-2019. Since the absolute number of Dutch cases was lower, these were selected over 2008-2019. The different methods for the identification of maternal deaths by AMSM/ENCMM are described in the Table S1.

### **Data collection**

Each case file was fully translated from French to Dutch or inversely by PdV, who is fluent in both languages. Medical records included antenatal charts, medical charts on management of PPH, laboratory and microbiology results, operation reports and autopsy reports. In France, information is extracted by two clinical assessors designated to collect on-site information by completing an elaborate standardized questionnaire. This information was translated on site at the Obstetrical, Perinatal and Pediatric Epidemiology Research Team (Epopé) unit of INSERM in Paris, France where fully anonymized medical records are stored, only accessible by the ENCMM coordination team. In the Netherlands, all charts are uploaded by the local maternity care worker reporting the maternal death. 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 Dutch cases were consulted on a secured online network only accessible by AMSM members.

The translated and anonymized medical records were accessible electronically on a protected server one month prior to a physical gathering for all six participating experts. The experts received an extensive informative document about organization of maternity care in both countries.

In January 2022, both teams met in Paris for a two-day meeting consisting of three parts. (1) Presentation of the French/Dutch PPH-guidelines followed by a discussion between the experts. (2) Presentation of the cases by the experts followed by a systematic discussion in English led by a moderator highly trained in CEMD, fluent in French and English (CDT). The discussion was observed and documented by an epidemiologist from INSERM involved in the confidential enquiries in France for several years (MS) and PdV. (3) Presentation of the identified improvable care factors and formulation of lessons learned by the experts. Differences emerging from the discussion on national PPH-guidelines and CEMD practices resulted in recommendations.

## **Analysis**

Patient and hospital characteristics were analyzed for each case (PdV). Cause of death was classified according to the International Classification of Diseases and Related Health Problems (ICD-10), followed by preventability of death, defined as any action or inaction that could have prevented fatal outcome.[13] Results were compared with previous conclusions by CNEMM/AMSM. Improvable care factors were classified per topic. Qualitative data were expressed as number (percentage) and quantitative variables as median (range). Statistical significance testing was deemed not necessary since data were purely descriptive. Each woman’s care was systematically assessed by the French/Dutch experts on appropriateness of clinical care (pre-conceptional care, pregnancy follow up, obstetric care, anesthesiologic care, intensive care), organization of healthcare (equipment and materials, communication, quality of documentation, transportation) and interaction of the patient with the healthcare system (failure of follow up of the patient, social vulnerability, mental vulnerability), number of preventable deaths according to level of care of delivery hospital. Most relevant and redundant improvable factors resulted in lessons learned accompanied by case-histories to illustrate the subtleties of culture and context brought to light by our binational meeting.

Statistical analysis was performed using Stata® v16 software.

**Ethical considerations:** For the Dutch data, ethical approval was waived since this is not required for CEMD, considered an essential element to improve birth care. In France, ENCMM is approved by the National Data Protection Authority (CNIL) and thus ethical approval was not required either. Collected data are fully anonymized and publications following analysis of these data cannot be traced back to individual patients nor to health workers. Informed consent was therefore not required.

## Results

Maternal, pregnancy and hospital characteristics are presented in Table 1. Differences were mainly related to hospital facilities such as an adult intensive care unit (ICU), blood bank and access to an interventional radiology unit. In France, 5/7 (71%) women who died gave birth in a hospital without an ICU whereas this was zero for the Netherlands where acute obstetric care is generally only provided in hospitals with an ICU. Hospital facilities were more limited in France, necessitating frequent patient-transfer to better adapted organizational structures.

**Table 1.** Patient characteristics, hospital characteristics, cause of death and preventability of death of individual PPH related maternal deaths from France and the Netherlands

