Severe maternal morbidity in Ireland

NATIONAL PERINATAL EPIDEMIOLOGY CENTRE

ANNUAL REPORT 2016

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List of Acronyms and Abbreviations

ACVS - Advanced Cardiovascular Support

BCVS - Basic Cardiovascular Support

BMI - Body Mass Index

CCU - Critical Care Unit

CS - Caesarean section

HDU - High Dependency Unit

HPO - Healthcare Pricing Office

HSE - Health Service Executive

ICNARC - Intensive Care National Audit and Research Centre

ICU - Intensive Care Unit

MOH - Major obstetric haemorrhage

MDE Ireland - Maternal death enquiry Ireland

NM - Near Miss

NOCA - National Office of Clinical Audit

NPEC - National Perinatal Epidemiology Centre

NPRS - National Perinatal Reporting System

PE - Pulmonary embolism

PH - Peripartum hysterectomy

PMR - Perinatal Mortality Rate

SCASMM - Scottish Confidential Audit Severe Maternal Morbidity

SMC - Severe Maternal Complication

SMM - Severe maternal morbidity

TGCS - Robson Ten Group Classification System (Robson Classification System)

WHO - World Health Organisation

Foreword

Welcome the 2016 Severe Maternal Morbidity (SMM) Report from the National Perinatal Epidemiology Centre (NPEC). The most heartening aspect about this report is the commendable commitment of the busy Irish maternity units to go beyond clinical care and contribute to this national audit in order to help improve maternal care for women in Ireland. Working and learning together we can ensure that all pregnant and recently pregnant women receive safe high quality care in appropriate settings.

While the maternal mortality rate in Ireland is comparatively low, there has been an increasing incidence of severe maternal morbidity reported in recent years, particularly the incidence of major obstetric haemorrhage. This is similar to findings in other high income countries and highlights the importance of continual surveillance of maternal outcomes in our maternity services. However, it is important that we do not focus on rates and numbers alone. We should remember that severe maternal morbidity events can have a profound psychological effect on a woman's and her partner experience of childbirth.

A positive development to highlight is the implementation of recommendations from earlier maternal morbidity reports. All maternity units in the Republic of Ireland now contribute data to the NPEC audit on severe maternal morbidity. Recently, the interaction with the National Women and Infant's Health Programme (NWIHP) in assessing our recommendations with a view to implement nationally, has been a most welcome development.

This report adds to a body of evidence to allow us to make international comparisons and learn more about maternal morbidity in Ireland. I commend that all healthcare professionals involved in the maternity service be aware of the findings in this report.

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Acknowledgements

The content of this report reflects the commitment and dedication of many people within Irish maternity units and the National Perinatal Epidemiology Centre (NPEC).

It is with sincere thanks and appreciation that the NPEC would like to acknowledge the many healthcare professionals who contribute to this NPEC audit on severe maternal morbidity. In particular, we extend our thanks to the unit co-ordinators who co-ordinate the collection of data on severe maternal morbidity at centre level, many of whom do so without protected time for clinical audit (see Appendix A). This report would not have been possible without their dedicated support and co-operation.

The NPEC also acknowledge the members of the NPEC Maternal Morbidity Group for their guidance in the continual optimisation of the NPEC national clinical audit of severe maternal morbidity (Appendix B). We thank the NPEC Governance Committee, which represents a diverse range of key stakeholders from maternity centres and universities throughout the country, for their support and guidance as the Centre continues to grow and evolve (Appendix C).
We also gratefully acknowledge the National Office of Clinical Audit (NOCA), whose endorsement of this report is included in Appendix D.

Executive summary

The fifth report from the National Clinical Audit of Severe Maternal Morbidity (SMM) in Ireland reports on 406 cases of SMM occurring in all 19 Irish maternity units in 2016. Additionally, it presents findings from the Confidential Audit of Critical Care in Obstetrics in Ireland 2016. Fifteen of 19 Irish maternity units participated, including two large tertiary referral units and thirteen smaller units.

The SMM rate is a composite rate of a group of clearly defined severe morbidities. Almost three quarters of the women (n=293, 72.2%) who experienced SMM in 2016 were diagnosed with one morbidity; 21% (n=85, 20.9%) were diagnosed with two morbidities; 6% (n=23, 5.7%) with three morbidities; and 1% (n=5, 1.2%) with four morbidities.

Since the inception of the audit in 2011, the incidence of SMM has increased annually. In 2016, the rate of SMM was 6.46 per 1,000 maternities or one in 155 maternities. This represented a 68% rate increase from the base year 2011. However, the Irish SMM rate in 2016 was similar to the rate of 7.3 per 1,000 maternities reported by the most recent comparable audit in Scotland in 2012, which used the same composite rate for SMM.

Major obstetric haemorrhage (MOH) remains the most frequently reported SMM event in 2016, accounting for just over half (53%) of SMM cases. The incidence of MOH cases has increased from 2.34 per 1,000 maternities in 2011 to 3.39 per 1,000 maternities in 2016, an overall increase of 45% (rate ratio=1.45, 95% CI=1.18-1.77, p-value<0.001), which is highly statistically significant.

Admission to an intensive or coronary care unit (ICU/CCU) was the second most common event, having been reported in over a third (39.4%) of SMM cases. Just over one third (34.4%) of the women admitted to an ICU/CCU in 2016 had not experienced a SMM as defined in this audit. This shows a reduction in the occurrence of this phenomenon (recording 46% in 2015) which had shown a steady increase over the past years of the audit.

The next most common reported morbidities were renal or liver dysfunction (8.4%), septicaemic shock (6.9%), peripartum hysterectomy (6.7%) and pulmonary embolism (5.9%).

In 2016, the number and rate of cases for each SMM excluding MOH, ICU/CCU admission and septicaemia were broadly in line with those reported in 2011-2015. The rate of septicaemic shock in 2016 (0.45 per 1,000 maternities) was almost double the rate for 2011-2015 (p-value=0.005). The successive increases observed since 2013 may be a true increase in incidence or an increased awareness and recognition of sepsis.

The incidence of peripartum hysterectomy (PH) in 2016 showed a moderate increase (0.43 per 1,000 maternities or approximately one in approximately 2,300 maternities). This was still within the range that might be expected based on previous years and is similar to the rate in the United Kingdom (0.41 per 1,000 births). Abnormal placentation, primarily morbidly adherent placenta, was the most commonly reported indication for PH (74.1%).

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

in rates of MOH between units may also reflect variances in practices of estimating blood loss. We have reflected on methods of estimating blood loss in units with high and low rates of MOH and observed a lack of standardisation.

One unit had a MOH rate above the 95% upper limit for the national rate of 3.39 per 1,000 maternities. This unit has been notified in accordance with the National Office of Clinical Audit (NOCA) escalation process.

Three units with high MOH rates in 2015 followed the NOCA escalation process and reviewed their data and related clinical practices. One unit was found to have overestimated their number of MOH cases. One unit implemented quality improvement initiatives including increased training for staff and use of a specific proforma in the event of post-partum haemorrhage. The third unit confirmed that their quantitative approach for estimating blood loss led to effective case ascertainment.

The perinatal mortality rate (PMR) among infants born to women who experienced SMM was 39.1 per 1,000 births, i.e. one in 25 of the infants died. This is approximately seven times the perinatal mortality rate observed for all births in Ireland.

Similar to previous years, multiple pregnancy was associated with an almost fourfold increased risk of morbidity. The SMM rate associated with multiple pregnancy was 23.85 per 1,000 maternities compared to a rate of 5.77 per 1,000 maternities for singleton pregnancy in 2016.

In the Confidential Audit of Critical Care in Obstetrics in Ireland, the incidence of women requiring Level 2 Care was 8.7 per 1,000 maternities or one in 114 maternities. The number of women requiring Level 3 Care, either solely or in combination with Level 2 Care, was 0.47 per 1,000 maternities or one in 2,127 maternities.

While the location of care for women requiring Level 3 Care was in an ICU/CCU facility, the location of care for women requiring Level 2 Care varied depending on the size of the maternity unit. Smaller maternity units, recorded greater utilisation of ICU/CCU facilities. The type of organ support required and underlying pathology are detailed in this report.

Key findings in 2016:

Severe maternal morbidity

- There was a statistically significant increase in the rate of Severe Maternal Morbidity (SMM) and major obstetric haemorrhage (MOH) in 2016 compared to the base year 2011.
- The rate of SMM was 6.46 per 1,000 maternities or one in 155 maternities.
- MOH remains the most commonly reported morbidity.
- Variation in rates of SMM and MOH were identified between units.
- Multiple pregnancy was associated with an almost fourfold increased risk of SMM
- The perinatal mortality rate among infants in women experiencing SMM is approximately seven times the rate observed for all births in Ireland.

Confidential Audit of Critical Care in Obstetrics in Ireland

- One in 109 women required either Level 2 Care and/or Level 3 Care.
- The need for higher levels of maternal care is not predictable in approximately half of cases and thus has implications for resource planning.

Introduction

This is the fifth report of the national clinical audit on severe maternal morbidity (SMM) in the Republic of Ireland (ROI). SMM has been acknowledged internationally as an important quality indicator of obstetric care and maternal welfare, particularly in developed countries where maternal death rates are relatively low. Further, there is evidence that commonly occurring life-threatening complications during or shortly after pregnancy, such as major obstetric haemorrhage (MOH), are under reported as they less frequently lead to death in high-resourced countries. In this context, the NPEC in collaboration with the NPEC Maternal Morbidity Group, has collected and analysed data on SMM from Irish maternity units since 2011. The fundamental aim of the audit is to provide a national review of clearly defined severe maternal morbidities, to identify quality improvement initiatives and make recommendations for the improvement of maternal care for women in Ireland.

The report is divided into two sections (Figure I) with additional information provided in the Appendices. Section One provides information on the occurrence of clearly defined severe maternal morbidities occurring in Ireland in 2016.

Section Two presents findings from the Confidential Audit on Critical Care in Obstetrics in Ireland in 2016. This latter audit compliments the SMM audit to further evaluate maternal outcomes. Commenced in 2014, the purpose of this audit is to address the dearth of national data on prevalence rates for women who require Level 2 Care and Level 3 Care and the location where these higher levels of care are provided. The audit compliments the Intensive Care National Audit and Research Centre (ICNARC) and is the second in a series of topic specific case assessment audits conducted by the NPEC on a triennial basis.

Section 1 contains the main findings of the Severe Maternal Morbidty (SMM) audit including

- National and international comparisons of SMM rates
- Prevelance of specicific SMM
- Distribution of SMM by Robson Ten Group Classification System
- Maternal characteristics, management of delivery and neonatal outcome in women experiencing SMM
- ICU admission and Level of Care provided to women experiencing SMM

Section 2 contains findings from the Confidential Audit of Critical Care in Obstetrics in Ireland

- Specific findings for women who required Level 2 Care only
- Specific findings for women who required Level 3 Care

Figure I: Sections of this 2016 Severe Maternal Morbidity Report.

Recommendations

Recommendations from previous reports being addressed by the National Women's and Infants Health Programme.

The following recommendations have been escalated to the National Women's and Infants Health Programme and are being progressed.

- Formal counselling support should be made available for all women and their partners following a severe maternal morbidity: this is already currently available in some units but not all.
- The NPEC endorses the multidisciplinary training in the management of postpartum haemorrhage advocated by the National Clinical Programme for Obstetrics and Gynaecology. 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.
- 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 tool-kit would assist standardisation of such an approach.
- The location where critical care for the pregnant or recently pregnant woman is provided varies across maternity units according to available resources: in small units, critical care is often provided in the Intensive Care Unit/ Critical Care Unit (ICU/CCU). It is thus recommended that in such units, the appropriate resources and training for the care of the critically ill woman in obstetrics are in place within the ICU/CCU. For maternity units with greater than 2,500 births per annum, consideration should be given to resourcing the unit with the capacity to provide Level 2 Care.
- All pregnant or recently pregnant women should have equitable access to the most appropriate critical care facility for her needs and a national maternal retrieval service should be provided. This supports the recommendations of the National Maternity Strategy.[1]
- A structured notification system between ICU departments and the maternity unit responsible for a woman's care during pregnancy should be developed to improve communication.

1 Department of Health. Creating a Better Future Together: National Maternity Strategy, 2016-2026. Dublin; 2016

Based on findings from this and previous reports, the NPEC Severe Maternal Morbidity Group makes the following recommendations:

The following recommendations have been escalated to the National Women's and Infants Health Programme and are being progressed.

- Robust clinical audit on adverse maternal outcomes requires the protected time of clinical staff. Funding should be provided by the Health Service Executive (HSE) to facilitate same.
- The Robson Ten Group Classification System (TGCS) is a method providing a common starting point for further detailed analysis within which all perinatal outcomes can be measured and compared. The NPEC encourages all units to collect TGCS data in order to facilitate local and national audit.
- A public health education programme on maternal morbidity and modifiable risk factors should be developed.
- Maternal Newborn Clinical Management System (MN_CMS) data from Irish maternity units should be collated to identify the influence of risk factors for SMM in Ireland including: ethnicity, maternal age, body mass index (BMI), smoking and employment status.
- There is a need to review the SMM audit components and definitions with a view to enhancing the quality of data and lessons for care. This in keeping with best practice and will be actioned by the NPEC SMM group.
- To facilitate and enhance the scope of audit, a national standardised approach to obtaining consent for processing data from service users should be considered in light of the recent General Data Protection Regulation (GDPR) 2016.[2]

2 European Data Protection Law. General Data Protection Regulation 2016. Available at www.eu-gdpr.org

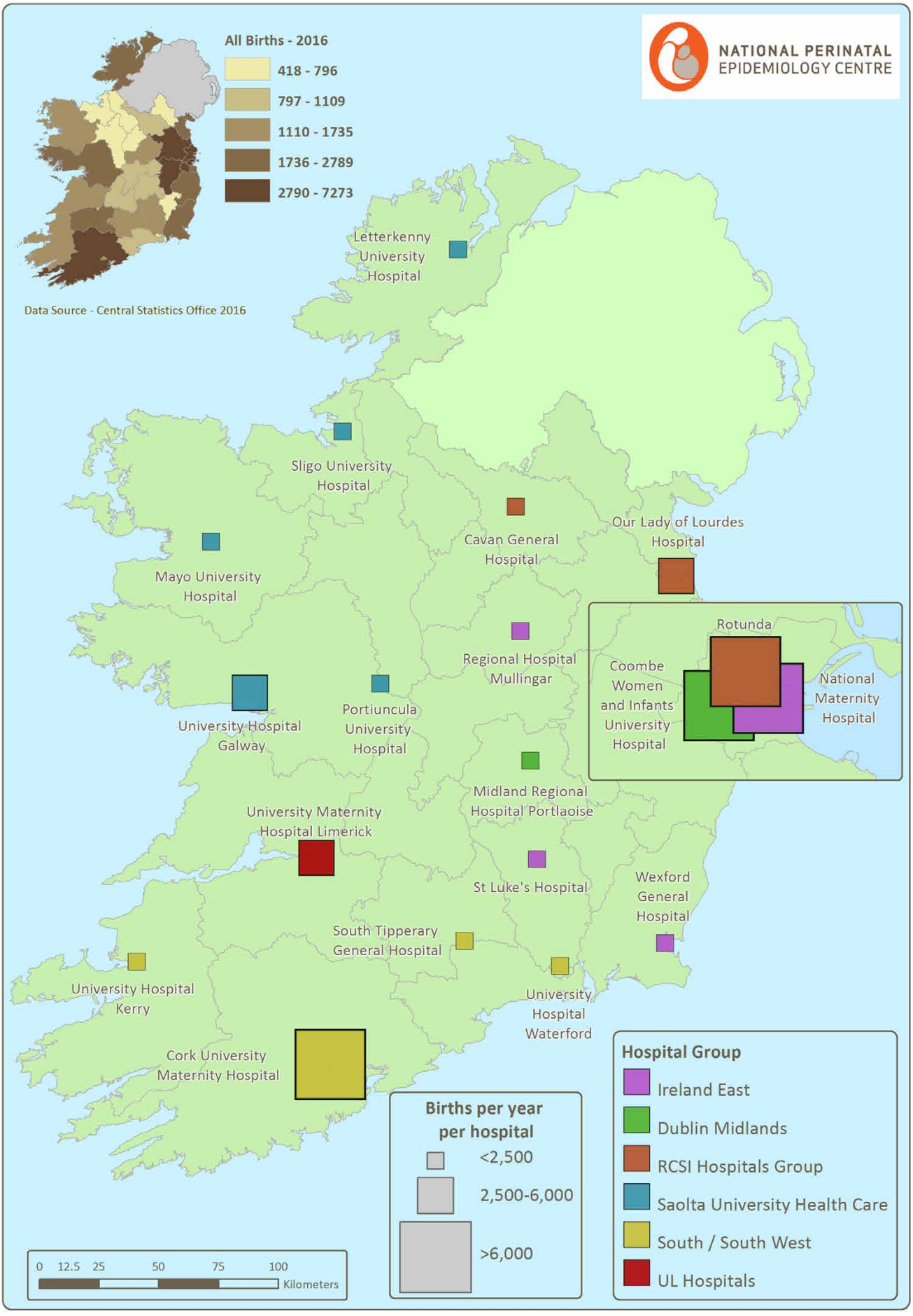


Figure II: Map of maternity units and hospital groups in the Republic of Ireland

Methods

To allow for international comparison, the NPEC adapted the validated methodology of the Scottish Confidential Audit of Severe Maternal Morbidity (SCASMM) to evaluate severe maternal morbidity (SMM) in Ireland. This methodology utilises organ dysfunction criteria described by Mantel et al,[3] with modifications used by SCASMM to include intervention based criteria.[4] Implemented nationally in 2011, this data collection tool, adapted for the Irish setting, has been endorsed by the Clinical Advisory Group at the Institute of Obstetrics and Gynaecology and the HSE National Obstetric Programme Working Group.

Data recording

Since the inception of the audit in 2011, all but one maternity unit has contributed data for the years 2011, 2012, 2014 and 2015, with all maternity units submitting data for the years 2013 and 2016. In 2016, there were 19 maternity units in the Republic of Ireland. Data on SMM events occurring between 1 January and 31 December 2016 were submitted using a standardised notification dataset, either electronically via the secure online NPEC database or alternatively by paper format (See Appendix E). The dataset is completed based on data on maternal and fetal characteristics recorded in clinical records. The data are subsequently processed by NPEC in a pseudonymised format, which means that they cannot be attributed to a specific individual without the use of additional information, and only the submitting unit has access to this information.

Revised data for 2015

In this report, comparisons are made between SMM cases in 2016 and those of previous years, in particular 2015. The SMM Annual Report for 2015 specified that there were 381 cases in that year. As part of the clinical audit process, some maternity units were asked to review their SMM cases registered for 2015. This identified nine cases that did not meet case inclusion criteria. While these nine cases were included in the Annual Report for 2015, they have been removed from the SMM database. Findings specified for 2015 in the current report are based on the 372 cases in the revised database for 2015.

Recommendations:

- Robust clinical audit on adverse maternal outcomes requires the protected time of clinical staff. Funding should be provided by the Health Service Executive (HSE) to facilitate same.
- To enhance the scope of audit, a national standardised approach to obtaining consent for processing data from service users should be considered in light of the recent General Data Protection Regulation (GDPR) 2016.

