



NATIONAL PERINATAL
EPIDEMIOLOGY CENTRE



SEVERE MATERNAL MORBIDITY

in Ireland

Annual Report 2021

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List of Acronyms and Abbreviations

ACVS – Advanced Cardiovascular Support

BCVS – Basic Cardiovascular Support

BMI – Body Mass Index

CCU – Coronary Care Unit

CS – Caesarean section

HELLP – Hemolysis, ELevated liver enzymes, and a Low Platelet count syndrome

HDU – High Dependency Unit

HPO – Healthcare Pricing Office

HSE – Health Service Executive

ICU – Intensive Care Unit

LSCS – Lower segment caesarean section

MAP – Morbidly Adherent Placentation

MOH – Major obstetric haemorrhage

MDE Ireland – Maternal death enquiry Ireland

NCCA – National Centre for Clinical Audit

NICU – Neonatal Intensive Care Unit

NOCA – National Office of Clinical Audit

NPEC – National Perinatal Epidemiology Centre

NPRS – National Perinatal Reporting System

NWIHP – National Women and Infant Health Programme

PE – Pulmonary embolism

PET – Pre-eclampsia Toxaemia

PH – Peripartum Hysterectomy

PMR – Perinatal Mortality Rate

SCASMM – Scottish Confidential Audit Severe Maternal Morbidity

SCBU – Special Care Baby Unit

SMC – Severe Maternal Complication

SMM – Severe maternal morbidity

TGCS – Ten Group Classification System (Robson Classification System)

WHO – World Health Organization

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Preface

The NPEC audit on Severe Maternal Morbidity (SMM) commenced in 2011; during that time, the Irish maternity services have faced many challenges including resourcing issues, increasingly complex pregnancies and increased expectations of women and their families. Despite this, the Irish maternity units have evolved and endeavoured to provide excellent care based on international evidence-based practice. This persisted during 2020 as the COVID-19 pandemic changed our world. In 2021, we had the HSE Cyber-attack and subsequent impact on IT systems which made collation of audit data particularly challenging. The services have found the way to support the assessment of care by active involvement in this and other audits – I commend them for that work and am grateful to all who are involved in providing the care and measuring the outcomes.

The provision of data to this audit and other national audits is undertaken by staff often above and beyond their day job. Unit coordinators continue to validate data in the audit process despite being involved in the busy work of direct care and managing services. There remains a lack of real support in resourcing the important work of audit and assessment of care in our services; we again reflect this in our recommendations.

There have been many positive changes within the Irish maternity services in the lifetime of this audit; the development of the National Women and Infants Health Programme (NWIHP) and the continued national contribution of data on maternal outcomes to the NPEC to inform practice at a national level. As Director of the NPEC I am grateful that the maternity services in Ireland are collecting data that can influence and improve patient care. I wish to acknowledge the effort and time spent participating in the NPEC audits. Maternity units show a real commitment to assessing the care of pregnant women with complex care needs. Studying SMM allows us all to assess the quality of care in our maternity services.

Through the work of Maternal Death Enquiry, Ireland we know the incidence of maternal mortality is thankfully low; this leaves fewer cases from which to learn. Examining SMM provides us with opportunities to look at the care provided to women who may indeed be very ill and at risk of death, to identify good practice and areas for improvement. This report adds to a body of evidence that allows for both national and international learning for maternity services. Working and learning together, we can ensure that all pregnant and recently pregnant women receive safe high-quality care.

The rate of SMM in 2021 shows an increase following a drop in 2020 (the latter may have been a decreased

ascertainment due to the Covid-19 pandemic or a change in the population due to the pandemic such as isolation etc. altering rates). A notable change in 2021 was the increased rate of ICU/CCU admission with acute respiratory dysfunction in 2021; women experiencing COVID-19 infection in the majority.

Major obstetric haemorrhage remains the commonest and most significant morbidity in this audit; we are aware from this and other work that postpartum haemorrhage is also increasing in Ireland and internationally. This data has led to the development of a national quality improvement project by the NWIHP around PPH that is currently under way (See QR code).

It is also important that we always consider the data in the context of the individual woman's experience. The significant trauma associated with SMM events during the experience of childbirth can have a profound psychological effect on a woman, her partner, and their families. The input from our public/patient involvement partners brings this component of morbidity into focus and their input provides a real sound board to our endeavours and provides additional valuable insight.

I would like to take this opportunity to thank all maternity units in the Republic of Ireland for their ongoing commitment in contributing valuable data on maternity outcomes in these challenging times. I hope healthcare professionals and others involved in the maternity services will be aware of the findings in this report and use them to the benefit of pregnant and recently pregnant women. I would like to say a special word of thanks to our Patient Involvement Partners and welcome to two new representatives in 2023 from the Patient Advocacy Service.

We do receive direct feedback from colleagues about how they use this specific audit report during counselling of women who have sadly had a major morbidity. Their feedback suggests that women find it helpful to see they were not alone; this theme is supported by comments from our Patient Involvement Partners. It fits with my own personal experience also.



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Message from our public representative

This is my fifth year in authoring a lay summary of the NPEC Severe Maternal Morbidity (SMM) from a lay perspective. With each report I feel compelled to remind the reader that each of the statistics contained within this report is a woman at her most vulnerable. This can never be overstated.

With this and previous reports I am further educated on Severe Maternity Morbidity, and I am encouraged to see recommendations from previous reports taken on board and progressed; specifically in relation to Major Obstetric Haemorrhage (MOH), morbidly adherent placenta and blood loss. These reports offer us all an opportunity to learn. It is up to the organisations who have been identified to take ownership of progressing recommendations and whether they choose to learn from this report.

It is disappointing to note that the timeline associated with the submission of data continues to pose a challenge, but it further highlights the necessity of protected time for clinical staff (albeit in an over-stretched health service). The benefit to clinicians and service users because of the constant collation and evaluation of data from each of the 19 maternity units lends itself to enhanced awareness

and learning. This report is crucial when considering potential further learning & education.

Year on year the production of this report highlights the need for education; public health education and antenatal education. I have noted this recommendation since I became involved with the NPEC in 2017. If the woman is educated on maternal morbidity this may lessen her trauma. This message is from a lay perspective. I am not a medical person; I am the patient representative. Simply put, I was a patient.

Educate the woman on Maternal Morbidity, give her the tools to ask questions, take steps to alleviate her fears. Learn from her.

To not progress the recommendations within this report is a lost opportunity for all within the obstetrics and midwifery sector and it may perpetuate the fear for women on their maternity journey today.

Claire Jones

Patient Representative
NPEC Severe Maternal Morbidity Group

Acknowledgements

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 continue to co-ordinate the collection of data on severe maternal morbidity (SMM) at unit level. This report would not have been possible without their dedicated support and co-operation (see Appendix A). Collation of audit data at unit level was particularly challenging in 2021 following the HSE Cyber-attack and subsequent impact on IT systems. Further, the collation of data for the detailed NPEC MOH audit, commenced on January 1st 2021, was an additional challenge at unit level. The on-going support of unit co-ordinators in collating data is highly commendable, particularly as many do so without protected time for clinical audit. Additionally in relation to 2021 data, we thank the National ICU Audit manager in the National Office of Clinical

Audit (NOCA) for the collaboration in validation of ICU admission data.

The NPEC would like to acknowledge, with thanks, members of the NPEC Severe Maternal Morbidity Group for their guidance in the continual optimisation of the NPEC national clinical audit of severe maternal morbidity (Appendix B). We are grateful to the group for peer reviewing this report and offering alternative views and interpretations to its findings. We also 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 evolve (Appendix C).

We acknowledge the NOCA, whose welcomed endorsement of this report is included in Appendix D.

Executive summary

This tenth report from the National Clinical Audit of Severe Maternal Morbidity (SMM) in Ireland reports on 374 cases of SMM, among 58,953 maternities, occurring in the 19 Irish maternity units in 2021.