	Dutch cases N=7	French cases N=7
<b>PATIENT CHARACTERISTICS n (%)</b>		
<b>Age</b>		
20-29	1 (14)	0
30-39	6 (86)	5 (71)
>40	0	2 (29)
<b>Ethnicity</b>		
Caucasian	5 (71)	4 (67)
African	1 (14)	1 (14)
Caribbean	1 (14)	0
Asian	0	2 (29)
Obesity	0	0
<b>Parity</b>		
Nulli parous	2 (29)	3 (43)
Multi parous	5 (71)	4 (57)
Scarred uterus	1 (14)	3 (43)
<b>Mode of birth</b>		
Vaginal spontaneous	3 (43)	2 (29)
Instrumental	2 (29)	0
Cesarean section	2 (29)	5 (71)
<i>Planned</i>	0	0
<i>Emergency</i>	2 (29)	5 (71)
<b>PPH risk factors</b>		
Uterine scar	1 (14)	3 (43)
History of PPH	0	1 (14)
Pre-eclampsia	1 (14)	1 (14)
Multiple gestation	0	0
Macrosomia	2 (29)	1 (14)
Labor augmentation	2 (29)	2 (29)
Placenta previa	1 (14)	0

**Table 1. (continued)**

	<b>Dutch cases N=7</b>	<b>French cases N=7</b>
<b>Place of birth <sup>1</sup></b>		
Home	0	0
Out-patient in hospital birth	1 (14)	0
In-patient hospital birth	6 (86)	7 (100)
<b>CHARACTERISTICS DELIVERY HOSPITAL</b>		
<b>Number of births</b>		
< 500 births / year	0	1 (14)
>500 < 1500 births / year	2 (29)	2 (29)
> 1500 < 3000 births / year	4 (57)	1 (14)
> 3000 births / year	1 (14)	3 (43)
<b>Level of care <sup>2</sup></b>		
Primary care hospital	0	3 (43)
Secondary care hospital	4 (57)	2 (29)
Tertiary care hospital	3 (43)	2 (29)
<b>Facilities</b>		
Obstetrician present		
<i>On site 24h/24h</i>	3 (43)	5 (71)
<i>On call at night</i>	4 (67)	2 (29)
Anesthesiologist present		
<i>24h/24h on site</i>	5 (71)	5 (71)
<i>On call at night</i>	2 (29)	2 (29)
Adult intensive care unit	7 (100)	2 (29)
Embolisation unit	4 (57)	2 (29)
Blood bank	7 (100)	2 (29)
Laboratory	7 (100)	2 (29)