3 Mantel G et al. Severe Acute maternal morbidity: a pilot study of a definition for a near-miss. BJOG 1998; 105: 985-90
4 Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx

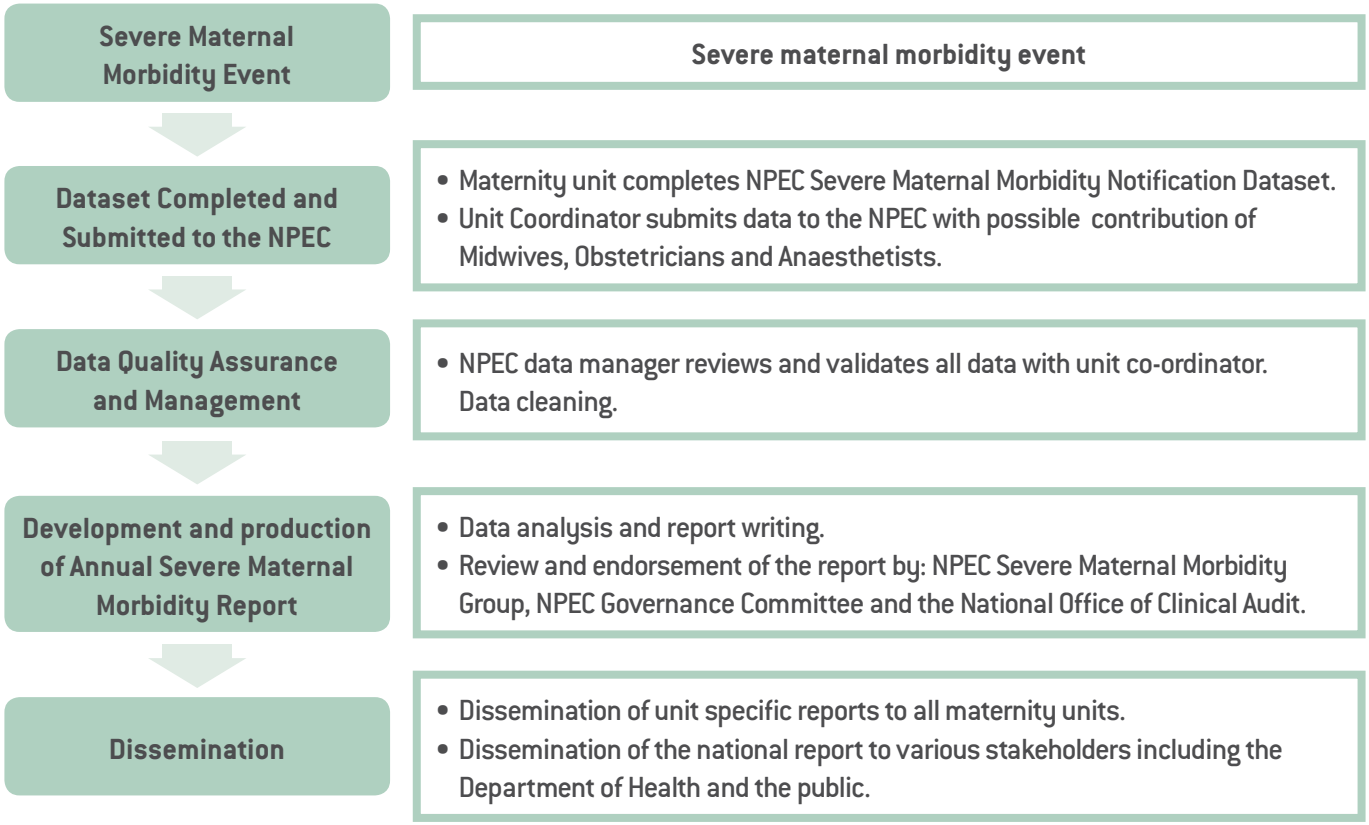


Figure III: NPEC data collection and management processes.

Figure III illustrates the NPEC data collection and management processes. There has been a steady improvement in the overall quality of data reported by maternity units since the implementation of the NPEC SMM notification dataset in 2011.

Definitions and inclusion criteria for audit

In this audit, a case of severe maternal morbidity (SMM) was defined as a pregnant or recently-pregnant woman (i.e. up to 42 days following the pregnancy end) who experienced any of the following seventeen, clearly defined, maternal morbidities in the reporting years 2012-2016: major obstetric haemorrhage (MOH), uterine rupture, eclampsia, renal or liver dysfunction, pulmonary oedema, acute respiratory dysfunction, pulmonary embolism, cardiac arrest, coma, cerebrovascular event, status epilepticus, septicaemic shock, anaesthetic complications, other morbidity and maternities involving peripartum hysterectomy, ICU/CCU admission and interventional radiology. Definitions for these morbidities are provided at the end of the notification form (Appendix E).

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.

In 2012-2016, uterine rupture was a specified morbidity for the audit whereas this was not the case in 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 six years of the audit.

Definitions and classification of the critically ill woman in Obstetrics

In January 2014 an audit on Critical Care in Obstetrics in Ireland was initiated by the NPEC for the triennium 2014-2016. Levels of care

were defined using National Guidelines for the Critically Ill Woman in Obstetrics (Appendix F).[5] Fifteen of 19 Irish maternity units contributed to this audit for the years 2014 - 2016, including two large tertiary referral maternity units and thirteen smaller maternity units.

In the case of a woman requiring Level 2 or Level 3 Care, participating units were asked to complete an additional form (Appendix G). The main clinical diagnosis, organ support required and specialist review during the critical care event were documented on this form. Additional data on maternal demographics and neonatal outcomes were reported on the NPEC SMM notification form (Appendix E).

Maternal morbidity was classified as direct, indirect or coincidental based on the main clinical diagnosis during the critical care event, using the WHO classification for maternal mortality (Appendix H).[6] Morbidity was further categorised using three different models for defining maternal morbidity: (a) the NPEC SMM methodology which utilises organ dysfunction and management based criteria, (b) the WHO organ-dysfunction criteria defined as Near Miss (NM)[7] (Appendix I) and (c) the WHO disease specific criteria Severe Maternal Complications (SMC) (Appendix J).

Robson Ten Group Classification System

In 2016, 13 of the 19 units that participated in the SMM audit also provided data on deliveries classified according to the Robson Ten Group Classification System[8] (TGCS; Appendix K). The incidence of MOH and other SMM were classified according to the TGCS for these 13 units. The deliveries in these units constituted 80.0% of the 62,871 deliveries in Ireland in 2016.

Rate calculations

The SMM rate is a composite rate of a group of clearly defined severe morbidities. 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.

Denominator data on the number of maternities were provided by the Healthcare Pricing Office (HPO).[9] The denominator underestimates the number of women at risk of SMM as it does not include women experiencing miscarriage, ectopic pregnancy and molar pregnancy, which may be reported as cases of SMM and thereby are included in the numerator. However, complete data on maternities resulting in miscarriage, ectopic pregnancy and molar pregnancy are not available and so, 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 was also the approach taken by the SCASMM.[10]

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.

Further analysis was conducted to assess variation in incidence rates between years, maternal age groups, and single and multiple

5 Clinical Practice Guideline No 30 (2014). Guideline for the Critically ill Woman in Obstetrics : Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive

6 The WHO application of ICD-10 to deaths during pregnancy, childbirth and puerperium: ICD MM. World Health Organisation 2012

7 Evaluating the quality of care for severe pregnancy complications. The WHO near-miss approach for maternal health. World Health Organization; 2011

8 Robson MS (2001). Classification of caesarean sections. Fetal and Maternal Medicine Review, 12, pp 23-39 doi:10.1017/S0965539501000122.

9 Healthcare Pricing Office. (2017) Perinatal Statistics Report 2016. (in press) Dublin: Health Service Executive. In Press

10 Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx

pregnancies. 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.

Funnel plots

Variations in SMM between maternity units could potentially be due to random chance or reflect differences in baseline characteristics of the childbearing population. For this reason, funnel plots were used to assess performance outcomes for individual units in comparison to the overall average.[11] In brief, the plot is a scatter diagram of individual maternity unit SMM rates against the number of maternities within that unit. The national rate is indicated by the solid straight line. The 95% confidence interval is indicated by the curved dashed line. The dashed lines represent the limits within which 95% of units are expected to lie (i.e. within two standard deviations). The 99.8% confidence interval for the national rate is plotted using solid lines. These solid lines represent the limits within which 99.8% of units are expected to lie (i.e. within three standard deviations). 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% and 99.8% 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 limits by chance alone whereas an observation outside the 99.8% confidence limits is especially rare, i.e. there is a 0.2% chance of this happening.

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.

11 Spiegelhalter D. (2002) Funnel plots for institutional comparison. Quality and Safety in Health Care; 11(4):390-91.

Main Findings

National rate

In 2016, the nineteen participating maternity units reported that 406 women experienced SMM as defined in this audit. Table 1 details the national number of cases, total maternities and SMM rates derived from the participating units in each of the six years of the audit, 2011-2016.

Table 1: Incidence of severe maternal morbidity (SMM) in Ireland, 2011-2016

	2011*	2012	2013	2014	2015	2016
Maternities in participating units	67,806	65,768	68,047	61,593	60,006	62,871
SMM cases	260	292	323	365	372	406
SMM rate (95% CI)	3.83 (3.36-4.31)	4.44 (3.92-4.96)	4.75 (4.22-5.27)	5.93 (5.31-6.54)	6.20 (5.59-6.84)	6.46 (5.85-7.12)
Rate ratio (95% CI)	1.00 (Ref.)	1.16 (0.98-1.37)	1.24 (1.05-1.46)	1.55 (1.32-1.81)	1.62 (1.38-1.89)	1.68 (1.44-1.97)
p-value		0.086	0.011	<0.001	<0.001	<0.001

Note: Maternities excluding those in one non-participating unit in 2011, 2012, 2014 and 2015. CI= confidence interval. Poisson 95% confidence intervals were calculated for the rate and rate ratios. *Cases of uterine rupture exclusive of major obstetric haemorrhage were not reported for 2011.

From 2011 to 2016, the SMM rate varied from 3.83 to 6.46 per 1,000 maternities or from one in 261 maternities to one in 155 maternities. Respectively, the SMM rate was 16%, 24%, 55%, 62% and 68% higher in 2012, 2013, 2014, 2015 and 2016 than in the base year 2011.

A comparable national audit in Scotland for the years 2003-2012, which uses the same composite rate for SMM as this audit, reported an SMM rate of 7.3 per 1,000 maternities for 2012.[12] The Irish SMM rate in 2016 was similar to the most recent Scottish rate (rate ratio=0.89, 95% CI=0.78-1.02, p-value=0.094).

The increase in SMM rate mirrors a continual increase in major obstetric haemorrhage (MOH) rate. It may also reflect an improvement in case ascertainment of MOH.

Specific morbidities

The SMM rate is a composite rate of a group of clearly defined severe morbidities. Almost three quarters of the women (n=293, 72.2%) who experienced SMM in 2016 were diagnosed with one morbidity; 21% (n=85, 20.9%) were diagnosed with two morbidities; 6% (n=23, 5.7%) with three SMMs; and 1% (n=5, 1.2%) with four morbidities.

In the first three years of the NPEC SMM audit, MOH was the most frequently reported SMM event. In 2014 and 2015, admission to an intensive or coronary care unit (ICU/CCU) was as common as MOH. MOH was again the most commonly reported morbidity in just over half of the SMM audit cases in 2016 (Table 2). The next most common reportable SMM events were renal or liver dysfunction (8.4%), septicaemic shock (6.9%), peripartum hysterectomy (6.7%) and pulmonary embolism (5.9%).

The incidence of eclampsia in Ireland remains low (0.22 per 1,000) and compares favourably with the values in UK (0.27 per 1,000) and

12 Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx

Netherlands (5.4 per 10,000) for 2014.[13] When comparing to European rates, the Irish values for uterine rupture (1.3 per 10,000) also rank as one of the lowest rates across several countries (Austria reported the lowest prevalence among all the countries studied with 1.6 per 10,000 deliveries).[14]

In 2016, the number and rate of cases for each SMM other than MOH and ICU/CCU admission were broadly in line with those reported in 2011-2015 (Table 2). An exception was septicaemic shock, the rate in 2016 was almost double the rate for 2011-2015 (rate ratio=1.86, 95% CI=1.21-2.87, p-value=0.005). Very few cases of septicaemic shock were reported in 2011 and 2012 but there were notable and successive increases in 2013, 2014 and 2015. This may be a true increase in incidence or may be associated with an increased awareness and recognition of sepsis with the development of the National Sepsis Guideline.[15]

Recent reports on maternal mortality in Ireland and the UK have identified thrombosis/ thromboembolism as a leading direct obstetric cause of maternal death. At 0.38 per 1,000 maternities or one in 2,620 women, the incidence of pulmonary embolism (PE) in 2016 was higher though still in line with the rate in 2011-2015. This value was also higher than the reported PE rate in the UK (1.4 per 10,000 maternities).[16] Notwithstanding, we believe the current Irish rate may represent an underestimate as many post-natal cases will be unknown to maternity units as the women present to general hospitals: the maternity services may not be aware of the event. The NPEC Severe Maternal Morbidity Group have endeavoured to develop a

Table 2: Incidence of specific severe maternal morbidities (SMMs) in Ireland, 2011-2016

	2011-2015		2016	
	n(%)	Rate(95% CI)	n(%)	Rate(95% CI)
Major obstetric haemorrhage	850(52.7)	2.67(2.49-2.86)	215(53.0)	3.39(2.92-3.85)
ICU/coronary care unit admission	725(45)	2.28(2.11-2.45)	160(39.4)	2.54(2.14-2.95)
Renal or liver dysfunction	152(9.4)	0.48(0.4-0.56)	34(8.4)	0.54(0.36-0.73)
Septicaemic shock	76(4.7)	0.24(0.18-0.29)	28(6.9)	0.45(0.28-0.61)
Peripartum hysterectomy	102(6.3)	0.32(0.26-0.38)	27(6.7)	0.43(0.26-0.59)
Pulmonary embolism	79(4.9)	0.25(0.19-0.3)	24(5.9)	0.38(0.23-0.54)
Acute respiratory dysfunction	37(2.3)	0.15(0.1-0.2)	14(3.4)	0.22(0.1-0.34)
Eclampsia	51(3.2)	0.16(0.12-0.21)	14(3.4)	0.22(0.1-0.34)
Pulmonary oedema	44(2.7)	0.14(0.1-0.18)	12(3.0)	0.19(0.08-0.3)
Uterine rupture	45(2.8)	0.14(0.1-0.18)	8(2.0)	0.13(0.04-0.22)
Interventional radiology	33(2)	0.10(0.07-0.14)	5(1.2)	0.08(0.01-0.15)
Anaesthetic problem	20(1.2)	0.06(0.03-0.09)	5(1.2)	0.08(0.01-0.15)
Cerebrovascular event	21(1.3)	0.07(0.04-0.09)	4(1.0)	0.06(0-0.13)
Cardiac arrest	18(1.1)	0.06(0.03-0.08)	2(0.5)	0.03(0-0.08)
Status epilepticus	7(0.4)	0.02(0.01-0.04)	2(0.5)	0.03(0-0.08)
Coma	0(0)	0(0-0)	0(0)	0(0-0)
Total women affected	**1612**	**5.07(4.82-5.32)**	**406**	**6.46(5.85-7.12)**

Note: n represents number of women affected by the specific morbidity; more than one morbidity may apply per woman % is based on the total number of women affected; rate is per 1,000 maternities; 95% CI=95% confidence interval; ICU=intensive care unit; Uterine rupture was not recorded by the audit in 2011 unless associated with MOH.

13 Schaap, T. P., Knight, M., Zwart, et al. (2014). Eclampsia, a comparison within the International Network of Obstetric Survey Systems. Bjog, 121(12), 1521-1528.
14 Vandenberghe, G. , et al. (2018), The INOSS study of uterine rupture: a descriptive multi-country population based study. BJOG: Int J Obstet Gy. Accepted Author Manuscript.
15 Department of Health (2014) Sepsis management. Guideline No 6
16 Lawson B, Nair M, Kochanski P, Kurinczuk JJ, Knight M. UKOSS Annual Report 2017. Oxford: National Perinatal Epidemiology Unit 2017

methodology in order to capture and audit these cases of PE more accurately, however, it is proving difficult to achieve. Hospital In-Patient Enquiry (HIPE) data are also being reviewed. The NPEC has commenced a case assessment audit of PE in maternity units in 2017 in place of the Confidential Audit on Critical Care in Obstetrics.

To allow for direct comparison with findings from the Scottish Confidential Audit of Severe Maternal Morbidity (SCASMM), the NPEC adapted their methodology of using two management proxies (admission to ICU/CCU and Interventional Radiology) to identify women at high risk of severe morbidity. It is important to note that the use of Interventional Radiology (IR) is a procedure performed to prevent bleeding in women at high risk of MOH. Further, as very few hospitals have the resources to provide IR, the frequency of IR cannot be considered as being nationally represented. In this audit, the reported incidence of IR is low at 0.08 per 1,000 maternities.

Major obstetric haemorrhage

The incidence of MOH was 3.39 per 1,000 maternities in 2016. The equivalent incidence of MOH for the most recent year with available data in Scotland (2012) was 5.8 per 1,000 maternities (95% CI=5.2-6.5), 71% higher than the Irish rate. [17]

The national audit in Scotland showed that their increasing incidence of SMM over a decade was due to an increase in the incidence of MOH. The NPEC previously showed that Ireland experienced an increasing trend in postpartum haemorrhage during 1999 to 2009.[18]

Figure 1 illustrates the trend in the rate of SMM as defined in this audit and the separate trends for MOH and ICU/CCU admission. An increasing number of MOH cases has been reported to this audit over the six-year period 2011-2016 (Table 2; Figure 1).

The incidence of MOH cases increased from 2.34 per 1,000 maternities in 2011 to 3.39 per 1,000 maternities in 2016, an overall increase of 45% (rate ratio=1.45, 95% CI=1.18-1.77, p-value<0.001), which is highly statistically significant.

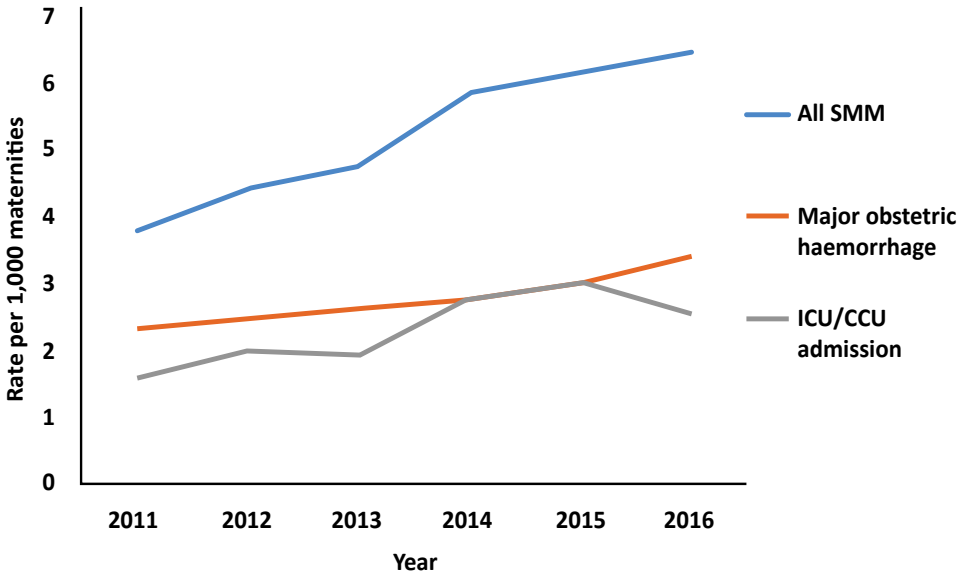


Figure 1: Trend in the rate of severe maternal morbidity (SMM), major obstetric haemorrhage and intensive care unit/coronary care unit (ICU/CCU) admission, 2011-2016

17 Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx
18 Lutomski J et al. (2012) Increasing trends in atonic postpartum haemorrhage in Ireland: an 11-year population-based cohort study. BJOG; 119: 306-14.

Over half of the MOH cases (57.3%) recorded in this audit met only one of the case criteria for major obstetric haemorrhage (57.3%; Table 3), usually the one related to estimated blood loss ≥ 2,500 mls. Some 27% met two criteria and most of these cases involved an estimated blood loss exceeding 2,500ml. In a further one in six cases (16%), all three criteria were met. Two cases met the sole criterion of receiving a blood transfusion of at least five units and a further twelve women met the transfusion criteria in addition to experiencing a blood loss of at least 2,500ml (Table 3). For these women there was no reported receipt of coagulation factors. These criteria all suggest significant bleeding, which suggests the need to review the definition for MOH.

