Severe maternal morbidity in Ireland

NATIONAL PERINATAL EPIDEMIOLOGY CENTRE

ANNUAL REPORT 2012 and 2013

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Acknowledgements

Welcome to the second report from the National Perinatal Epidemiology Centre (NPEC) Audit of Severe Maternal Morbidity in Ireland. This is also the first report published by the NPEC since it aligned with the National Office of Clinical Audit (NOCA). The NOCA was established in 2012 with the purpose of providing assisted governance to sustainable clinical audit programmes across all health services at national level in order to improve outcomes for Irish patients. Our participation in NOCA ensures a process by which we can close the audit loop. This begins with bench marking clinical care with identified standards, such as those set by the National Clinical Programme in Obstetrics and Gynaecology, the Institute of Obstetrics and Gynaecology and the Faculty of Paediatrics, and ends with implementing change for the improvement of patient safety and quality of care. The NOCA Governance Board endorsement of this Report is in Appendix A.

Severe maternal morbidity (SMM) has gained much attention in developed countries over the last decade as an important quality indicator of obstetric care and maternal welfare. The main reason for this is that maternal mortality, historically used as a quality indicator of maternity services, is now very low in high-resourced countries. Further, there is evidence that commonly occurring life-threatening complications, such as major obstetric haemorrhage (MOH), are underexposed as they less frequently lead to death in high-resourced countries.

The absence of international consensus on definitions of SMM is problematic and impedes comparative analysis between similarly resourced countries. Whereas some definitions have included management-based systems and an organ-based definition, others propose a morbidity continuum, beginning with health and normal pregnancy, moving along the spectrum of morbid events to death. This concept, described by Mantel et al.[1], conveys that maternal death only represents the 'tip of the iceberg'.

In this context, the NPEC established a multidisciplinary specialist Maternal Morbidity Advisory Group in 2010 to advise on the investigation of SMM in Ireland: members of the Group are listed in Appendix B. In collaboration with the Maternal Morbidity Advisory Group, the NPEC has collected and analysed anonymised maternal morbidity data from Irish units since 2011 using the validated and respected Scottish Confidential audit (SCASMM) methodology. This has allowed for comparison of maternal outcomes with a relatively similar health care provision service and pregnant population. The NPEC would like to acknowledge with thanks the Reproductive Health Programme of the National Health Service (NHS) Quality Improvement Scotland for permission to modify and use their Severe Maternal Morbidity Notification and Major Obstetric Haemorrhage forms for use in Ireland.

Measurement of the outcome of care in Irish maternity services is central to the development of safe and high quality health care. Support from all Irish maternity units is instrumental in the success of this national audit. On behalf of the NPEC, I extend my sincere thanks and appreciation to the many midwives, obstetricians and administration staff who have voluntarily contributed data to this audit (Appendix C). This is particularly laudable considering the impact on staffing levels resulting from the ongoing recruitment moratorium within the Health Service Executive (HSE).

1 Mantel G et al. Severe Acute maternal morbidity: a pilot study of a definition for a near-miss. BJOG 1998; 105: 985-90.

For the first three years of this national audit of SMM, a detailed assessment of cases of major obstetric haemorrhage was undertaken. This had provided a very valuable assessment of the most common and significant maternal morbidity as detailed in this Report. In addition, unsolicited feedback from units has suggested other valuable effects of partaking in national audits. Specific examples include the following:

"this highlighted the significant number of patients being transfused and led to a review of our transfusion policy"

"on completing the detailed audit form, we documented in our unit inconsistent approaches in the order of procedures to arrest bleeding"

"this provided an excellent audit tool and allowed a standard approach to evaluating our MOH cases"

"this audit led to improved multidisciplinary interaction in assessment of our cases"

"the feedback and comparison with other units is very valuable"

I would also like to acknowledge and thank members of the Maternal Morbidity Advisory Group (Appendix B) for their intellectual input and guidance in implementing this audit nationally.

Instrumental to the success of the NPEC, as it continues to grow and evolve, is the NPEC Governance Committee. Members of this committee represent a diverse range of key stakeholders from maternity units and universities throughout the country (Appendix D).

Lastly, I would like to thank the staff of the NPEC (Appendix E) for their work and dedication to the mission of the Centre, in translating clinical audit data and epidemiological evidence to inform maternity services for families in Ireland.

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Executive summary

This is the second report from the national audit of severe maternal morbidity (SMM) in Ireland. It reports on 615 cases of SMM that occurred in maternity units in 2012 and 2013. There were 292 cases in 2012 notified by nineteen of the country's 20 maternity units and 323 cases notified for 2013 when all 20 units participated.

Over the three years of this audit, the reported incidence of SMM in Irish maternity units increased from 3.83 per 1,000 maternities in 2011 to 4.44 per 1,000 in 2012 and 4.75 per 1,000 in 2013, suggesting an upward trend in SMM. Despite this, the incidence of SMM in Ireland compares favourably with the rate reported from the methodologically comparable national audit in Scottish maternity units (SCASMM) over similar years. The most recently reported Scottish SMM rate is 7.3 per 1,000 maternities for 2012.

The majority of the women (70%) who experienced SMM in 2012 and 2013 were diagnosed with one SMM, one in four (24%) were diagnosed with two severe morbidities, 6% with three and 1% of the women were diagnosed with four morbidities.

Similar to findings in the Scottish audit, major obstetric haemorrhage (MOH) was the most frequently reported SMM (55%). The next most common reportable SMM events were admission to intensive care unit or coronary care unit (ICU/CCU; 42%), renal or liver dysfunction (7%), peripartum hysterectomy (7%) and pulmonary embolism (6%).

The 341 reported MOH cases gave an incidence rate of 2.55 per 1,000 maternities in 2012/2013, less than half the equivalent rate in Scotland for the same years. Uterine atony was the most common underlying cause (38%) of MOH followed by retained placenta/membranes (17%). This mirrors findings from successive SCASMM reports. The vast majority of MOH cases (84%) occurred during or after birth, 18% occurred in the intrapartum period and two thirds in the postpartum period. Almost all women who experienced MOH (93%) received a blood transfusion.

Admission into an ICU/CCU has been used as a marker for SMM internationally and is a reportable event in this audit. MOH was associated with 41% of the 261 ICU/CCU admissions reported for 2012/2013. However, an increasing proportion of reported ICU/CCU cases had no other associated SMM as defined in this audit (25% in 2011, 35% in 2012 and 41% in 2013). Our discussions with the units suggests such ICU/CCU admissions reflect resource issues in maternity units when women need a higher level of monitoring. This finding is one of the motivations for the new NPEC Audit of Critical Care in Obstetrics in Ireland which is currently being implemented in maternity units across the country.

There were 42 reported cases of peripartum hysterectomy (PH) in 2012 and 2013 giving a national rate of 0.31 per 1,000 maternities or approximately one in every 3,200 maternities. This PH rate is similar to national rates reported in the UK and the Netherlands of 0.41 and 0.33 per 1,000 births respectively. The majority of PH cases (81%) were associated with MOH. Eighty percent of all women who required PH had a previous caesarean section and for most of these cases morbidly adherent placenta was a causal factor for PH. This adds to the growing evidence of an association between previous caesarean section, morbidly adherent placenta and PH and suggests that if caesarean section rates continue to increase there may be an

associated increase in the rate of PH. Over half (54.8%) of the women who required a PH were admitted to ICU which also indicates that resources required to manage these women extend well beyond surgical costs.

Recent reports on maternal mortality in Ireland and the UK have identified that thrombosis and thromboembolism as a leading cause of maternal deaths due to direct obstetric causes.

The incidence of pulmonary embolism (PE) reported in this audit in 2012/2013 was 0.27 per 1,000 maternities or one in 3,700 women. Notwithstanding the small numbers involved, this audit also identified that the risk of PE in cases of peripartum hysterectomy (95 per 1,000 maternities or approximately one in ten maternities) is several hundred times greater than the risk in all maternities.

While the number of cases was small, there were sixteen cases of septic shock reported for 2013 in contrast to four reported cases in each of the two preceding years. This may be a true increase in incidence or may be associated with an increased awareness and recognition of sepsis.

The perinatal mortality rate (PMR) among infants born to women who experienced SMM was 51.5 per 1,000 births, i.e. one in 20 of the infants died. This is eight times the perinatal mortality rate observed for all births in Ireland.

Multiple pregnancy was associated with a more than fourfold increased risk of SMM. The SMM rate was 4.4 per 1,000 maternities associated with singleton pregnancy in 2013 and was 20.7 per 1,000 maternities for multiple pregnancy.

The mode of delivery for two thirds of the women who experienced SMM was caesarean section. While this is over twice the caesarean section rate for all births nationally, the majority of caesarean sections in cases of SMM were carried out prior to labour which may reflect the clinical complexity of the pregnancy rather than mode of delivery influencing risk of SMM.

Variation in rates of SMM and MOH were identified between units. However, differences between units must be interpreted with caution, as they are likely related to differences in the risk profile of the pregnant women presenting to the units rather than the care given.

The association between maternal age and risk of SMM followed a J-shaped curve. The lowest SMM rate, at 3.1 per 1,000, was among women aged 20-24 years. The rate was marginally higher for younger women. Otherwise, the SMM rate increased with increasing maternal age. Respectively, 35-39 year-olds and women over 40 years of age had almost twice and three times the SMM rate of 20-24 year-olds.

Women with higher parity, i.e. para 3+, were overrepresented among SMM cases compared to the general pregnant population.

There was evidence that being of non-caucasian ethnicity was linked to increased risk of SMM. However, assessment of the association between maternal characteristics, such as body mass index, smoking and socio-economic status, and risk of SMM is hampered by the lack of available national data for the population of pregnant women in Ireland.

The detailed MOH audit identified trends in management and monitoring of cases over the three years of the MOH audit. There was an increase in the presence of obstetric consultants, senior midwives and anaesthetic consultants attending cases of MOH in later years. This may be in response to the national guideline which recommends a multidisciplinary care approach with early direct consultant and senior staff involvement in the management of postpartum haemorrhage. However, in cases identified as high risk in the antenatal period due to known or suspected morbidly adherent placenta, there was a decrease in the reported presence of a consultant obstetrician at delivery.

In almost all MOH cases (98.8%) it was stated that the unit had a protocol for the management of MOH and management of the MOH adhered to the protocol in 87.5% of cases. Quality of care as self-assessed by reporting units in cases of MOH was reported as appropriate in the vast majority (85.6%) of cases. For a small proportion of cases (2.9%) it was reported that management of the case was suboptimal impacting on the adverse outcome. It must be acknowledged that these findings are based on unit self-assessment.

The use of obstetric early warning charts in the monitoring of patients was reported in 75% of MOH cases in 2012/2013, a marked increase on the 45% reported rate of their use for MOH cases in 2011. This is likely related to the development and lead up to the full implementation of the national Irish Maternity Early Warning System (IMEWS) in 2014.

In summary, the findings of this national SMM audit highlight the clear need for on-going prospective audit in order to identify adverse maternal outcomes. Although SMM may reflect the complexity of the pregnant population, it also acts as a surrogate measure of quality of care in the maternity services. The findings from the detailed MOH audit, carried out for the years 2011-2013, suggest good practice in terms of the care provided including the involvement of senior multidisciplinary staff and appropriate monitoring and treatments. Further audit of adverse maternal outcomes can guide clinical practice and inform prospective counselling of women at high risk of severe maternal morbidity.

Recommendations

Based on the findings of this report, the NPEC makes the following recommendations:

- While outcomes are positive with regard to the management of major obstetric haemorrhage described in this report and acknowledging the publication in 2012 of the national clinical practice guideline on primary postpartum haemorrhage, there may be value in developing national guidance on antepartum haemorrhage and on management of abnormally adherent placenta.

- Collation of an agreed national dataset from maternity services needs to be made possible in order to facilitate examination of factors influencing obstetric outcomes including severe maternal morbidity. This may be achieved through the implementation of the Maternal Newborn - Clinical Management System.

- While available in some units, formal counselling support should be available for all women and their partners following a severe maternal morbidity across all units in Ireland.

- Variances between units in intensive care unit admission rates warrant further investigation. This is a focus of the new NPEC Audit of Critical Care in Obstetrics in Ireland, which, with the support of colleagues in the maternity services will establish resource needs in levels of care and lead to better service provision.

- The NPEC Maternal Morbidity Advisory Group endorses the national clinical programme's multidisciplinary training in the management of postpartum haemorrhage. We recommend the development and national implementation of a specific proforma to improve management and documentation during a major obstetric haemorrhage event whether in the antenatal or postnatal period. An example of such a proforma is included in Appendix F.

- A quantitative approach involving volume and weight assessment to estimate blood loss should be considered for use in all maternity units. Development of a national toolkit would assist standardisation of such an approach.