The SMM rate is a composite rate of a group of clearly defined severe maternal morbidities. Nearly three quarters of the women who experienced SMM in 2021 were diagnosed with one morbidity (n=264, 70.6%); 23.3% (n=87) were diagnosed with two morbidities; 5% (n=18, 4.8%) with three SMMs; 1% (n=4, 1.1%) with four morbidities and one woman (0.3%) experienced a total of six morbidities.

Since 2015, the SMM rate in Ireland has been relatively stable at approximately six cases per 1,000 maternities and the rate in 2021 (6.34 per 1,000) was slightly higher than in 2020. The incidence has changed from one case of SMM for every 260 maternities in 2011 to one case in 158 maternities in 2021. However, the increase was largely confined to the first years of the audit.

Major obstetric haemorrhage (MOH) remains the most frequently reported SMM event in 2021, accounting for over half (53.2%) of SMM cases. The incidence of MOH cases increased from 2.30 per 1,000 maternities in 2011 to 3.38 per 1,000 maternities in 2021, an overall increase of 47%. An increase in MOH was observed in the early years of the audit and the current 2021 rate is similar to the incidence in recent years. The main reported cause of MOH for women with a vaginal delivery in 2021 was retained placenta/membranes (45.8%), while for women who had a caesarean section, the most common primary cause of MOH reported was uterine atony (30.9%) followed by placenta praevia (20.6%).

Variations in rates of SMM and MOH were identified between units. However, such differences must be interpreted with caution, as they may be related to differences in the risk profile of pregnant women presenting to the maternity hospitals rather than the care given. Differences in rates of MOH between units may also reflect variances in practices of estimating blood loss.

The second most common SMM recorded was admission to an intensive or coronary care unit (ICU/CCU); reported in two fifths (40.4%) of SMM cases. MOH was the most common SMM associated with ICU/CCU admission (29%) followed by Acute Respiratory Dysfunction (19%), in 2021. Compared to recent years there was an increase in the number of women admitted to an ICU/CCU who had not experienced a SMM as defined in this audit, in 2021, this was experienced by 40.4% of the women.

In the reporting year 2021, a severe 'third and fourth wave' of the COVID-19 pandemic affected Ireland when the virulent variants of concern (Alpha and Delta) were found to impact on maternal and fetal wellbeing compared to 2020. In this 2021 SMM audit, 35 women were reported as experiencing a COVID-19 related illness. Of these 35 cases all but 1 woman were cared for in ICU and the length of stay in ICU ranged from 1 to 60 days. One woman, not cared for in ICU, was admitted to a HDU in a general hospital for non-invasive respiratory support.

As in previous years, data on ICU/CCU admission show that in the Irish context, admission to these units does not infer a requirement for Level 3 Care. Approximately one in three of the women admitted to an ICU/CCU required Level 3 Care (31%); one third of the women admitted to ICU/CCU required Level 2 Care (33%) and over one third required Level 1 Care (36%).

Although there was a consistent rate of peripartum hysterectomy (PH) of approximately 0.33 per 1,000 maternities in the early years of this audit, the rate has increased in recent years. In 2019-2021 this was 42% higher than in 2011-2013, at 0.47 per 1,000, indicating that approximately one in every 2000 women giving birth in Ireland experience a peripartum hysterectomy. Placenta Accreta Spectrum (PAS) was the most commonly reported indication for PH (n=16/25, 64.0%), followed by MOH with a blood loss \geq 2.500ml due to uterine atony (n=4/25, 16.0%).

A significantly higher risk of MOH, ICU/CCU admission, peripartum hysterectomy and pulmonary embolism was reported for women with high BMI.

In those who experienced SMM there was an over-representation of women of Asian ethnicity (6.7% of SMM cases) compared with the population aged 15-49 years in this ethnic group (2.7%). Women of Black ethnicity (3.2% vs 1.6% in population) and Irish Traveller (1.6% vs 0.7% in population) were also over-represented.

The rate associated with multiple pregnancy (25.81 per 1,000 maternities) was over four times higher than the rate associated with singleton births (5.37 per 1,000).

The perinatal mortality rate (PMR) associated with women experiencing SMM (31.09 per 1,000 births) was five times the perinatal mortality rate observed for all births in Ireland in 2020 (the most recent year with available PMR data).

Recommendations from previous reports that have been progressed

Recommendation:

- **'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 National Women and Infants Health Programme (NWIHP), in collaboration with the NPEC, have developed a national quality improvement initiative to evaluate postpartum haemorrhage (PPH) rates. This includes the development of a standardised national approach in estimating blood loss and a focus on identifying better management of PPH (Appendix E). For more information, please email pqhii@ucc.ie.

Recommendation:

- **The implementation of a case assessment audit of major obstetric haemorrhage audit (MOH) is essential as it continues to be the leading cause of severe maternal morbidity.**

From January 2021 to December 31st 2022, the NPEC has conducted a national case assessment audit of women experiencing a MOH using a validated quality assessed tool. Cases of MOH were identified in this SMM audit. Findings from the MOH audit will be published in the NPEC 2022 annual SMM report. This will enhance learning and identify any possible change in practice or risk factors in the profile of the pregnant population compared to findings of the NPEC MOH audit 2011-2013.

Recommendation:

- **Research on the incidence of morbidly adherent placenta in Ireland is warranted.**

Research on morbidly adherent placenta, more recently described as Placental Accreta Spectrum (PAS) is underway. Further, under the auspices of the NWIHP and the Institute of Obstetrics and Gynaecology (IOG), a national clinical practice guideline on 'Diagnosis and Management of Placenta Accreta Spectrum (PAS) was published in January 2023.

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

Organisations have been identified to take ownership of progressing these 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 the same. Owner; Quality and Patient Safety Directorate (NQPSD).
- **A public health education programme on maternal morbidity and modifiable risk factors** should be developed. Owner; in discussion with the National Women and Infants Health Programme (NWIHP) to progress this.
- **Antenatal education:**
 - (a) Antenatal education/information should be provided by the multidisciplinary team to women to ensure an understanding of maternal morbidity and complication awareness.
 - (b) When a pregnant woman is identified as high risk for significant morbidity, specific education should be available during her antenatal care and at birth preparation.

(c) The national standards on antenatal education should provide guidance on specific education for maternal morbidity awareness.

Owner; the National Women and Infants Health Programme (NWIHP) to progress these.

- **Internationally, social inequalities have been shown to impact on risk of SMM. There is a need to establish the evidence in this regard in Ireland. This requires improved maternity data at national level and more research in order to establish this evidence.**

There is an opportunity with the Maternal Newborn Clinical Management System (MN_CMS) data from Irish maternity units to mine data at a national level. These data could be collated to identify the influence of risk factors for SMM in Ireland including ethnicity, maternal age, body mass index (BMI), smoking, employment status and other socio-economic factors. This should overcome the current deficit in the pregnant population data at national level. Owner; the NPEC to progress this.

Key findings in 2021 on Severe Maternal Morbidity

- The rate of SMM was 6.34 per 1,000 maternities or one in 158 maternities.
- Between 2011-2021, the SMM rate has increased by 65%. Since 2015, the SMM rate has been relatively stable.
- MOH remains the most reported morbidity with a rate of 3.38 per 1,000 maternities.
- The reporting of several, less frequent SMMs has increased in recent years, namely peripartum hysterectomy and pulmonary embolism, although a gradual decrease has been noticed in incidence of renal or liver dysfunction and septicaemic shock.
- In 2021, variants of COVID-19 impacting on maternal and fetal wellbeing affected Ireland. Among the 34 pregnant or recently pregnant women admitted to ICU with COVID-19, over half (n=23, 67.6 %) required advanced respiratory support and 4 (11.4%) required ECMO thus indicating the severity of illness among this cohort and the requirement for higher levels of care.
- A significantly higher risk of MOH, ICU/CCU admission, peripartum hysterectomy and pulmonary embolism was reported for women with high BMI.
- The SMM rate associated with multiple pregnancy was 4.5 times higher than the rate associated with single birth.
- The risk of perinatal mortality associated with SMM was 5 times higher than for all births in 2020.