Table 3: Case criteria for major obstetric haemorrhage (MOH) in 2016

Total MOH cases	N=215
Met one criterion	122(57.3)
Estimated blood loss ≥ 2500ml	97(79.5)
Received blood products as treatment for coagulopathy	23(18.9)
Transfused ≥ 5 units of blood	2(1.6)
Met two criteria	57(26.8)
Blood loss ≥ 2500ml and received blood products for coagulopathy	43(75.4)
Blood loss ≥ 2500ml and transfused ≥ 5 units of blood	12(21.1)
Received blood products for coagulopathy and transfused ≥ 5 units of blood	2(3.5)
Met all three criteria	34(16)

Note: Values are shown as n(%) unless otherwise stated; Information on MOH criteria missing on one case.

Peripartum hysterectomy

There were 27 reported cases of peripartum hysterectomy (PH) in 2016 giving a national PH rate of 0.43 per 1,000 maternities or approximately one in 2,300 maternities. While the rate in 2016 was one third higher than in 2011-2015 (rate ratio=1.34, 95% CI=0.88-2.05, p-value<0.001), it was still within the range that might be expected considering the number and relative rarity of PH. Ireland's PH rate has been consistent for a number of years, at approximately 0.33 per 1,000 births, and is similar to the rate in the United Kingdom (0.41 per 1,000 births) and the Netherlands (0.33 per 1,000 births).[19,20]

Major obstetric haemorrhage, as defined in this audit, was associated with over half the cases of PH (n= 16, 59.3%). Abnormal placentation, primarily morbidly adherent placenta, was the most commonly reported indication for PH (20/27, 74.1%), followed by MOH (5/27, 18.5%). Cervical cancer and postnatal sepsis/necrosis were the reported indication for PH for the other two cases. All but one of the 27 PH cases (96.3%) involved caesarean section delivery (CS) and the vast majority of the women had a previous CS (n=21, 77.8%). These findings are similar to that of a recent Irish study on PH. [21]

19 Knight M, Kurinczuk JJ, Spark P and Brocklehurst P. United Kingdom Obstetric Surveillance System Steering Committee. Caesarean delivery and peripartum hysterectomy, Obstet Gynecol 2008; 111 January (1); 97-105
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
21 Campbell, Sarah M. et al. Peripartum hysterectomy incidence, risk factors and clinical characteristics in Ireland. Eur J Obstet Gynecol Reprod Biol 2016, Volume 207 , 56 - 61

Admission to ICU/CCU

The incidence of maternity admissions into an ICU/CCU has been increasing in recent years and reached 3.02 per 1,000 in 2015 (Figure 1). The rate decreased by 15% to 2.54 per 1,000 in 2016. Table 4 details the specific SMMs involved in the 160 cases admitted into an ICU/CCU. Over one in three of these cases involved MOH (38.1%), 8.1% involved septic shock and a similar proportion related to peripartum hysterectomy. Fourteen cases (8.8%) involved acute respiratory dysfunction and nine cases (5.6%) involved pulmonary embolism.

Table 4: Specific severe maternal morbidities (SMMs) in women admitted to an intensive care unit or coronary care unit (ICU/CCU) in Ireland, 2016

	n(%)
Total women admitted to ICU/CCU	160(100)
Major obstetric haemorrhage	61(38.1)
Septicaemic shock	13(8.1)
Peripartum hysterectomy	13(8.1)
Renal or liver dysfunction	7(4.4)
Acute respiratory dysfunction	14(8.8)
Pulmonary embolism	9(5.6)
Pulmonary oedema	5(3.1)
Anaesthetic problem	5(3.1)
Interventional radiology	3(1.9)
Eclampsia	2(1.3)
Cerebrovascular event	3(1.9)
Uterine rupture	1(0.6)
Cardiac arrest	2(1.3)
Status epilepticus	0(0)
Coma	0(0)
None of the above**	55(34.4)

Note: n represents number of women affected by the specific morbidity; % is based on the total number of women admitted to ICU/CCU in 2016. More than one morbidity may apply per woman; **women admitted to ICU due to other morbidities or other issues not listed.

Just over one third of the women admitted into an ICU/CCU in 2016 had not experienced a severe morbidity as defined in this audit (34.4%, n=55 of 160). This shows a reduction in the occurrence of this phenomenon (recording 46% in 2015) which had shown a steady increase over the early years of the audit (Figure 2). It must be acknowledged that admission to ICU/CCU in cases not meeting the criterion of a SMM as defined in this audit does not imply inappropriate use of ICU/CCU facilities but suggests the requirement of a higher level of observation or maternal care.

These cases, requiring a higher level of observation (Level 1 or Level 2 Care) related to issues following maternal complications including post partum haemorrhage (PPH) with a blood loss < 2,500 mls, which affected one in four women (n=14, 25.5%) and hypertensive disorders which were experienced in a further 25.5% (n=14) of women. Twenty percent of these ICU admissions reported sepsis (n=11 ,20%) of which the majority (n=7, 63.6%) were due to respiratory infections. A further six (10.9%) cases were attributed to cardiac complications / monitoring and the remaining cases were due to other obstetric complications.

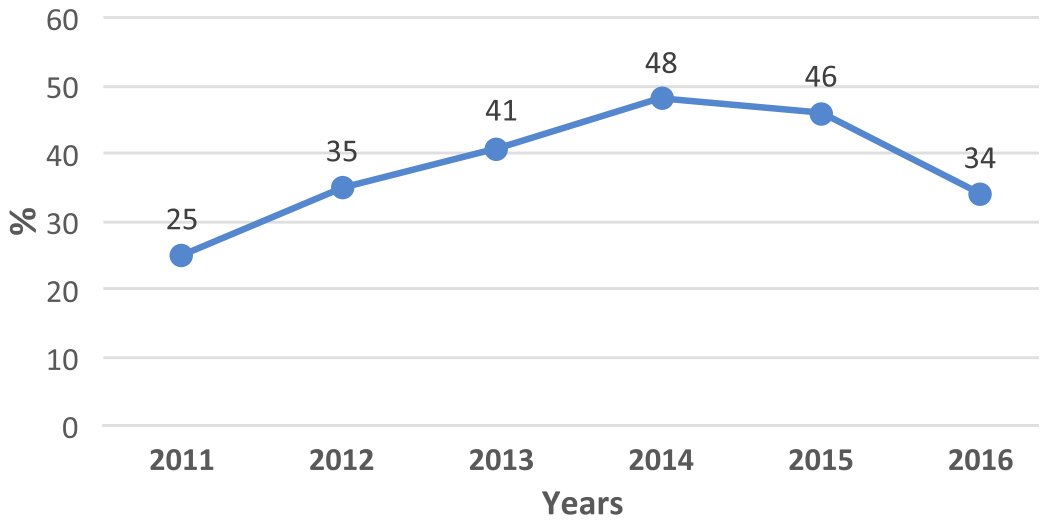


Figure 2: Proportion of cases admitted to ICU not experiencing a severe morbidity as defined in this audit, 2011-2016

The vast majority of ICU admissions with no other reported morbidity as defined in this audit (n=50, 90.1%) occurred in small maternity units. Fifty percent of these cases occurred in two small units with on-site ICU facilities but without obstetric high dependency facilities. Feedback from these units indicated that the rate of such ICU/CCU admissions reflected resource issues in cases where women required a higher level of monitoring. In these two units, more than half of the 25 ICU admissions with no other SMM as defined in this audit required Level 1 Care (n=16, 64.0%). Only one of these 25 cases required Level 3 Care and the remaining nine cases required Level 2 Care (43.6%).

Robson Ten Group Classification System (TGCS)

The Robson Ten Group Classification System (TGCS), is a method providing a common starting point for further detailed analysis within which all perinatal outcomes can be measured and compared.[22] The system classifies all pregnant women into one of 10 categories that are mutually exclusive and, as a set, totally comprehensive (see Appendix K).[23] The categories are based on five basic obstetric characteristics that are routinely collected for all maternities: parity, gestational age, onset of labour, foetal presentation and number of foetuses.

Thirteen of the 19 maternity units that participated in the SMM audit also classified their maternities according to the Robson Ten Group Classification System (Appendix K). The 50,296 maternities in these units accounted for 80.0% of the 62,871 maternities in all 19 maternity units. The incidence of MOH and of other SMM, excluding cases of MOH and cases admitted to ICU/CCU only, in the thirteen maternity units that submitted Robson TGCS data is detailed in Table 5.

For the thirteen units, the MOH rate was 3.36 per 1,000 maternities and the rate of other SMM was 2.07 per 1,000 maternities. Notwithstanding the relatively small numbers involved when examining by TGCS, there was evidence of increased risk of MOH in Group 8 (women with multiple pregnancies) and in Group 10 (women with premature deliveries) and evidence of increased risk of other SMM in Group 10.

22 Robson M et al. The 10-Group Classification System (Robson classification), induction of labor, and cesarean delivery. International Journal of Gynecology and Obstetrics 131 (2015) S23–S27

23 Robson MS (2001). Classification of caesarean sections. Fetal and Maternal Medicine Review, 12, pp 23-39 doi:10.1017/S0965539501000122.

Table 5: Incidence of major obstetric haemorrhage (MOH) and severe maternal morbidity (SMM) excluding MOH by Robson TGCS in thirteen Irish maternity units, 2016

Group	Group description	Deliveries	Delivered by CS	MOH		Other SMM*	
		N	%	n	Rate 95% CI	n	Rate 95% CI
All		**50,296**	**31.6**	**169**	**3.36 (2.87-3.91)**	**104**	**2.07 (1.69-2.51)**
1	**Nulliparous, singleton, cephalic, >37/40, spontaneous labour**	8,843	13.7	18	2.04 (1.21-3.22)	9	1.02 (0.47-1.93)
2	**Nulliparous, singleton, cephalic, >37/40 induced or elective CS**	8,198	43.1	29	3.54 (2.37-5.08)	16	1.95 (1.12-3.17)
3	**Multiparous (excluding previous CS), singleton, cephalic, >37/40, spontaneous labour**	12,505	2.0	19	1.52 (0.91-2.37)	5	0.40 (0.13-0.93)
4	**Multiparous (excluding previous CS), singleton, cephalic, >37/40 induced or elective CS**	7,823	14.8	25	3.20 (2.07-4.72)	12	1.53 (0.79-2.68)
5	**Previous CS, singleton, cephalic, >37/40, induced or elective CS**	7,819	79.7	28	3.58 (2.38-5.18)	20	2.56 (1.56-3.95)
6	**All nulliparous women with a single breech pregnancy**	948	94.7	5	5.27 (1.71-12.31)	4	4.22 (1.15-10.8)
7	**All multiparous breech (including previous CS)**	886	92.8	1	1.13 (0.03-6.29)	3	3.39 (0.7-9.9)
8	**All multiple pregnancies (including previous CS)**	1,028	66.8	19	18.48 (11.1-28.9)	5	4.86 (1.58-11.35)
9	**All women with a single pregnancy with a transverse or oblique lie, including women with previous uterine scars**	162	100.0	1	6.17 (0.16-34.39)	2	12.35 (1.50-44.60)
10	**All singleton, cephalic, <36/40 (including previous CS)**	2,084	45.7	24	11.52 (7.38-17.14)	28	13.44 (8.93-19.42)

Note: Rates per 1,000. CI=95% confidence interval. Poisson 95% confidence intervals were calculated. CS=Caesarean section; *Other SMM excludes cases of MOH and cases of ICU admission only; Robson Group could not be determined for 12 MOH cases and 14 cases of other SMM.

Recommendation:

- Robust clinical audit on adverse maternal outcomes requires the protected time of clinical staff. Funding should be provided by the Health Service Executive (HSE) to facilitate same.
- To enhance the scope of audit, a national standardised approach to obtaining consent for processing data from services users would be beneficial.

Variation in rates by maternity unit

Variation in the 2016 SMM rate across the participating nineteen maternity units is illustrated in the funnel plot in Figure 3. The solid line represents the national SMM rate of 6.46 per 1,000 maternities. The dashed curves represent the limits within which 95% of units are expected to lie (i.e. within two standard deviations). The solid curves represent the limits within which 99.8% of units are expected to lie (i.e. within three standard deviations). 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 regards to the 95% confidence limits, we can expect, on average, one in 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.

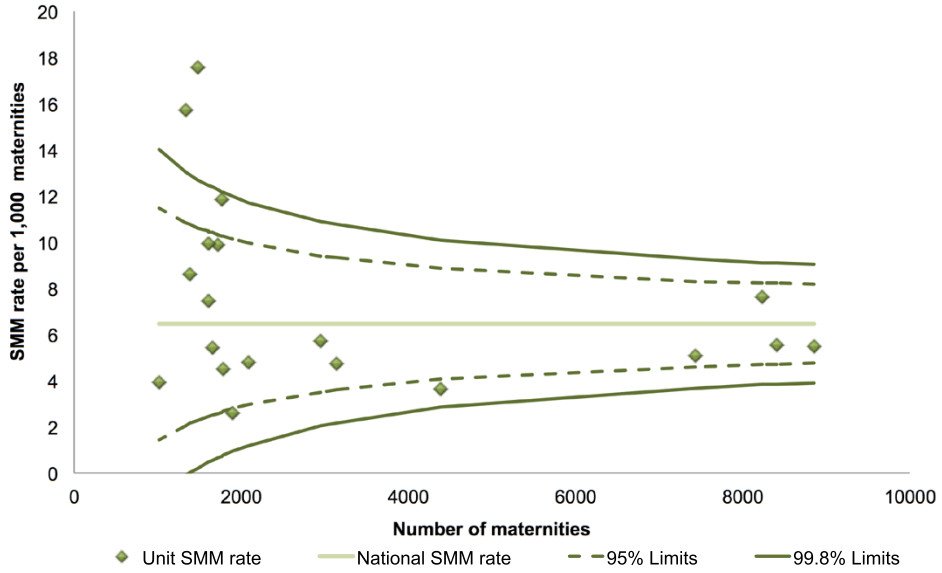


Figure 3: Funnel plot of the rate of severe maternal morbidity (SMM) by maternity unit, 2016

From Figure 3, it can be seen that three units have an SMM rate above the 95% upper limit and two units have an SMM rate above the 99.8% upper limit. The rate for these two outlying units is approximately 2.5 times the national rate (17.59 and 15.74 vs. 6.46 per 1,000 maternities).

A high proportion of the SMM cases for the unit with the highest rate (n=11 of 26, 42.3%) 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. Feedback from this unit identified that these were cases requiring monitoring above normal ward standard and due to low levels of staff in the unit, this could only be achieved by admission to the ICU.

It can also be seen from Figure 3 that two of the country's maternity units had an SMM rate just below the lower 95% limit (2.64 and 3.65 vs. 6.46 per 1,000 maternities).

The funnel plot in Figure 4 illustrates the variation in the SMM rate by maternity unit after exclusion of 57 cases admitted to an ICU/CCU with no other SMM experienced as defined in this audit. The adjusted national SMM rate was 5.55 per 1,000 maternities. The plot shows that two units had an SMM rate above the 95% upper limit but not above the 99.8% upper limit.

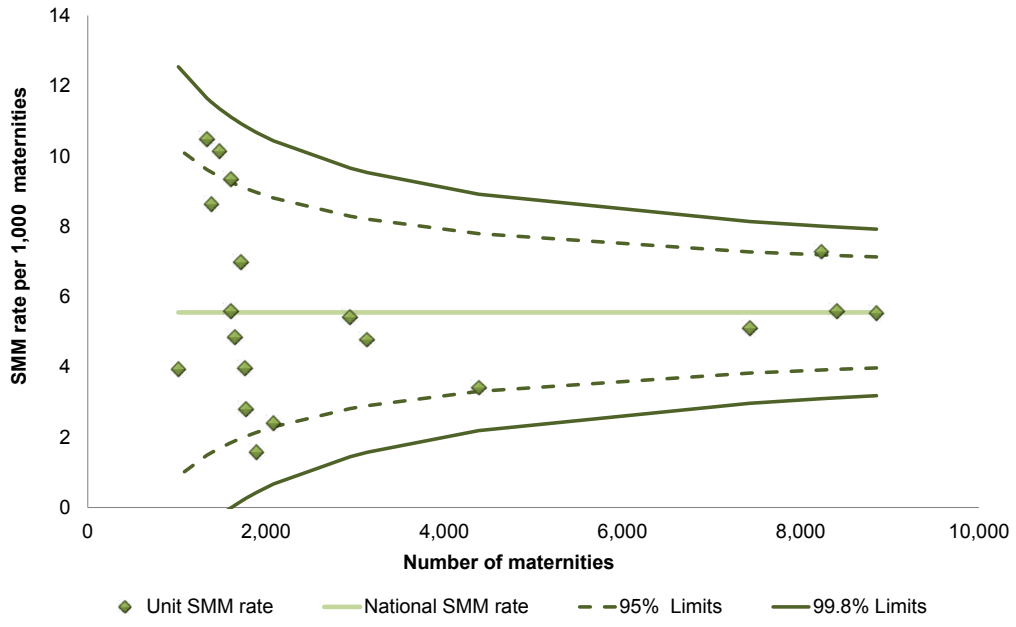


Figure 4: Funnel plot of the rate of severe maternal morbidity (SMM) by maternity unit excluding cases admitted to an ICU/CCU with no other SMM experienced as defined in this audit, 2016

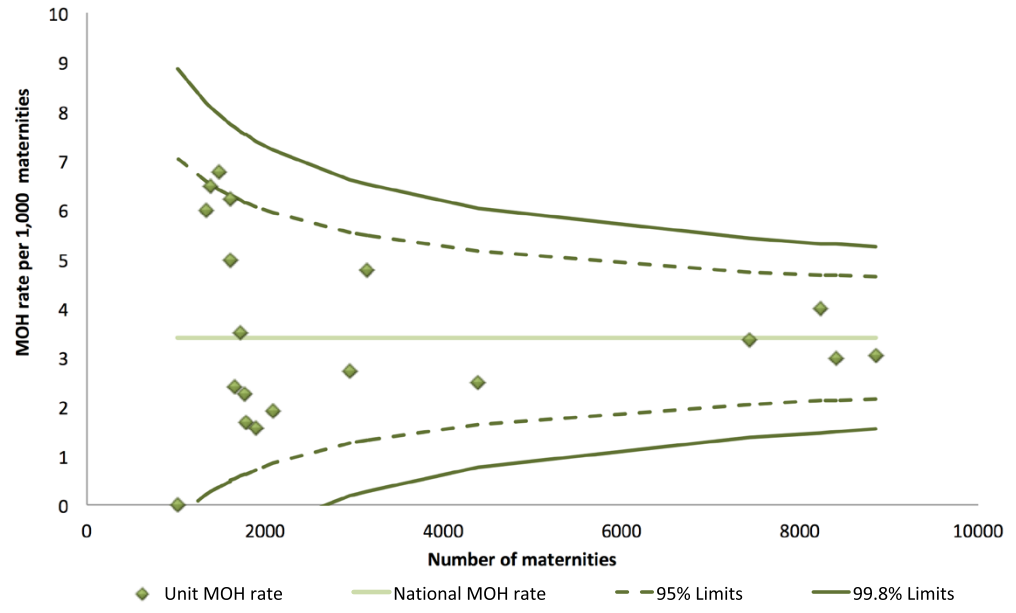


Figure 5: Funnel plot of the rate of major obstetric haemorrhage (MOH) by maternity unit, 2016

Figure 5 illustrates variation in the rate of MOH across the country's nineteen maternity units in 2016. One unit had a rate above the 95% upper limit for the national rate of 3.39 per 1,000 maternities but the rate was not above the 99.8% upper limit.