**Table 1. (continued)**

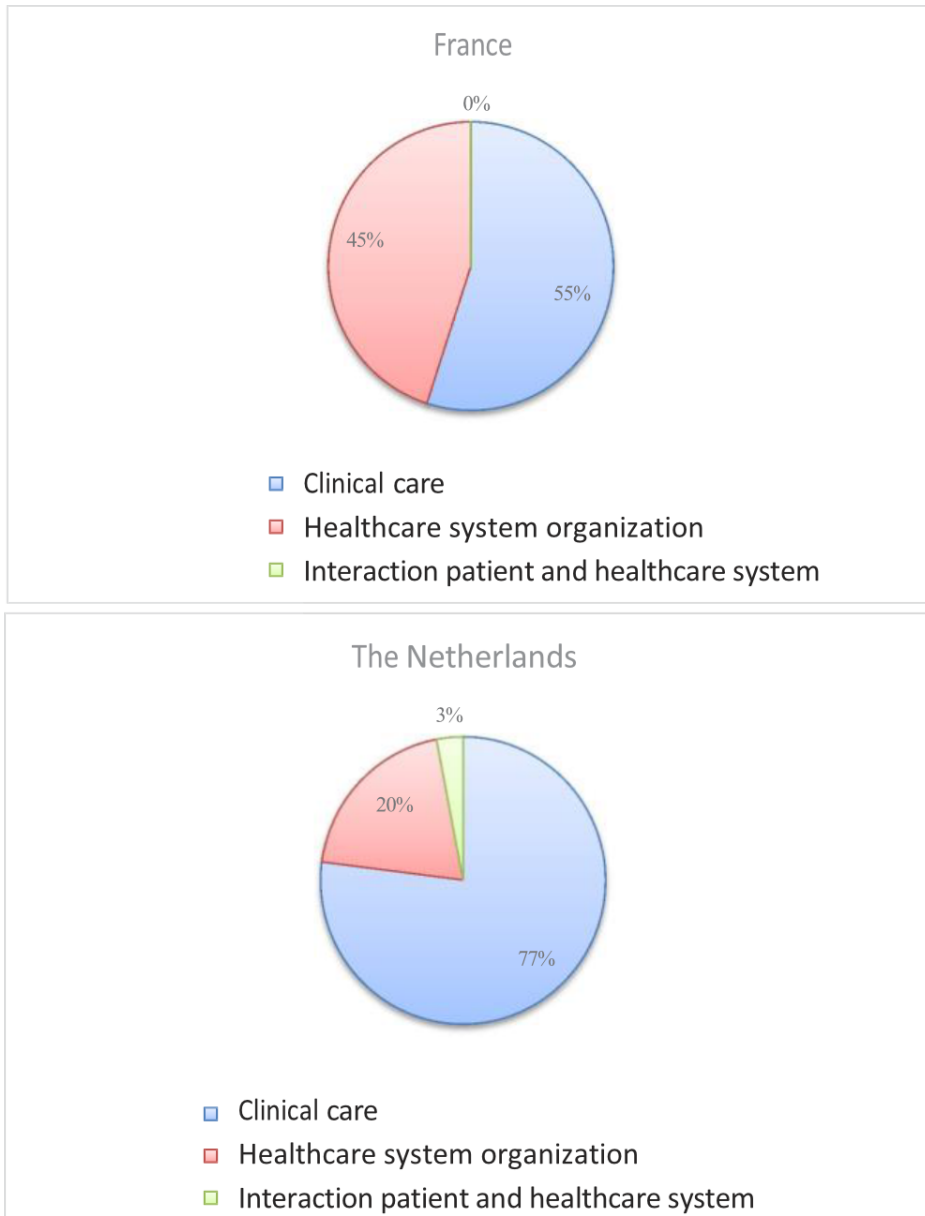
	Dutch cases N=7		French cases N=7	
	Binational review	AMSM	Binational review	CNEMM
<b>Cause of death</b>				
Atony	4 (67)	5 (71)	5 (71)	5 (71)
Surgical lesion	2 (29)	2 (29)	2 (29)	2 (29)
Other	1 (14)	0	0	0
<b>Preventability of death</b>				
No conclusion	0	0	1 (14)	1 (14)
Not preventable	1 (14)	0	0	0
Perhaps preventable	0	1 (14)	0	2 (29)
Probably preventable	6 (86)	6 (86)	6 (86)	4 (67)
<b>Preventable deaths according to level of care</b>				
<i>Primary care</i>	0		3 (43)	
<i>Secondary care</i>	4 (57)		2 (29)	
<i>Tertiary care</i>	2 (29)		1 (14)	

Abbreviations: AMSM = Auditcommissie Maternale Sterfte en Morbiditeit; CNEMM = The French national expert committee on maternal mortality; PPH= postpartum hemorrhage

<sup>1</sup> Place of birth could be at home or at the hospital as outpatient or inpatient. This distinction was made following the maternity care system in the Netherlands where low risk parturients can have a home birth with their own midwife. If a parturient wishes to give birth at a hospital without a medical indication, she can have an outpatient in hospital birth which means her own midwife and not the hospital oversees the birth. Women with a medical indication give birth under responsibility of the hospital (inpatient).

<sup>2</sup> Primary care hospital: local, general hospital / secondary care hospital: regional, general hospital / tertiary care hospital: central, academic hospital

Improvable care factors were identified for all maternal deaths and classified per topic (Table 2). For France, most new perspectives were related to organization of healthcare. For the Netherlands, new insights related especially to clinical care (Figure 1). Lessons learned with regards to improving maternity care are presented along with case histories (Box 1).



**Figure 1.** Improvable care factors for France ( $n = 30$ ) and the Netherlands ( $n = 34$ ) categorized per topic. Several improvable care factors could be categorized under more than one case.