- For women at expected high risk of major obstetric haemorrhage, clear plans should be included in the maternity healthcare record and consideration should be given to the use of interventional radiology. The feasibility of providing such a service in all health service regions should be assessed.

- Robust clinical audit of perinatal outcomes in all maternity units in Ireland is vital for patient care. Such audit requires the protected time of clinical staff. Funding should be provided by the Health Service Executive (HSE) to ensure that staffing levels allow protected time for clinical audit.

- All maternity units should continue to collect and submit data on severe maternal morbidity to inform the maternity services through the NPEC national audit on severe maternal morbidity. A multidisciplinary approach, involving consultant obstetricians, consultant anaesthetists, senior midwives and senior trainees is recommended to ensure complete case ascertainment. The NPEC is aware that some units find regular multidisciplinary meetings assist this.


Total Fertility Rate
Births per woman over childbearing years
<2.0
2.0 - 2.1
2.1 - 2.2
>2.2
NATIONAL PERINATAL EPIDEMIOLOGY CENTRE
Data Source: Central Statistics Office 2011
Letterkenny General
Sligo General
Cavan General
Mayo General
Midland Regional Hospital
National Maternity Hospital
Portiuncula
University Hospital Galway
Mid-Western Regional Hospital
Kerry General
Waterford Regional
HSE Regions
West
South
Mid-Leinster
North-East
Hospitals According to Number of Annual Births
small <2,000
medium 2,000 - 5,999
large >6,000
0 12.5 25 50 75 100
Kilometers

Methods

Data recording

There were 20 maternity units in Ireland in 2012 and 2013. Nineteen of the units contributed data to this audit for 2012 and all 20 units contributed for 2013. The individual contributors and co-ordinators for the audit within each participating maternity unit are listed in Appendix C. These are designated midwives, obstetric consultants or specialist registrars who complete the NPEC Severe Maternal Morbidity Notification Form (Appendix G). This is a validated data collection tool originally designed for the Scottish Confidential Audit of Severe Maternal Morbidity. The form was adapted for the Irish setting and contains minimal information on maternal and delivery characteristics.

For this audit, a case of severe maternal morbidity (SMM) was defined as a pregnant or recently-pregnant woman who experienced any of the following seventeen maternal morbidities in 2012 and 2013: major obstetric haemorrhage, uterine rupture, peripartum hysterectomy, eclampsia, renal or liver dysfunction, pulmonary oedema, acute respiratory dysfunction, pulmonary embolism, cardiac arrest, coma, cerebrovascular event, status epilepticus, septicaemic shock, anaesthetic complications, admission to an intensive care or coronary care unit, interventional radiology and other severe morbidity. Definitions for these morbidities are provided at the end of the Notification Form.

The other severe morbidity category was included to explore whether further specific morbidities warrant inclusion in the audit. Findings are not provided in this report for cases in this category unless one of the other specified morbidities was also experienced.

For 2012 and 2013, uterine rupture was a specified morbidity for the audit whereas this was not the case for 2011, the first year of the audit. This change has led to a small increase in reportable cases of SMM. However, most cases of uterine rupture meet the criteria for major obstetric haemorrhage and were therefore reported in all three years of the audit.

In the case of major obstetric haemorrhage (defined as blood loss of at least 2,500ml, transfusion of five or more units of blood or documented treatment for coagulopathy), participating units were asked to complete an additional detailed case assessment form. The NPEC Severe Maternal Morbidity Notification Form and the Major Obstetric Haemorrhage Form are available for download on the NPEC website (http://www.ucc.ie/en/npec/npec-clinical-audits/).

Denominator data on the number of maternities were provided directly by individual maternity units. The denominator underestimates the number of women at risk of SMM as it does not include miscarriage, ectopic pregnancy and molar pregnancy, which may be reported as cases of SMM and thereby included in the numerator. However, complete data on maternities resulting in miscarriage, ectopic pregnancy and molar pregnancy are not available and therefore, to ensure uniformity, the denominator was restricted to live births and stillbirths of babies weighing at least 500g. The approach of not including miscarriage, ectopic pregnancy and molar pregnancy in the denominator is also the approach taken by the Scottish Confidential Audit of Severe Maternal Morbidity.

Data analysis

In keeping with the international published literature in this area, the incidence rate of SMM and of specific morbidities are calculated per 1,000 maternities resulting in the live birth or stillbirth of a baby weighing at least 500g. For incidence rates 95% confidence intervals were calculated using the Normal approximation of a binomial proportion confidence interval.

Funnel plots are used to illustrate both the variation in incidence rates across participating maternity units and the deviation of the rate for each individual unit from the national rate. The national rate is plotted as a straight line. A 95% confidence interval for the national rate is plotted using a dashed line. The width of the confidence interval is adjusted to allow for meaningful comparison between unit-specific rates and the national rate. The confidence interval is wider for smaller units reflecting the lack of precision in rates calculated based on small numbers. The confidence interval narrows for larger maternity units, giving the diagram a 'funnel' shape. Maternity unit rates outside the 95% confidence interval are statistically significantly different from the national rate. In general, one in 20 units would be expected to lie outside the 95% confidence interval by chance alone.

Some of the variation in rates across maternity units will be due to differences in the profile of the women attending the maternity units. Data are not available to allow for adjustment of the profile of women attending the country's maternity units. For this reason, we recommend conservative interpretation of differences between the rates of units and their deviation from the national rate.

Further analysis was conducted to assess variation in incidence rates between years, maternal age groups, single and multiple pregnancies and between Ireland and Scotland. This analysis involved using Poisson regression which calculates a rate ratio (for example, the rate in one year divided by the rate in the previous year). Rate ratios have the advantage of being easy to interpret. A rate ratio is greater than one if a rate is greater than the rate to which it is being compared. For example a rate ratio of 1.25 indicates the rate being examined is 25% higher than (or 1.25 times) the rate to which it is being compared. Conversely, a rate ratio will be less than one if a rate is less than the rate to which it is being compared. For example a rate ratio of 0.80 indicates that the rate being examined is equivalent to 80% of the rate to which it is being compared, i.e. it is 20% lower. The Poisson regression analysis provides a 95% confidence interval for the rate ratio and the associated p-value, both of which indicate whether the rate difference is in line with what might be expected due to chance. A rate difference is considered to be beyond what might be expected by chance, i.e. statistically significant, if the 95% confidence interval for the rate ratio does not include the value one. This is equivalent to the p-value derived from the analysis being less than 0.05. If the p-value is less than 0.001 then the rate difference may be considered highly statistically significant.

Severe maternal morbidity

National rate

The nineteen participating maternity units reported that 292 women experienced severe maternal morbidity (SMM) in 2012, as defined in this audit. For 2013, all 20 maternity units in the country participated and reported that 323 women experienced SMM. Thus, 615 women were reported as experiencing SMM in the two years. Table 1 details the number of cases, total maternities and SMM rates for the three years of this audit, 2011-2013.

Table 1: Incidence of severe maternal morbidity (SMM) in Ireland, 2011-2013

	2011*	2012	2013	2012/13
Maternities in participating units	67,806	65,768	68,047	133,815
SMM cases	260	292	323	615
SMM rate	3.83	4.44	4.75	4.60
(95% CI)	(3.36-4.31)	(3.92-4.96)	(4.22-5.27)	(4.23-4.96)
Rate ratio	1.00	1.16	1.24	1.20
(95% CI)	(Ref.)	(0.98-1.37)	(1.05-1.46)	(1.04-1.39)
p-value		0.086	0.011	0.014

Note: 95% CI=95% confidence interval. * Cases of uterine rupture exclusive of major obstetric haemorrhage were not reported for 2011.

From 2011 to 2013, the SMM rate varied from 3.83 to 4.75 per 1,000 maternities or from one in 260 maternities to one in 210 maternities. Respectively, the SMM rate was 16%, 24% and 20% higher in 2012, 2013 and 2012/13 than the base year 2011. This is equivalent to an annual rate increase of 11% (annual rate ratio=1.11, 95% CI=1.02-1.20, p-value=0.011). While three years is too short a time period to establish trends, this extent of increase is beyond expected yearly variation and this was also the conclusion of an analysis that excluded cases of uterine rupture exclusive of MOH reported in 2012 (n=9) and 2013 (n=6), cases that were not reported to the audit in 2011. However, the increase may be associated with improved case ascertainment over these first years of the audit.

The most recent data from the methodologically comparable national audit in Scotland reported an SMM rate of 7.3 per 1,000 maternities for 2012. The Irish SMM rate for the same year is almost 40% lower than the Scottish rate (rate ratio=0.61, 95% CI=0.52-0.71, p-value<0.001).

Specific morbidities

Approximately 70% of the women (n=425, 69.1%) who experienced SMM in 2012 and 2013 were diagnosed with one SMM, one in four (n=149, 24.2%) were diagnosed with two severe morbidities, 6% (n=35, 5.7%) with three and 1% of the women (n=6, 1.0%) were diagnosed with four morbidities.

Major obstetric haemorrhage (MOH) was the most frequently reported event, being involved in over half of the SMM cases each year (Table 2). The incidence of MOH was 2.55 per 1,000 maternities in 2012/13. The equivalent incidence of MOH in Scotland for 2012 was 5.8 per 1,000 maternities (95% CI=5.2-6.5), more than twice the Irish rate.

Table 2: Incidence of specific severe maternal morbidities (SMMs) in Ireland, 2011-2013

	2011	2012	2013	2012/13	Rate(95% CI)
	n	n	n	n (%)	
Major obstetric haemorrhage (MOH)	159	164	177	341(55.4)	2.55(2.27-2.82)
ICU/coronary care unit admission	111	130	131	261(42.4)	1.95(1.71-2.19)
Renal or liver dysfunction	26	22	21	43(7.0)	0.32(0.22-0.42)
Peripartum hysterectomy	23	22	20	42(6.8)	0.31(0.22-0.41)
Pulmonary embolism	12	18	18	36(5.9)	0.27(0.18-0.36)
Eclampsia	12	8	16	24(3.9)	0.18(0.11-0.25)
Uterine rupture	NR	14	10	24(3.9)	0.18(0.11-0.25)
Pulmonary oedema	8	11	10	21(3.4)	0.16(0.09-0.23)
Septicaemic shock	4	4	16	20(3.3)	0.15(0.08-0.22)
Acute respiratory dysfunction	5	3	6	9(1.5)	0.07(0.02-0.11)
Cardiac arrest	7	7	1	8(1.3)	0.06(0.02-0.10)
Anaesthetic problem	7	5	3	8(1.3)	0.06(0.02-0.10)
Interventional radiology	16	3	5	8(1.3)	0.06(0.02-0.10)
Cerebrovascular event	6	4	3	7(1.1)	0.05(0.01-0.09)
Status epilepticus	3	0	0	0(0.0)	0(0-0)
Coma	0	0	0	0(0.0)	0(0-0)
Total women affected	**260**	**292**	**323**	**615(100)**	**4.60(4.23-4.96)**

Note: n represents number of women affected by the specific morbidity; % is based on the total number of SMM cases in 2012/13; rate is per 1,000 maternities in 2012/13; 95% CI=95% confidence interval; ICU=intensive care unit; NR=not recorded by the audit in 2011 unless associated with MOH.

The national audit in Scotland showed that their increasing incidence of SMM over the past decade was due to an increase in MOH. The NPEC previously showed that Ireland experienced an increasing trend in postpartum haemorrhage between the years 1999 to 2009.[2] An increasing number of MOH cases has been reported to this audit over the three-year period 2011-2013 (Table 2). The incidence of MOH cases increased from 2.34 per 1,000 maternities in 2011 to 2.49 per 1,000 in 2012 and 2.60 per 1,000 in 2013, an overall increase of 11% (rate ratio=1.11, 95% CI=0.90-1.37, p-value=0.344), which is not beyond what might be expected in yearly variation for rates of such magnitude.

2 Lutomski J et al. Increasing trends in atonic postpartum haemorrhage in Ireland: an 11-year population-based cohort study. *BJOG* 2012; 119: 306-14.

The incidence of Irish SMM cases not involving MOH has increased more notably by 44% during 2011-2013 (rate ratio=1.44, 95% CI=1.12-1.86, p-value=0.005). There were 101 such cases reported for 2011 (rate=1.49, 95% CI=1.19-1.79 per 1,000 maternities), 128 cases for 2012 (rate=1.95, 95% CI=1.60-2.29 per 1,000 maternities) and 146 cases for 2013 (rate=2.14, 95% CI=1.79-2.50 per 1,000 maternities).

Most other specific morbidities were reported in less than 10% of the SMM cases (Table 2). There were 42 reported cases of peripartum hysterectomy (PH) in 2012 and 2013 giving a national rate of 0.31 per 1,000 maternities or approximately one in every 3,200 maternities. This PH rate is similar to national rates reported in the UK and the Netherlands of 0.41 and 0.33 per 1,000 births respectively. An indepth description of these cases of PH is provided later in this Report.