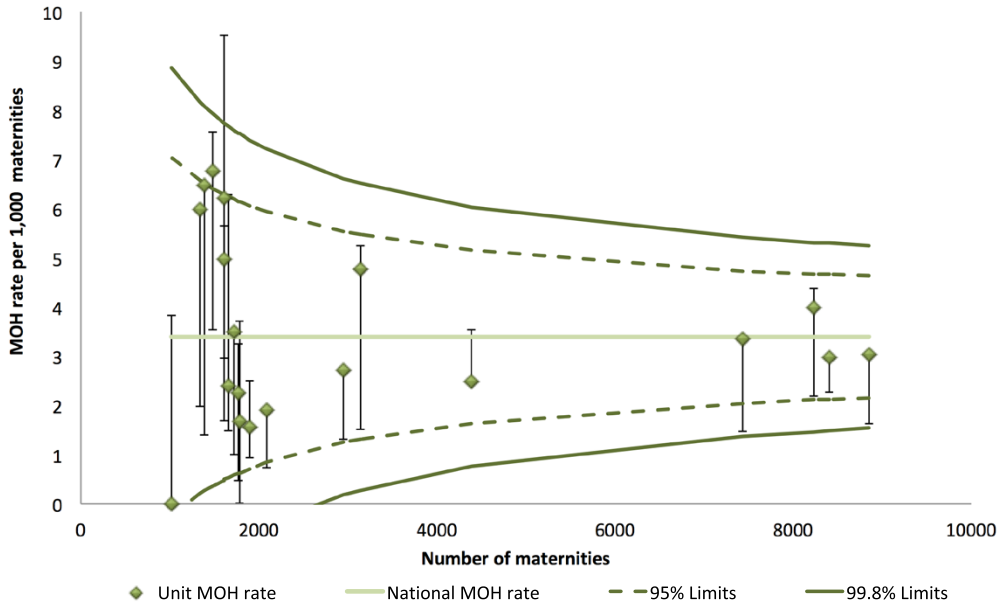


Figure 6: Funnel plot of the rate of major obstetric haemorrhage (MOH) in 2016 and its variation for each maternity unit for the years 2011-2016

Note: The error bars illustrate the variation in each unit's annual MOH rate since 2011

Figure 6 is identical to Figure 5 in that it illustrates the rate of MOH in Irish maternity units in 2016. However, in Figure 6 we have added error bars to illustrate the range of the annual MOH rate observed in each unit since 2011. Considering this six-year period, most of the units with over 2,000 births had their highest or nearly highest MOH rate in 2016. The expected greater volatility in the MOH rate in smaller units is evident.

Variances in rates of MOH between units may reflect variances in practices of estimating blood loss. We have reflected on methods of estimating blood loss in units with high and low rates of MOH and observed a lack of standardisation.

We have previously recommended that a quantitative approach involving volume and weight assessment to estimate blood loss be considered for use in all maternity units and that development of a national tool-kit would assist standardisation of such an approach. These recommendations are being addressed by the National Women and Infant Health Programme. While no one tool may be completely accurate in estimating blood loss, a standard quantitative approach should facilitate a less variable assessment of blood loss.

Maternal characteristics

Age

Maternal age, was recorded for 405 of the 406 cases of severe maternal morbidity (SMM) in 2016 and ranged from 16 to 51 years. The mean age was 33.0 years (standard deviation = 5.5 years). The age distribution of women who experienced SMM in 2013-2016 is detailed in Table 6. In 2016, 68% were aged 30-39 years which was similar to the population of women who gave birth in 2016 (65.4%). Women aged 35 years or over were somewhat overrepresented: they accounted for 42.0% of SMM cases in 2016 compared to 36.1% of the population who gave birth that year. This is reflected in the SMM rate calculated by maternal age based on data for 2016 (Table 6), whereby the highest SMM rate was among 35-39 year-olds and women over 40 years of age.

Table 6: Age distribution of women who experienced severe maternal morbidity (SMM), 2013-2016

Age group	SMM 2013 (N=319)	SMM 2014* (N=363)	SMM 2015* (N=371)	SMM 2016* (N=405)	All maternities 2016[1]	SMM rate 2016 (95% CI)	Rate ratio (95% CI)
<20yrs	6(1.9)	5(1.4)	3(0.8)	7(1.7)	1.7%	6.38 (2.56-13.14)	1.37 (0.59-3.18)
20-24yrs	20(6.2)	33(9.1)	34(9.2)	24(5.9)	8.2%	4.65 (2.98-6.92)	Ref.
25-29yrs	44(13.6)	57(15.7)	66(17.8)	63(15.6)	17.9%	5.59 (4.29-7.15)	1.20 (0.75-1.92)
30-34yrs	118(36.5)	126(34.7)	117(31.5)	141(34.8)	36.1%	6.22 (5.24-7.34)	1.34 (0.87-2.06)
35-39yrs	100(31.0)	110(30.3)	117(31.5)	134(33.1)	29.3%	7.28 (6.1-8.63)	1.57 (1.01-2.42)
≥40yrs	35(10.8)	32(8.8)	34(9.2)	36(8.9)	6.8%	8.44 (5.91-11.69)	1.82 (1.08-3.04)

Note: Values are shown as n(%) unless otherwise stated. Data for all maternities are from Perinatal Statistics Report 2016. 1Healthcare Pricing Office (HPO). Dublin: HPO, 2018. SMM rate per 1,000 births. * Maternal age was not known for two women in 2014, one woman in 2015 and 2016. Poisson 95% confidence intervals were calculated for the rare ratios.

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 2016 broadly reflected that of the general population of women aged 15-49 years as reported from the most proximal national census (Table 7).[24] In those who experienced SMM there was a slight overrepresentation of women whose ethnicity was described as Black as they made up 5.2% of SMM cases compared to 1.6% of the population aged 15-49 years in this ethic group. Similarly, women of Asian and Irish traveller ethnicity were over-represented in experiencing SMM when compared to the percentage of females aged 15-49 years of those ethnicities in the Irish population.

Table 7: Ethnicity of women who experienced severe maternal morbidity (SMM), 2016

	SMM 2016 (N=406)	15-49 year-old female population, 2016[1] %
White Irish	301(74.1)	77.1
Irish Traveller	6(1.5)	0.7
Other white background	44(10.8)	13.3
Asian/Asian Irish	23(5.7)	2.7
Black/Black Irish	21(5.2)	1.6
Other/mixed	3(0.7)	1.8
Not recorded	8(2)	2.7

Note: Values are shown as n(%) unless otherwise stated. [1] Central Statistics Office. (2018). Census 2016.

24 Central Statistics Office. (2018). Census 2016.

Body mass index

Body mass index (BMI) for the women who experienced SMM in 2016 ranged from 16.4 to 55.4kgm^{-2}. BMI was not known for 34 (8.4%) of the women. This represents a marginal improvement in the level of reporting of BMI (91.6%) when compared with SMM cases in 2015 (90.1%).

Over one third of the women who experienced SMM in 2016 had a BMI in the healthy range (38.7%), 36.3% were overweight and 23.1% were obese (Table 8). In comparison to 2015 SMM data, this represented a noticeable increase in the proportion of women experiencing a SMM who were in the overweight category (from 29.9% in 2015 to 36.3 % in 2016) with a corresponding reduction in women in the healthy category (from 46.6% in 2015 to 38.7% in 2016). It was also observed that of the total of women experiencing two SMMs or three SMMs in 2016, a higher proportion were categorised as overweight or obese (69.6% of women and 57.1% respectively).

There are no national data available on BMI for the pregnant population in Ireland. The BMI profile in this 2016 audit is similar to that of the women in the 2015 Healthy Ireland Survey.[25] However, interpretation of this comparison must consider the weight gain due to pregnancy for the women who experienced SMM as the Healthy Ireland Survey was of the general population.

Table 8: Body mass index (BMI) of women who experienced severe maternal morbidity (SMM), 2016

BMI category (kgm^{-2})	SMM 2015 (N=335)*	SMM 2016 (N=372)*	Healthy Ireland Survey 2015 %
Underweight (<18.5)	5(1.5)	7(1.9)	3
Healthy (18.5-24.9)	156(46.6)	144(38.7)	44
Overweight (25.0-29.9)	100(29.9)	135(36.3)	31
Obese (≥30.0)	74(22.1)	86(23.1)	22

Note: Values are shown as n(%) unless otherwise stated. * BMI was not known for 37 women in 2015 and 34 women in 2016.

Table 9 details the percentage of women experiencing specific morbidities who were categorised as either overweight or obese.

As previously mentioned, 60% of women who experienced a morbidity had a high BMI (36.3% overweight and 23.1% obese). High BMI has been associated with maternal mortality and morbidity, in particular morbidities such as pulmonary embolism and complications of anaesthetics.[26,27,28]

As shown in Table 9, among those who had specific maternal morbidities, women with high BMI were largely over-represented in the group of those affected by anaesthetic problems, cerebrovascular events, pulmonary oedema and pulmonary embolism.

25 Ipsos MRBI (2015). Healthy Ireland Survey 2015. Dublin: The Stationery Office.
26 Knight M, UKOSS. Antenatal pulmonary embolism: risk factors, management and outcomes. BJOG 2008; 115 (4):453-461
27 Malinowski AK, Bomba-Opoñ D et al. Venous thromboembolism in obese pregnant women: approach to diagnosis and management. Polish Gynaecology 2017; vol. 88, Issue 8: 453–459
28 Beckett VA, Knight M, Sharpe P. The CAPS Study: incidence, management and outcomes of cardiac arrest in pregnancy in the UK: a prospective, descriptive study. BJOG; 2017, vol 124, Issue 9: 1374-1381

Table 9: Proportion of women with higher Body mass index (BMI) who experienced severe maternal morbidity (SMM), 2016

Morbidity	Women with high BMI n(%)	Women with lower BMI n(%)
Major obstetric haemorrhage	115(59)	80(41)
Pulmonary oedema	10(83.3)	2(16.7)
Pulmonary embolism	18(78.3)	5(21.7)
Acute respiratory dysfunction	8(72.7)	3(27.3)
Anaesthetic problem	5(100)	--
Cerebrovascular event	4(100)	--

High BMI = BMI in the category overweight (25.0-29.9) and obese (≥30.0); Lower BMI = BMI in the category underweight (<18.5) or healthy (18.5-24.9)

Smoking, alcohol and drug misuse

Smoking status at the time of the first hospital booking appointment was known for 91.4% of the 406 women. Of these, 8.6 % (n=32 of 371) were reported to have been smoking at the time of the first booking. The prevalence of smoking during pregnancy is not routinely published for all Irish pregnancies but rates of 12%, 15%, 16% and 19% have been reported for England, Northern Ireland, Wales and Scotland, respectively.[29]

The quantity smoked was recorded for 26 of the 32 women who were smokers at the time of the first hospital booking appointment. Most commonly, these women smoked 5 or 10 cigarettes per day (range: 3-30). Of these 26 women, six were reported to have given up smoking during pregnancy (n=6 of 26, 23.1%, unknown for six cases of women smoking).

Alcohol drinking status at the time of the first hospital booking appointment was not known for 16.7% of the women (n=68). Of the 338 women with available data, only 2.7% were reported to be drinking alcohol (n=9).

Five women were recorded as having a documented history of drug abuse or attendance at a drug rehabilitation unit (1.3%, n=5 of 398, unknown for eight cases).

Recommendation:

- Maternal and Newborn Clinical Management System (MN_CMS) data from Irish maternity units should be collated to identify the influence of risk factors for SMM in Ireland including: ethnicity, maternal age, BMI, smoking and employment status.

29 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

Previous pregnancy

Forty five percent (45.4%) of the women who experienced a SMM in 2016 were nulliparous which is similar with previous years (Table 10). Women without any previous completed pregnancies (nulliparous) were over-represented in the group of individuals experiencing SMM, when comparing with all the maternities in Ireland for the same year. Conversely, women who had had one previous completed pregnancy, i.e. para 1, were underrepresented among the SMM cases when compared with the population of women birthing in Ireland in 2016 (26.8% versus 35.0%).

This is reflected in the SMM rate, which was lowest for para 1 women at 4.91 per 1,000 maternities. The SMM rate for women who had more than one previous completed pregnancy, i.e. para 2 and para 3+, was similar to the overall national rate of 6.46 per 1,000. However, the SMM rate for these women was 30-40% higher than for para 1 women. Nulliparous women had the highest SMM rate at 7.66 per 1,000, 56% higher than the rate for para 1 women.

Table 10: Distribution of parity for women who experienced severe maternal morbidity (SMM), 2013-2016

Parity	SMM 2013 (N=321)*	SMM 2014 (N=359)*	SMM 2015 (N=371)*	SMM 2016 (N=403)*	All maternities 2016	SMM rate 2016 (95% CI)	Rate ratio (95% CI)
Nulliparous	122(38.0)	152(42.3)	152(41.0)	183(45.4)	38.0%	7.66 (6.59-8.85)	1.56 (1.23-1.98)
Para 1	97(30.2)	101(28.1)	107(28.8)	108(26.8)	35.0%	4.91 (4.03-5.93)	(Ref.)
Para 2	55(17.1)	67(18.7)	65(17.5)	73(18.1)	18.0%	6.46 (5.06-8.12)	1.31 (0.98-1.77)
Para 3+	47(14.6)	39(10.9)	47(12.7)	39(9.7)	9.1%	6.84 (4.87-9.36)	1.39 (0.97-2.01)

Note: Values are shown as n(%) unless otherwise stated; * Parity was not known for two, six, one and three cases in 2013, 2014, 2015 and 2016, respectively. Data for all maternities are from Perinatal Statistics Report 2016. Healthcare Pricing Office (HPO). Dublin: HPO, 2018

Previous early pregnancy loss was reported for nearly one third of the women who experienced SMM in 2016 (31.3%, 126 of 402; unknown for four women). Seventeen women (4.2%) had previously experienced three or more pregnancies that ended before 24 weeks gestation.

Obstetric factors associated with the severe maternal morbidity event

For 10% of the women who experienced SMM in 2016, their pregnancy was the result of infertility treatment (n=42 of 405, 10.4%; unknown for one woman). In nearly three quarters of these cases the method of infertility treatment was in vitro fertilisation (n=31, 73.8%).

The prevalence of a previous caesarean section was over 45% among the women who had previously given birth (n=97 of 217, 44.7%; not known for eight women.

Gestation at delivery or pregnancy end for women who experienced a SMM ranged from five to 42 weeks. For over two thirds of the women affected (67.9%), their pregnancy went full term (Table 11). For a further 20.8%, their pregnancy ended at moderate-to-late pre-term gestation (32-36 weeks). For 4% of the women, the end of pregnancy occurred before 22 weeks gestation.

Table 11: Gestation at delivery or pregnancy end for women who experienced severe maternal morbidity, 2013-2016

	2013 (N=317)*	2014 (N=348)*	2015 (N=367)*	2016 (N=399)*
Pre-viable (<22wks)	11(3.5)	14(4.0)	20(5.4)	16(4)
Extremely pre-term (22-27wks)	15(4.7)	14(4.0)	14(3.8)	9(2.3)
Very pre-term (28-31wks)	14(4.4)	19(5.4)	25(6.8)	18(4.5)
Moderate/late pre-term (32-36wks)	73(23.0)	78(22.3)	63(17.2)	83(20.8)
Term (37-41wks)	204(64.4)	224(64.0)	241(65.7)	271(67.9)
Post-term (42wks+)	0(0.0)	1(0.3)	4(1.1)	2(0.5)

Note: Values are shown as n(%) unless otherwise stated; * Gestation was not known for six ,15, five and seven cases in 2013, 2014, 2015 and 2016 respectively.

Severe maternal morbidity associated with early pregnancy loss

Early pregnancy loss (i.e. delivered before 24 weeks gestation and birthweight less than 500g) was experienced by 18 of the 404 women (4.5%, unknown for two cases). These involved 11 cases of miscarriage (2.7%) and seven cases of ectopic pregnancy (1.7%). Thirteen of the early pregnancy loss cases were diagnosed with one SMM (eight cases of miscarriage and five cases of ectopic pregnancy) and four cases were diagnosed with two SMMs (two cases of miscarriage and two cases of ectopic pregnancy). One additional case of miscarriage was diagnosed with three SMMs.

Major Obstetric Haemorrhage was the most frequently reported SMM associated with twelve cases of early pregnancy loss (six miscarriages and six ectopic pregnancies). There were four cases with admission to ICU/CCU of which one was associated with miscarriage and the remaining related to ectopic pregnancies. Septicaemic shock was reported in four cases, all associated with miscarriage. Other reported SMMs in the early pregnancy loss cases included uterine rupture (n=3) and pulmonary embolism (n=1).

Severe maternal morbidity associated with multiple pregnancy

A total of 386 women had an SMM which was not associated with early pregnancy loss (unknown for one case). As shown in Table 12, among these women 29 had a multiple birth (n=29 of 385, 7.5%; single/multiple birth not known for one woman). Twenty-eight of the multiple births involved twins and one involved quadruplets. In Ireland in 2016, multiple births made up 1.9% of all maternities (n=1,216 of 62,871). Thus, multiple pregnancy was 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 5.77 per 1,000 maternities associated with singleton pregnancy in 2016 and a 4 times higher rate of 23.85 per 1,000 maternities for multiple pregnancy (p-value<0.001).

These findings are similar to the most recent reports 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%).[30]

Table 12: Single and multiple birth for women who experienced severe maternal morbidity (SMM) but who did not experience early pregnancy loss, 2013-2016

	SMM 2013 (N=323)	SMM 2014 (N=338)*	SMM 2015 (N=351)*	SMM 2016 (N=385)*	All maternities 2016	SMM rate (95% CI)	Rate ratio (95% CI)
Single	296(91.6)	314(92.9)	328(93.4)	356(92.5)	98.1%	5.77 (5.19–6.41)	1.00 (Ref.)
Multiple	27(8.4)	24(7.1)	23(6.6)	29(7.5)	1.9%	23.85 (16.0-34.25)	4.13 (2.83-6.03)

Note: Data for all maternities are from Perinatal Statistics Report 2017. Healthcare Pricing Office (HPO). Dublin: HPO, 2017 (in press). Values are shown as n(%) unless otherwise stated. SMM rate per 1,000 births. *Not known for nine women in 2014, two cases in 2015 and one case in 2016. Poisson 95% confidence intervals were calculated for the rate ratios.

30 Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). 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 386 (three cases unknown) women whose SMM was not associated with early pregnancy loss in 2016 was caesarean section (Table 13). This is over twice the 32.6% caesarean section rate occurring in all births nationally in 2016.[31] 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. Over one in three women had a vaginal delivery (36%), usually spontaneously (23.5%).

Table 13: Primary mode of delivery (excluding those who experienced early pregnancy loss) for women who experienced severe maternal morbidity, 2013-2016

	2013 (N=309)*	2014 (N=337)*	2015 (N=349)*	2016 (N=383)*
Vaginal	**102(33.0)**	**114(33.8)**	**124(35.5)**	**138(36)**
Spontaneous	73(23.6)	67(19.9)	73(20.9)	90(23.5)
Assisted breech	3(1.0)	-	7(2.0)	0(0)
Ventouse	16(5.2)	25(7.4)	29(8.3)	30(7.8)
Non-rotational forceps	10(3.2)	18(5.3)	15(4.3)	14(3.7)
Rotational forceps	-	4(1.2)	-	4(1)
Caesarean section	**207(67.0)**	**223(66.2)**	**225(64.5)**	**245(64)**
Elective LSCS (no labour)	59(19.1)	54(16.0)	63(18.1)	55(14.4)
Emergency LSCS (no labour)	77(24.9)	99(29.4)	79(22.6)	101(26.4)
Elective LSCS (labour)	5(1.6)	7(2.1)	3(0.9)	7(1.8)
Emergency LSCS (labour)	63(20.4)	61(18.1)	79(22.6)	81(21.1)
Classical	3(1.0)	25(7.4)	1(0.3)	1(0.3)

Note: Values shown are n(%) unless otherwise stated; * Mode of delivery was not known for two, ten, two and three cases in 2013, 2014, 2015 and 2016, respectively. For cases of multiple birth when mode of delivery differed for the babies, the more complex mode of delivery was taken as the primary mode. LSCS=Lower segment caesarean section. Data excludes 12, 18, 19 and 18 cases of early pregnancy loss in 2013, 2014, 2015 and 2016 respectively.

Recommendation

- A public health education programme on maternal morbidity and modifiable risk factors should be developed.