Introduction

This is the tenth published report of the national clinical audit on severe maternal morbidity (SMM) in the Republic of Ireland (ROI). SMM has been widely acknowledged as an important quality indicator of obstetric and maternity care, particularly in developed countries where maternal fatality rates are relatively low.^{1,2} As outlined in our recent study on maternal morbidity and mortality, maternal death, although tragic, is the last point in the spectrum of adverse pregnancy events, representing the tip of the iceberg of adverse maternal outcomes. For each maternal fatality occurring, many more women survive and may carry with them long-term consequences. The low rates of maternal fatalities may indicate that morbidities are managed effectively but their prevention requires greater attention.³

In this context, the NPEC in collaboration with the NPEC Severe Maternal Morbidity Advisory 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 surveillance of the incidence of women experiencing severe maternal morbidities, to identify quality improvement initiatives and make recommendations for the improvement of maternal care for women in the ROI.

The current report provides information on the incidence of clearly defined SMM events occurring in the ROI in 2021. Information on maternal characteristics, management of delivery and neonatal outcome in women experiencing SMM are also detailed.

Since the inception of the SMM audit, the NPEC has conducted a series of topic-specific case assessment audits on a rolling basis (Figure 1). These audits have provided additional, in-depth and valuable information on major obstetric haemorrhage (MOH) for the reporting years 2011-2013 and the level of care provided to the critically ill women in obstetrics for the reporting years 2014-2016. Results of these audits have been reported in annual SMM reports and are available on the NPEC website at

www.ucc.ie/en/npec/npec-clinical-audits. For the triennia 2017 to 2019, the NPEC conducted a detailed case assessment audit on women experiencing Pulmonary Embolism (PE) during pregnancy and up to 42 days following the pregnancy end. Due to the small incidence rate in this cohort of women and the power of analysis, findings from this audit will be reported separately in 2023.

From January 1st 2021 to December 31st 2022, an audit of women experiencing a MOH was re-launched and for the year 2023, the NPEC aim to conduct a new detailed case assessment audit of women Eclampsia (see Figure 1).

The NPEC advocates for a multidisciplinary approach to case ascertainment and review to ensure all relevant SMM and MOH cases are recorded at unit level and reported to the NPEC audits.



Figure 1: Topic-specific audits conducted by the NPEC.

¹Geller SE, Cox SM, Callaghan WM, Berg CJ. Morbidity and mortality in pregnancy: Laying the Groundwork for Safe Motherhood. *Women's Health Issues*. 2006;16(4):176-88.

²Tabassum F DC, Peter v D, Priya A, Rachel V, Ozge T, Laura A Magee, Nynke vD B, Lale Say. Measuring maternal health: focus on maternal morbidity. *Bulletin of the World Health Organisation*. 2013;93(10):794-6.

³S Leitao et al., "Maternal Morbidity and Mortality: An Iceberg Phenomenon," *BJOG: An International Journal of Obstetrics & Gynaecology* 129, no. 3 (September 23, 2021): 402-11.

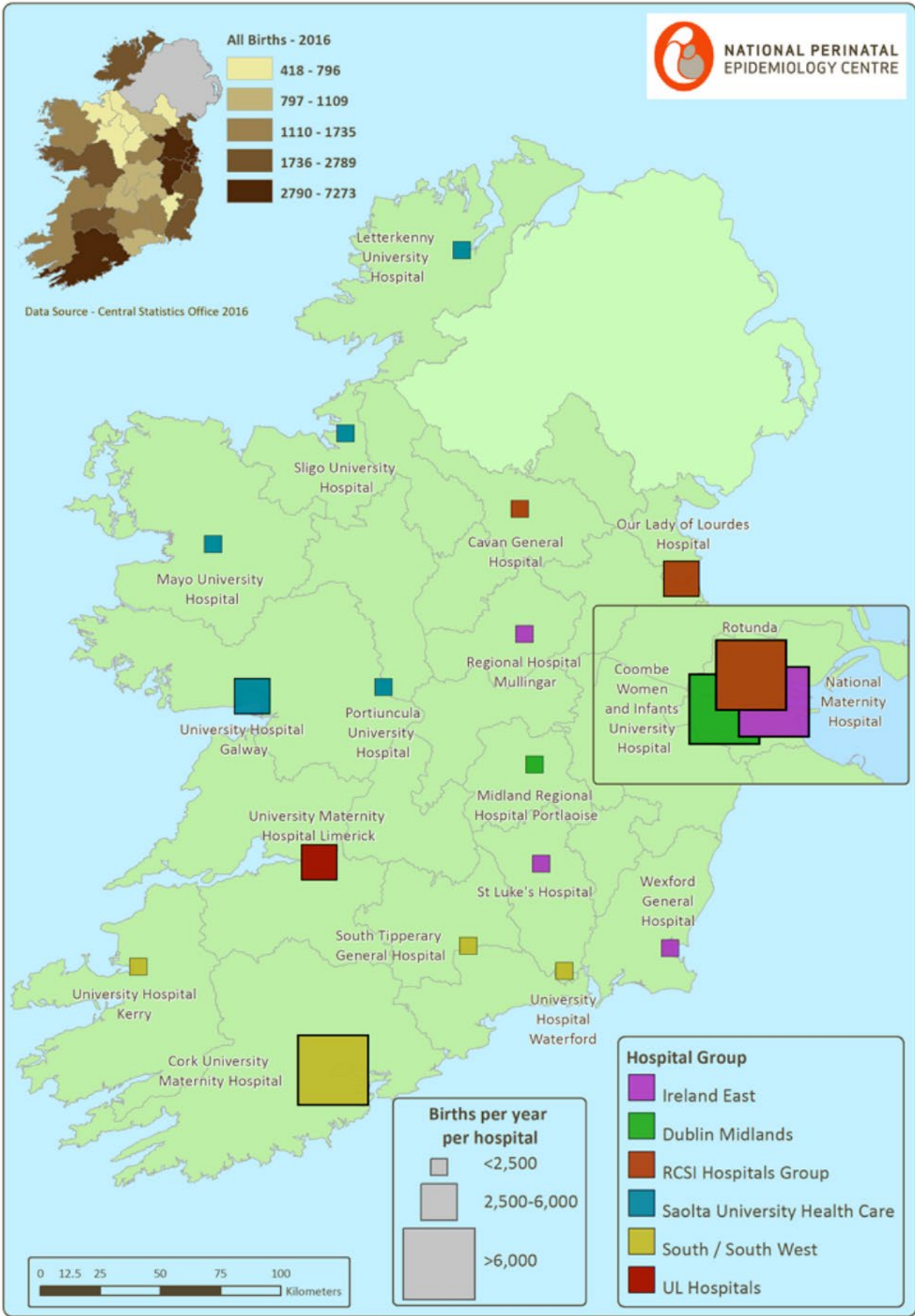


Figure II: Map of maternity units and hospital groups in the Republic of Ireland, 2021.

Methods

The term, “maternal morbidity” encompasses a wide range of chronic and acute conditions which may result in obstetric complications during pregnancy, labour, delivery and the puerperium. However, there is an absence of international consensus on definitions of “severe maternal morbidity”. 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,⁴ with modifications used by SCASMM to include intervention-based criteria.⁵ 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

In 2021, there were 19 maternity units in the Republic of Ireland (Figure II). Data on SMM events occurring between 1 January and 31 December 2021 were submitted using a standardised notification dataset electronically, via the secure online NPEC database. The SMM notification form is available on the NPEC website at: www.ucc.ie/en/npec/npec-clinical-audits/severematernalmorbidity/severematernalmorbidityreportsandforms/ (QR code available in footnote). 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.

Within NPEC the data are examined and, when necessary, reviewed with unit co-ordinators to ensure reported cases meet the specified audit criteria. In the event of in-utero or postpartum transfers between maternity units, cases of potential duplication in reporting are identified, thus ensuring data consistency and accuracy.

Figure III illustrates the NPEC data collection and management processes in the SMM audit. 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. However, the timeliness of data submission remains a challenge in maternity units. As mentioned previously, this challenge was magnified in 2021 following the Cyber-attack on HSE websites. The lack of dedicated resources for clinical audit continues to impact negatively on timely collation of data at unit level.

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.