Recent reports on maternal mortality in Ireland and the UK have identified thrombosis/ thromboembolism as a leading direct obstetric cause of maternal death. The incidence of pulmonary embolism (PE) reported in this audit in 2012/2013 was 0.27 per 1,000 maternities or one in 3,700 women.

While the number of cases was small, there were sixteen cases of septic shock reported for 2013 in contrast to four reported cases in each of the two preceding years. This may be a true increase in incidence or may be associated with an increased awareness and recognition of sepsis.

As an internationally-recognised marker for SMM, admission into an intensive care unit or coronary care unit (ICU/CCU) was a reportable event in this audit and occurred for 42% of the SMM cases in 2012/13 (n=261). Table 3 details the specific SMMs involved in the 261 cases admitted into an ICU/CCU. Approximately 40% of these cases involved MOH, 9% involved peripartum hysterectomy and 6% involved renal or liver dysfunction.

In 2012 and 2013 a high proportion of women admitted into ICU/CCU (38%, n=99 of 261) had not experienced a severe morbidity as defined in this audit. This phenomenon has increased over the three years of the audit. In 2011, 2012 and 2013, the proportion of cases admitted to an ICU/CCU with no associated severe morbidity was 25%, 35% and 41%, respectively (2011: n=28 of 111, 25.2%; 2012: n=46 of 130, 35.4%; 2013: n=53 of 131, 40.5%).For the years 2012 and 2013 almost half (n=45) of these cases occurred in two small maternity units with on-site ICU facilities. Feedback from these units indicated that the rate of such ICU/CCU admissions reflected resource issues in terms of staffing levels and high dependency facilities when women needed a higher level of monitoring. This is evidence of safe practice for these particular units.

Table 3: Specific severe maternal morbidities (SMMs) associated with admission to an intensive care unit or coronary care unit (ICU/CCU) in Ireland, 2012/13

	n(%)
Major obstetric haemorrhage (MOH)	108(41.4)
Peripartum hysterectomy	23(8.8)
Renal or liver dysfunction	15(5.7)
Pulmonary embolism	10(3.8)
Eclampsia	9(3.4)
Pulmonary oedema	8(3.1)
Septicaemic shock	7(2.7)
Uterine rupture	6(2.3)
Acute respiratory dysfunction	6(2.3)
Cardiac arrest	5(1.9)
Cerebrovascular event	4(1.5)
Interventional radiology	2(0.8)
Anaesthetic problem	1(0.4)
None of the above	99(37.9)
Total women admitted to ICU/CCU	**261(100)**

Note: n represents number of women affected by the specific morbidity; % is based on the total number of women admitted to ICU/CCU in 2012/13.

Variation in rates by maternity unit

Variation in the 2012/13 SMM rate across Ireland's 20 maternity units is illustrated in the funnel plot in Figure 1. The solid line represents the national SMM rate (4.60 per 1,000 maternities). The dashed lines represent the limits of the 95% confidence interval around the national rate. These limits are adjusted according to the number of maternities at each unit and are wider for smaller units reflecting the greater volatility in rates based on small numbers. In applying 95% confidence limits, we can expect, on average, one of the twenty units to have a rate outside the dashed lines. However, differences between units must be interpreted with caution, as they may not reflect care given but could reflect differences in levels of reporting and/or differences in the risk profile of the pregnant women presenting to the units.

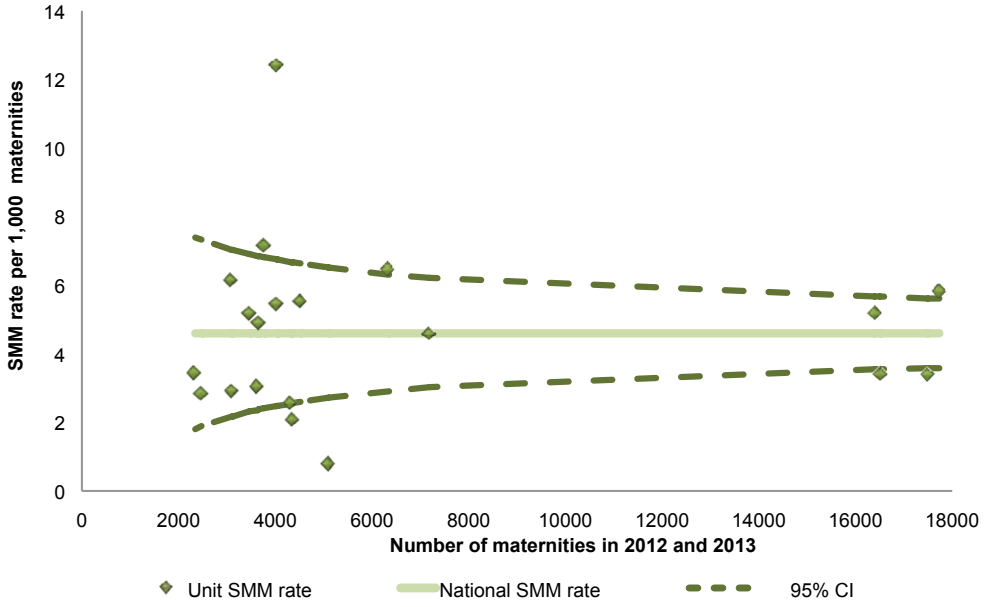

Figure 1: Funnel plot of the rate of severe maternal morbidity (SMM) by maternity unit, 2012/13

From Figure 1 it can be seen that two units have outlying SMM rates, one with a rate far below the lower limit of the confidence interval and another with a rate far beyond the upper limit. The NPEC is working with the former unit to review case ascertainment. Analysis of the SMM cases from the unit with the highest rate showed that the majority were reported because they met the SMM criterion of being admitted to an ICU/CCU with no other SMM experienced as defined in this audit. These are patients requiring monitoring above normal ward standard and due to low levels of staff in this unit, this could only be achieved by admission to the ICU. This is evidence of good practice in prioritising patient safety in the context of constrained staffing levels. This unit is working to address this situation with an evolving business plan.

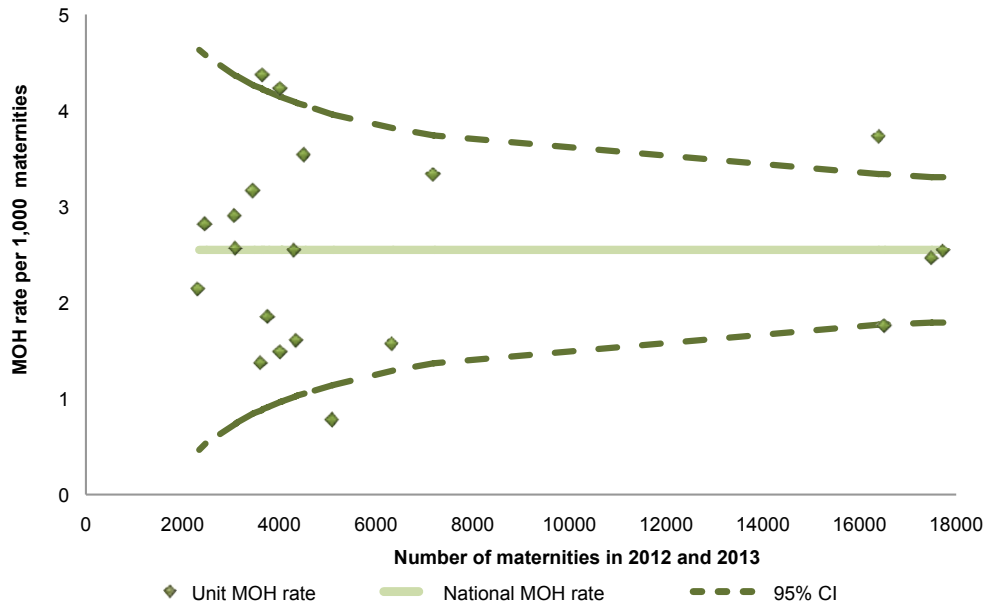

Figure 2: Funnel plot of the rate of major obstetric haemorrhage (MOH) by maternity unit, 2012/13

Figure 2 illustrates variation in the rate of MOH across the 20 maternity units in the country in 2012/13. A small number of units are outside the limits of the confidence interval for the rate although by a relatively small margin. Analysis of the data suggested that this may reflect variation across units in the method used to estimate blood loss.

Maternal characteristics

Age

Maternal age for the 615 cases of severe maternal morbidity (SMM) in 2012 and 2013 ranged from 16 to 48 years. The average age was 33 years in each year (Standard deviation = 6 years). The age distribution of women who experienced SMM in 2012 and 2013 is detailed in Table 4. Just over 60% were aged 30-39 years which was also the case for the population of women who gave birth in 2013. However, there was evidence of an increased risk of SMM among women aged at least 35 years as they were overrepresented in the audit. Women in this age range accounted for 42% of SMM cases in 2013 compared to 32% of the population who gave birth that year.

This is reflected in the SMM rate calculated by maternal age based on data for 2013 (Table 4), which followed a J-shaped curve. The lowest SMM rate, at 3.1 per 1,000 births was associated with women aged 20-24 years. The rate was marginally higher for women aged under 20 years. Otherwise, the SMM rate increased with increasing maternal age. Respectively, 35-39 year-olds and women over 40 years of age had almost twice (p-value=0.015) and three times (p-value<0.001) the SMM rate of 20-24 year-olds.

Table 4: Age distribution of women who experienced severe maternal morbidity (SMM) in 2012 and 2013

Age group	SMM 2012 (N=283)	SMM 2013 (N=319)	SMM 2012/13 (N=602)	All maternities 2013	SMM rate 2013 (95% CI)	Rate ratio (95% CI)
<20yrs	3(1.0)	6(1.9)	9(1.5)	2.0%	4.35	1.39
					(0.81-7.90)	(0.56-3.46)
20-24yrs	14(4.8)	20(6.2)	34(5.5)	9.4%	3.14	1.00
					(1.74-4.54)	(Ref.)
25-29yrs	60(20.5)	44(13.6)	104(16.9)	20.3%	3.19	1.02
					(2.23-4.16)	(0.60-1.73)
30-34yrs	88(30.1)	118(36.5)	206(33.5)	36.7%	4.73	1.51
					(3.86-5.59)	(0.94-2.42)
35-39yrs	97(33.2)	100(31.0)	197(32.0)	25.8%	5.70	1.82
					(4.56-6.83)	(1.12-2.94)
≥40yrs	30(10.3)	35(10.8)	65(10.6)	5.7%	8.97	2.86
					(5.95-11.99)	(1.65-4.96)

Note: Values are shown as n(%) unless otherwise stated. Data for all maternities are from Perinatal Statistics Report 2013. Healthcare Pricing Office (HPO). Dublin: HPO, 2014. SMM rate per 1,000 maternities.

Ethnicity

There are no national data available on ethnicity for the pregnant population in Ireland. The distribution by ethnic group of the women who experienced SMM in 2012/13 closely reflected that of the general population of women aged 15-49 years as reported from the most recent national census (Table 5). Three-quarters were of white Irish ethnicity, a little lower than the 80% reported as white Irish by the census.[3] In those who experienced SMM there was an overrepresentation of women whose ethnicity was described as Black/ Black Irish. This group made up 7% of SMM cases but only 1.6% of the population aged 15-49 years.

Table 5: Ethnicity of women who experienced severe maternal morbidity (SMM) in 2012 and 2013

	SMM 2012/13 (N=615)	15-49 year-old female population, 2011 %
White Irish	454(73.8)	80.4
Irish Traveller	4(0.7)	0.7
Other white background	71(11.5)	12.5
Asian/Asian Irish	35(5.7)	2.4
Black/Black Irish	43(7.0)	1.6
Other/mixed	1(0.2)	1.0
Not recorded	7(1.1)	1.4

Note: Values are shown as n(%) unless otherwise stated.

Body mass index

Body mass index (BMI) for the women who experienced SMM in 2012 and 2013 ranged from 16 to 56kgm^{-2}. BMI was not known for 78 (13%) of the women. This indicates an improvement in reporting as BMI was not known for 29% of reported SMM cases in 2011. Less than half of the women who experienced SMM had a BMI in the healthy range, 30% were overweight and one in four were obese (Table 6). This BMI profile closely matches that of the women in the 2007 Survey of Lifestyle, Attitudes and Nutrition (SLÁN).[4] However, interpretation of this comparison must consider the weight gain due to pregnancy for the women who experienced SMM and the fact that the SMM and SLAN data are not coterminous. However, there are no national data available on BMI for the pregnant population.