31 Healthcare Pricing Office. (2018) Perinatal Statistics Report 2016. Dublin: Health Service Executive. [in press]

Maternal care details

The level of maternal care provided has been recorded since the 2014 SMM audit. Virtually all of the women who experience SMM in 2016 required an increased level of support/ critical care (Table 14). Almost half required Level 1 Care (44.8%), 47.3% required Level 2 Care and 6.9% required Level 3 Care.

Table 14: Level of maternal care provided to 406 women during clinical SMM events in Ireland, 2016

Level of Care	Definition	N(%)
Level 0: Normal ward care	Care of low risk pregnant women	4(1)
Level 1: Additional monitoring or intervention, or step down from higher level of care	Patients at risk of their condition deteriorating and needing a higher level of observation or those recently relocated from higher levels of care	182(44.8)
Level 2: Single organ support	Patients requiring invasive monitoring/ intervention including support for a single failing organ system (incl. use of arterial and CVP lines, excl. advanced respiratory support)	192(47.3)
Level 3: Advanced respiratory support alone, or support of two or more organ systems	Patients requiring advanced respiratory support (mechanical ventilation) alone or basic respiratory support along with support of at least one additional organ	28(6.9)

Only approximately one in six of the women admitted to an ICU/CCU required Level 3 Care (17.5%); almost half of women admitted to ICU/CCU required Level 2 Care and 33.8% required Level 1 Care (Table 15). This highlights that admission to an ICU/CCU does not infer that a woman has a requirement for Level 3 Care. Half of the 54 women admitted to an ICU/CCU requiring Level 1 Care only did not experience another SMM as defined by this audit (n=27, 50%).

Table 15: Level of maternal care provided to women during specific clinical SMM events in Ireland, 2016

	n(%)	Level 0 n(%)	Level 1 n(%)	Level 2 n(%)	Level 3 n(%)
Total of women	**406(100)**	**4(1)**	**182(44.8)**	**192(47.3)**	**28(6.9)**
Major obstetric haemorrhage	215(53)	1(0.5)	113(52.6)	88(40.9)	13(6)
ICU/coronary care unit admission	160(39.4)	-	54(33.8)	78(48.8)	28(17.5)
Renal or liver dysfunction	34(8.4)	-	5(14.7)	27(79.4)	2(5.9)
Septicaemic shock	28(6.9)	-	7(25)	19(67.9)	2(7.1)
Peripartum hysterectomy	27(6.7)	-	8(29.6)	15(55.6)	4(14.8)
Pulmonary embolism	24(5.9)	2(8.3)	12(50)	8(33.3)	2(8.3)
Uterine rupture	8(2)	1(12.5)	1(12.5)	6(75)	-
Pulmonary oedema	12(3)	-	4(33.3)	6(50)	2(16.7)
Eclampsia	14(3.4)	-	2(14.3)	11(78.6)	1(7.1)
Interventional radiology	5(1.2)	-	-	5(100)	-
Acute respiratory dysfunction	14(3.4)	-	-	-	14(100)
Cerebrovascular event	4(1)	-	1(25)	2(50)	1(25)
Status epilepticus	2(0.5)	-	1(50)	1(50)	-
Cardiac arrest	2(0.5)	-	1(50)	-	1(50)
Anaesthetic problem	5(1.2)	-	2(0)	1(0)	2(0)

Note: % shown refers to level of care per each type of morbidity; ICU=intensive care unit; more than one morbidity may apply per woman.

For Major Obstetric Haemorrhage, the majority of cases required Level 1 Care (52.6%) while 40.9% required Level 2 Care and 6% required Level 3 Care. As expected clinically, higher levels of critical care/monitoring were required for the women experiencing life-threatening maternal morbidities, e.g. acute respiratory dysfunction and cardiac arrest.

Neonatal outcomes

Of the 386 women whose SMM was not associated with early pregnancy loss (not known for two women), a total of 416 babies were delivered: 356 singleton births, 28 twin births (56 babies) and one birth of quadruplets. Information on neonatal outcome in terms of perinatal death was available for 409 of these infants. Of the 409 births, there were 14 stillbirths, two early neonatal deaths and no known late neonatal deaths. Therefore, in total, there were 393 live born infants.

Only two of the 14 stillbirths were associated with a multiple pregnancy (one twin and one from quadruplets), whereas both of the early neonatal deaths were associated with singleton pregnancies. Gestation at delivery for these 16 perinatal deaths occurred before 22 weeks for the two early neonatal death cases (12.5% of all perinatal deaths). For one delivery (6.3%) gestation was 22-27 weeks (extremely pre-term), for two babies (12.5%) it was very pre-term (28-31 weeks) and seven stillbirths (43.8%) were delivered at late pre-term (32-36weeks). The four (25.0%) additional stillbirths were delivered at term (37-41 weeks). Over half of the 12 women affected by perinatal deaths (n=7, 58.8%) experienced major obstetric haemorrhage.

The mortality rate based on the 14 stillbirths and two early neonatal deaths among the 409 infants was 39.1 per 1,000 births, i.e. approximately 4% or one in 25 of the infants died. This rate was 6.7 times the perinatal mortality rate observed for all births in Ireland in 2016 (p-value<0.001; Table 16). 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. [32]

Table 16: Perinatal mortality among infants born to women with SMM in Ireland in 2016 compared to perinatal mortality among all infants born in Ireland

	Perinatal deaths	Births	PMR (95% CI)	Rate ratio (95% CI)
All births 2016*	374	64,133	5.8(5.3-6.5)	1.0(Ref.)
SMM 2016	16	409	39.1(22.4-63.5)	6.71(4.07-11.06)

Note: PMR=perinatal mortality rate per 1,000 births; * Manning E, Leitao S, Corcoran P, McKernan J, de Foubert P, Greene RA, on behalf of the Perinatal Mortality Group. Perinatal Mortality in Ireland Annual Report 2016. Cork: National Perinatal Epidemiology Centre, 2017. Poisson 95% confidence intervals were calculated for the rate and the rate ratios.

Approximately 5% (n=19, 4.7%) of the 408 live born infants were intubated following delivery and less than half (n=188, 46.1%) were transferred to the Special Baby Care Unit (SBCU) or Neonatal Intensive Care Unit (NICU; Table 17).

Table 17: Selected neonatal outcomes, 2016

	N=408*
Intubation following delivery	19(4.7)
Transfer to SBCU/NICU	188(46.1)

Note: SCBU=Special Baby Care Unit; NICU=Neonatal Intensive Care Unit.* n= total number of live births, neonatal outcome unknown for eight babies.

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 Severe Maternal Morbidity may reflect the complexity of the pregnant population, it also acts as a surrogate measure of quality of care in the maternity services.

32 Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from:http://www.healthcareimprovementscotland.org/our_work/reproductive,_maternal_child/programme_resources/scasmm.aspx

Section 2. Confidential Audit of Critical Care in Obstetrics in Ireland

This section of the report presents findings from the third and final year of the audit of critical care in obstetrics in Ireland. The purpose of this audit is to address the dearth of national data on the prevalence rates for women who require Level 2 and Level 3 Care and the location where higher levels of care are provided. While all Level 3 intensive care patients will be admitted to a Level 3 Care Unit and be readily identifiable in future Intensive Care National Audit and Research Centre (ICNARC) data, estimation of the requirement for Level 2 Care is more complicated. Women requiring Level 2 Care may have all or part of their critical care needs met in a maternity unit, but at the present time there is no national data recording this activity.

Fifteen of the nineteen Irish maternity units have contributed data to this audit for the years 2014 to 2016, including; two large tertiary referral maternity units and 13 smaller maternity units. In the case of a woman requiring Level 2 or Level 3 Care, participating units were asked to complete a specific proforma (Appendix G). The main clinical diagnosis, organ support required and specialist review during the critical care event were documented on this form. Additional data on maternal demographics and neonatal outcomes were reported on the NPEC SMM notification form.

Levels of critical care

National and International guidelines have recommended that the terms *high dependency* and *intensive care* be replaced by the term critical care.[33,34] The term *critical care* has a more precise definition whilst the terms *maternal critical care, high dependency care* and *high risk maternity care* are not interchangeable. Figure 2.1 shows the type of unit of care available in the various maternity units in the country.

Within the term *critical care*, care is subdivided into four levels, dependent on organ support and the level of monitoring required independent of clinical diagnosis. Levels of care are detailed in Appendix F.

33 Clinical Practice Guideline No 30 (2014). Guideline for the Critically ill Woman in Obstetrics : Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive
34 Royal College of Obstetricians and Gynaecologists (2011).Maternal Critical Care Working Group. Providing equity of critical and maternity care for the critically ill pregnant or recently pregnant woman.

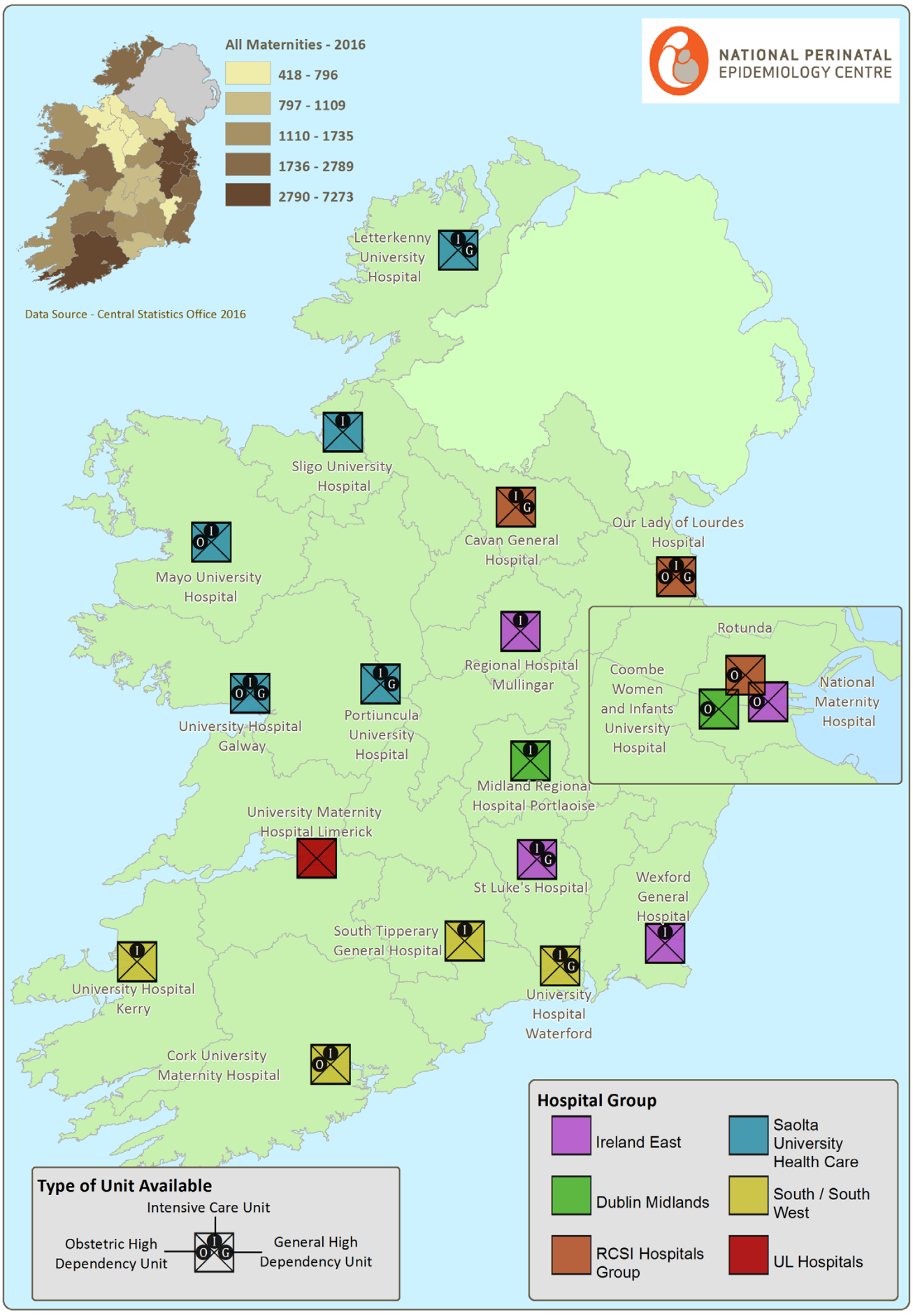


Figure 2.1 - Map of maternity units and hospital groups in the Republic of Ireland according to type of unit of care available (2016)

Main findings

Overall, 370 women, out of 40,196 maternities cared for in the fifteen reporting units, required either Level 2 or Level 3 Care (Table 2.1). This gives a rate of 9.2 per 1,000 maternities or one in 109 maternities. Of these, 351 women required Level 2 Care only (8.73 per 1,000 maternities or one in 114 maternities) and 19 women required Level 3 Care, either solely or in combination with Level 2 Care, during the clinical event (0.47 per 1,000 maternities or one in 2,127 maternities).

Table 2.1: Sequence of critical care provided to women who required Level 2 or 3 Care, 2016

Level of Critical Care	N(%)
Level 2 Care only	351(94.9)
Level 2 followed by Level 3 Care	1(0.3)
Level 2 followed by Level 3 followed by Level 2 Care	4(1.1)
Level 3 Care only	6(1.6)
Level 3 followed by Level 2 Care	8(2.2)

Duration of critical care

The duration of care for the vast majority of women who required Level 2 Care only (88.9%), did not exceed two days (Figure 2.2). The maximum duration for Level 2 Care was 9 days and 8.0% of women were provided Level 2 Care for three to four days. Of the 19 women who required Level 3 Care, the maximum duration of Level 3 Care was 17 days (duration of care missing for two women). For the majority (70.6%) of these cases, the duration of Level 3 Care did not exceed four days.

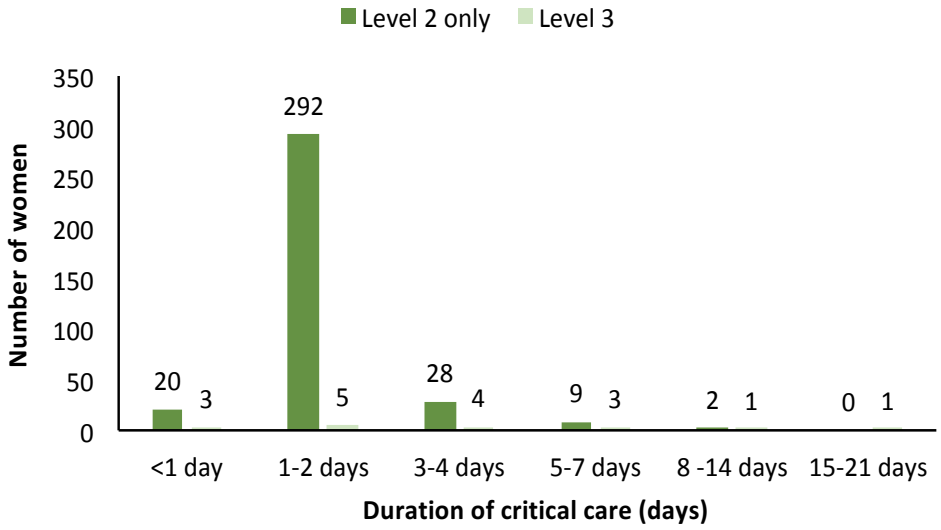


Figure 2.2: Duration of critical care for women who required Level Care 2 only and Level 3 Care, 2016

Note: The duration of Level 3 Care was unknown for two women.

Pre-existing co-morbidities and antenatal risk assessment

Data on pre-existing co-morbidities was available for 344 of the 351 women who required Level 2 Care only and for all the 19 women requiring Level 3 Care. Over forty percent of the women needing Level 2 Care only had pre-existing co-morbidities (n=171, 48.7%) and over half of the women requiring Level 3 Care had pre-existing co-morbidities (n=11, 57.9%; Figure 2.3).

The pregnancy risk level during the antenatal period was recorded for 322 of the 351 women requiring Level 2 Care only and for all the 19 women requiring Level 3 Care. The pregnancy was identified as high risk in over forty percent of women requiring Level 2 Care only (n= 163, 46.4%) and in 52.6% (n=10) of women who required Level 3 Care. This suggests that the need for higher levels of maternal care is not predictable in approximately half of women requiring critical care and thus has implications for resource planning.

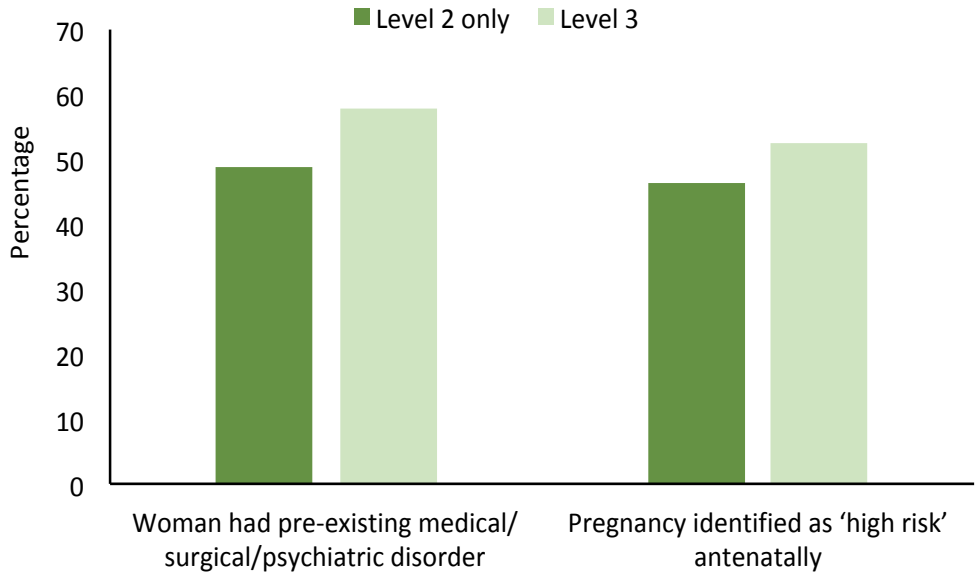


Figure 2.3: Pre-existing co-morbidities and antenatal risk assessment for women who required Level 2 and Level 3 Care, 2016

Maternal characteristics

Body mass index (BMI) for the women who required Level 2 or Level 3 Care in 2016 ranged from 16.4 to 49.8 kgm^{-2}. BMI was not known for 30 of the 370 women requiring these types of care. This level of BMI reporting is similar to that for SMM cases in the previous audit years.

Just under forty percent (n=128, 37.6%) of these women had a BMI in the healthy range, 34.7% (n=118) were overweight and one quarter of the women (25.9%, n=88) were obese (Table 2.2). This BMI profile closely matches that of all women who experienced SMM in 2016, as defined in the NPEC SMM audit, and of the general population of women sampled in the 2015 Healthy Ireland Survey.

Table 2.2: Body mass index (BMI) of women who required Level 2 or Level 3 Care, 2016

BMI category (kgm^{-2})	Level 2 or 3 2016 (N=340)*	SMM 2016 (N=372)*	Healthy Ireland Survey 2015 %
Underweight (<18.5)	6(1.8%)	7(1.9%)	3
Healthy (18.5-24.9)	128(37.6%)	144(38.7%)	44
Overweight (25.0-29.9)	118(34.7%)	135(36.3%)	31
Obese (≥30.0)	88(25.9%)	86(23.1%)	22

Note: Values are shown as n(%) unless otherwise stated. * BMI was not known for 30 women who required Level 2 or Level 3 Care and 34 SMM cases.

Over half of the women who required Level 2 or Level 3 Care in 2016 were nulliparous (n=212, 57.6%; Table 2.3). This is higher than was observed among all women who experienced SMM in 2016 and is also higher than in the population of women who gave birth in 2016, thus nulliparous women are over-represented amongst those who required Level 2 or Level 3 Care. The number of multiparous women who required Level 2 or Level 3 Care was broadly similar to the number who experienced SMM in 2016 and in the case of Para 2 and Para 3+ women, similar to the population who gave birth in 2016.