**Table 2.** Improvable care factors identified by the experts of the binational review categorized per topic

	French cases	Dutch cases
Number of cases (n)	7	7
Total number of improvable care factors (n)	30	34
Median number of improvable care factors per patient	3	4
<b>Clinical care (n)<sup>1</sup></b>		
<b>Preconceptional care</b>		
<i>In vitro fertilisation despite advanced maternal age</i>	1 (14)	0
<b>Pregnancy follow up</b>		
<i>Insufficient diagnostic testing when indicated</i>	1 (14)	1 (14)
<i>Failure to consider timely birth</i>	0	1 (14)
<b>Obstetric care</b>		
<i>Delay in PPH diagnosis</i>	3 (43)	2 (29)
<i>Delay in PPH treatment</i>	3 (43)	6 (86)
<i>Inadequate PPH treatment (no hemostatic surgery)</i>	0	4 (57)
<i>Lack of recognition of PPH risk factors</i>	2 (29)	0
<i>Absence of senior staff for PPH management</i>	0	2 (29)
<b>Anesthesiologic care</b>		
<i>Delayed coagulation testing</i>	0	3 (43)
<i>Delayed transfusion treatment</i>	5 (71)	4 (57)
<i>Inadequate transfusion treatment</i>	2 (29)	2 (29)
<b>ICU care</b>		
<i>Delayed treatment</i>	0	1 (14)
<i>Inadequate treatment</i>	0	1 (14)

**Table 2. (continued)**

	French cases	Dutch cases
<b>Organization of the healthcare system (n)</b>		
Equipment and materials		
<i>Lack of blood products</i>	1 (14)	0
<b>Communication</b>		
<i>Lack of leadership</i>	3 (43)	1 (14)
<i>Surgical safety checklist not used</i>	4 (57)	0
<b>Quality of documentation of the case files</b>		
<i>Lacking documentation</i>	1 (14)	5 (71)
<i>Inadequate documentation</i>	2 (29)	2 (29)
<b>Transportation</b>		
<i>Inadequate indication for transfer</i>	0	1 (14)
<i>Poorly organized transfer</i>	2 (29)	0
<b>Interaction of the patient and the health care system (n)</b>		
Failure of follow up of the patient	0	0
Mental vulnerability	0	0
Social vulnerability	0	1 (14)

Abbreviations: PPH = postpartum hemorrhage; ICU= intensive care unit

<sup>1</sup> Number of cases

Improvable clinical care focused mainly on manual placenta removal (MPR) and on performing hemostatic surgery (vascular ligation/uterine compression sutures). In some Dutch cases, a significant time delay was noticed between PPH diagnosis and MPR at the operating theatre. The French experts suggested this delay could be reduced by performing MPR at the labor ward in presence of an epidural, which is not standard practice in the Netherlands. There was a difference between the binational experts with regard to the use of hemostatic surgery. The Dutch preferred arterial embolization earlier in the chain of events whereas the French had a lower threshold to perform hemostatic surgery. Although this finding could be partly explained by differences in national recommendations, the experts also hypothesized that the more restricted use of hemostatic surgery in the Netherlands might have resulted in an more important barrier to perform this type of surgery among obstetricians in the Netherlands.

Organization of the healthcare system could mainly be improved through better communication between maternity care workers and optimization of hospital facilities. It was clear from the French cases that sign-outs at the end of surgery were not common practice. In the Netherlands this would include sponge and instrument counts, the recap of any surgical or anesthesiologic problems and special notices for the postoperative management and such a sign-out is performed before leaving the operating theatre after any procedure in presence of all the maternity workers concerned. Furthermore, in the French cases, several reports disclosed the absence of someone having a ‘helicopter’ view engendering situational unawareness. There was no direction of the team and responsibilities were sometimes unclear, resulting in delays in appropriate management.

The differences between the French/Dutch PPH-guidelines resulted in topics for future research and matters to keep in mind when updating national PPH-guidelines (Table 3). The importance of the national context of these recommendations was stressed for the prevention and management of PPH in women refusing blood products; indeed, whereas in France the law allows doctors to transfuse Jehovah’s witnesses in case of vital risk, in the Netherlands this is not possible without the woman’s consent.

**Table 3.** Recommendations from the experts from the binational CEMD for future updates of national PPH guidelines

Topic	Recommendation
Mode of birth	Guidelines could adapt management strategies for PPH to mode of birth since this could reduce the need for invasive surgery for PPH after vaginal birth and reduce delay in patients that underwent caesarean section.
Second-line uterotonics	Some of the different point of views on the use of second-line uterotonics arise from the absence of high-level evidence on this topic. Clear guidance is needed on which type of uterotonics should be included in the guidelines and trials should focus on timing of the administration of second-line uterotonics once initial management of PPH fails.
Guidance for women refusing blood products	Each guideline should have clear guidance on multidisciplinary management of women refusing transfusion of blood products. Guidelines could include a checklist as part of their standardized protocol that would list the different blood products and alternative treatments and provide information on preconceptionally counseling, pregnancy follow up and intra partum care. An informed consent signed by the patient is recommended. Guidelines should be adapted to each national context to ensure optimal management of PPH.