Table 6: Body mass index (BMI) of women who experienced severe maternal morbidity (SMM) in 2012 and 2013

BMI category (kgm^{-2})	SMM 2012/13 (N=537)*	SLAN 2007 %
Underweight (<18.5)	10(1.9)	2
Healthy (18.5-24.9)	237(44.1)	44
Overweight (25.0-29.9)	160(29.8)	31
Obese (≥30.0)	130(24.2)	23

Note: SLAN=Survey of Lifestyle, Attitudes and Nutrition. Values are shown as n(%) unless otherwise stated. * BMI was not known for 78 women.

3 Central Statistics Office. Profile 7 Religion, Ethnicity and Irish Travellers. 2012. Dublin: The Stationary Office.
4 Harrington J, Perry I, Lutomski J, Morgan K, McGee H, Shelley E, Watson D, Barry M. Survey of Lifestyle, Attitudes and Nutrition in Ireland: Dietary Habits of the Irish population. 2008. Dublin: The Stationary Office.

Smoking, alcohol and drug misuse

Smoking status at the time of the first hospital booking appointment was not known for 9% of the women (n=58, 9.4%). Of the remainder, one in nine were reported to have been smoking (Table 7). The prevalence of smoking during pregnancy is not routinely known for all Irish pregnancies but rates of 12%, 15%, 16% and 19% have been reported for England, Northern Ireland, Wales and Scotland, respectively.[5]

The quantity being smoked was recorded for 53 of the 64 smokers in this audit. On average, they were smoking 11 cigarettes per day though one in four (n=13, 24.5%) were reported to be smoking 20 cigarettes per day. Ten women were reported to have given up smoking during their pregnancy, three before and seven after their first hospital booking appointment.

Table 7: Smoking status at time of first hospital booking for women who experienced severe maternal morbidity in 2012 and 2013

	2012 (N=273)*	2013 (N=284)*	2012/13 (N=557)*
Smoking	**32(11.7)**	**32(11.3)**	**64(11.5)**

Note: Values are shown as n(%) unless otherwise stated. * Smoking status was not known for 58 women.

Alcohol drinking status at the time of the first hospital booking appointment was not known for 41% of the women (n=252, 41.0%). Of the 363 women with available data, only 6% were reported to be drinking alcohol (n=23, 6.3%). Seven women (1.2%) were recorded as having a documented history of drug abuse.

Previous pregnancy

Approximately 40% of the women who experienced SMM in 2012 and 2013 were nulliparous which is in line with the population of maternities in Ireland (Table 8).

Table 8: Distribution of parity for women who experienced severe maternal morbidity (SMM) in 2012 and 2013

Parity	SMM 2012 (N=288)*	SMM 2013 (N=321)*	SMM 2012/13 (N=609)*	All maternities 2013
Nulliparous	**119(41.3)**	**122(38.0)**	**241(39.6)**	**38.4%**
Para 1	**88(30.6)**	**97(30.2)**	**185(30.4)**	**35.2%**
Para 2	**43(14.9)**	**55(17.1)**	**98(16.1)**	**17.4%**
Para 3+	**38(13.2)**	**47(14.6)**	**85(14.0)**	**9.1%**

Note: Values are shown as n(%) unless otherwise stated; * Parity was not known for four cases in 2012 and two cases in 2013. Data for all maternities are from Perinatal Statistics Report 2013. Healthcare Pricing Office (HPO). Dublin: HPO, 2014

There was an overrepresentation of women of higher parity, i.e. para 3+, among the SMM cases compared with the overall population (14% vs. 9%). As a corollary, 30% of the SMM cases were para 1 compared to 35% of the national population of women giving birth.

5 EURO-PERISTAT Project with SCPE and EUROCAT. European Perinatal Health Report. The health and care of pregnant women and babies in Europe in 2010. May 2013. Available www.europeristat.com

Gestation of pregnancy

Gestation at delivery or pregnancy end ranged from six to 42 weeks. For two thirds of the women affected, their pregnancy went full term (Table 9). For a further one in five their pregnancy ended at moderate to late pre-term gestation (32-36 weeks). For 4-5% of the women, the end of pregnancy occurred before 22 weeks gestation.

Table 9: Gestation at delivery or pregnancy end for women who experienced severe maternal morbidity in 2012 and 2013

	2012 (N=287)*	2013 (N=317)*	2012/13 (N=604)*
Pre-viable (<22wks)	15(5.2)	11(3.5)	26(4.3)
Extremely pre-term (22-27wks)	4(1.4)	15(4.7)	19(3.1)
Very pre-term (28-31wks)	22(7.7)	14(4.4)	36(6.0)
Moderate/late pre-term (32-36wks)	50(17.4)	73(23.0)	123(20.4)
Term (37-41wks)	192(66.9)	204(64.4)	396(65.6)
Post-term (42wks+)	4(1.4)	0(0.0)	4(0.7)

Note: Values are shown as n(%) unless otherwise stated; * Gestation was not known for five cases in 2012 and six cases in 2013.

Multiple pregnancy

Forty-six of the 615 women who experienced SMM in 2012 and 2013 had a multiple pregnancy (7.5%; Table 10). There were 45 twin pregnancies and one triplet pregnancy. In Ireland in 2012 and 2013, multiple births made up 1.8% of all maternities (n=2,559 of 138,661). Thus, multiple pregnancy was approximately four times more common in cases of SMM than in all maternities, a reflection of the increased risk of SMM associated with multiple pregnancy. This is evident from the national SMM rate of 4.4 per 1,000 maternities associated with singleton pregnancy in 2013 and a more than four times higher rate of 20.7 per 1,000 maternities for multiple pregnancy that year (p-value<0.001). These findings are similar to findings from Scotland where 6.4% of SMM cases with available data in 2012 were associated with twin pregnancies, four times higher than their proportion of twin births in 2012 (1.5%).

Table 10: Singleton and multiple pregnancy for women who experienced severe maternal morbidity (SMM) in 2012 and 2013

	SMM 2012 (N=292)	SMM 2013 (N=323)	SMM 2012/13 (N=615)	All maternities 2013	SMM rate 2013 (95% CI)	Rate ratio (95% CI)
Singleton	273(93.5)	296(91.6)	569(92.5)	98.1%	4.44	1.00
					(3.97-4.92)	(Ref.)
Multiple	19(6.5)	27(8.4)	46(7.5)	1.9%	20.74	4.67
					(13.85-27.62)	(3.15-6.92)

Note: Data for all maternities are from Perinatal Statistics Report 2013. Healthcare Pricing Office. Dublin: HPO, 2014. Values are shown as n(%) unless otherwise stated. SMM rate per 1,000 maternities.

6 Scottish Confidential Audit of Severe Maternal Morbidity: 9th Annual Report (2013). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx

Mode of delivery

The mode of delivery for two thirds of the women who experienced SMM was caesarean section (Table 11). This is over twice the caesarean section rate occurring in all births nationally in 2012 (29%). The majority of caesarean sections in cases of SMM were carried out prior to labour which may reflect the clinical complexity of the pregnancy rather than mode of delivery influencing risk of SMM. Almost one in three women had a vaginal delivery, usually spontaneously. The Other category relates to cases occurring before fetal viability and include miscarriages and laparotomy.

Table 11: Primary mode of delivery for women who experienced severe maternal morbidity in 2012 and 2013

	2012 (N=291)*	2013 (N=321)*	2012/13 (N=612)*
Vaginal	82(28.2)	102(31.8)	184(30.1)
Spontaneous	56(19.2)	73(22.7)	129(21.1)
Assisted breech	2(0.7)	3(0.9)	5(0.8)
Ventouse	10(3.4)	16(5)	26(4.2)
Non-rotational forceps	14(4.8)	10(3.1)	24(3.9)
Caesarean section	193(66.3)	207(64.5)	400(65.4)
Elective LSCS (no labour)	64(22)	59(18.4)	123(20.1)
Elective LSCS (labour)	5(1.7)	5(1.6)	10(1.6)
Emergency LSCS (no labour)	52(17.9)	77(24)	129(21.1)
Emergency LSCS (labour)	71(24.4)	63(19.6)	134(21.9)
Classical	1(0.3)	3(0.9)	4(0.7)
Other	16(5.5)	12(3.7)	28(4.6)

Note: Values shown are n(%) unless otherwise stated; * Mode of delivery was not known for one case in 2012 and two cases in 2013. For four of the 46 cases of multiple birth mode of delivery differed for the babies and the more complex mode of delivery was taken as the primary mode. LSCS=Lower segment caesarean section. Other relates to cases occurring before fetal viability and includes miscarriage and laparotomy.

Neonatal outcomes

For the 615 women who experienced SMM in 2012 and 2013, a total of 633 babies were delivered. There were 542 singleton births, 44 twin births and one birth of triplets. Information on neonatal outcome was available for 583 (92.1%) of these infants. There were 18 stillbirths, 12 early neonatal deaths and two late neonatal deaths. The perinatal mortality rate based on the 30 stillbirths and early neonatal deaths was 51.5 per 1,000 births, i.e. approximately 5% or one in 20 of the infants died. This rate was eight times the perinatal mortality rate observed for all births in Ireland in 2012 (p-value<0.001), the most recent year for which data are available (Table 12). However, the rate is in line with the perinatal mortality rate among infants born to women with SMM in Scotland in recent years, which ranged from 17 to 64 per 1,000 maternities.[6]

Table 12: Perinatal mortality among infants born to women with SMM in Ireland in 2012/2013 compared to perinatal mortality among all infants born in Ireland in 2012

	Perinatal deaths	Births	PMR (95% CI)	Rate ratio (95% CI)
All births 2012*	445	71755	6.2	1.0
			(5.6-6.8)	(Ref.)
SMM 2012/2013	30	583	51.5	8.3
			(33.2-69.8)	(5.7-12.0)

Note: PMR=perinatal mortality rate per 1,000 births; * Manning E, Corcoran P, Meaney S, Greene RA, on behalf of the Perinatal Mortality Group. Perinatal Mortality in Ireland Annual Report 2012. Cork: National Perinatal Epidemiology Centre, 2014.

Approximately 8% of infants were intubated following delivery and 39% were transferred to the Special Baby Care Unit (SBCU) or Neonatal Intensive Care Unit (NICU; Table 13). NICU transfer was required for almost two thirds of the twins compared to approximately one in three singletons.

Table 13: Select neonatal outcomes by number of gestations

	Singletons (N=542)	Twins (N=88)	Triplets (N=3)	Total (N=633)
Intubation following delivery (%)	42(7.7)	7(8.0)	0(0.0)	49(7.7)
Transfer to SBCU/NICU (%)	187(34.5)	54(61.4)	3(100.0)	244(38.5)

Note: SBCU=Special Baby Care Unit; NICU=Neonatal Intensive Care Unit.

Major obstetric haemorrhage

Case criteria

Eighty percent of the 341 MOH cases reported in 2012 and 2013 met the criterion of exceeding 2,500ml of blood loss, half met the criterion of receiving blood products as treatment for coagulopathy and 43% of cases were transfused five or more units of blood (Table 14). Comparison between 2012 and 2013 indicated that the number of MOH cases meeting the blood loss and coagulopathy criteria increased in line with the overall increase in the total number of MOH cases reported whereas there was a drop in the number of cases transfused five or more units of blood.

Table 14: Case criteria met for major obstetric haemorrhage in 2012 and 2013

	2012 (N=163)	2013 (N=178)	2012/13 (N=341)
Estimated blood loss ≥ 2500ml	129(79.1)	144(80.9)	273(80.1)
Received blood products as treatment for coagulopathy	81(49.7)	94(52.8)	175(51.3)
Transfused ≥ 5 units of blood	83(50.9)	65(36.5)	148(43.4)

Note: Values are shown as n(%) unless otherwise stated. Some cases met more than one criterion and therefore the percentages sum to more than 100%.

Half of the MOH cases met one of the case criteria only (Table 15), usually the one related to blood loss. One in four cases met two criteria and again most of these cases involved an estimated blood loss exceeding 2,500ml. In a further one in four cases, all three criteria were met.

Table 15: Combinations of case criteria met for major obstetric haemorrhage in 2012 and 2013

	2012/13 (N=341)
Met one criterion	171(50.1)
Estimated blood loss ≥ 2500ml	120(35.2)
Received blood products as treatment for coagulopathy	35(10.3)
Transfused ≥ 5 units of blood	16(4.7)
Met two criteria	85(24.9)
Blood loss ≥ 2500ml and received blood products for coagulopathy	38(11.1)
Blood loss ≥ 2500ml and transfused ≥ 5 units of blood	30(8.8)
Received blood products for coagulopathy and transfused ≥ 5 units of blood	17 (5.0)
Met all three criteria	85(24.9)

Note: Values are shown as n(%) unless otherwise stated

Sixteen women met the sole criterion of receiving a blood transfusion of at least five units and a further 30 women received such a transfusion in addition to experiencing blood loss of at least 2,500ml (Table 15). For these 46 women there was no reported receipt of coagulation factors. For significant transfusions in this setting, consideration should be given to transfusing coagulation factors including fibrinogen.[7]

Cause

Uterine atony was the most common cause of MOH (Table 16). It was associated with 38% of the MOH cases, more than twice the percentage associated with the next most common cause, retained placenta / membranes. No cause was reported for five (1.5%) of the MOH cases. The frequency of the causes reported in 2012/2013 is very similar to that reported for 2011 cases of MOH when uterine atony and retained placenta/ membranes were associated with causing 43% and 17% of MOH cases, respectively.