Table 2.3: Distribution of parity for women who required Level 2 or Level 3 Care, 2016

Parity	Level 2 or 3 2016 (N=368)*	SMM 2016 (N=403)*	All maternities 2016
Nulliparous	212(57.6%)	183(45.4%)	38.0%
Para 1	71(19.3%)	108(26.8%)	35.0%
Para 2	51(13.9%)	73(18.1%)	18.0%
Para 3+	34(9.2%)	39(9.7%)	9.1%

Note: Values are shown as n(%) unless otherwise stated; * Parity was not known for two women who required Level 2 or Level 3 Care and three SMM cases. Data for all maternities are from Perinatal Statistics Report 2016. Healthcare Pricing Office (HPO). Dublin: HPO, 2017

Multiple Pregnancies

Compared to the population of women who gave birth in 2016, there was a large over-representation of women with multiple pregnancies amongst those who required Level 2 or Level 3 Care (Table 2.4).

Table 2.4: Single and multiple births in women who required Level 2 or Level 3 Care, 2016

	Level 2 or 3 2016 (N=359)*	SMM 2016 (N=385)**	All maternities 2016
Single	323(89.7%)	356(92.5%)	98.1%
Multiple	36(10%)	29(7.5%)	1.9%

Note: Data for all maternities are from Perinatal Statistics Report 2016. Healthcare Pricing Office (HPO). Dublin: HPO, 2017. *Single and multiple pregnancy unknown for 11 women requiring Level 2 or 3 care; **Single and multiple births in women in 2016 whose SMM was not associated with early pregnancy loss, unknown for 3 cases (2 cases not know if early pregnancy loss or not and one case not known multiple/single pregnancy)

Specific findings for women who required Level 2 Care only

Maternal morbidity in women requiring Level 2 Care

Maternal morbidity was classified as direct, indirect or coincidental based on the main clinical diagnosis during the critical care event, using the WHO classification for maternal mortality (Appendix H).[35] Briefly described, direct maternal morbidities refer to obstetric complications of the pregnancy state while indirect maternal morbidities refer to medical complications resulting from pre-existing disease, or disease that developed during pregnancy which was not the result of direct obstetric causes, but which was aggravated by the physiological effects of pregnancy. The majority of women (92.9%) requiring Level 2 Care in this critical care audit were classified as having a direct obstetric morbidity, 7.1% had an indirect morbidity (n=25) and there were no cases due to coincidental causes (Table 2.5). The main causes of direct obstetric morbidity in women who required Level 2 Care were attributable to hypertensive disorders (57.3%) and obstetric haemorrhage (25.1%).

The absence of international consensus on definitions of SMM is problematic and impedes comparative analysis and uniform case-identification criteria. The WHO defines *severe **maternal complications*** as potentially life-threatening conditions and a *maternal near miss* as an event where a woman who nearly died but survived a complication during pregnancy, childbirth or within 42 days of termination of pregnancy.[36]

Table 2.5 demonstrates the number of maternal morbidities identified using three different classification systems for maternal morbidity: the NPEC SMM (pg. 5 of Appendix E), the WHO Near Miss (NM) criteria (Appendix I) and the WHO Severe Maternal Complication (SMC) criteria (Appendix J). Sixty percent of direct morbidities (n=130) fulfilled the NPEC SMM criteria, however, 17 (13.1%) of these cases fulfilled the criteria due to ICU admission only (not experiencing any additional morbidities included in the SMM audit). All of the cases with direct causes of SMM satisfied the WHO Severe Maternal Complication (SMC) criteria. However, only 9.8% of the cases matched the WHO Near Miss (NM) criteria (two additional cases, 0.6%, did not have sufficient data to determine these criteria).

Considering the NPEC SMM and WHO Near Miss (NM) definitions utilise organ dysfunction criteria, it is evident that a number of women requiring Level 2 Care do not experience organ dysfunction as their clinical needs were identified and treated before organ dysfunction occurred. This is similar to findings of a recent study of HDU admissions in a tertiary referral maternity unit in Ireland.[37]

35 The WHO application of ICD-10 to deaths during pregnancy, childbirth and puerperium: ICD MM. World Health Organisation 2012
36 World Health Organisation, Evaluating the quality of care for severe pregnancy complications. The WHO near-miss approach for maternal health. World Health Organization; 2011
37 O'Malley E, Popivanov P, Fergus A and Byrne B. Maternal Near Miss: what lies beneath? European Journal Obstetric Gynaecology Reproductive Biology 2016;199

Table 2.5: Classification of maternal morbidity in women who required Level 2 Care in 2016 according to the NPEC Severe Maternal Morbidity (SMM), WHO Near Miss (NM) and WHO Severe Maternal Complication (SMC).

Maternal morbidity	N(%)	NPEC SMM		WHO Severe Maternal Complication (SMC)	WHO Near Miss (NM)	
		SMM cases	ICU only		Meets criteria	Insufficient Data
All (Direct, Indirect and Coincidental)	**351 (100%)**	**143/351 (59.3%)**	**23**	**351/351 (100%)**	**32/351 (9.12%)**	**8/351 (2.3%)**
Direct	**326/351 (92.9%)**	**130/326 (39.8%)**	**17**	**326/326 (100%)**	**31/326 (9.5%)**	**8/326 (2.4%)**
Pregnancy with abortive outcome	--	--		--	--	
Hypertensive disorders	**201/351 (57.3%)**	44/201 (21.9%)	16	201/201 (100%)	3/201 (1.5%)	2/201 (1%)
Obstetric Haemorrhage	**88/351 (25.1%)**	67/88 (33.3%)	0	88/88 (100%)	25/88 (28.4%)	1/88 (1.1%)
Pregnancy related infection	**29/351 (8.3%)**	11/29 (37.9%)	0	29/29 (100%)	3/29 (10.3%)	5/29 (17.2%)
Other obstetric complications	**7/351 (2%)**	7/7 (100%)	1	7/7 (0%)	--	--
Unanticipated complications of management	**1/351 (0.3%)**	1/1 (100%)	0	1/1 (100%)	--	--
Indirect	**25/351 (7.1%)**	**13/25 (52%)**	**6**	**25/25 (100%)**	**1/25 (4%)**	**0 (0%)**
Non obstetric complications	**25/351 (7.1%)**	13/100 (52%)	6	25/25 (100%)	1/1 (4%)	0 (0%)
Coincidental	--	--		--	--	

Organ support required

Overall, among the 351 women who received Level 2 Care, the most common organ support required was Basic Cardiovascular Support (BCVS; n=271, 77.2%). BCVS alone was provided in 38.7% of these 271 cases. This type of organ support was also facilitated in combination with neurological support, in 34.8% of cases, or with Basic Respiratory support (BRS) in 3.7% of the 271 cases (Table 2.6). BCVS constituted invasive monitoring, primarily arterial line placement, and or IV anti-hypertensive.

Cases where Basic Cardiovascular Support (BCVS) and neurological support were required were also frequent (n=122, 34.8%). Among these cases the primary indication for transfusion of magnesium sulphate was mainly for the prophylaxis of eclampsia in severe pre-eclampsia (n=116, 95.1%).

Table 2.6: Single organ support required during Level 2 Care, 2016

Organ support required	N (%)
Basic Cardiovascular Support (BCVS)	**271(77.2%)**
BCVS alone	136(38.7%)
BCVS and Magnesium Sulphate Infusion (and Neurological)	122(34.8%)
BCVS and Basic Respiratory Support (BRS)*	13(3.7%)
Advanced Cardiovascular Support (ACVS)	**1(0.3%)**
Basic Respiratory Support (BRS)	**7(2%)**
Magnesium Sulphate Infusion (Neurological) alone	**72(20.5%)**
Renal	**--**
Hepatic	**--**

*BRS and BCVS occurring simultaneously during the episode count as a single organ support

Location during Level 2 Care

For women who required Level 2 Care only, the highest support level location during the clinical event is detailed in Table 2.7. Across the 15 participating units, over seventy percent of these women were treated in an obstetric HDU (n=246 of 351, 70.1% one case unknown) and over one in six were treated in an ICU/CCU (n=64,18.2%).

In maternity units with fewer than 2,500 births per year, the number of women who required Level 2 Care only was 77. (Highest level of support was missing for one location.) The majority of women requiring Level 2 Care were treated in an ICU/CCU (n=49, 63.6%). This proportion decreases in medium-size maternities (units with 2,500-6,000 births per year) where only 31.8% of women (n=14) were provided Level 2 Care in ICU/CCU. In tertiary referral hospitals, only one case was cared for in ICU/CCU (n=1, 0.4%). Variances across units in location of care for women requiring Level 2 Care may reflect differences in resources available for obstetric Level 2 Care and a dependence on ICU/CCU facilities.

In maternity units with 2,500-6,000 births per year (medium-sized units), approximately half of the women who required Level 2 Care were treated in an obstetric HDU (n=20, 45.5%), and this was the main location for Level 2 Care in tertiary referral hospitals (n=225, 97.8%). HDU and ICU/CCU facilities available to maternity units in Ireland are illustrated on page 43 of this report.

Table 2.7: Highest level support location for women who required Level 2 Care in 15 Irish maternity units, 2016

	No of women who required Level 2 Care only	Delivery suite/ Ward	Theatre	Obstetric HDU	General hospital HDU	ICU/CCU
All 15 reporting units	351	29(8.3%)*	4(1.1%)*	246(70.1%)*	7(2%)*	64(18.2%)*
Maternity units with <2,500 deliveries	77	21(27.3%)	2(2.6%)*	1(1.3%)*	3(3.9%)*	49(63.6%)*
Maternity units with 2,500-6,000 deliveries	44	7(15.9%)	0(0%)	20(45.5%)	3(6.8%)	14(31.8%)
Tertiary referral hospital (>6,000 deliveries)	230	1(0.4%)	2(0.9%)	225(97.8%)	1(0.4%)	1(0.4%)

Note: For women who were treated in more than one care setting during the clinical event, the setting offering the highest level of support is reported. *Highest level of support location missing for one case.

Inter-hospital Transfer

Data on transfer details was available for 350 of the 351 women requiring Level 2 Care. Of these 350 cases, 12 (3.4%) were transferred from another maternity unit for Level 2 Care. The majority of these transfers happened within the recipient unit's HSE hospital network group (n=9, 75%).

Maternal monitoring prior to and during Level 2 Care

IMEWS

National guidelines recommend the use of the Irish Maternity Early Warning System (IMEWS) to monitor all women who are clinically pregnant or who were delivered within the previous 42 days.[38] In the majority of 350 cases (n=246 of 350, 70.3% unknown for one case), an IMEWS was used to monitor women prior to commencement of Level 2 Care. Of the 104 (29.6%) cases where an IMEWS was not used, it was reported that the woman was either cared for in a location which utilised a different monitoring tool (theatre, n=31, 29.8%; labour ward, n=45, 43.3%; among others) or admitted from home (n=5, 4.8%).

Data on use of an IMEWS chart following commencement of Level 2 Care was known for 332 (of 351). An IMEWS was used during Level 2 Care in the management of half of the women (n=168, 50.6%). In incidences where IMEWS was not used during Level 2 Care, a different monitoring tool was used in one quarter of the cases (n=80, 25%, unknown for 26 cases).

Invasive monitoring

Approximately seventy percent of cases with Level 2 Care (n=235, 67.7%, unknown for four cases) required invasive monitoring. Arterial line monitoring was the most common method used (applied in 226 of 235 cases, 96.2%, unknown for three cases). Central venous catheter (CVP) line was used in 32 cases (13.7% of 234, unknown for three cases). Table 2.8 outlines the incidence of invasive monitoring per category of maternal morbidity.

Table 2.8: Invasive monitoring of women requiring Level 2 Care, 2016

Main Clinical Diagnosis	CVP line (N=32)	Arterial line (N=226)
Direct	**30(93.8%)**	**210(92.9%)**
Pregnancy with abortive outcome	--	--
Hypertensive disorders	6(18.8%)	98(43.4%)
Obstetric Haemorrhage	15(46.9%)	83(36.7%)
Pregnancy related infection	9(28.1%)	23(10.2%)
Other obstetric complications	0(0%)	5(2.2%)
Unanticipated complications of management	0(0%)	1(0.4%)
Indirect	**2(6.3%)**	**16(7.1%)**
Non obstetric complications	2(6.3%)	16(7.1%)
Coincidental	--	--

Note: More than one invasive monitoring procedure was required in some cases therefore the percentages sum to more than 100%.

38 Clinical 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 Clinical Strategy and Programmes, Health Service Executive.

Specialist review during Level 2 Care

Early consultation with anaesthetic staff is recommended in cases where there is a concern or a high risk of rapid maternal deterioration.[39] The vast majority of women requiring Level 2 Care were reviewed by a non-obstetric medical specialist (n=342, 97.4%), most commonly by an anaesthetist (n=333, 94.9%). Figure 2.4 shows the number of women reviewed per type of non-obstetric medical specialist.

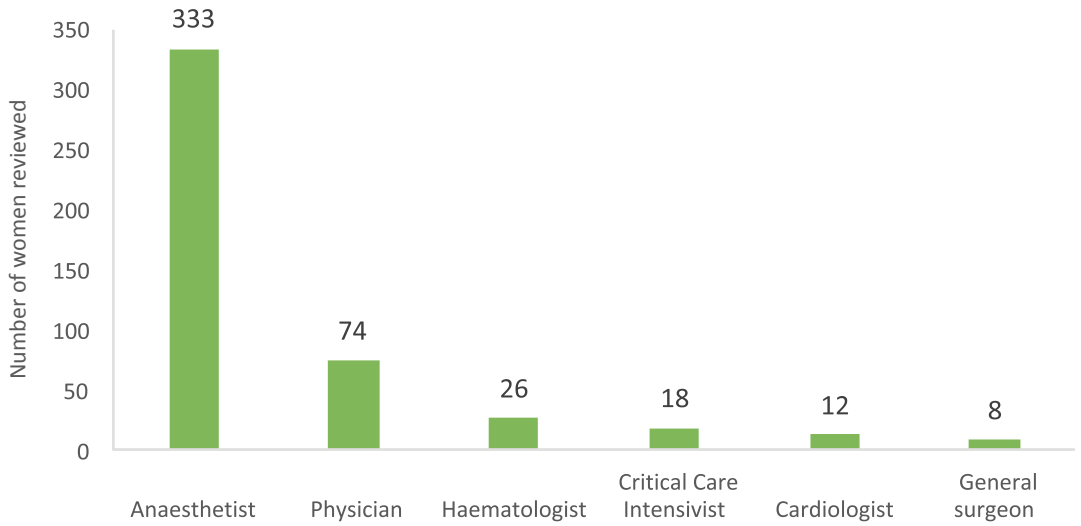


Figure 2.4: Non obstetric medical specialist review during Level 2 Care, 2016

Early Pregnancy loss

Some of the cases requiring Level 2 Care (n=7, 8%) were linked to early pregnancy loss (pre-viable). Most of these (n=5) were associated with obstetric haemorrhage and two further cases were associated with pregnancy-related infection.

Neonatal outcome/care

Data on neonatal outcome was available for 339 of the 351 women requiring Level 2 Care. Among these, eleven (3.2%) experienced perinatal deaths: there were eight stillbirths and three early neonatal deaths.

Location of neonatal care during maternal Level 2 Care

It has been recommended that models of critical care should consider nursing mother and baby together unless precluded by a clinical indication.[40] Of the 317 cases where a live born infant was delivered and for which data on neonatal care was recorded, the majority of infants (n=248, 78.2%) were not cared for at the same location as the mother during Level 2 Care.

Among the infants cared for at a different location from the mothers (n=248), a total of 93 (37.4%) were admitted to SCBU and the same number of babies were cared for in the NICU. In the remaining cases, care for the infant was provided at the postnatal ward (n=50, 20.1%) or at home (n=11, 4.4%).

In the majority of the 186 cases where neonatal admission to SCBU/NICU occurred, the indication was for the neonate's own clinical condition (n=141; 75.8%). For the 45 (24.2%) infants who did not have a clinical indication for admission to the SBCU/NICU, the location of maternal care was in an ICU for the majority of cases (n=23, 51.1%). In addition, one third of mothers in this group was cared for in HDU (n=15 of 45, 33.3%).

39 Clinical Practice Guideline No 30 (2014). Guideline for the Critically ill Woman in Obstetrics : Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive
40 Providing equity of critical and maternity care for the critically ill pregnant or recently pregnant woman. Maternal Critical Care Working Group. Royal College of Obstetricians and Gynaecologists (2011)

Specific findings for women who required Level 3 Care

Maternal morbidity in women requiring Level 3 Care

Based on the WHO classification system for maternal deaths, over three quarters (73.7%) of the women requiring Level 3 Care were classified as having a direct obstetric morbidity, five (26.3%) were due to indirect causes and there were no cases attributed to a coincidental cause (Table 2.9). This is in contrast to national and UK data on maternal mortality which has shown that a higher proportion of maternal deaths were due to indirect obstetric causes compared to direct causes.[41,42]

Table 2.9 demonstrates the number of maternal morbidities identified using the three different definitions for maternal morbidity: the NPEC SMM, the WHO Near Miss (NM) and the WHO Severe Maternal Complication (SMC) criteria. In contrast to the women requiring Level 2 Care only, all of the maternal morbidity cases requiring Level 3 Care satisfied the criteria for the NPEC SMM (100%) and the WHO Near Miss (NM) (100%). The majority of SMM cases with Level 3 Care also matched the WHO Severe Maternal Complication (SMC) criteria (73.7%).

Table 2.9: Classification of maternal morbidity in women who required Level 3 Care in 2016 according to the NPEC Severe Maternal Morbidity (SMM), WHO Near Miss (NM) and WHO Severe Maternal Complication (SMC) criteria

Maternal morbidity	N (%)	NPEC SMM	WHO Near Miss (NM)	WHO Severe Maternal Complication (SMC)
All (Direct, Indirect and Coincidental)	19(100%)	19(100%)	19(100%)	14(73.7%)
Direct	14(73.7%)	14(100%)	14(100%)	11(78.6%)
Pregnancy with abortive outcome*	--	--	--	--
Hypertensive disorders	1(5.3%)	1(100%)	1(100%)	1(100%)
Obstetric Haemorrhage	8(42.1%)	8(100%)	8(100%)	8(100%)
Pregnancy related infection	2(10.5%)	2(100%)	2(100%)	2(100%)
Other obstetric complications	1(5.3%)	1(100%)	1(100%)	0(0%)
Unanticipated complications of management	2(10.5%)	2(100%)	2(100%)	0(0%)
Indirect	5(26.3%)	5(100%)	5(100%)	3(60%)
Non obstetric complications	5(26.3%)	5(100%)	5(100%)	3(60%)
Coincidental	--	--	--	--

Note: Maternal morbidity definition criteria: NPEC SMM, the WHO Near Miss (NM) and the WHO Severe Maternal Complication (SMC) criteria.*Includes complications associated with early pregnancy loss.

41 O'Hare MF, Manning E, Corcoran P, Greene RA on behalf of MDE Ireland. Confidential Maternal Death Enquiry in Ireland, Report for 2013 - 2015. Cork: MDE Ireland, December 2017.
42 Knight M, Kenyon S, Brocklehurst P, Neilson J, Shakespeare J, Kurinczuk JJ (Eds.) on behalf of MBRRACE-UK. Saving Lives, Improving Mothers' Care - Lessons learned to inform future maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2013–15. Oxford: National Perinatal Epidemiology Unit, University of Oxford 2017.

Organ support required

Of the 19 women who required Level 3 Care, advanced respiratory support (n=17, 89.5%) and basic cardiovascular support (BCVS) (n=18, 94.7%) were the most common organ support provided required for women requiring Level 3 Care (Table 2.10). Haematological support was required for over half of cases (n=11, 57.9%).

Table 2.10: Organ support required during Level 3 Care, 2016

Organ support required	N (%)
Advanced Respiratory Support	17(89.5%)
Basic Cardiovascular support (BCVS)	18(94.7%)
Advanced Cardiovascular Support (ACVS)	6(31.6%)
Haematological	11(57.9%)
Neurological	1(5.3%)
Renal	4(21.1%)

Note: More than one organ support is required in Level 3 Care therefore the percentages sum to more than 100%.