**Table 3. (continued)**

Topic	Recommendation
Timing of management	Guidelines could provide more detailed recommendations on when to escalate management of PPH and advert senior staff. More details are needed concerning timing of interventions such as second line uterotonics, intra uterine balloon tamponade and more invasive interventions as well as on resuscitation therapy.
Risk assessment	Guidelines should provide tools for PPH risk assessment in order to identify patients at high risk of PPH before birth as well as after birth so that customized preventive measures can be taken and post-partum surveillance can be intensified.

Recommendations on the conduct and organization of CEMD are presented in Table 4. The finding that Dutch cases were more often lacking documentation on pregnancy follow-up (4/7, 67%) and anesthesiologic care (2/7, 29%) could well be explained by the method of information extraction, the French committee members collecting data on the spot after the maternal death.

**Table 4.** Recommendations from the experts from the binational CEMD on organization of confidential enquiries into maternal deaths

Topic	Recommendations
Composition national committee of maternal deaths	We recommend that audit committees are represented by care providers from both primary and secondary care hospitals since this contributes to a more homogenous representation of medical care provided in a country.
Identification of deaths	In addition to direct notification of cases to the audit committee, linkage of birth registries and hospital discharge databases with death registries could improve completeness of reported maternal deaths. This is crucial to obtain a reliable identification of maternal deaths and adequate overview of incidence of maternal death in a country.
Electronic reporting	Countries should reflect on how to implement an electronic system for reporting cases of maternal death in which case files can be uploaded through a protected online server
Information extraction	On site visiting and documenting seems to provide more complete case files which contributes to a more in-depth review of the case which could lead to better identification of improvable factors.
Safety	Safety of the confidential enquiry should be maintained. Efforts should be made to strengthen the confidence in the audit team and making maternity care workers less uncomfortable by reporting maternal deaths and providing all the available information on the case.

## Discussion

Our review brings to light that multinational reviews of maternal deaths can identify opportunities for improvement of care that go beyond the lessons learned already identified by national enquiries, by adding the perspective from a different context of care. Main lessons learned for France focus on organization of healthcare, in particular on implementation of surgical checklists and assignment of leadership. Principal lessons learned for the maternity care workers in the Netherlands are mainly related to clinical care, stressing to reduce delay of third stage of labor by considering manual placenta removal (MPR) under epidural and the performance of hemostatic surgery rather sooner than later. These lessons learned could be adapted to each national structure. Our review provides tools for organization of CEMD like identification of maternal deaths and electronic reporting and ideas for future updates of PPH-guidelines such as more guidance on women declining blood products.

A strength of our study is the interaction between experts of two national audit committees resulting in a complementary and critical detection of improvable care factors from a different perspective. Linguistic barriers were minimized by translation of all medical records into the experts' native language. The professional experience of PdV as a resident in obstetrics and gynecology in both countries facilitated the conduct of this binational enquiry. Limitations of our study included some medical records being incomplete and small study size. The longer study period for the Netherlands (2008-2019) as compared to France (2013-2019) was not considered a limitation since the Netherlands have not seen any major adjustment in PPH-recommendations from 2008 on, other than the introduction of tranexamic acid following the WOMAN trial.[14] Although there was no anesthesiologist included among the Dutch experts, this was done on purpose since, contrary to France, PPH care in the Netherlands is generally obstetrician-led with no (obstetric) anesthesiologist present at the labor ward.

The literature does not provide clear evidence on which anesthetic technique is more effective for MPR.[15] General anesthesia with intubation is recommended in case of hemodynamic instability, even if an epidural catheter is in place, to protect the airway and to control ventilation. MPR under epidural (if already in place) has been reported as a safe alternative for general anesthesia since it is faster and preventative for risks associated with general anesthesia such as airway compromise and aspiration.[16, 17] Depending on organizational structures such as the presence of an anesthesiologist at the labor ward, spinal anesthesia could be

performed at the labor ward if an epidural is not yet in place, in the absence of hemodynamic instability and coagulation disorders.[18] Yet, little data exist on patient satisfaction and intraoperative discomfort regarding the different types and routes of anesthesia during this procedure.