There was one reported cause for 70% (n=240, 70.4%) of the 341 MOH cases in 2012/2013. Uterine atony was also most common in this regard, being the sole cause of one in five MOH cases (Table 16).

7 Royal College of Obstetricians and Gynaecologists. Prevention and management of postpartum haemorrhage. Green-top Guideline No. 52. London RCOG; 2009 [www.rcog.org.uk/globalassets/documents/guidelines/gt52postpartumhaemorrhage0411.pdf]

Table 16: Reported causes of major obstetric haemorrhage in 2012 and 2013

	Sole cause	Associated cause
Uterine atony	72(21.1)	130(38.1)
Retained placenta/membranes	26(7.6)	58(17.0)
Bleeding from uterine incision	29(8.5)	49(14.4)
Placenta praevia	23(6.7)	44(12.9)
Abruption	19(5.6)	27(7.9)
Morbidly adherent placenta	6(1.8)	27(7.9)
Vaginal laceration	16(4.7)	25(7.3)
Uterine rupture	6(1.8)	8(2.3)
Cervical laceration	2(0.6)	5(1.5)
Broad ligament haematoma	1(0.3)	4(1.2)
Uterine inversion	1(0.3)	1(0.3)
Other specified cause	39(11.4)	66(19.4)
Ruptured ectopic pregnancy	7(2.1)	7(2.1)
Coagulopathy	3(0.9)	7(2.1)
Uterine anomaly	2(0.6)	5(1.5)

Note: Values are shown as n(%) unless otherwise stated. Associated causes are not mutually exclusive and therefore percentages add up to over 100%.

Of the 341 women who experienced MOH in 2012/2013, 221 were parous patients (para 1+; 65.0%, data unknown for one case). History of previous caesarean section was known for 176 of these 221 women (79.6%). Of these, 35% had a previous caesarean section and 21% had two or more previous caesarean sections (Table 17).

The number of previous caesarean sections appeared to influence the involvement of placenta praevia and/or morbidly adherent placenta as causes of MOH (Table 17). One or both were reported for 12% of MOH cases in women who had never had a previous caesarean section. They were cited as causing 21% of MOH cases in women with one previous caesarean section and they were associated causes for most of the MOH cases in women with a history of two or more previous caesarean sections.

Table 17: Placenta praevia and morbidly adherent placenta as causal factors of major obstetric haemorrhage by number of previous caesarean sections

Number of previous caesarean sections	Placenta praevia and/or morbidly adherent placenta reported as cause(s)		Total
	Yes	No	
0	9(11.7)	68(88.3)	77(43.8)
1	13(21.0)	49(79.0)	62(35.2)
≥2	22(59.5)	15(40.5)	37(21.0)
Total	44(25.0)	132(75.0)	176(100)

Note: Values are shown as n(%) unless otherwise stated; History of previous caesarean section was known for 176 of the 221 women who had previously given birth.

Onset and location

The vast majority of the reported MOH cases (n=282, 84%) occurred during or after birth – 18% intrapartum and two thirds in the postpartum period (Table 18). Four percent of cases occurred before 20 weeks gestations while one in eight occurred later in pregnancy but before birth.

Table 18: Timing of onset of major obstetric haemorrhage in 2012 and 2013

	2012 (N=162)*	2013 (N=174)*	2012/13 (N=336)*
Early pregnancy (<20 weeks)	7(4.3)	5(2.9)	12(3.6)
Antepartum	17(10.5)	25(14.4)	42(12.5)
Intrapartum	31(19.1)	30(17.2)	61(18.2)
Postpartum	107(66.0)	114(65.5)	221(65.8)

Note: Values are shown as n(%) unless otherwise stated. * Timing of onset was not known for one case in 2012 and for four cases in 2013.

Almost all cases of MOH occurred in obstetric-led units (Table 19) which is to be expected considering that 84% of cases occurred during or after birth and almost all births in the country take place in obstetric-led units. In twelve cases of MOH, the woman was at home at the onset of haemorrhage. Most of these cases were antepartum (n=7, 58%) and none occurred intrapartum.

Table 19: Location of onset of major obstetric haemorrhage in 2012 and 2013

	2012 (N=143)*	2013 (N=135)*	2012/13 (N=278)*
Consultant-led unit	139(97.2)	127(94.1)	266(95.7)
At home	4(2.8)	8(5.9)	12(4.3)

Note: Values are shown as n(%) unless otherwise stated. * Location of onset was not known for 20 cases in 2012 and for 43 cases in 2013.

Mode of delivery

Caesarean section was the primary mode of delivery for 61% of the women who experienced MOH in 2012 and 2013 (Table 20). This was the case for 67% of the women who experienced MOH in 2011. One in three women had a vaginal delivery and for the vast majority of these women it was spontaneous vaginal delivery. The category titled 'other' included instances of miscarriage and laparotomy related to cases where the gestational age was less than 22 weeks.

Table 20: Primary mode of delivery for women who experienced major obstetric haemorrhage in 2012 and 2013

	2012 (N=164)	2013 (N=177)	2012/13 (N=341)
Vaginal	55(33.5)	64(36.2)	119(34.9)
Spontaneous	37(22.6)	43(24.3)	80(23.5)
Assisted breech	2(1.2)	1(0.6)	3(0.9)
Ventouse	5(3.0)	12(6.8)	17(5.0)
Non-rotational forceps	11(6.7)	8(4.5)	19(5.6)
Caesarean section	101(61.6)	108(61.0)	209(61.3)
Elective LSCS (no labour)	33(20.1)	37(20.9)	70(20.5)
Elective LSCS (labour)	2(1.2)	2(1.1)	4(1.2)
Emergency LSCS (no labour)	27(16.5)	32(18.1)	59(17.3)
Emergency LSCS (labour)	39(23.8)	35(19.8)	74(21.7)
Classical	0(0.0)	2(1.1)	2(0.6)
Other	8(4.9)	5(2.8)	13(3.8)

Note: Values are shown as n(%) unless otherwise stated; For two of the 31 cases of multiple birth the mode of delivery differed for the babies and the more complex mode of delivery was taken as the primary mode. LSCS=Lower segment caesarean section; Other included instances of miscarriage and laparotomy related to cases where the gestational age was less than 22 weeks.

Mode of labour

Considering the 328 women who gave birth (119 by vaginal delivery and 209 by caesarean section; Table 20), the majority laboured (n=197, 60.1%). Onset of labour was spontaneous for most of these women (n=119, 62.0%) and was induced for 38% of cases (n=73, 38.0%; onset of labour unknown for five cases). This is higher than the average rate of induction of labour in Irish maternity units of 29% (based on data obtained from 13 maternity units which accounted for 80% of maternities in Ireland in 2013) suggesting an increased risk of MOH following induction.

Emergency caesarean section delivery at full cervical dilatation

An increased risk of maternal morbidity has been associated with caesarean section performed at full cervical dilatation compared to caesarean section performed during the first stage of labour.[8] In this audit, an emergency caesarean section delivery at full cervical dilatation was reported for 16 women. This equates to 25.4% of the MOH cases in 2012/2013 delivered by emergency caesarean section in labour. For 14 of these cases (87.5%), a consultant obstetrician was present and in seven cases performed the delivery; this reflects a high level of compliance for senior staff involvement as advised in such cases. The indication for half of these operative deliveries in 2012/2013 was failed instrumental delivery. The indication in the other cases related to the presentation, failure to progress or fetal bradycardia. There were 10 emergency caesarean deliveries at full cervical dilatation reported for 2011 accounting for 6.7% of the MOH cases for that year and for seven of the 10 cases, a consultant obstetrician was present.

8 Allen VM, O'Connell CM, Baskett TF. Maternal and Perinatal morbidity of caesarean delivery at full cervical dilatation compared with caesarean delivery in the first stage of labour. BJOG. 2005; 112:986-90

Management of major obstetric haemorrhage

It is widely acknowledged that the management of MOH requires a multidisciplinary care approach with early direct consultant and senior staff involvement. Figure 3 illustrates the reported presence of health professionals during management and care of MOH in each of the three years of this audit. An obstetric registrar and an anaesthetic registrar were present for in excess of 90% of MOH cases and theatre staff were present for approximately 90% of cases each year. There was an increase in the documented presence of obstetric consultants, senior midwives and anaesthetic consultants in cases of MOH over the three years.

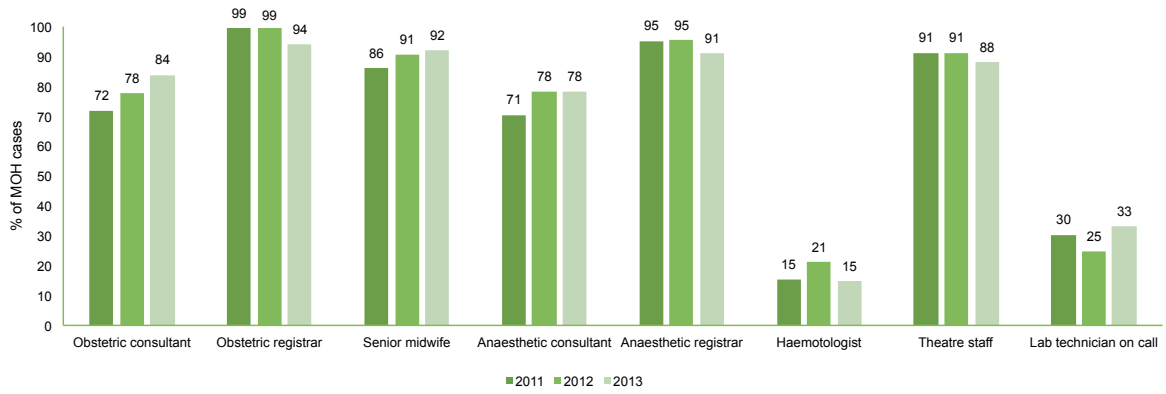

Figure 3: Presence of healthcare professionals during management and care of major obstetric haemorrhage (MOH), 2011-2013

Note: Percentages illustrated above were calculated after excluding cases where the presence of the healthcare professional was not known.

Placenta praevia and accreta

It has been identified that women with placenta praevia/accreta are at very high risk of major post-partum haemorrhage.[9] There were 46 cases of MOH (13.5%) in 2012 and 2013 which were known cases of placenta praevia. There were 16 cases (4.7%) for which morbidly adherent placenta was suspected. In total, one or both of these risk factors were known or suspected for 49 cases of MOH (14.4%) in 2012 and 2013. The management of these cases is detailed in Table 21 in comparison to 23 similar cases reported to this audit for 2011. Elective caesarean section was planned for three quarters of the 2012/13 cases compared to approximately 90% of the cases in 2011. An obstetric consultant was present at the delivery in 86% of cases in 2012/2013 compared to 96% of cases in 2011 and interventional radiology was used in just 4% of cases in 2012/2013 compared to one in three cases in 2011. Blood salvage was planned and occurred in 8% and 6% of the cases in 2012/2013, respectively, whereas these actions were not reported for known or suspected cases of placenta praevia/accreta in 2011.

9 Clinical Practice Guideline No 17 (2012). Guideline for the Prevention and Management of Primary Postpartum Haemorrhage: Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive.

Table 21: Management of major obstetric haemorrhage cases with known placenta praevia and/or suspected placenta accreta

Action undertaken	2011 (N=23)	2012/2013 (N=49)
Elective caesarean section planned	21 (91.3)	38(77.6)
Obstetric consultant present at delivery	22 (95.7)	42(85.7)
Interventional radiology undertaken	8 (35%)	2(4.1)
Blood cell salvage was planned	--	4(8.2)
Blood cell salvage occurred	--	3(6.1)

Note: Values are shown as n(%) unless otherwise stated.

Use of uterotonic agents

Current guidelines recommend the routine use of prophylactic oxytocin in the management of the third stage of labour.[10] A prophylactic uterotonic agent was administered to at least 90% of the women who gave birth and experienced MOH. This was the case in each of this audit's three years and despite the high prevalence, an increase in the use of these agents has been reported, ranging from 91.5% in 2011 (n=139 of 152), to 93.5% in 2012 (n=145 of 156) to 95.3% in 2013 (n=164 of 172).