Location of Level 3 Care

For women requiring Level 3 Care, ICU was the location of care for all of the 19 cases. In these, the ICU facility where care was provided, was on a co-located site for the majority of cases (n=14, 73.7%): and the remainder (n=5, 26.3%) were cared for in an off-site location within the maternity unit's HSE regional network. Information on whether there was a delay in accessing the ICU facility was known for 17 of the 19 cases. For 15 of these cases (88.2%) there was no delay in accessing the ICU facility.

Communication and specialist review prior to Level 3 Care

Communication of critical information is an essential component of patient care, safety and risk management. A key recommendation in national guidelines is the necessity for a multidisciplinary care plan in the management of the critically ill pregnant woman.[43]

Information on whether a written multidisciplinary care plan accompanied the maternal transfer details to Level 3 Care was available for 13 of 19 cases. Of these, a written multidisciplinary care plan accompanied the maternal transfer details in the majority of cases (n=12, 92.3%).

It was reported that in fourteen of the 19 cases requiring Level 3 Care (unknown for 5 cases) a discussion between the obstetric team and the anaesthetist or critical care intensivist occurred prior to admission to this level of care. All the 19 women were reviewed by an anaesthetist or critical care intensivist prior to admission for Level 3 Care. As such, it is reasonable to assume that a discussion between the obstetric team and anaesthetist or critical care intensivist in all cases.

Interdisciplinary communication following Level 3 Care

Data on written interdisciplinary communication was available for 16 of the 19 Level 3 Care cases. For all but two of these 16 cases (n=14, 87.5%), a written discharge summary of Level 3 Care was received by the referring obstetric team.

Data on what personnel was notified of maternal outcome was available for 14 of the 16 cases where a written discharged communication was available. The referring Consultant Obstetrician was notified of maternal outcome in all these 14 cases. Among this group, the senior midwife was notified of maternal outcome in ten cases (71.4%) and the women's GP was notified in five cases (35.7%).

43 Clinical Practice Guideline No 30 (2014). Guideline for the Critically ill Woman in Obstetrics : Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive

Maternal monitoring prior to and during Level 3 Care

For over one third (n=7, 36.8%) of the women requiring Level 3 Care, an IMEWS was used to monitor the woman prior to commencement of Level 3 Care. Of the 12 (63.2%) cases where an IMEWS was not used for maternal monitoring prior to Level 3 Care, it was reported that the woman was cared for in a location using another physiological monitoring tool (theatre, n=11, 91.7% and A&E, n=1, 8.3%).

The use of a specific physiological track and trigger tool for maternal monitoring during Level 3 Care was used in the majority of cases (n=15, 93.8%, unknown for three case).

Invasive monitoring

Almost all (n=18, 94.7%) women required invasive monitoring during Level 3 Care. A CVP line was required in the majority of cases (n=14, 82.4%, unknown for two cases) and an arterial line was used in 13 of cases (72.2 %, unknown for one case). There were no other form of invasive monitoring required.

Early Pregnancy loss and Neonatal outcome/care

There were no cases of early pregnancy loss (pre-viable) in the women who required Level 3 Care. Only one of the 19 women experienced a stillbirth, with no additional perinatal deaths being recorded for maternities requiring Level 3 Care.

Location of neonatal care during maternal Level 3 Care

None of the 17 cases where a live born infant was delivered had care provided at the same location as the mother during Level 3 Care. The majority of infants were admitted to the SCBU/NICU (n=10, 58.8%), five infants were cared for at home (29.4%) and a further two cases (11.8%) were nursed on a postnatal ward.

Of the 10 infants who were admitted to SCBU/NICU, admission was required for the neonate's own clinical condition in the majority of cases (n=5, 55.6%).

In summary

This is the third and final year of the Confidential Audit of Critical Care in Obstetrics in Ireland. For the first time data on the provision of Level 2 and Level 3 Care in obstetrics has been recorded at national level. One in 114 women required Level 2 Care and one in 2,127 women required Level 3 Care.

While the location of Level 3 Care was provided in an ICU setting, Level 2 Care was provided in a number of settings: overall, Level 2 Care was provided in an obstetric HDU in the majority (70%) of cases but there was a higher use of ICU/CCU facilities in smaller units. It is evident that a number of women requiring Level 2 Care do not experience organ dysfunction as their clinical needs were identified and treated before organ dysfunction occurred. The need for higher levels of maternal care is not predictable in approximately half of women requiring critical care and thus has implications for resource planning.

Appendix A: Hospital co-ordinators and contributors 2016

Hospital	Co-ordinators	Additional contributors
Cavan General Hospital	Dr Rukhsana Majeed	Ms Karen Malocca
Coombe Women and Infants University Hospital	Ms Julie Sloan	Dr Sharon Sheehan and Dr Bridgette Byrne
Cork University Maternity Hospital	Ms Geraldine Hayes, Ms Denise Malone, Ms Paulette De Foubert	Prof Richard Greene Ms Claire Everard
University Hospital Kerry	Ms Mary Stack Courtney	
Limerick University Maternity Hospial	Dr Mendinaro Imcha, Dr Alison DeMaio, Ms Bernie Nolan	Ms Sandra O Connor
Letterkenny General Hospital	Ms Mary Lynch	Ms Evelyn Smith
Mayo University Hospital, Castlebar	Ms Diane Brady, Ms Pauline Corcoran	Dr Hilary Ikele, Dr Meabh Ní Bhuinneain
Regional Hospital, Mullingar	Ms Marie Corbett	
Midland Regional Hospital, Portlaoise	Ms Ita Kinsella Ms Emma Mullins	
National Maternity Hospital	Dr Mary Higgins, Dr Tara Rigney and Dr Aoife Morris	
Our Lady of Lourdes Hospital, Drogheda	Ms Siobhan Weldon, Ms Sinead Dow	Dr. S O'Coigligh
Portiuncula University Hospital, Ballinasloe	Ms Aisling Dixon, Ms Priscilla Neilan	
Rotunda Hospital, Dublin	Dr Sharon Cooley, Dr Mark Hehir, Dr Niamh Keating	
Sligo University Hospital	Ms Madeleine Munnelly	Dr Heather Langan
South Tipperary General Hospital	Ms Siobhan Kavanagh	
St Luke's Hospital, Kilkenny	Ms Connie McDonagh, Ms Fiona Dalton	
University Hospital Galway	Ms Siobhan Canny	
University Hospital Waterford	Ms Janet Murphy	
Wexford General Hospital	Ms Helen McLoughlin	

Appendix B: Severe Maternal Morbidity Group Members

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

Dr Sharon Cooley, Consultant Obstetrician & Gynaecologist, The Rotunda Hospital.
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI.

Ms. Deirdre Daly, Lecturer in Midwifery, Trinity College Dublin.
Nominated by Deputy Nursing Services Director, HSE.

Ms Anne Fallon, Lecturer in the School of Nursing and Midwifery, National University of Ireland, Galway.

Dr Mary Higgins, Consultant Obstetrician & Gynaecologist, National Maternity Hospital, Holles Street, Dublin 2.
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI.

Ms Claire Jones, Patient Representative

Ms. Ita Kinsella, Clinical Midwife Manager 2, Midland Regional Hospital Portlaoise.

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, Castlebar, Co. Mayo.
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI.

Dr Cliona Murphy, Consultant Obstetrician & Gynaecologist, Coombe Women & Infants University Hospital, Dolphins Barn, Dublin 8.
Nominated by the Institute of Obstetricians & Gynaecologists, RCPI.

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

Ms. Edel Manning, Research Midwife, National Perinatal Epidemiology Centre, Severe Maternal Morbidity Audit Project Manager

Mr. Paul Corcoran PhD, Epidemiologist, National Perinatal Epidemiology Centre.

Appendix C: NPEC Governance Committee

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

Professor Tom Clarke, Consultant Neonatologist, Rotunda Hospital (Retired)

Dr Sharon Cooley, Institute of Obstetrics and Gynaecology Representative

Ms. Marie Cregan, Patient Representative, University College Cork

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

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

Professor Richard Greene, Consultant Obstetrician & Gynaecologist, Cork University Maternity Hospital, Director of the National Perinatal Epidemiology Centre

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

Dr. Rhona Mahony, Master, National University Hospital

Professor Fergal Malone, Master, The Rotunda Hospital

Professor Eleanor Molloy, Faculty of Paediatrics Representative

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

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

Dr. Sharon Sheehan, Master, Coombe Woman and Infants University Hospital

Ms Sheila Sugrue, National Lead Midwife, Office of the Nursing & Midwifery Services

Ms Collette Tully, NOCA Executive Director, National Office of Clinical Audit

Ms Ann O'Byrne, Chair of the national Designated Midwifery Officer Group - Home Births

Appendix D: National Office of Clinical Audit (NOCA) endorsement of the Severe Maternal Morbidity in Ireland Annual Report 2016

NOCA National Office of Clinical Audit

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

01st June 2018

Severe Maternal Morbidity in Ireland, Annual Report 2018

Dear Professor Greene,

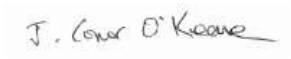
I acknowledge receipt of the Severe Maternal Morbidity in Ireland Report 2016 and confirm following circulation to the NOCA Governance Board and feedback garnered from our membership, we are delighted to endorse this report.

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.

You and your NPEC colleagues are to be congratulated for the quality of the report and manner in which you continue to engage with maternity services to maintain this work.

Please accept this as formal endorsement from the NOCA Governance Board of the Severe Maternal Morbidity in Ireland Report 2016

Yours sincerely,



Professor Conor O' Keane FFPath FRCPI
Chair
National Office of Clinical Audit Governance Board

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Appendix E: NPEC Severe Maternal Morbidity Notification Form

NATIONAL PERINATAL EPIDEMIOLOGY CENTRE

CONFIDENTIAL AUDIT
OF
SEVERE MATERNAL MORBIDITY IN IRELAND

Notification Form: 2016

Hospital Name _____

Completed by _____
(Please print name and staff grade)

Date of clinical event: ☐☐/☐☐/☐☐

Time of onset of clinical event: ☐☐:☐☐

Woman's details:

Age ☐

Parity: ☐ + ☐
(Status prior to delivery)

Height at booking _____cm

Weight at booking _____kg

BMI ☐

Date of delivery: ☐☐/☐☐/☐☐
(or pregnancy end)

Gestation at delivery/pregnancy end ☐
(Completed weeks)

1a. 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 ☐

1b. Was the care of this woman transferred from another hospital Yes ☐ No ☐

If yes please indicate timing of transfer in relation to pregnancy status:

Woman transferred with fetus in-utero ☐ Woman transferred following delivery of baby ☐

Name of referring maternity unit: _____

1

2a. 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 Obstetric history: Did the woman have a previous caesarean section Yes ☐ No ☐

6. This Pregnancy

6 a. Was this pregnancy the result of infertility treatment? Yes ☐ No ☐ Unknown ☐

6 b. If yes please specify method of fertility treatment _____

7. Was this an early pregnancy loss? No ☐ Yes: Miscarriage ☐ Yes: Ectopic pregnancy ☐

If early pregnancy loss please go to question 10

8 Delivery Details

8a. Onset of Labour: Spontaneous ☐ Induced ☐ Never in labour ☐

8b. Lie of fetus at delivery Longitudinal ☐ Oblique ☐ Transverse ☐

8c. Presentation at delivery Cephalic ☐ Breech ☐ Other ☐

8d. Number of fetuses/babies in this delivery ☐

9. 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	☐	☐

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10. 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 and/or ≥ 24 weeks gestation			

11.Maternal Care Details

11a. Location of Care during clinical event:

Please tick all that apply

On the ward ☐ Delivery Suite ☐ Theatre ☐ High dependency unit ☐ ICU/CCU ☐

11b. Level of Care Required:

Please indicate the **highest level** of care required during the clinical event:

Level of care	**Definition**	**Please tick one box**
Level 0: Normal ward care	Care of low risk pregnant women	
Level 1: Additional monitoring or intervention, or step down from higher level of care	Patients at risk of their condition deteriorating and needing a higher level of observation or those recently relocated from higher levels of care	
Level 2: Single Organ Support**	Patients requiring invasive monitoring/ intervention* including support for a single failing organ system (excluding advanced respiratory support).	
Level 3: Advanced respiratory support alone, or support of two or more organ systems**	Patients requiring advanced respiratory support (mechanical ventilation) alone or basic respiratory support along with support of at least one additional organ.	

*** invasive monitoring/intervention includes the use of arterial and CVP lines**
****Examples of level 2 and 3 care in the critically ill pregnant or recently pregnant woman are outlined below**

Level 2 examples
Basic Respiratory Support (BRS): 50% or more oxygen via face-mask to maintain oxygen saturation; Continuous Positive Airway Pressure (CPAP), Bi-Level Positive Airway Pressure (BIPAP)
Basic Cardiovascular Support (BCVS): Intravenous anti-hypertensive, to control blood pressure in pre-eclampsia; Arterial line used for pressure monitoring or sampling; CVP line used for fluid management and CVP monitoring to guide therapy
Advanced Cardiovascular Support (ACVS): Simultaneous use of at least two intravenous, anti-arrhythmic/anti-hypertensive/vasoactive drugs, one of which must be a vasoactive drug; Need to measure and treat cardiac output
Neurological Support: Magnesium infusion to control seizures / prophylaxis of eclampsia in severe PET
Hepatic Support: Management of acute fulminant hepatic failure, e.g. from HELLP syndrome or acute fatty liver, such that transplantation is being considered

Level 3 examples
Advanced Respiratory Support: Invasive mechanical ventilation

Support of two or more organ systems: Renal support and BRS; BRS/BCVS and an additional organ supported; Intracranial pressure monitoring

Reference: Saravanakumar K, Davies L, Lewis M, Cooper GM.. High dependency care in an obstetric setting in the UK. Anaesthesia 2008:63, 1081–6.

Maternal Morbidity Category

(See page 5 for definitions)

Please tick all that apply

1. Major obstetric haemorrhage (MOH) ☐ *please identify the criteria met for MOH in the opposite column accordingly. More than 1 can apply	☐ Estimated blood loss ≥ 2500mls ☐ Transfused with ≥ 5 units of blood ☐ Received treatment for coagulopathy
2. Uterine rupture	
3. **Peripartum hysterectomy** (PH) *please specify indication for PH in text box below	
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** **Duration of ICU care in days/ part days (e.g. 1.5 days)**	
16. Other severe morbidity, please specify	
17. **Interventional radiology (IR)**	

Please use this space to enter any additional relevant information.

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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.

Appendix F: National Guidelines for the critically ill woman in obstetrics[43]

Examples of Maternity Care Required at ICS Levels of Support for Critical Care (Saravanakumar et al., 2008)

Level of Care	Maternity Example
Level 0: Normal ward care	Care of low risk pregnant woman
Level 1: Additional monitoring or intervention, or step down from higher level of care	• Risk of haemorrhage • Oxytocin infusion • Mild pre-eclampsia on oral anti-hypertensive/fluid restriction etc. • A woman with a medical condition such as congenital heart disease, or insulin dependent diabetes.
Level 2: Single organ support	**Basic Respiratory Support (BRS)** • 50% or more oxygen via face-mask to maintain oxygen saturation • Continuous Positive Airway Pressure (CPAP), Bi-Level Positive Airway Pressure (BIPAP) **Basic Cardiovascular Support (BCVS)** • Intravenous anti-hypertensive, to control blood pressure in pre-eclampsia • Arterial line used for pressure monitoring or sampling • CVP line used for fluid management and CVP monitoring to guide therapy **Advanced Cardiovascular Support (ACVS)** • Simultaneous use of at least two intravenous, anti-arrhythmic/anti-hypertensive/vasoactive drugs, one of which must be a vasoactive drug • Need to measure and treat cardiac output **Neurological Support** • Magnesium infusion to control seizures (not prophylaxis) • Hepatic support • Management of acute fulminant hepatic failure, e.g. from HELLP syndrome or acute fatty liver, such that transplantation is being considered
Level 3: Advanced respiratory support alone, or support of two or more organ systems above	**Advanced Respiratory Support** • Invasive mechanical ventilation **Support of two or more organ systems** • Renal support and BRS • BRS/BCVS and an additional organ supported • Intracranial pressure monitoring

43 Clinical Practice Guideline No 30 (2014). Guideline for the Critically ill Woman in Obstetrics : Institute of Obstetricians and Gynaecologists, Royal College of Physicians of Ireland and Directorate of Strategy and Clinical Programmes, Health Service Executive

Appendix G: NPEC Critical Care Form 2016 Detailed Case Assessment Level 2 and Level 3

NATIONAL PERINATAL EPIDEMIOLOGY CENTRE

CONFIDENTIAL AUDIT of

Critical Care in Obstetrics in Ireland

2016

Detailed Case Assessment Form of Level 2 & Level 3 Critical Care in Obstetrics

Please ensure that a Severe Maternal Morbidity Notification Form is completed along with this booklet

Please return completed forms to:
Edel Manning
Project manager
National Perinatal Epidemiology Centre
Department of Obstetrics and Gynaecology
5th Floor, Cork University Maternity Hospital
Wilton
Cork

Rationale for this confidential Audit

As part of the on-going confidential clinical audit on severe maternal morbidity in Ireland, the National Perinatal Epidemiology Centre (NPEC) aims to conduct an audit on pregnant or recently pregnant women (this includes women in the postpartum period and women following early pregnancy loss) requiring Level 2 and Level 3 Critical Care. Please see Table1 on page 8 for definitions.

Objectives of this audit are:

- To identify the number of women requiring Level 2 and Level 3 Care in the Irish maternity services
- To identify the location where critical care is provided
- To identify resources and other issues impacting on access to and provision of Level 3 care
- To evaluate the use of ICU/CCU facilities within the Irish Maternity Services.

Please note obstetric patients who are admitted to ICU will be subject to the Intensive Care National Audit and Research Centre, (ICNARC) audit. The NPEC confidential audit on critical care in obstetrics compliments the ICNARC audit from an obstetric view point. There is no duplication of data collection.

The NPEC is sincerely grateful for your contribution to this audit

Inclusion criteria for the audit of Critical Care in Obstetrics:

All pregnant or recently pregnant women (up to and including 42 days following delivery, miscarriage, termination of pregnancy or ectopic pregnancy) who require Level 2 or Level 3 Care.

Guidelines for completing notification and case assessment forms

- Definitions and examples of levels of care are outlined in Table1 on page 8
- Abbreviations are outlined in Table 2 on page 8
- Please mark the category box on the top of page 1 indicating Level of critical care provided/sequence of care
- 'Not known' codes should be used as sparingly as possible
- **Please ensure that the NPEC Severe Maternal Morbidity Notification Form is completed (either online via the NPEC online database or in hard copy form) along with this form**
- Relevant sections to be completed for Level 2 and Level 3 Care are outlined below:

Women requiring Level 2 Care only	• Section 1 & 2 (questions 1- 17) • Ensure Severe Maternal Morbidity Notification Form has been completed
Women requiring Level 3 Care only	• Sections 1 & 3 (questions 1 - 6 and 18 - 33) • Ensure Severe Maternal Morbidity Notification Form has been completed
Women requiring Level 2 and Level 3 Care	• Sections 1 & 2 & 3 (questions 1 - 33) • Ensure Severe Maternal Morbidity Notification Form has been completed

Thank you for taking the time to complete this form

Critical Care in Obstetrics

Section 1

Hospital Name:_____
(Please print)

Completed by:_____
(Please print name and staff grade)

NPEC Reference Number:

_____
(As issued from the online database)

1. Category of the level of Critical Care required in this clinical event
If applicable please indicate the sequence of critical care provided in this clinical event:

Level 2 Care only	
Level 3 Care only	
Level 2 Care followed by Level 3 Care	
Level 3 Care followed by Level 2 Care	
Level 2 Care followed by Level 3 Care followed by Level 2	

2. Date of Clinical Event: ☐☐/☐☐/☐☐
Day **Month** **Year**

3. Time of Event: [:] **(24 hour clock)**

4a. Maternal age: [ ] **4b. Parity:** (Status prior to delivery) ☐ + ☐

5. Did this woman have a medical/surgical or psychiatric disorder that pre-existed this pregnancy?

Yes ☐ No ☐
If yes, please specify disorder(s) _____

6. Was this pregnancy identified as 'high risk' during the antenatal period? Yes ☐ No ☐

Section 2: Level 2 Care

7. Duration of Level 2 Care in days/ part days: [ ] **Days**
(e.g.1.5 days)

8. Location where Level 2 Care was provided in this clinical event (*Please tick all that apply*):
Ward ☐ (*Please specify type, maternity/gynaecology/general*)_____

Delivery Suite ☐ Theatre ☐ Dedicated HDU /Maternity Hospital ☐

Dedicated HDU/ General Hospital ☐ ICU ☐ CCU☐

Other, please specify ☐_____

9. Location of maternal care prior to Level 2 Care

Home ☐ Ward ☐(*Please specify type: maternity/gynaecology/general*)_____

Delivery Suite ☐ Theatre ☐ Dedicated HDU/Maternity Hospital ☐

Dedicated HDU/General Hospital ☐ ICU ☐ CCU ☐

Other, please specify ☐_____

Inter-hospital Transfer

10a. Was this woman transferred from another hospital for Level 2 Care?