Definitions and inclusion criteria for the 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 fourteen, clearly defined, organ dysfunction morbidities in the reporting years 2011-2021: 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, septicæmic shock, anaesthetic complications and maternities involving peripartum hysterectomy. To allow for direct comparison with the SCASMM, two management proxies for maternal morbidity - ICU/CCU admission and interventional radiology were also included. Definitions for all reportable SMM events are provided at the end of the notification form (Appendix F).

The SCASMM methodology, adopted by this SMM national audit, defined MOH as occurring if one of the following criteria were met: estimated blood loss of at least 2,500ml; transfusion of five or

⁴Mantel GD, Buchmann E, Rees H, Pattinson RC. Severe Acute maternal morbidity: a pilot study of a definition for a near-miss. BJOG 1998; 105: 985-90

⁵Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from: www.healthcareimprovementscotland.org/our_work/reproductive_maternal_child/programme_resources/scasmm.aspx



QR code to webpage with SMM forms, manuals and reports.

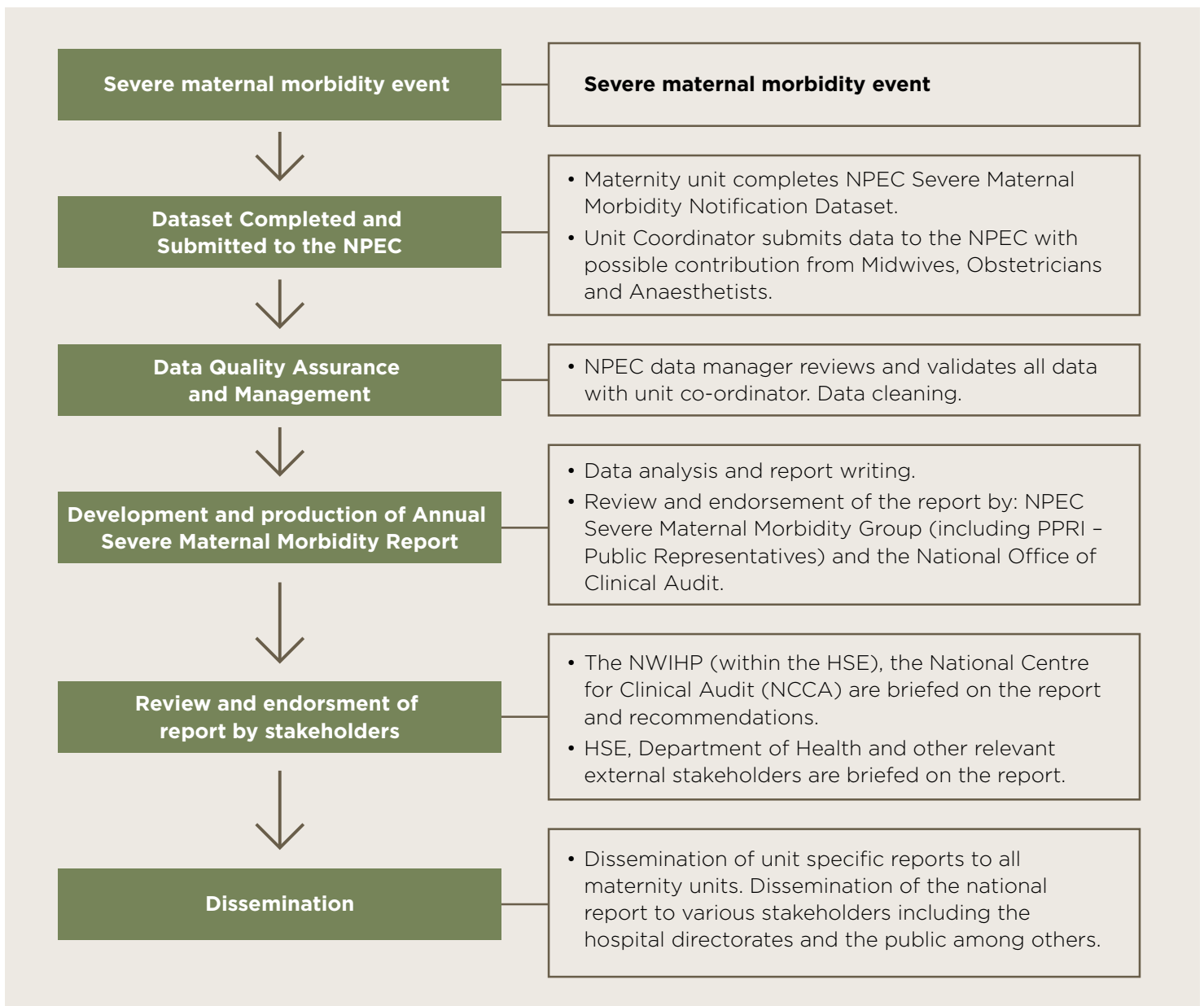


Figure III: NPEC data collection and management processes.

more units of blood; and receiving treatment for coagulopathy. In recent years, there has been an increase in the number of MOH cases reported solely because treatment was received for coagulopathy, which reflects change in practice based on current national guidelines on the management of PPH. In order to adjust for this change in practice, the MOH findings in this report are based on MOH cases with an estimated blood loss of at least 2,500ml or a transfusion of five or more units of blood. Similarly, the SMM findings are based on these MOH cases and cases of any of the other SMMs listed above.

From 2013, 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 ten years of the audit.

Ten Group Classification System

In 2021, data from units that participated in the SMM audit also provided data on all women who gave birth classified according to the Robson Ten Group Classification System (TGCS; Appendix G). For three units, data was used from their 2020 data submission to calculate the total number of maternities. Data on 58,248 maternities were examined and classified by the Robson TGCS. The incidence of MOH aggregated for these 19 units was classified according to the Robson TGCS. The NPEC and the Irish Maternity Indicator System (IMIS) continue to work together to consolidate the data collection of the Robson TGCS.

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. For incidence rates, 95% confidence intervals were calculated using exact Poisson confidence limits unless stated otherwise.

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.

All denominator data used for this report were the number of maternities based on the number of women who gave birth in hospital as enumerated by the Hospital In-Patient Enquiry (HIPE), operated by the Healthcare Pricing Office (www.hpo.ie).

The denominator based on number of women who gave birth 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 women who gave birth to a live born or stillborn baby. The approach of not including miscarriage, ectopic pregnancy and molar pregnancy in the denominator was also the approach taken by the SCASMM and confidential enquiries on maternal deaths in Ireland and the UK.^{6, 7, 8}

The infrequency of some specific rarer SMMs compared to those more frequently recorded, such as MOH and ICU/CCU admission, makes it difficult to assess time trends based on the annual rate. The ten-year period of the SMM audit is now long enough to allow these morbidities time trends to be examined by triennium. Hence, rates of renal dysfunction, peripartum hysterectomy, pulmonary

embolism and septicaemic shock were calculated by triennium.

The absence of national data on BMI, ethnicity, social-economic status among other data points, means that the risk of SMM associated with these factors remains unknown. Internationally, social inequalities have been shown to impact on the risk of SMM. There is a need to establish the evidence in this regard in Ireland. The ongoing implementation of the national electronic chart (MN_CMS) across all maternity units will hopefully address this deficit in national data.

Rate ratios

Further analysis was conducted to assess variation in incidence rates between years, maternal age groups, and single and multiple 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. They are interpreted against the rate to which they are being compared (the reference group/reference rate). 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.

⁶Scottish Confidential Audit of Severe Maternal Morbidity: 10th Annual Report (2014). Available from: www.healthcareimprovementscotland.org/our_work/reproductive,_maternal__child/programme_resources/scasmm.aspx

⁷O'Hare MF, Manning E, Corcoran P, Greene RA on behalf of MDE Ireland. Confidential Maternal Death Enquiry in Ireland, Report for 2018 - 2020. Cork: MDE Ireland, November 2022.

⁸Knight M, Bunch K, Patel R, Shakespeare J, Kotnis R, Kenyon S, Kurinczuk JJ (Eds.) on behalf of MBRRACE-UK. Saving Lives, Improving Mothers' Care Core Report - Lessons learned to inform maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2018-20. Oxford: National Perinatal Epidemiology Unit, University of Oxford 2022.