Table 22: Use of prophylactic uterotonic agents by mode of delivery for women who gave birth and experienced major obstetric haemorrhage in 2012 and 2013

	Vaginal delivery (N=119)	Caesarean section (N=209)	Total (N=328)
Any uterotonic agent	113(95.0)	196(93.8)	309(94.2)
Syntocinon	90(75.6)	192(91.9)	282(86.0)
Syntometrine	35(29.4)	27(12.9)	62(18.9)
Other	8(6.7)	10(4.8)	18(5.5)

Note: Values are shown as n(%) unless otherwise stated. The category 'Other' mostly involved the use of ergometrine. More than one agent was administered in some cases and therefore the percentages may sum to more than 100%.

For the women who gave birth and experienced MOH in 2012 and 2013, there was a difference in the specific prophylactic uterotonic agents administered (Table 22). Three quarters of the women who gave birth by vaginal delivery received syntocinon compared to 92% of the women delivered by caesarean section. Syntometrine was administered twice as often to women delivering vaginally compared to women who delivered by caesarean section (29% vs. 13%). One in eight women received both syntocinon and syntometrine (n=39 of 328, 11.9%) irrespective of mode of delivery (vaginal delivery: n=15 of 119, 12.6%; caesarean section delivery: n=24 of 209, 11.5%).

The use of uterotonic agents for women experiencing MOH associated with uterine atony is detailed in Table 23 for the three years of this audit in Ireland, 2011-2013. Data from the most recent Scottish Confidential Audit of Severe Maternal Morbidity, for the year 2012, have been included for comparative purposes. [11]

10 Clinical Practice Guideline No 17 (2012). Guideline for the Prevention and Management of Primary Postpartum Haemorrhage: Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive.
11 Scottish Confidential Audit of Severe Maternal Morbidity: 9th Annual Report (2013). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx

Table 23: Uterotonic agent used among women experiencing MOH associated with uterine atony in Ireland 2011-2013 and in Scotland 2012

Uterotonic agent	Ireland 2011 (N=68)	Ireland 2012 (N=63)	Ireland 2013 (N=67)	Scotland 2012
Syntocinon infusion (40 units)	63(92.6)	60(95.2)	65(97.0)	93%
Syntocinon 5-10 units (IM/IV)	50(73.5)	28(44.4)	39(58.2)	61%
Syntometrine 5mg (IM)	22(32.4)	19(30.2)	18(26.9)	NR
Ergometrine 0.5mg (IM/IV)	22(32.4)	23(36.5)	28(41.8)	67%
Carboprost 0.25mg (IM)	46(67.6)	44(69.8)	45(67.2)	66%
Misoprostol 200 μg/mcg(PO/PV)	57(83.8)	44(69.8)	48(71.6)	34%
Tranexamic acid 1g	6(8.8)	11(17.5)	7(10.4)	NR

Note: Values are shown as n(%) unless otherwise stated. More than one agent was administered in some cases and therefore the percentages may sum to more than 100%. IM=Intramuscular or intra-myometrial; IV=Intravenous; PO=orally; PV=vaginally; NR=not reported

Syntocinon infusion was received by over 90% of the women in each year in Ireland and there was a suggestion of an increase as its use ranged from 93% in 2011 to 95% in 2012 and 97% in 2013. The use of syntocinon infusion was similar in Scotland.

Fewer than one in three of the women received syntometrine in Ireland and there was a suggestion that its use may be diminishing in this subgroup of MOH cases. Conversely, ergometrine was administered more often over the three-year period. However, most of the women did not receive ergometrine in Ireland whereas two thirds of the women experiencing MOH due to uterine atony received the drug in Scotland. Carboprost was administered in two thirds of cases, in each year and in both countries.

There was a far higher reported use of misoprostol in Ireland compared with Scotland. This finding is surprising given that the current national clinical practice guideline on postpartum haemorrhage highlights the lack of data supporting the efficacy of misoprostal.[12,13]

12 Clinical Practice Guideline No 17 (2012). Guideline for the Prevention and Management of Primary Postpartum Haemorrhage: Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive.
13 Mousa HA. & Alfirevic Z. (2007) Treatment for primary postpartum haemorrhage. Cochrane Database Syst Rev2007 Jan 24;(1):CD003249.

Haemostatic surgical procedures

The incidence of haemostatic surgical procedures undertaken for women experiencing MOH is detailed in Table 24 for the three years of this audit in Ireland, 2011-2013, and for Scotland for the year 2012, the most recent year with available data.[14]

None of the listed procedures were undertaken for 17-25% of the women who experienced MOH in Ireland in 2011-2013 (2011: n=29 of 159, 18.2%; 2012: n=27 of 164, 16.5%; 2013: 45 of 177, 25.4%).

Table 24: Haemostatic surgical procedures undertaken for women experiencing major obstetric haemorrhage in Ireland 2011-2013 and in Scotland 2012

Procedure	Ireland 2011 (N=159)	Ireland 2012 (N=164)	Ireland 2013 (N=177)	Scotland 2012
Manual removal of placenta/retained tissue	36(22.6)	41(25.0)	35(19.8)	NR
Repair of vaginal/cervical lacerations	33(20.8)	29(17.7)	19(10.7)	NR
Re-suturing CS uterine incision / suturing of lateral extension	15(9.4)	18(11.0)	20(11.3)	NR
Intra-uterine balloon tamponade	47(29.6)	48(29.3)	44(24.9)	24%
Intra-myometrial carboprost	25(15.7)	21(12.8)	13(7.3)	NR
Haemostatic brace uterine suturing	12(7.5)	19(11.6)	12(6.8)	6%
Bilateral ligation of uterine arteries	4(2.5)	11(6.7)	5(2.8)	1%
Uterine artery embolization (interventional radiology)	8(5.0)	2(1.2)	3(1.7)	3%
Bilateral ligation of iliac arteries	1(0.6)	1(0.6)	2(1.1)	1%
Hysterectomy	22(13.8)	18(11.0)	16(9.0)	6%

Note: Values are shown as n(%) unless otherwise stated. More than one agent was administered in some cases and therefore the percentages may sum to more than 100%. CS=caesarean section; NR=not reported

Intra-uterine balloon tamponade was the most common haemostatic surgical procedure being undertaken for approximately one in four women experiencing MOH each year in Ireland and in Scotland. The next most common procedure, manual removal of placenta/retained tissue was required for 20-25% of MOH cases in Ireland.

Repair of vaginal/cervical lacerations was required less often over the three years in Ireland, being undertaken for one in five Irish MOH cases in 2011 compared to one in nine cases in 2013. There was a halving of the incidence of intra-myometrial carboprost from 16% in 2011 to 7% in 2013.

Across the three years, a smaller proportion of women experiencing MOH required a hysterectomy, ranging from 14% in 2011 to 9% in 2013. Hysterectomy was required for a smaller proportion of MOH cases in Scotland.

Re-suturing of caesarean section uterine incisions and/or suturing of lateral extensions was undertaken for one in nine Irish cases of MOH. The remaining procedures (haemostatic brace uterine suturing, bilateral ligation of uterine arteries, uterine artery embolization and bilateral ligation of iliac arteries) were relatively rare as they were in Scotland. The only possible exception was bilateral ligation of uterine arteries which was undertaken for 3-7% of Irish MOH cases compared to 1% of Scottish cases.

14 Scottish Confidential Audit of Severe Maternal Morbidity: 9th Annual Report (2013). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx

Blood transfusion, resuscitation and monitoring

Actions undertaken related to the resuscitation of the MOH patients in 2012/2013 are detailed in Table 25. For the vast majority, venous access was obtained, two large venous cannulae were sited and oxygen given. This is in keeping with national guidelines on postpartum haemorrhage.[15]

With respect to intravenous fluid replacement while awaiting compatible blood, national guidelines recommend a maximum total volume of 3.5 litres of clear fluids (up to 2 litres of crystalloid followed by up to 1.5 litres of colloid).[15] The recommended 3.5 litre maximum was exceeded in 15% of MOH cases with available data (n=43 of 289, 14.9%). One in four cases received over 2 litres of crystalloid (n=74 of 290, 25.5%). Fifty-five women (16.1%) did not receive a colloid solution. Of those that did, one in ten were reported to have received more than 1.5 litres (n=23 of 240, 9.6%).

Of the 341 cases of MOH in 2012 and 2013, 93% (n=318, 93.3%) were reported as having received a blood transfusion, as was reported for cases of MOH in 2011. Of the 23 cases of MOH who were not reported to have received a blood transfusion in 2012/2013 (including three cases with missing data), three women were reported as having refused the transfusion.

Table 25: Actions undertaken related to the resuscitation of women who experienced major obstetric haemorrhage in 2012 and 2013

	n(%)
Venous access achieved prior to the event	314(92.1)
Venous access achieved during the event	274(80.4)
Two large venous cannulae sited	304(89.1)
Oxygen given	287(84.2)
Blood transfusion performed	318(93.3)
Specialist equipment used to provide warm, rapid transfusion	198(58.1)

Categories are not mutually exclusive and may add up to over 100%.

Of the 318 MOH cases reported to have received a blood transfusion, the total number of units transfused was specified for 298 (93.8%) and ranged from one to 24 units. The vast majority of these women received 2-6 units (n=236, 79.2%). Types of transfusions and the range of units transfused are detailed in Table 26.

Table 26: Type of transfusion and units transfused in cases of major obstetric haemorrhage in 2012 and 2013

Type	Number of women transfused (N=318)	Range of units transfused
Red blood cells		
"Emergency" O negative blood	82(25.8)	1-18
Group specific uncross-matched blood	14(4.4)	1-5
Cross-match blood	274(86.2)	1-24
Blood products		
Fresh frozen plasma	81(25.5)	1-20
Fibrinogen concentrate	134(42.1)	1-12
Platelets	73(23.0)	1-8
Octoplas	125(39.3)	1-23
Activated factor VII	3(0.9)	5-16

Note: Values are shown as n(%) unless otherwise stated. Categories are not mutually exclusive and may add up to over 100%.

15 Clinical Practice Guideline No 17 (2012). Guideline for the Prevention and Management of Primary Postpartum Haemorrhage: Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive.

For almost all MOH patients in 2012/2013 there was regular monitoring of blood pressure, pulse and urine output and use of a pulse oximeter and Foley catheter (Table 27). This was also reported for cases in 2011. There was a marked increase in the use of the obstetric early warning chart. It was used for less than half of the MOH patients in 2011 (n=67, 45%) compared to three quarters of MOH patients in 2012/2013.

Table 27: Actions undertaken in the monitoring of women who experienced major obstetric haemorrhage in 2012 and 2013

	n(%)
Obstetric early warning chart	254(74.5)
Blood pressure monitored (at least every 15 minutes)	334(97.9)
Pulse monitored (at least every 15 minutes)	334(97.9)
Pulse oximeter used	328(96.2)
Foley catheter in-situ	336(98.5)
Urine output measured regularly	332(97.4)
Central venous pressure line	79(23.2)
Arterial line	184(54.0)

Categories are not mutually exclusive and add up to over 100%.

For 80 MOH cases in 2012/2013, it was reported that an obstetric early warning chart was not used (data were not recorded for seven cases). Just over half of the women in these cases were admitted to an ICU (n=42, 52.5%), a further 28% (n=22, 27.5%) were managed in a high dependency room on the labour ward and 4% were admitted to a general high dependency unit (n=3, 3.8%).

National guidelines recommend continuous close monitoring of women in appropriate settings following major postpartum haemorrhage and the audit identifies good adherence to this advice. Considering all 341 women who experienced MOH in 2012/2013, one in three were admitted to an ICU (n=111 of 338, 32.8%; data missing for three cases), a further 43% (n=146 of 338, 43.2%) were managed in a high dependency room on the labour ward and 9% were admitted to a general high dependency unit (n=29 of 338, 8.6%).

Quality of care in major obstetric haemorrhage

The detailed MOH questionnaire requests each unit to self-assess lessons to be learnt from care given. Data on the classification of management was not provided for 63 cases (18.5%). For the other 278 cases of MOH, appropriate care was reported for 85.6% (n=238), management of 11.5% (n=32) of cases was described as incidental suboptimal care which did not affect the outcome but where lessons could be learned. There were eight cases (2.9%) where the management of the case was described as suboptimal care impacting on the outcome. These viewpoints were either based on consensus at a risk management meeting (51.7%), clinical case presentation (14.8%), informal clinical discussion (20.9%) or personal opinion (20.2%).

A time delay in access to theatre was reported for five cases (1.5%) of major obstetric haemorrhage; the approximate wait time ranged from 10 to 100 minutes.