Yes ☐ No ☐ (*If no, please go to question 11a*)

***Inter-hospital transfer only:**

10b. Was the referring hospital within your HSE regional hospital network? Yes ☐ No ☐

10c. Please indicate below all heath care professionals in attendance during transfer (*please specify grade*)**:**

Anaesthetist ☐_____ Obstetrician ☐ _____

Midwife ☐_____ Nurse ☐_____ Other, please specify ☐_____

11a. Please identify the organ system that required support during Level 2 Care
(Please refer to page 8 for examples of organ support required in Level 2 Care)

_____

_____

11b. If a Magnesium Sulphate infusion was transfused, what was the primary indication for the transfusion:

Maternal: treatment for eclamptic seizure☐ Fetal neuroprotection only☐

Maternal: prophylaxis of eclampsia in severe pre-eclampsia☐

12. Please specify the main clinical diagnosis during Level 2 Care in this clinical event:

_____

_____

Maternal monitoring prior to commencement of Level 2 Care

13a. Was an IMEWS chart used prior to commencement of Level 2 Care?
Yes ☐ No ☐(*please go to question 13d*)

13b. If yes, on average how often were physiological observations recorded?

(e.g. every 30 minutes) Every ☐ hours ☐ minutes

13c. What was the highest IMEWS score recorded prior to commencement of Level 2 Care?

_____

13d. If an I-MEWS chart was not used prior to commencement of Level 2 Care, please indicate why not?

_____

Maternal monitoring during Level 2 Care:

14a. Was an IMEWS chart used during Level 2 Care? Yes ☐ No ☐

14b. Was the patient monitored using another specific physiological track and trigger system/tool?
Yes ☐ No ☐ *(please go to question 14d)*

14c. Were patient specific triggers identified using this system/ tool? Yes ☐ No ☐

14d. Was invasive monitoring used? Yes ☐ No ☐
(If yes, *please tick all that apply*)
CVP line ☐ Arterial line ☐ Other ☐ please specify_____

Specialist review:
15. Was the woman reviewed by a non-obstetric medical specialist? Yes ☐ No ☐
(If yes, *please tick all that apply*)
Anaesthetist ☐ Critical Care Intensivist ☐ Haematologist ☐ General surgeon ☐

Physician ☐_____ Neurosurgeon ☐ Cardiologist ☐ Psychiatrist ☐
(*Please specify speciality*)

Neonatal Care:

16a. Location of neonate during maternal Level 2 Care
Not applicable/not delivered or early pregnancy loss ☐ With mother ☐ (*go to question 17a*)

Not with mother ☐ please specify location _____

16b If neonatal care was transferred to SBCU/NICU, was SBCU/NICU care required for the neonate's own clinical condition? Yes ☐ No ☐

Discharge from Level 2 Care

17a Please indicate the level of care required at discharge from Level 2 Care:
Level 0 ☐ Level 1 ☐ Level 3 ☐

17b Please identify the discharge location of this women following Level 2 Care:

Ward ☐(*Please specify type, maternity/gynaecology/general*)_____
Delivery Suite ☐ Theatre ☐ Dedicated HDU Maternity Hospital ☐

Dedicated HDU General Hospital ☐ ICU ☐ CCU ☐ Maternal Death ☐

Other, please specify ☐_____

Please use this space to enter any relevant issues regarding provision of Level 2 Care in this event

Section 3: Level 3 Care

18. Duration of Level 3 care in days/part days (e.g. 1.5 days): ☐ **Days**

19a. Please identify the location where Level 3 Care was provided

ICU ☐ CCU ☐ Other, please specify ☐_____

19b. Where was the ICU/CCU care facilitated?

Co-located site ☐ Off maternity hospital site/ within the HSE regional network ☐

Off maternity hospital site/ not within the regional network but within the HSE* ☐ In another jurisdiction* ☐

***If applicable, please specify reason for transfer of care outside your unit's HSE regional network**

_____

20. Was there a delay in accessing an ICU/CCU bed? Yes ☐ No ☐

If yes, what was the estimated time delay in hours? ☐

21. Location of care prior to commencement of Level 3 Care:

Ward ☐ (*Please specify type, maternity/gynaecology/general*)_____

Delivery Suite ☐ Theatre ☐ Dedicated HDU Maternity Hospital ☐

Dedicated HDU General Hospital ☐ ICU ☐ CCU ☐

Other, please specify ☐_____

22. What was the highest level of care provided prior to commencement of Level 3 Care? ☐

23a. Was the woman reviewed by an Anaesthetist or Critical Care Intensivist prior to ICU/CCU admission?

Yes ☐(*If yes, please go to question 24a*) No ☐ Unknown ☐

23b. Was there a discussion between the Obstetric Team and the Anaesthetist or Critical Care Intensivist prior to admission?

Yes ☐ No ☐ Unknown ☐

Maternal monitoring prior to commencement of Level 3 Care

24a. Was an IMEWS chart used prior to commencement of Level 3 Care?

Yes ☐ No ☐ (*If no, please go to question 24d*)

24b. If yes, on average how often were physiological observations recorded?

(e.g. every 30 minutes) Every ☐ hours ☐ minutes

24c. What was the Highest IMEWS score recorded prior to commencement of Level 3 Care?

_____

24d. If an IMEWS chart was not used prior to commencement of Level 3 Care, please indicate why not?

_____

Maternal monitoring during Level 3 Care

25a. Was the patient monitored using a specific physiological track and trigger system/tool?

Yes ☐ No ☐ Unknown ☐

Invasive monitoring:

25b. Was invasive monitoring used during Level 3 Care? Yes ☐ No ☐ Unknown ☐

(If yes, please tick all that apply)

CVP line ☐ Arterial line ☐ Other ☐ please specify_____

Communication/ transfer details:

26. Did a written multidisciplinary care plan accompany the maternal transfer details to location of Level 3 Care?

Yes ☐ No ☐ Unknown ☐

If yes, which of the following were identified in the care plan?
(Please tick all that apply)

Consultant Obstetrician ☐ Consultant Anaesthetist ☐ ICU/CCU Intensivist ☐ Senior Midwife ☐

Neonatologist ☐ Other, please specify ☐_____

27. Please indicate all healthcare professionals in attendance during transfer to location of Level 3 Care
(*Please specify grade*)

Anaesthetist ☐_____ Obstetrician ☐ _____

Midwife ☐_____ Other ☐_____

28. Please specify the main clinical diagnosis prior to commencement of Level 3 Care

_____

_____

29. Please specify the clinical diagnosis at discharge from Level 3 Care

_____

_____

30. Please indicate in the Table below any organ dysfunction identified and organ support required both at commencement of and during Level 3 Care (*Please tick all that apply*)

Organ Dysfunction/Support	**At commencement of Level 3 Care**	**During Level 3 Care**	**Not applicable**	**Unknown**
Respiratory Support: Basic Respiratory support (Definition page 8)				
Advanced respiratory support (mechanical ventilation)				
Neurological Dysfunction/Support: Prolonged unconsciousness (lasting ≥ 12 hours)…….				
Coma (including metabolic coma)…….				
Stroke……				
Uncontrollable fits/status epilepticus……				
Total paralysis……..				
Lowest total Glasgow Score				
Cardiac Dysfunction/Support: Cardiac Arrest…….				
Cardiopulmonary Resuscitation……				
Use of continuous Cardiac Vasoactive Drugs……..				
Severe hypoperfusion (lactate ≥ 4 mmol/L or severe acidosis (PH <7.1)……				
Renal Dysfunction/Support: Oligouria, non-responsive to fluids or diuretics				
Dialysis for Acute Renal Failure				
Severe acute azotemia (creatinine ≥ 300 µmol/ml or ≥ 3.5 mg/dL)				
Coagulation/Haematological Dysfunction/Support: Disseminated Intravascular Coagulopathy (DIC) …..				
Severe thrombocytopenia (< 50, 000 platelets/ml).....				
Transfusion of blood or red cells (≥ 5 units)……				
Hepatic Dysfunction: Jaundice in the presence of pre-eclampsia, eclampsia				
Severe Acute Hyperbilirubinemia (bilirubin > 100 µmol /L or > 6.0 mg/dL)				
Uterine Dysfunction: Uterine haemorrhage or infection leading to hysterectomy……..				
Sepsis or Severe Systemic infection				
Multi Organ Failure				

Location of neonate during Level 3 Care

31 a. Location of Neonatal Care:

Not delivered or early pregnancy loss ☐ (*please go to question 32*) With mother ☐ (*please go to question 32*)

Not with mother☐, please specify location _____(*please go to 31b*)

31b. If neonatal care was transferred to SBCU/NICU, was SBCU/NICU care required for the neonate's own clinical condition? Yes ☐ No ☐

32. Discharge details from Level 3 Care

Please indicate the level of care required at discharge from Level 3 Care?

Level 0 Care ☐ Level 1 Care ☐ Level 2 Care ☐ Maternal Death ☐

Where was the discharge destination of this women following Level 3 Care?

Ward ☐ (*Please specify type, maternity/gynaecology/general*)_____

Delivery Suite ☐ Dedicated HDU Maternity Hospital ☐ Dedicated HDU General Hospital ☐

Maternal Death☐ Other, please specify ☐_____

33a Was a written discharge summary of Level 3 Care received by the referring Obstetric Team/Unit?

Yes ☐ (*Please answer 33b*) No ☐ Unknown ☐

33b Please indicate all personnel notified of maternal outcome following Level 3 Care:

Referring Consultant Obstetrician☐ Consultant Neonatologist☐ Consultant Anaesthetist☐

Critical Care Intensivist☐ Physician☐please specify speciality_____

Senior Midwife☐ General Practitioner☐ Public Health Nurse☐ Consultant Psychiatrist☐

Other ☐ please specify_____

Thank you for taking the time to complete this form

Definitions of Levels of Care

Table 1: Definitions of Level of Care

Level of care	Definition
Level 0: Normal ward care	Care of low risk pregnant women
Level 1: Additional monitoring or intervention, or step down from higher level of care	Patients at risk of their condition deteriorating and needing a higher level of observation or those recently relocated from higher levels of care
Level 2: Single Organ Support**	Patients requiring invasive monitoring */ intervention including support for a single failing organ system (excluding advanced respiratory support).
Level 3: Advanced respiratory support alone, or support of two or more organ systems**	Patients requiring advanced respiratory support (mechanical ventilation) alone or basic respiratory support along with support of at least one additional organ.

*** Invasive monitoring includes the use of arterial and CVP lines**

Examples of Critical Care, Level 2 and Level 3:

Level 2 Care:
Basic Respiratory Support (BRS): 50% or more oxygen via face-mask to maintain oxygen saturation; Continuous Positive Airway Pressure (CPAP), Bi-Level Positive Airway Pressure (BIPAP)

Basic Cardiovascular Support (BCVS): Intravenous anti-hypertensive, to control blood pressure in pre-eclampsia; Arterial line used for pressure monitoring or sampling; CVP line used for fluid management and CVP monitoring to guide therapy

Advanced Cardiovascular Support (ACVS): Simultaneous use of at least two intravenous, anti-arrhythmic/anti-hypertensive/vasoactive drugs, one of which must be a vasoactive drug; Need to measure and treat cardiac output

Neurological Support: Magnesium Sulphate infusion to control seizures / other

Hepatic Support: Management of acute fulminant hepatic failure, e.g. from HELLP syndrome or acute fatty liver, such that transplantation is being considered

Level 3 Care:
Advanced Respiratory Support: Invasive mechanical ventilation

Support of two or more organ systems: Renal support and BRS;

BRS/BCVS and an additional organ supported (BRS and BCVS occurring simultaneously during the episode count as a single organ support);

Intracranial pressure monitoring

References: Saravanakumar K, Davies L, Lewis M, Cooper GM. High dependency care in an obstetric setting in the UK. *Anaesthesia* 2008:63, 1081-6

Table 2: Abbreviations

Abbreviation	Definition
CCU	Coronary Care Unit
HDU	High Dependency Unit
ICU	Intensive Care Unit
I-MEWS	Irish Maternity Early Warning System

If you have questions or difficulties regarding any aspect of the form, please do not hesitate to contact Edel Manning at: e.manning@ucc.ie, telephone: (021) 4205042

Appendix H: Classification of maternal mortality WHO Application of ICD-10

The WHO Application of ICD-10 to deaths during pregnancy, childbirth and the puerperium: ICD-MM[44]

Maternal Death	Deaths of women while pregnant or within 42 days of the end of the pregnancy* from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes
Direct	Deaths resulting from obstetric complications of the pregnant state (pregnancy, labour and puerperium), from interventions, omissions, incorrect treatment or from a chain of events resulting from any of the above.
Indirect	Deaths resulting from previous existing disease, or disease that developed during pregnancy and which was not the result of direct obstetric causes, but which was aggravated by the physiological effects of pregnancy.
Coincidental	Deaths from unrelated causes which happen to occur in pregnancy or the puerperium.

*Includes giving birth, ectopic pregnancy, miscarriage or termination of pregnancy.

Direct causes	Examples of potential causes of deaths
1. Pregnancies withabortive outcome	Abortion, miscarriage, ectopic pregnancy and other conditions leading to maternal death and a pregnancy with abortive outcome
2. Hypertensive disorders	Oedema, proteinuria and hypertensive disorders in pregnancy, childbirth and the puerperium
3. Obstetric Haemorrhage	Obstetric diseases or conditions directly associated with haemorrhage
4. Pregnancy related infection	Pregnancy-related, infection-based diseases or conditions
5. Other obstetric complications	All other direct obstetric conditions not included in groups to 1–4
6. Unanticipated complications of management Indirect causes	Severe adverse effects and other unanticipated complications of medical and surgical care during pregnancy, childbirth or the puerperium
Indirect causes	
***7.* Non obstetric complications**	Non-obstetric conditions e.g. Cardiac disease, Neurological disease, Infection not as a directresult of pregnancy, Other indirect causes
8. Unknown /Undetermined	Maternal death during pregnancy, childbirth and the puerperium where the underlying cause is unknown or was not determined
9. Coincidental causes	Death during pregnancy, childbirth and the puerperium due to external causes

44 World Health Organisation The WHO Application of ICD-10 to deaths during pregnancy, childbirth and the puerperium: ICD-MM 2012 France.

Appendix I: The WHO organ-dysfunction criteria defined as Near Miss[45]

Severe maternal complication	Definition
Cardiovascular dysfunction	shock, use of continuous vasoactive drugs, cardiac arrest, cardio-pulmonary resuscitation, severe hypoperfusion (lactate >5mmol/L or >45mg/dL) or severe acidosis (pH<7.1)
Respiratory dysfunction	acute cyanosis, gasping, severe tachypnea (respiratory rate>40 bpm), severe bradypnea (respiratory rate<6 bpm), severe hypoxemia (P A02/ Fi02<200 02 saturation <90% for ≥60m in) or intubation and ventilation not related to anaesthesia
Renal dysfunction	oliguria non responsive to fluids or diuretics, dialysis for acute renal failure or severe acute azotemia (creatinine ≥300umol/ml or ≥3.5 mg/ dL)
Coagulation/haematologic dysfunction	failure to form clots, massive transfusion of blood or red cells (≥ 5 units) or severe acute thrombocytopenia (<50,000 platelets/ ml)
Hepatic dysfunction	jaundice in the presence of pre-eclampsia, severe acute hyperbilirubinemia (bilirubin>100umol/L or >6.0mg/dL)
Neurologic dysfunction	prolonged unconsciousness / coma (lasting >12 hours), stroke, status epilepticus / uncontrollable fits or global paral
Uterine dysfunction/hysterectomy	haemorrhage or infection leading to hysterectomy
Multiple organ dysfunction	

45 Evaluating the quality of care for severe pregnancy complications. The WHO near-miss approach for maternal health. World Health Organization; 2011

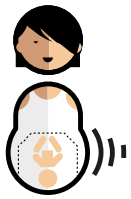
Appendix J: The WHO classification of severe maternal complications[46]

Severe maternal complication	Definition
Severe postpartum haemorrhage	Genital bleeding after delivery, with at least one of the following: perceived abnormal bleeding (≥ 1000 ml) or any bleeding with hypotension or blood transfusion.
Severe pre-eclampsia	Persistent systolic blood pressure of 160 mmHg or more or a diastolic blood pressure of 110 mm Hg; proteinuria of 5 g or more in 24 hours, oliguria of < 400 ml in 24 hours; and HELLP syndrome or pulmonary oedema. Excludes eclampsia.
Eclampsia	Generalised fits in a patient without a previous history of epilepsy. Includes coma in pre eclampsia.
Severe systemic infection or sepsis	Presence of fever (body temperature > 38 degrees C), a confirmed or suspected infection (e.g. chorioamnionitis, septic abortion, endometritis, pneumonia), and at least one of the following: heart rate > 90, respiratory rate > 20, leukopenia (white blood cells < 4000), leucocytosis (white cells > 12 000).
Uterine rupture	Rupture of uterus during labour confirmed by laparotomy.

46 Evaluating the quality of care for severe pregnancy complications. The WHO near-miss approach for maternal health. World Health Organization; 2011

Appendix K: The Robson Ten Group Classification System[47]

GROUP 1

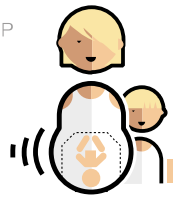


Nulliparous women with a single cephalic pregnancy, ≥37 weeks gestation in spontaneous labour

GROUP 2

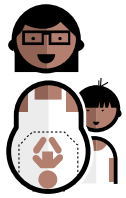
Nulliparous women with a single cephalic pregnancy, ≥37 weeks gestation who either had labour induced or were delivered by caesarean section before labour

GROUP 3



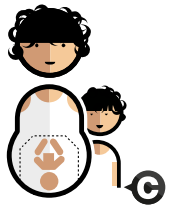
Multiparous women without a previous uterine scar, with a single cephalic pregnancy, ≥37 weeks gestation in spontaneous labour

GROUP 4



Multiparous women without a previous uterine scar, with a single cephalic pregnancy, ≥37 weeks gestation who either had labour induced or were delivered by caesarean section before labour

GROUP 5



All multiparous women with at least one previous uterine scar, with a single cephalic pregnancy, ≥37 weeks gestation

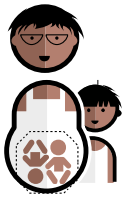
GROUP 6

All nulliparous women with a single breech pregnancy

GROUP 7

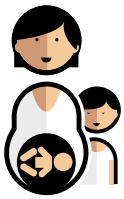
All multiparous women with a single breech pregnancy, including women with previous uterine scars

GROUP 8



All women with multiple pregnancies, including women with previous uterine scars

GROUP 9



All women with a single pregnancy with a transverse or oblique lie, including women with previous uterine scars

GROUP 10

All women with a single cephalic pregnancy <37weeks gestation, including women with previous scars

47 Robson Classification: Implementation Manual. Geneva: World Health Organization; 2017. Licence: CCBY-NC-SA3.0IGO

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