Funnel plots

Variations in SMM rates 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.⁹ 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 exact binomial standard errors). 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 exact binomial standard errors). The width of the confidence interval is adjusted to allow for a 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 (Figure IV).

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 a conservative interpretation of differences between the rates of units and their deviation from the national rate.

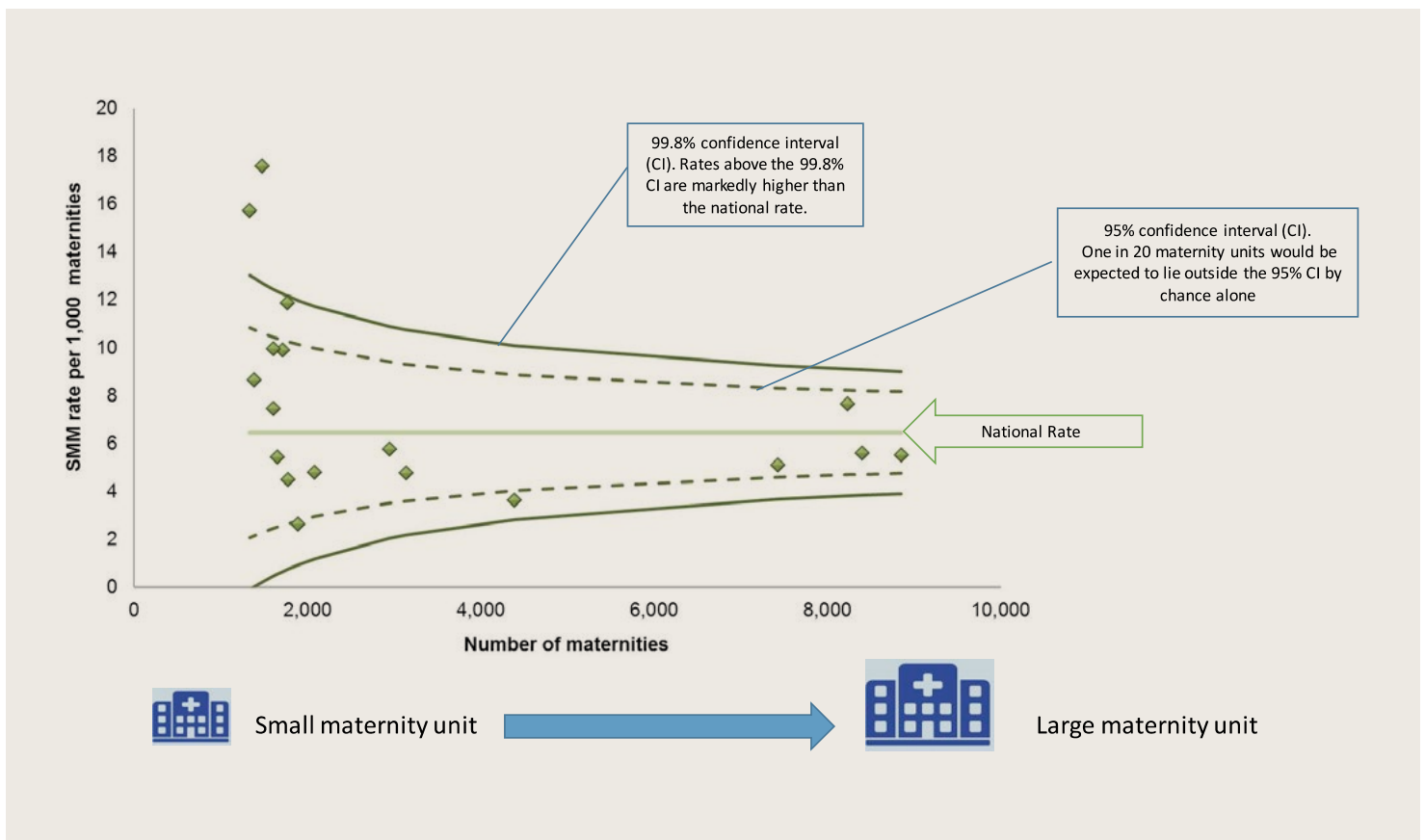


Figure IV: Diagram outlining the interpretation of a funnel plot.

⁹Spiegelhalter D. (2002) Funnel plots for institutional comparison. *Quality and Safety in Health Care*; 11(4):390-91.

Data Quality Statement

In the NPEC the maintenance of data at high quality standards is a priority. The purpose of this data quality statement is to support the interpretation and quality of the information contained in this report.

This quality statement, presented in www.ucc.ie/en/npec/npec-clinical-audits/severematernalmorbidity/ has been developed in line with the Health Information and Quality Authority (HIQA) guidance on data quality framework for health and social care.¹⁰ The statement describes the quality of the data according to five data quality dimensions as defined by HIQA:

1. Relevance
2. Accuracy and reliability
3. Timeliness and punctuality
4. Coherence and comparability
5. Accessibility and clarity

The National Clinical Audit of Severe Maternal Morbidity adheres to following national and international legislation and standards:

- The European Union General Data Protection Regulation 2016
- The Data Protection Act 1988 and the Data Protection (Amendment) Act 2003
- Data Protection Act 2018 (Section 36(2)) (Health Research) Regulations 2018
- Information Management Standards for National Health and Social Care Data (2017)
- National Office of Clinical Audit Standards for National Clinical Audit
- National Standards for Safer Better Healthcare (2012)
- FAIR (Findable, Accessible, Interoperable, and Re-usable) Data Principles.

¹⁰Health Information and Quality Authority. (2018) Guidance on a data quality framework for health and social care 2018. Available from www.hiqa.ie/sites/default/files/2018-10/Guidance-for-a-data-quality-framework.pdf

Main Findings

National rate

In 2021, the 19 Irish maternity units reported that 374 women experienced one or more SMM as defined in this audit. Table 1 details the national number of cases, total maternities and SMM rates derived from the participating units since the first year of the audit, 2011.

Table 1: Incidence of severe maternal morbidity (SMM) in Ireland, 2011-2021

Year	Maternities (n)	SMM cases (n)	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011	66,188	255	3.85 (3.39-4.36)	1.00 (ref.)	---
2012	64,184	278	4.33 (3.84-4.87)	1.12 (0.95-1.33)	0.177
2013	66,073	307	4.65 (4.14-5.20)	1.21 (1.02-1.42)	0.027
2014	61,182	347	5.67 (5.09-6.30)	1.47 (1.25-1.73)	<0.001
2015	59,497	355	5.97 (5.36-6.62)	1.55 (1.32-1.82)	<0.001
2016	62,417	387	6.20 (5.60-6.85)	1.61 (1.37-1.88)	<0.001
2017	60,480	372	6.15 (5.54-6.81)	1.60 (1.36-1.87)	<0.001
2018	59,592	382	6.41 (5.78-7.09)	1.66 (1.42-1.95)	<0.001
2019	57,983	375	6.47 (5.83-7.16)	1.68 (1.43-1.97)	<0.001
2020	55,281	328	5.93 (5.31-6.61)	1.54 (1.31-1.81)	<0.001
2021	58,953	374	6.34 (5.72-7.02)	1.65 (1.40-1.93)	<0.001

Note: Rate ratios compare the rate for each year against the rate for the baseline year 2011. P-values assess the statistical significance of the difference between the rate for each year and the rate in 2011. Poisson 95% confidence intervals were calculated for the rate and rate ratios. Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI = confidence interval.

Based on this national clinical audit, the SMM rate of 6.34 per 1,000 maternities in 2021 was 65% higher than the rate of 3.85 per 1,000 maternities in 2011. Thus, the incidence has changed from one case of SMM for every 260 maternities in 2011 to one case in 158 maternities in 2021. The increase was largely confined to the first years of the audit, which could reflect enhancement of case ascertainment as the SMM audit matured. The SMM rate has been relatively stable at approximately six cases per 1,000 maternities since 2015.