International guidelines on obstetric haemorrhage were available for the reporting years of this audit and an Irish guideline on Prevention and Management of Primary Postpartum Haemorrhage has been available since 2012.[16] For almost all cases (n=337, 98.8%) it was stated that the unit had a protocol for the management of MOH, and in the vast majority of cases (n=295, 87.5%) the management of the MOH case adhered to the protocol. Adherence was not specified in 22 cases (6.5%) and there were 20 cases (5.9%) where the management of the case did not adhere to the unit's protocol.

Frequent monitoring of parameters was reported for almost all MOH patients as detailed in Table 27 above. The use of obstetric early warning charts in the monitoring of patients was reported in 75% of cases in 2012/2013, a marked increase of the 45% reported rate of their use for MOH cases in 2011. This may be related to the lead up to the implementation of a national Irish Maternity Early Warning System (IMEWS) in 2014.[17] Parameters may also have been recorded on flow charts such as high dependency charts.

Summary of learning points described by units

Eight of the reporting units described examples of both good practice and learning points gleaned in assessment of individual MOH cases. The small proportion of units describing learning points in detail is perhaps disappointing but nevertheless lessons identified may be used on a national level to improve clinical care. Recurrent reported themes are summarised below:

Identified positive practices

- Early consultant and senior staff involvement.
- Multidisciplinary approach with good interdisciplinary communication.
- On-going multidisciplinary skills and drills educational programmes.
- Pre-delivery counselling of women at high risk for MOH of the potential need for blood transfusion and or peripartum hysterectomy.

Learning points

- Absence of documented management plan in the antenatal period in some high risk cases.
- Suboptimal estimation and recording of blood loss.
- Requirement for a specific proforma to document management and fluid balance during a major obstetric haemorrhage event.
- Use of MEWS to identify impending maternal collapse.
- Suboptimal interdisciplinary communication impacting on patient care
- Challenges faced by a stand-alone maternity unit when transfer of a woman for critical care to another site is required.

16 Clinical Practice Guideline No 17 (2012). Guideline for the Prevention and Management of Primary Postpartum Haemorrhage: Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive.

17 Clinical Practice Guideline No 25 (2014). The Irish Maternity Early Warning System (IMEWS) Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive

Peripartum hysterectomy

For the combined years 2012 and 2013, 42 cases of peripartum hysterectomy (PH) were reported by contributing units giving a national rate of 0.31 per 1,000 maternities or approximately one in every 3,200 maternities. There was no clustering of PH cases identified in any one maternity unit. As mentioned earlier, the PH rate found in this audit is similar to that of a previous Irish study[18], and to national rates reported in the UK and the Netherlands of 0.41 and 0.33 per 1,000 births respectively.[19,20]

Eight of the reported cases of PH were not associated with major obstetric haemorrhage (MOH) as defined in this audit. All eight were delivered by caesarean section prior to labour with three hysterectomies being reported as a planned procedure. The indication for delivery in this cohort was morbidly adherent placenta in the majority of these cases (n=5) with a further three cases reporting cervical cancer, uterine anomaly and uterine rupture (in a case of chorioangioma in a molar pregnancy). Of the 34 cases of PH associated with MOH, the reported cause of haemorrhage was not always attributed exclusively to one clinical risk factor (Table 28). For almost half of the cases (47.1%) there was more than one reported cause of MOH. The most commonly reported causes were placenta praevia (n=18, 52.9%), morbidly adherent placenta (n=14, 41.2%), uterine atony (n=11, 32.4%) and bleeding from uterine incision (n=7, 20.6%). A planned interventional radiology was carried out in two cases. Uterine rupture was not an identified cause of haemorrhage in any case of PH associated with MOH in this cohort.

Table 28: Cause of major obstetric haemorrhage in women experiencing peripartum hysterectomy in 2012 and 2013

	Associated cause		Only cause	
	n	%	n	%
Morbidly adherent placenta	14	41.2	1	2.9
Placenta praevia	18	52.9	5	14.7
Uterine atony	11	32.4	5	14.7
Cervical laceration	1	2.9	1	2.9
Bleeding from uterine incision	7	20.6	4	11.8
Other cause*	4	11.8	2	5.9

*Other cause includes infection and other specific causes

18 Murphy, CM, Murad, K, Deane, R, Byrne, B, Geary, MP, Mc Auliffe, FM. Severe maternal morbidity for 2004-2005 in the three Dublin maternity hospitals. Eur J Obstet Gynecol 2009: 143:34-37

19 Knight M, Kurinczuk JJ, Spark P and Brocklehurst P. United Kingdom Obstetric Surveillance System (UKOSS) Annual Report 2007. National Perinatal Epidemiology Unit, Oxford.

20 Kwee A, Bots ML, Visser GH, Bruinse HW. Emergency peripartum hysterectomy:a prospective study in The Netherlands. Eur J Obstet Gynecol Reprod Biol 2006;124(2):187–92

Haemostatic surgical procedures

The reported incidence of haemostatic surgical procedures undertaken for the 34 women who experienced MOH and required a hysterectomy in Ireland in 2012 and 2013 is detailed in Table 29. Early recourse to PH is recommended when conservative measures fail to arrest obstetric bleeding, especially where bleeding is associated with placenta accrete or uterine rupture, and should not be delayed until the woman is in extremis.[21]

Table 29: Haemostatic surgical procedures undertaken for women who experienced major obstetric haemorrhage and required a hysterectomy in Ireland in 2012 and 2013

Procedure	(N=34)
Intra-uterine balloon tamponade	10(29.4)
Manual removal of placenta/retained tissue	5(14.7)
Repair of vaginal/cervical lacerations	1(2.9)
Intra-myometrial carboprost	2(5.9)
Re-suturing CS uterine incision/ suturing of lateral extension	3(8.8)
Haemostatic brace uterine suturing	4(11.8)
Bilateral ligation of uterine arteries	5(14.7)
Uterine artery embolization (interventional radiology)	2(5.9)
Bilateral ligation of iliac arteries	1(2.9)

Categories are not mutually exclusive and add up to over 100%.

Mode of delivery

Caesarean section was the mode of delivery for all but one of the 42 women requiring PH with the majority (n= 32, 78%) carried out prior to the onset of labour (Table 30).

The NPEC detailed audit form on MOH seeks to record the grade of the obstetrician performing the caesarean section. This was recorded for 30 of the 34 women who had a PH associated with MOH. For three quarters of these cases (n=23, 76.7%) the caesarean section was carried by a consultant obstetrician. A registrar or specialist registrar carried out the procedure in five (16.7%) and two (6.7%) cases, respectively. For these seven cases, a consultant obstetrician was present for four deliveries and was informed of the other three cases.

Table 30: Mode of delivery in women experiencing peripartum hysterectomy in 2012 and 2013

Mode of delivery	(N=41)*
Non-rotational forceps vaginal delivery	1(2.4)
Elective LSCS not in labour	20(48.8)
Elective LSCS in labour	1(2.4)
Emergency LSCS not in labour	12(29.3)
Emergency LSCS in labour	5(12.2)
Classical caesarean section	2(4.9)

Note: Values are shown as n(%) unless otherwise stated. * Mode of delivery was not known for one case.

21 Clinical Practice Guideline No 17 (2012). Guideline for the Prevention and Management of Primary Postpartum Haemorrhage: Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive.

Co-morbidities

A number of severe maternal co-morbidities, as defined in this audit, were associated with women who had a PH (Table 31). As mentioned above, the vast majority experienced MOH. Over half (n=23, 54.8%) of the women were admitted to ICU and four (9.5%) of the cases were complicated by a pulmonary embolism. Notwithstanding the small numbers involved, this suggests that the risk of pulmonary embolism in cases of PH (4 of 42, i.e. 95 per 1,000 maternities) is several hundred times greater than the risk in all maternities (0.27 per 1,000; rate ratio = 352, 95% confidence interval = 125-989, p-value < 0.001).

Table 31: Severe maternal morbidity associated with women experiencing peripartum hysterectomy in 2012 and 2013

	(N=42)
Major obstetric haemorrhage	34(81.0)
ICU admission	23(54.8)
Pulmonary embolism	4(9.5)
Pulmonary oedema	1(2.4)
Acute respiratory dysfunction	1(2.4)

Causal factors

A number of studies over the last decade have identified an association between PH, previous caesarean section and placenta accreta.[22,23,24] In this audit, data on previous caesarean section in cases of PH was available for 35 women. The majority of these (n=28, 80.0%) had a previous caesarean section with over half (n=19, 54.3%) having two or more previous caesarean sections (Table 32).

Morbidly adherent placenta was a causal factor for PH in half of the 35 cases with data on history of previous caesarean section (n=17, 48.6%). All but one of the women in these 17 cases (n=16, 94.1%) had a previous caesarean section with most (11, 64.7%) having two or more previous caesarean sections (Table 31).

Table 32: Causal factors in 2012 and 2013 cases of peripartum hysterectomy by number of previous caesarean sections

Number of previous caesarean sections	Placenta praevia	Morbidly adherent placenta	Praevia and morbidly adherent placenta	Other causes	Total
0	1	0	1	5	7(20.0)
1	0	1	4	4	9(25.7)
≥2	5	2	9	3	19(54.3)
Total	6(17.1)	3(8.6)	14(40.0)	12(34.3)	35(100)

Note: Excludes missing data for seven of 42 cases of peripartum hysterectomy; Values are shown as n(%) unless otherwise stated. Other causes were uterine atony (n=6), bleeding from uterine incision (n=4); infection (n=1) and cervical laceration (n=1).

22 Knight M, Kurinczuk J, Spark P,and Brocklehurst P, for the UKOSS. Cesarean Delivery and Peripartum Hysterectomy. American college of Obstetricians and Gynaecologists 2008 Vol111, No.1 97-105

23 Flood K, Said S, Geary M, Robson M, Fitzpatrick C and Malone F. Changing trends in peripartum hysterectomy over the last 4 decades. Am J Obstet Gynecol 2009;200:632.e1-632.e6.

24 Kwee A, Bots ML, Visser GH, Bruinse HW. Emergency peripartum hysterectomy: a prospective study in The Netherlands. Eur J Obstet Gynecol Reprod Biol 2006;124:187–92.

Appendix A: National Office of Clinical Audit Governance Board endorsement of Severe Maternal Morbidity in Ireland Annual Report 2012 and 2013

NOCA National Office of Clinical Audit

Professor Richard A. Greene
Director
National Perinatal Epidemiology Centre
5th Floor, Cork University Maternity Hospital
Wilton
Cork

24th April 2015

Dear Professor Greene,

I write to thank you and your colleagues Dr Paul Corcoran and Edel Manning, for your detailed presentation to the NOCA Governance Board, 15th April 2015 of NPEC's Severe Maternal Morbidity in Ireland - Annual Report 2012 & 2013.

You and the extended NPEC Team, Advisory Groups and hospital data collectors are to be commended for this work. This report serves to highlight the value of sustainable audit to inform quality improvement of obstetric care in Ireland.

As discussed with the NOCA Board, variances noted between ICU admissions nationally and the need to carry out a full review would be extremely beneficial and help inform service delivery of critical care for obstetrics. We look forward to the output of such a review.

The NOCA Board and Executive Team will continue to support NPEC governance efforts and in particular highlight the national requirement for resource commitment to ensure sustainable clinical audit of perinatal and maternal outcomes.

Please accept this as formal endorsement from the NOCA Board of the Severe Maternal Morbidity in Ireland Annual Report 2012 & 2013.