Implementation of surgical checklists such as those proposed by the World Health Organization could improve patient outcome by better information transfer during and after surgery. This creates more awareness of PPH-risk factors which can optimize postpartum surveillance.[19] Explicit assignment of leadership during PPH to better coordinate teamwork and adhere to PPH drills could be pointed out loud. This can be trained by (multidisciplinary) simulation training.[20, 21] The lack of resources and PPH-coordination contributed to preventability of death particularly in primary care hospitals. In this context, centralization of acute obstetric care has been proposed to improve maternal outcome. However, others have suggested this may paradoxically worsen outcome through longer travel times.[22] Guidelines may therefore include a minimum of standards necessary to provide acute obstetric care -for both the infant and the woman- such as access to blood products and biochemistry facilities as has been proposed by ACOG.[23]

The absence of specific recommendations for patients declining blood products such as Jehovah's witnesses is a recurrent problem among guidelines in high-income countries. Having a 130-fold increased PPH-related mortality risk, specific guidance on the counselling of these women could be integrated in clinical practice guidelines including pre-labor optimization of hemoglobin, cell salvage and a description of the minimal resources required for a hospital to provide labor care to these women. [24,25] The need to adapt these recommendations to each national context was illustrated in this article.

## **Conclusion**

The findings of our binational review of hemorrhage related maternal deaths emphasize that there are still opportunities to improve maternity care among women suffering from PPH in high income countries. We encourage the performance of multinational confidential enquiries to identify improvable care factors through a different context of care.

**Box 1.** Lessons learned formulated by the experts from the binational CEMD

**Lessons learned on clinical care**

**Obstetric care**

In case of retained placenta, regular monitoring of fundal height, volume of blood loss and vital parameters are recommended. Maternity care workers should anticipate PPH when delay of third stage of labor exceeds 30 minutes.

To reduce delay between PPH diagnosis and manual removal of placenta, it can be considered to manually remove the placenta under epidural analgesia at the labor ward.

There seems to be a significant barrier for obstetricians to perform hemostatic surgery such as uterine compression sutures and vascular ligation. This procedure can however be lifesaving and should be performed rather sooner than later after failure of second-line uterotonics and intra uterine balloon tamponade, especially in women giving birth by cesarean section and in hospitals without recourse to transcatheter radiological embolization. Simulation training sessions on how to perform this type of surgery could be implemented to train these surgical skills.

*A 25-year-old had an uncomplicated vaginal birth under epidural. Fifty minutes later, bleeding started while the placenta was still retained. When the obstetrician arrived 5 minutes afterwards, she had already lost 1,2L of blood despite second-line uterotonics. The placenta was manually removed under general anesthesia at the operating theatre 35 minutes after start bleeding. Blood loss was estimated at 3,5L at that point and she had become hemodynamically unstable despite interventions. The patient died at the operating room due to cardiac arrest. The French experts concluded that the long delay between decision to transfer the patient to the operating theater and the actual manual placenta removal probably contributed to this death.*

**Anesthesiologic care**

In case of major obstetric hemorrhage it can be considered to use ketamine instead of propofol. Due to its combination of rapid blood - cerebral transfer kinetics and sympathomimetic hemodynamic effects, ketamine is more adapted in case of hypovolemic shock.

Timely coagulation screening seems critical in the course of PPH and we recommend this should be regularly monitored during the course of PPH. National guidelines could detail the timing of these tests to ensure optimal transfusion.

*A 28-year-old patient who gave birth vaginally, was transferred to the operating room for removal of placental remnant and PPH. At arrival at the operating theatre, blood loss was estimated at 2L and she had a blood pressure of 95/40mmHG, and a cardiac frequency of 115 beats per minutes. Sedation was performed by a rapid sequence induction and intubation with propofol 10mg/ml, 300 mg IV. When placental remnant was removed, blood loss was estimated at 4L. Soon after, the patient had a cardiac respiratory arrest. She dies 45 min later. The French experts concluded that the dose of propofol was very high in this case. Ketamine or a reduced dose of propofol in this hemodynamic instable patient would have been more appropriate (0.5-1mg/kg or less) since propofol reduces system vascular resistance and has myocardial depressant effects.*

**Box 1. (continued)****Lessons learned on clinical care****ICU care**

If a patient presents signs of a septic shock after severe PPH, uterine necrosis should be part of the differential diagnosis. If this suspicion is high, a hysterectomy should be performed rather sooner than late.