Specific severe maternal morbidities

The SMM rate is a composite rate of a group of clearly defined severe maternal morbidities. Nearly three quarters of the women who experienced SMM in 2021 were diagnosed with one morbidity (n=264, 70.6%); 23.3% (n=87) were diagnosed with two morbidities; 5% (n=18, 4.8%) with three SMMs; 1% (n=4, 1.1%) with four morbidities and one woman (0.3%) experienced a total of six morbidities.

As in recent years, major obstetric haemorrhage (MOH) was the most reported morbidity in 2021, accounting for over half of all SMM cases (53%; Table 2). The second most common reportable SMM was ICU/CCU admission, which was experienced by 151 women (40.4%). The next most frequently reported SMM event in 2021 was acute respiratory dysfunction (7.5%), primarily associated with COVID-19 infection, which represented a threefold increase in the incidence of this SMM compared to previous years. Further frequently reported SMM included renal or liver dysfunction (7%), peripartum hysterectomy (6.7%) and pulmonary embolism (5.9%). Uterine rupture was diagnosed in 16 women (4.3%) and septic shock in 13 women (3.5%). The remaining eight specific SMMs were relatively rare, being experienced by fewer than fifteen women with each accounting for no more than 2% of the reported SMM cases (Table 2).

Major obstetric haemorrhage (MOH)

Of the 199 MOH cases reported in 2021, 80% (n=159, 79.9%) involved an estimated blood

Table 2: Incidence of specific severe maternal morbidities (SMMs) in Ireland, 2021

Incidence of organ dysfunction SMM	n(%)
Major obstetric haemorrhage	199(53.2)
Acute respiratory dysfunction	28(7.5)
Renal or liver dysfunction	26(7)
Peripartum hysterectomy	25(6.7)
Pulmonary embolism	22(5.9)
Uterine rupture	16(4.3)
Septicaemic shock	13(3.5)
Eclampsia	7(1.9)
Pulmonary oedema	7(1.9)
Cerebrovascular event	6(1.6)
Anaesthetic problem	5(1.3)
Cardiac arrest	3(0.8)
Status epilepticus	1(0.3)
Coma	0(0)
Incidence of SMM based on management criteria	
ICU/CCU admission	151(40.4)
Interventional radiology	5(1.3)
Total women affected	374(100)

Note: n represents the 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; ICU = intensive care unit; CCU = coronary care unit.

loss $\geq 2,500$ ml without a transfusion of ≥ 5 units of blood, 2% (n=4) involved a transfusion of ≥ 5 units of blood without an estimated blood loss of $\geq 2,500$ ml (in one case, estimated blood loss $\geq 2,500$ was not recorded) and 18% of MOH cases (n=36, 18.1%) met both criteria.

Six (3.0%) of the 199 cases of MOH reported in 2021 were associated with early pregnancy loss (including early and late miscarriage and one termination of pregnancy) and occurred between nine and nineteen weeks gestation.

For the other 193 women who experienced MOH, 97 gave birth by caesarean section and 96 had a vaginal birth. The vast majority of these further MOH cases occurred on day of delivery (n=179, 92.8% of 193), primarily postnatally. A further 14 cases of MOH occurred in the postnatal period (day 1 to day 14 post-delivery).

As shown in Table 3, the main reported cause of MOH for women that delivered vaginally in 2021 was retained placenta/membranes (n=44), while for women who had a caesarean section, the most common primary cause of MOH reported was

Uterine atony (n=30) followed by Placenta praevia (n=20). There were 2 cases where the cause of MOH was not documented in the clinical notes.

Among the 16 cases where 'other' cause of MOH was reported, a wide variety of conditions were associated with the MOH including: multiple adhesions, fibroids, vascular lower segment and in three cases profound coagulopathy.

The increasing rates of MOH warrant further investigation. As discussed earlier, recommendations from previous SMM reports have been progressed with a detailed audit of MOH events, identified in this SMM audit, relaunched and conducted nationally in 2021 and 2022 by the NPEC. Findings from this audit, to be published in early 2024, will enhance learning and identify any possible change in practice, risk factors or in the profile of the pregnant population compared to findings of the NPEC MOH audit 2011-2013. Further, learning from the Postpartum Quality Improvement Initiative (PPHQII) will address a standardised approach in estimating blood loss and in the management and review of PPH/MOH events.¹¹

¹¹Postpartum Quality Improvement Initiative. Available at pphqii@ucc.ie

Table 3: Primary cause of major obstetric haemorrhage (MOH) by mode of delivery, 2021

	Total	Vaginal delivery	Caesarean Section
Uterine atony	55(2.7.6%)	25(26%)	30(30.9%)
Retained placenta/membranes	47(23.6%)	44(45.8%)	2(2.1%)
Placenta praevia	20(10.1%)	0(0%)	20(20.6%)
Vaginal laceration/haematoma	15(7.5%)	14(14.6%)	1(1%)
Bleeding from uterine incision	14(7%)	0(0%)	14(14.4%)
Placenta Accreta Spectrum (PAS)*	13(6.5%)	0(0%)	13(13.4%)
Abruption	8(4.1%)	3(3.1%)	5(5.2%)
Cervical laceration	3(1.5%)	3(3.1%)	0(0%)
Uterine inversion	2(1%)	2(2.1%)	0(0%)
Uterine rupture	2(1%)	0(0%)	1(1%)
Other	20(10.1%)	5(5.2%)	11(11.3%)
Total	199(100%)	96(100%)	97(100%)

*Includes placenta accreta or percreta. Mode of delivery unknown for 6 cases.

Trends in major obstetric haemorrhage (MOH)

There were 199 MOH cases in 2021 giving a rate of 3.38 per 1,000 maternities, which is very similar to the incidence in recent years (Table 4). An increase in MOH was observed in the early years of the SMM audit; the rate in 2021 was 47% higher than it was in 2011. MOH remains one of the main challenges for service providers and clinical staff as highlighted in a recent research study on increasing MOH rates in Ireland.¹²

Table 4: Incidence of major obstetric haemorrhage (MOH) in Ireland, 2011-2021

Year	Maternities (n)	MOH cases (n)	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011	66,188	152	2.30 (1.95-2.69)	1.00 (ref.)	---
2012	64,184	149	2.32 (1.96-2.73)	1.01 (0.81-1.27)	0.925
2013	66,073	157	2.38 (2.02-2.78)	1.03 (0.83-1.29)	0.764
2014	61,182	149	2.44 (2.06-2.86)	1.06 (0.85-1.33)	0.611
2015	59,497	159	2.67 (2.27-3.12)	1.16 (0.93-1.45)	0.181
2016	62,417	192	3.08 (2.66-3.54)	1.34 (1.08-1.66)	0.007
2017	60,480	169	2.79 (2.39-3.25)	1.22 (0.98-1.51)	0.079
2018	59,592	190	3.19 (2.75-3.68)	1.39 (1.12-1.72)	0.003
2019	57,983	192	3.31 (2.86-3.81)	1.44 (1.17-1.78)	<0.001
2020	55,281	181	3.27 (2.81-3.79)	1.43 (1.15-1.77)	<0.001
2021	58,953	199	3.38 (2.92-3.88)	1.47 (1.19-1.82)	<0.001

Note: Rate ratios compare the rate for each year against the rate for the baseline year 2011. P-values assess the statistical significance of the difference between the rate for each year and the rate in 2011. Poisson 95% confidence intervals were calculated for the rate and rate ratios. Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI = confidence interval.

¹²Greene RA, McKernan J, Manning E, Corcoran P, Byrne B, Cooley S, et al. Major obstetric haemorrhage: Incidence, management and quality of care in Irish maternity units. *European Journal of Obstetrics and Gynecology and Reproductive Biology*. 2021;257:114-20.

Intensive care unit/coronary care unit (ICU/CCU) admission

Table 5 details the specific SMMs involved in the 151 cases admitted into an ICU/CCU in 2021. Approximately 29% of these involved MOH, 19% (n=28) were associated with acute respiratory dysfunction and eight cases related to septicaemic shock (5.3%). A further 4.6% of ICU admissions (n=7) involved renal or liver dysfunction and 3.3% related to peripartum hysterectomy with a similar proportion relating to pulmonary embolism.