Yours sincerely,

Professor Sean Tierney
Chairman
National Office of Clinical Audit

National Office of Clinical Audit, 4th Floor, 121 St. Stephen's Green, Dublin 2 Tel: 4028577

Appendix B: Maternal Morbidity Advisory Group Members

Dr Bridgette Byrne, Consultant Obstetrician/Gynaecologist, Coombe Women & Infants University Hospital, Dublin
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Dr Deirdre Daly, Assistant Professor in Midwifery, Trinity College Dublin
Nominated by Deputy Nursing Services Director, HSE

Prof Declan Devane, Professor of Midwifery, National University of Ireland, Galway
Nominated by Deputy Nursing Services Director, HSE

Dr Michael Geary, Consultant Obstetrician/Gynaecologist, Rotunda Hospital, Dublin (until August 2014)
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Dr Miriam Harnett, Consultant Anaesthetist, Cork University Hospital (until August 2014)
Nominated by the Irish College of Anaesthetists

Dr Mary Higgins, Consultant Obstetrician/Gynaecologist, National Maternity Hospital, Dublin (since August 2014)
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Ms Ita Kinsella, Clinical Midwife Manager 3, Midland Regional Hospital, Portlaoise
Nominated by Deputy Nursing Services Director, HSE

Dr Cliona Murphy, Consultant Obstetrician & Gynaecologist, Coombe Women & Infants University Hospital, Dublin (since August 2014)
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Ms Janet Murphy, Advanced Midwife Practitioner, Waterford Regional Maternity Hospital
Nominated by Deputy Nursing Services Director, HSE

Dr Meabh Ni Bhuinneain, Consultant Obstetrician & Gynaecologist, Mayo General Hospital (since August 2014)
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Dr Ray O'Sullivan, Consultant Obstetrician/Gynaecologist, St. Luke's Hospital, Kilkenny
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI

Prof Richard A Greene (Chair), Consultant Obstetrician/Gynaecologist, Cork University Maternity Hospital
Director of the National Perinatal Epidemiology Centre

Ms Edel Manning, Research Midwife, National Perinatal Epidemiology Centre, Severe Maternal Morbidity Project Coordinator

Ms Jennifer Lutomski, Epidemiologist, National Perinatal Epidemiology Centre (until August 2014)

Mr Paul Corcoran PhD, Senior Lecturer in Perinatal Epidemiology, National Perinatal Epidemiology Centre

Appendix C: Hospital co-ordinators and contributors 2012 and 2013

Hospital	Co-ordinators	Additional contributors
Cavan General Hospital	Dr Rukhsana Majeed Ms Karen Malocca	Dr Salah Aziz, Ms Margaret Mulvany
Coombe Women and Infants University Hospital	Dr Bridgette Byrne	
Cork University Maternity Hospital	Ms Katie Burke Ms Geraldine Hayes	Dr Miriam Harnett
Kerry General Hospital, Tralee	Ms Claire Fleming Kelliher Ms Mary Stack Courtney	
Letterkenny General Hospital	Ms Raphael Dalton, Ms Mary Doherty, Ms Geraldine Hanley, Ms Mary Lynch	Ms Evelyn Smith
Mayo General Hospital, Castlebar	Ms Pauline Corcoran Ms Diane Brady	Dr Hilary Ikele Dr Meabh Ní Bhuinneain
Midland Regional Hospital, Mullingar	Ms Marie Corbett	
Midland Regional Hospital, Portlaoise	Ms Ita Kinsella Ms Emma Mullins	Dr Miriam Doyle
Mid-Western Regional Maternity Hospital, Limerick	Ms Therese O Donoghue	
Mount Carmel Hospital, Dublin	Ms Catherine Halloran Ms Felicity Doddy	Dr Valerie Donnelly
National Maternity Hospital, Dublin	Dr Jennifer Hogan Dr Vicky O Dwyer	
Our Lady of Lourdes Hospital, Drogheda	Ms Anne Keating	Dr Seosamh Ó Cóigligh
Portiuncula Hospital, Ballinasloe	Ms Mary Burke	
Rotunda Hospital, Dublin	Dr Sharon Cooley	
Sligo General Hospital	Ms Juliana Henry	Dr Heather Langan
South Tipperary General Hospital, Clonmel	Ms Siobhan Kavanagh	
St Luke's Hospital, Kilkenny	Ms Connie McDonagh	
University Hospital Galway	Ms Siobhan Canny	Dr Geraldine Gaffney
Waterford Regional Hospital	Ms Janet Murphy	
Wexford General Hospital	Ms Helen McLoughlin	

Appendix D: NPEC Governance Committee

Chair: *Dr Michael Robson, Consultant Obstetrician and Gynaecologist, National Maternity Hospital

Dr Michael Brassil, Consultant Obstetrician and Gynaecologist, Portiuncula Hospital

Ms Fiona Cahill, Manager, National Office of Clinical Audit

Professor Tom Clarke, Consultant Neonatologist, Rotunda Hospital

***Dr Sam Coulter-Smith,** Master, Rotunda Hospital

Ms Marie Cregan, University College Cork - Patient Representative, nominated by HSE National Advocacy Unit

***Professor Declan Devane,** Chair of Midwifery, National University of Ireland, Galway

***Dr Geraldine Gaffney,** Senior Lecturer, National University of Ireland, Galway

Ms Ann Keating , Clinical Midwife Manager 3, Our Lady of Lourdes Hospital

Ms Geraldine Keohane, Director of Midwifery, Cork University Maternity Hospital

Dr Heather Langan, Consultant Obstetrician and Gynaecologist, Sligo General Hospital

Dr Rhona Mahony, Master, National Maternity Hospital

Ms Connie McDonagh, Clinical Midwife Manager 3, St. Luke's General Hospital

***Dr Eleanor Molloy,** Consultant Neonatologist, National Maternity Hospital

***Professor Deirdre Murphy,** Chair in Obstetrics, Trinity Centre for Health Sciences, St. James Hospital

Dr Edward O'Donnell, Consultant Obstetrician and Gynaecologist, Waterford Regional Hospital

Dr Mary O'Mahony, Specialist in Public Health Medicine, HSE

Dr Sharon Sheehan, Master, Coombe Women and Infants University Hospital

*denotes membership of Data Access Sub-Group

Appendix E: NPEC Staff

Professor Richard A Greene, Director

Paul Corcoran, Epidemiologist

Linda Drummond, Administrator

Jennifer Lutomski, Epidemiologist

Edel Manning, Research Midwife

Joye McKernan, Research Administrator

Sarah Meaney, Research Officer

Leanne O'Connor, Research Administrator

Appendix F: Obstetric Haemorrhage Proforma

Mother's Name _____

Date of birth _____

Hospital Number _____

Obstetric Haemorrhage Documentation

Date … /… /…. Time ……..
Clinical Area……..
Person completing form ……..Staff Grade……
Signature ……..……
Primary Cause of Obstetric Haemorrhage……
Total Estimated Blood Loss ……
Local obstetric emergency team activated Yes/No If Yes, time activated……..

	Name	Time informed	Time arrived
Clinical Midwife Manager			
Porter			
Consultant Obstetrician			
Consultant Anaesthetist			
Haematologist (or when contacted blood bank)			**N/A**

Other Staff present	Status	Other Staff present	Status

Management	Time	Treatment		Dose	Time	Order
Assess CAB, position & observations (MEWS)		Syntocinon (IM or slow IV injection)				
Oxygen		IM Syntometrine				
Cannula 1: Colour……		Syntocinon infusion				
Cannula 2: Colour……		Misoprostol				
FBC		Haemabate (Carboprost)	1			
Clotting screen & Cross match			2			
Crystalloids			3			
Assess urgency for transfusion			4			
Catheter			Further doses			
Bimanual compression						
Repair perineal trauma						

Blood products	Amount	Time	Further management		Details
RBC			Theatre	EUA	
FFP				B-Lynch	
Platelets				Balloon	
Cell salvage				Hysterectomy	
Other information	Blood warmer used Yes No			I Radiology	
	Body warmer used Yes No		Arterial line		Yes No
Debrief	Staff Yes No Woman/partner Yes No		HDU care/ ICU transfer		Yes No

Appendix G: Severe Maternal Morbidity Notification Form

NATIONAL PERINATAL EPIDEMIOLOGY CENTRE

CONFIDENTIAL AUDIT OF SEVERE MATERNAL MORBIDITY IN IRELAND

Notification Form: 2013

Hospital Name _____

Completed by _____
(Please print name and staff grade)

Date of event: ☐☐ ☐☐ ☐☐☐☐

Time of onset of event: ☐☐☐☐ (24 hour clock)

Woman's details

Number*: ☐☐ **Age** ☐☐ **Height at booking** _____cm

Weight at booking _____kg

* NPEC case number

BMI ☐☐ **Parity:** ☐ + ☐
(Status prior to delivery)

Date of delivery: ☐☐/☐☐/☐☐ **Gestation at delivery/pregnancy end** ☐☐
(or pregnancy end) (Completed weeks)

1. Ethnic group:

White Irish ☐ Irish Traveller ☐

Any other White background ☐ Please specify country of origin _____

Asian or Asian Irish ☐ Black or Black Irish ☐

Other, including mixed ethnic backgrounds: ☐ Not recorded ☐

1

2.a. Did the woman smoke at booking? Yes ☐ please specify quantity _____

No ☐ Not recorded ☐

2b. Did she give up smoking during pregnancy? Yes ☐ No ☐ Not recorded ☐ N/A ☐

3. Did the woman drink alcohol at booking? Yes ☐ No ☐ Not recorded ☐

4. Is there documented history of drug abuse or attendance at a drug rehabilitation unit?

None recorded ☐ Prior to this pregnancy ☐ During this pregnancy ☐

5. Mode of delivery:

	Baby 1	Baby 2*		Baby 1	Baby 2*
i) Spontaneous vaginal delivery	☐	☐	vi) Elective LSCS not in labour	☐	☐
ii) Assisted vaginal breech delivery	☐	☐	vii) Elective LSCS in labour	☐	☐
iii) Ventouse vaginal delivery	☐	☐	viii) Emergency LSCS not in labour	☐	☐
iv) Non-rotational forceps vaginal delivery	☐	☐	ix) Emergency LSCS in labour	☐	☐
v) Rotational forceps vaginal delivery	☐	☐	x) Classical Caesarean Section	☐	☐

Neonatal Outcome

Please answer yes or no as applicable

Baby Outcomes	Baby 1	Baby 2	Baby 3
Birth weight in grams			
Intubation following delivery			
Transferred to SBCU/NICU			
*Early Neonatal Death			
*Late Neonatal Death			
Intrauterine death ≥ 500g			
*Miscarriage			

*Please refer to reference manual for definitions

Maternal Morbidity Category

(See page 4 for definitions)

Please tick all that apply

1. Major obstetric haemorrhage*	
2. Uterine rupture	
3. Peripartum hysterectomy* *please specify indication for peripartum hysterectomy	
4. Eclampsia	
5. Renal or liver dysfunction	
6. Pulmonary oedema	
7. Acute respiratory dysfunction	
8. Pulmonary embolism	
9. Cardiac arrest	
10. Coma	
11. Cerebro-vascular event	
12. Status epilepticus	
13. Septicaemic shock	
14. Anaesthetic problem	
15. ICU/CCU admission* ***please specify indication for admission**	
16. Other severe morbidity, please specify	
17. Interventional radiology (IR)* 17a Planned	
17b. Unplanned	

***** For categories 1 (Major Obstetric Haemorrhage) and 17 (Interventional Radiology), please complete the NPEC Major Obstetric Haemorrhage Audit Form

Please use this space to enter any additional relevant information

Maternal Morbidity Definitions		
1	Major obstetric haemorrhage	Estimated blood loss ≥ 2500ml, or transfused 5 or more units of blood or received treatment for coagulopathy (Fresh Frozen Plasma; Fibrinogen Concentrate Substitution Therapy; Platelets) (Also includes ectopic pregnancy meeting these criteria)
2	Uterine rupture	A complete separation of the wall of the pregnant uterus, with or without expulsion of the fetus, involving rupture of membranes at the site of the uterine rupture or extension into uterine muscle separate from any previous scar, and endangering the life of the mother or fetus. Excluded: any asymptomatic palpable or visualised defect (e.g. dehiscence noted incidentally at caesarean delivery)
3	Peripartum hysterectomy	Peripartum hysterectomy
4	Eclampsia	Seizure associated with antepartum, intrapartum or postpartum symptoms and signs of pre-eclampsia
5	Renal or liver dysfunction	Acute onset of biochemical disturbance, urea >15mmol/l, creatinine>400mmol/l, AST/ALT >200u/l
6	Pulmonary oedema	Clinically diagnosed pulmonary oedema associated with acute breathlessness and O_2 saturation <95%, requiring O_2, diuretics or ventilation
7	Acute respiratory dysfunction	Requiring intubation or ventilation for >60 minutes (not including duration of general anaesthetic)
8	Pulmonary embolism	Increased respiratory rate (>20/min), tachycardia, hypotension. Diagnosed as "high" probability on V/Q scan or positive spiral chest CT scan. Treated by heparin, thrombolysis or embolectomy
9	Cardiac arrest	No detectable major pulse
10	Coma	Including diabetic coma. Unconscious for >12 hours
11	Cerebro-vascular event	Stroke, cerebral/cerebellar haemorrhage or infarction, subarachnoid haemorrhage, dural venous sinus thrombosis
12	Status epilepticus	Constant or near constant state of having seizures that last 30mins or more
13	Septicaemic shock	Shock (systolic blood pressure <80) in association with infection. No other cause for decreased blood pressure. Pulse of 120bpm or more
14	Anaesthetic problem	Aspiration, failed intubation, high spinal or epidural anaesthetic
15	ICU/CCU admission	Unit equipped to ventilate adults. Admission for one of the above problems or for any other reason. Includes CCU admissions
16	Other severe morbidity	Other severe morbidity, e.g. amniotic fluid embolism
17	Interventional radiology	Received planned (a) or unplanned (b) interventional radiology

Please notify all categories of Severe Maternal Morbidity, as outlined above, occurring during pregnancy or up to 42 days following delivery, miscarriage, termination of pregnancy or ectopic pregnancy.

NATIONAL PERINATAL
EPIDEMIOLOGY CENTRE

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