*A 38-year-old woman gave birth in a secondary care hospital by an uncomplicated cesarean section for suspicion of cephalo-pelvic disproportion. After 20 hours postpartum, she presented signs of a hemorrhagic shock. Emergency laparotomy was performed, removing 3L of bloodclots. A small bleeding artery was detected under the bladder flap and repaired and she was transferred to the ICU where her clinical condition initially improved. 10 days after giving birth, she suddenly presented signs of a septic shock. Clinical and laboratory exams suspect sepsis caused by uterine necrosis and the patient is treated by high doses of IV antibiotics. She dies 24h later. A microbiological exam shows the presence of uterine necrosis probably due to an episode of low cardiac output due to PPH resulting in a secondary infection with a streptococcus. The French experts concluded that the source of sepsis, the uterus, should have been removed since the clinical condition of the patient was good enough to perform surgery.*

**Lessons learned on organization of the health system****Equipment and materials**

The minimum resources needed to deal with unexpected PPH like presence of blood products, resuscitation skills and surgical skills should be defined in each protocol.

Discussion should exist on the safety of having a delivery ward with a very low number of births. Also, discussion should exist on having a delivery ward in a hospital without an adult ICU on site.

**Communication**

Hospitals should consider the use of surgical safety checklists such as proposed by the World Health Organization. Before the surgeon makes the skin incision a 'time-out' should be performed. Before the patient leaves the operating room, a 'sign-out' should be performed during which the whole team should be present and during which postpartum surveillance is discussed and adapted according to the patient's risk factors. These checklists could be adapted to each national structure.

Assignment of leadership during the course of PPH can clarify responsibilities in particular when two medical specialists are involved. Leadership can evolve along the course of PPH and should be pointed out loudly so as to make this clear to the whole team involved. This could be trained by implementing on site multidisciplinary simulation training on acute obstetric hemorrhage.

National guidelines could recommend the implementation of this type of training on a local and national level.

*A 39-year-old patient gave birth by an uncomplicated emergency cesarean section according to the surgical report of the obstetrician. Nevertheless, the report of the anesthesiologist mentions a hemodynamically unstable patient during the surgery, necessitating ephedrine twice. After finishing the operation, the obstetrician leaves. The report of the operating nurse describes 2000 mL of blood in the collector system after surgery. During that night, the patient becomes again hemodynamically unstable and an emergency laparotomy is performed. A large retroperitoneal hematoma is found. The source of the continuous bleeding cannot be detected and a hysterectomy is performed. Total amount of blood loss: 7000 ml. The woman dies 3 days later due to multi-organ failure. The Dutch experts concluded that the absence of communication between the anesthesiologist and the obstetrician, and the absence of a sign out, which could have alerted the medical team and increased vigilance during postpartum surveillance, probably contributed to worse maternal outcome.*

**Box 1. (continued)**

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**Lessons learned on clinical care**

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**Documentation**

Complete mandatory documentation of all events is recommended by using special PPH charts including vital parameters, timing and quantity of blood loss, timing of coagulation screening, timing of administration of pharmaceutical agents and blood products as well as timing of interventions and the names and functions of the staff involved. Creating such a timeline can help in obtaining insight on substandard care as well as excellent care.

Clear agreements on responsibilities for postpartum surveillance depending on where the patient is being monitored after vaginal birth or cesarean birth could improve quality of care. Agreements could include which parameters should be monitored, frequency and total duration of surveillance as well as specification on when the gynecologist and anesthesiologist should be notified.