The increased rate of ICU/CCU admission with acute respiratory dysfunction in 2021 was associated with women experiencing COVID-19 infection in the majority of cases (n=23/28, 82%). Details of these cases are provided in Table 6.2,

in the “COVID-19 and Severe Maternal Morbidity 2021” section.

Over two fifths of the women admitted into an ICU/CCU in 2021 had not experienced another SMM as defined in this audit (“none of the above” 40.4%, n=61/151). The values for 2021 represent an increase in the proportion of cases admitted to ICU for morbidities other than SMMs specified in this audit in comparison to last year’s values (Figure 1). As acknowledged in previous reports, admission to ICU/CCU in cases not meeting the criteria of 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 in units with limited resources.

Table 5: Specific severe maternal morbidities (SMMs) in women admitted to an intensive care unit or coronary care unit (ICU/CCU) in Ireland, 2021

	n(%)
Total women admitted to ICU/CCU	151(100)
Major obstetric haemorrhage	43(28.5)
Acute respiratory dysfunction	28(18.5)
Septicaemic shock	8(5.3)
Renal or liver dysfunction	7(4.6)
Peripartum hysterectomy	5(3.3)
Pulmonary embolism	5(3.3)
Uterine rupture	4(2.6)
Anaesthetic problem	4(2.6)
Cardiac arrest	3(2)
Interventional radiology	3(2)
Eclampsia	2(1.3)
Pulmonary oedema	2(1.3)
Cerebrovascular event	2(1.3)
Status epilepticus	1(0.7)
Coma	0(0)
None of the above*	61(40.4)

Note: n represents the number of women affected by the specific reportable SMM; % is based on the total number of women admitted to ICU/CCU in 2021. More than one SMM may apply per woman; *women admitted to ICU/CCU due to other morbidities or other issues not listed.

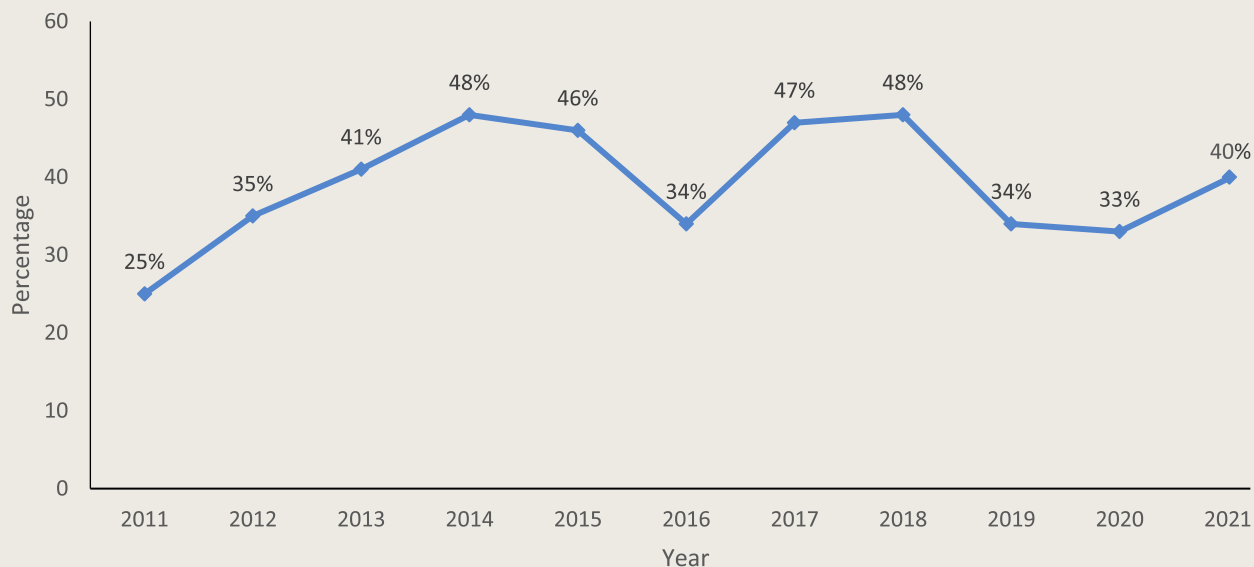


Figure 1: Proportion of cases admitted to ICU/CCU not experiencing a severe morbidity as defined in this audit, 2011-2021

These cases, requiring a higher level of observation (Level 1, 2 or 3 Care; Appendix H), were associated with a wide variety of maternal complications due to both direct obstetric (n=30, 49.2%) and non-obstetric causes (n=31, 50.8%). Direct obstetric complications included pre-eclampsia (n= 13, 43.3%), post-partum haemorrhage (PPH) with a blood loss \leq 2,500mls (n=10, 33.3%), pregnancy-related infection (n=3, 10%) and close monitoring following LSCS (n= 4, 13.3%). ICU admissions due to non-obstetric complications primarily included non-obstetric sepsis (n= 10, 32.3%: all related to Covid-19 infection), monitoring of cardiac conditions (n= 8, 25.8 %; of which one woman required open heart surgery), monitoring of neurological conditions and metabolic acidosis among other conditions.

In 2021, the vast majority of ICU/CCU admissions with no other reported morbidity as defined in this audit (n=61) occurred in small maternity units (n=43, 70.5%). Over half of these (n=24, 55.8 %) happened in four small units with on-site ICU/CCU facilities but without obstetric high

dependency facilities. Feedback from these units in previous years indicated that the rate of such ICU/CCU admissions reflected resource issues in cases where women required a higher level of monitoring. Of the 24 ICU admissions in these four units, with no other SMM as defined in this audit, two required Level 3 Care, nearly half required Level 2 Care (n=10, 41.7%) and the remaining women required Level 1 Care (n=12, 50.0%).

The correlation between maternity units with a birth rate less than 2,500 per annum and increased likelihood of Level 2 care provided in ICU/CCU facilities was identified in the NPEC National Audit of Critically Ill Women in Obstetrics.¹³

¹³Manning E, Leitao S, Corcoran P, McKernan J, de Foubert P, Greene RA, on behalf of the Severe Maternal Morbidity Group. Section 2 Confidential Audit of Critical Care in Obstetrics in Ireland in the Severe Maternal Morbidity in Ireland Annual Report 2016. Cork: National Perinatal Epidemiology Centre, 2018.

Trends in ICU/CCU admissions

A total of 151 women experienced intensive care unit/coronary care unit (ICU/CCU) admission in 2021, a rate of 2.56 per 1,000 maternities. The rate of ICU/CCU admission increased during the first years of the SMM audit, reaching 3.04 per 1,000 maternities in 2015. Since then, the rate has been in the range of 2.5-2.7 per 1,000 with one exception in 2020 when the rate dropped to 2.10 per 1,000 (Table 6.1).

Table 6.1: Incidence of intensive care unit/coronary care unit (ICU/CCU) admission in Ireland, 2011-2021

Year	Maternities	ICU/CCU admissions	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011	66,188	111	1.68 (1.38-2.02)	1.00 (ref.)	---
2012	64,184	130	2.03 (1.69-2.41)	1.21 (0.94-1.56)	0.144
2013	66,073	131	1.98 (1.66-2.35)	1.18 (0.92-1.52)	0.194
2014	61,182	171	2.79 (2.39-3.25)	1.67 (1.31-2.12)	<0.001
2015	59,497	181	3.04 (2.62-3.52)	1.81 (1.43-2.30)	<0.001
2016	62,417	160	2.56 (2.18-2.99)	1.53 (1.20-1.95)	<0.001
2017	60,480	149	2.46 (2.08-2.89)	1.47 (1.15-1.88)	0.002
2018	59,592	156	2.62 (2.22-3.06)	1.56 (1.22-1.99)	<0.001
2019	57,983	154	2.66 (2.25-3.11)	1.58 (1.24-2.02)	<0.001
2020	55,281	116	2.10 (1.73-2.52)	1.25 (0.96-1.62)	0.091
2021	58,953	151	2.56 (2.17-3.00)	1.53 (1.20-1.95)	<0.001

Note: Rate ratios compare the rate for each year against the rate for the baseline year 2011. P-values assess the statistical significance of the difference between the rate for each year and the rate in 2011. Poisson 95% confidence intervals were calculated for the rate and rate ratios. The maternities figures are the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI = confidence interval.