*A 32-year-old woman gave birth by an uncomplicated emergency cesarean section for fetal indication. Two hours later, she is found in hemorrhagic shock at the recovery ward. Emergency laparotomy is performed, and a uterine artery lesion is diagnosed. Despite surgical repair and massive transfusion therapy, adequate hemostasis cannot be achieved. A hysterectomy is carried out during which the patient has a cardiopulmonary arrest. Although spontaneous circulation returns, she develops diffuse intravascular coagulation and she eventually dies two days later due to multi-organ failure. Since there was no documentation of the follow up at the recovery ward, it was not clear for the experts whether post-operative surveillance had been adequate. Documentation of these parameters would have given better understanding of what happened at the operating ward and whether there was a lack of monitoring or whether abnormal vital parameters were not considered as such.*

**Transfer**

Transporting a hemodynamically instable patient is a serious risk. Referral to another hospital should therefore only be considered in hemodynamic stable patients. Benefits of care available at another facility should be weighed out against the potential risks of the transfer.

Poorly organized transfer can significantly contribute to morbidity and mortality and hospitals should aim for protocols dedicated to transferring patients with severe PPH. There needs to be consensus between the transferring and receiving health facility about timing of transfer and the equipment and skills of the medical staff accompanying the patient during transfer.

*A 29-year-old patient gave birth at a secondary care hospital and presented massive hemorrhage due to uterine atony. She was treated and stabilized by aggressive resuscitation therapy and referred to a tertiary hospital for transcatheter radiological embolization. However, just before transport she became again hemodynamically unstable reason why the anesthesiologist accompanied the patient in the ambulance during the transfer. Although the experts agreed on the fact that this patient should not have been transferred due to hemodynamic instability, they also noticed the transfer was extremely well organized by both the referring and the receiving facility which underlines the importance of regional protocols for referral of patients with severe PPH.*

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## Supplemental information

**Table S1.** Organizational differences between confidential enquiry into maternal deaths in France and the Netherlands

	<b>ENCMM</b>	<b>AMSM</b>
Implementation	1995	1981
Experts	6 obstetric gynecologists  5 anesthesiologists 2 midwives 1 intensive care physician 1 specialist in internal medicine 3 epidemiologists The experts are mandated for 3 years, renewable once. Members are employed at academic and non-academic hospitals. A psychiatrist participates in case of maternal suicide and an obstetrician with expertise in legal medicine participates when reviewing cases with autopsy.	8 obstetric gynecologists  1 obstetric anesthesiologist 2 registrars in obstetrics and gynecology Members are employed at academic and non-academic teaching hospital
Identification of deaths	Multisource death certificates; Direct declaration; linkage between national death- and birth-registers, national hospital discharge database. Deaths from metropolitan France and overseas departments are reported.	Direct reporting 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. The NethOSS is a national surveillance system of severe maternal morbidity and mortality.  No cross check or linkage
Information extraction	Standardized questionnaire  All medical records, including antenatal charts, pregnancy follow up, medical charts on management of PPH, laboratory and microbiology results, operation reports and autopsy reports.	Standardized questionnaire  All medical records, including antenatal charts, pregnancy follow up, medical charts on management of PPH, laboratory and microbiology results, operation reports and autopsy reports.

**Table S1. (continued)**

	<b>ENCMM</b>	<b>AMSM</b>
By whom	A duo of clinical assessors, independent from the clinical team in charge of the woman who died, is designated to collect on site information on the cases and fill in an elaborated standardized questionnaire.	The medical team implicated in the maternal death uploads all the documents on a secured server. The medical team reporting the case is asked to fill in a standardized questionnaire.
Review of deaths	Plenary reunion with all experts that all received a copy of the complete anonymized file and questionnaire filled in by the clinical assessors. Every case is presented by two experts followed by a discussion between all the experts in order to find consensus on the classification.	Plenary reunion with all experts that all had access to the complete file. Every case is presented by 1 expert followed by a discussion between all the expert in order to find consensus on the classification that is only accessible form members of the AMSM.
Classification of death	Cause of death by using ICD-10 code	Cause of death by using ICD-10 code
Evaluation of care and preventability factors	Clinical care Organization of the health care system Interaction patient with the health system	Clinical care Organization of the health care system Interaction patient with the health system
Number of plenary meetings yearly	6	4
Methods of dissemination	Report, published on the websites of INSERM and of the French Public Health Agency	No report
Frequency of dissemination	Triennial	No report

Abbreviations: PPH = postpartum hemorrhage, AMSM: Auditcomissie Maternale Sterfte en Morbiditeit.; ENCMM = French National Confidential Enquiry on Maternal Mortality