Figure 2 illustrates the trend in the rate of SMM as defined in this audit and the separate trends for MOH and ICU/CCU admission. A steady increase in the rate of SMM is evident from 3.85 to 6.34 per 1,000 maternities during 2011-2021. The increase in the SMM rate during the first half of this time period was primarily due to

the increase in ICU/CCU admissions. During the more recent years, the increase in the SMM rate largely reflected the increase in MOH. The lower SMM rate of 5.95 per 1,000 observed in 2020 was a consequence of the decrease observed in ICU/CCU admissions in that year.

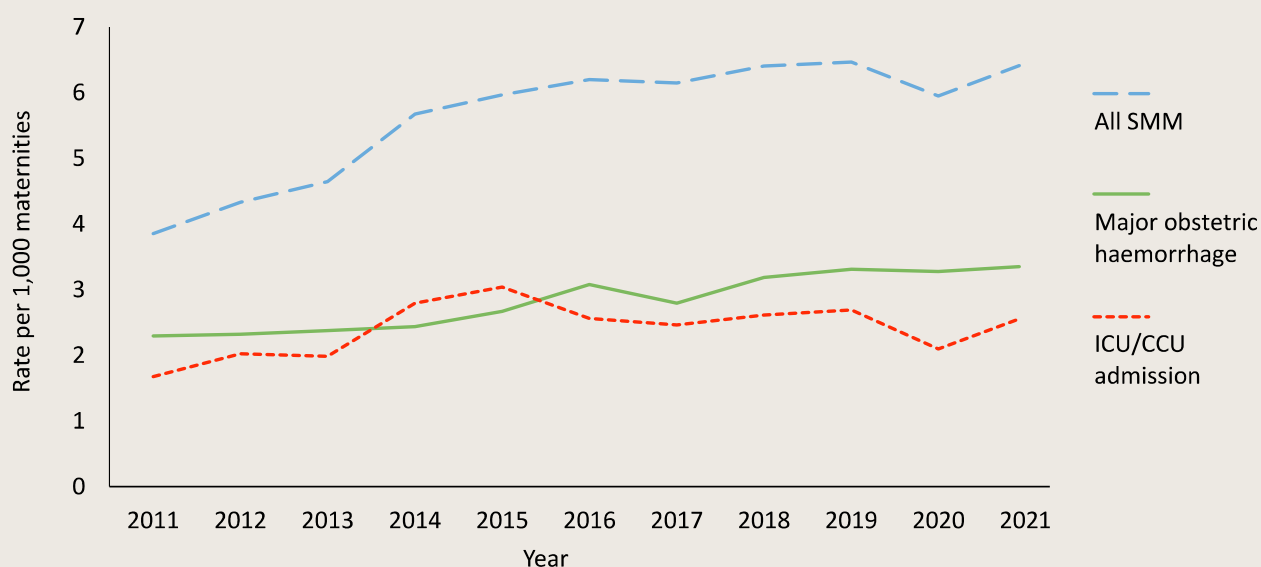


Figure 2: Trend in the rate of severe maternal morbidity (SMM), major obstetric haemorrhage and intensive care unit/coronary care unit (ICU/CCU) admission, 2011-2021

COVID-19 and Severe Maternal Morbidity 2021

The COVID-19 pandemic reached Ireland on the 29th of February 2020 and within three weeks, cases had been reported across the Island of Ireland. While ICU admission related to COVID-19 infection in pregnant or recently pregnant women were reported in just 4 cases in the 2020 NPEC SMM audit, this was in stark contrast to findings in this report.

In the reporting year 2021, a severe ‘third and fourth wave’ of the COVID-19 pandemic affected Ireland when the virulent variants of concern (Alpha- B.1.1.7 and Delta) were found to impact on maternal and fetal wellbeing.^{14, 15, 16} In the Irish context, from the 1st March 2020 to December 2021, the majority of admissions to ICU in pregnant and postpartum women occurred between January and December 2021.¹³ No maternal deaths were reported among this cohort.

Pregnant women have an increased risk of severe COVID-19 related illness compared to non-pregnant population. This was especially true for women in the third trimester. Increased risks include ICU admission, mechanical ventilation and receiving extracorporeal membrane oxygenation (ECMO).¹⁷

In this NPEC 2021 SMM audit, 35 women were reported as experiencing a COVID-19 related illness or COVID-19 respiratory disease. Of these 35 cases all but 1 woman were cared for in ICU and the length of stay in ICU ranged from 1 to 60 days (M=16, SD=18.5; Table 6.2). One woman not cared for in ICU was admitted to a HDU in a general hospital for non-invasive respiratory support.

Of the 34 women experiencing COVID-19 admitted to ICU, the majority were pregnant at time of admission (n=23, 67.6%), eleven (32.4%) were admitted on day of delivery of which ten women gave birth in a general hospital in Dublin without a co-located maternity unit onsite. One

woman was admitted during the postpartum period. All but two births resulted in live born infants. Of note neither of the two stillbirths were due to SARS-CoV-2 placentitis, as defined in Fitzgerald and O’Donoghue et al (2022).¹⁵

Among these 34 women admitted to ICU, over half (23, 67.6%) required advanced respiratory support and 4 women (11.4%) required ECMO thus indicating the severity of illness due to COVID-19 among this cohort and the requirement for higher levels of care in ICU settings outside the maternity units.

Table 6.2: Characteristics of ICU admissions in pregnant or recently pregnant women experiencing COVID-19 infection in 2021, (n=35).

	Mean (SD)
Length of stay in ICU (days) need to put range here is important	16 (18.5)
Maternal age (years)	32.6 (5.4)
Maternal BMI (kg/m ²)	31.4 (6.04)
Gestational age at delivery (weeks)	34.7 (6.7)
Gestational age at admission	31.2 (5.4)
	n (%)
Timing of ICU admission*	
Pregnant	23 (67.6%)
Same day of delivery	11 (32.4%)
Post-partum	1 (2.9%)
Ethnicity**	
White Irish	16 (47.0%)
Other white	9 (26.5%)
Asian	5 (14.7%)
Black	2 (5.9%)
Other mixed	2 (5.9%)
Acute Respiratory dysfunction requiring invasive ventilation	23 (65.7%)
Received ECMO	4 (11.4%)
Level of care	
Level 2	9 (25.7%)
Level 3	26 (74.3%)
Neonatal outcome	
Stillbirth	2 (5.7%)
Liveborn	33 (94.3%)

*One woman was admitted, antenatally, to HDU in general hospital.

**Ethnicity unknown for one individual

¹⁴Pregnant and Post-Partum women admitted to Intensive Care with confirmed COVID-19 infection - 1st March 2020 to 31st December 2021. HSE. EPI INSIGHT. Vol 24 Issue 2/ February 2023.

Available at <https://hdsc.newsweaver.ie/4otaa688p3/9cyikgz9vnz?lang=en&a=1&p=61280241&t=3130294>

¹⁵Dwyer, R., et al., NOCA Report on ICU Activity During COVID-19 Pandemic, Ireland, NOCA and ICU-BIS, 2021

¹⁶Fitzgerald, B. O’Donoghue, K., McEntagart, N., Gillan, J.E., Kelehan, P., et al., Fetal Deaths Due to SARS-CoV-2 Placentitis caused by SARS-CoV-2 Alpha, Arch Pathol Lab Med, Vol 146, May 2022

¹⁷Knight M, Bunch K, Vousden N, et al. Characteristics and outcomes of pregnant women admitted to hospital with confirmed SARS-CoV-2 infection in UK: national population based cohort study. BMJ. 2020;369:m2107 doi:10.1136/bmj.m2107

Trends in renal or liver dysfunction

The infrequency of some specific SMMs, such as renal or liver dysfunction, compared to MOH and ICU/CCU admission makes it difficult to assess time trends based on the annual rate. However, the time period of the SMM audit is long enough to allow their time trend to be examined by triennium. The 69 cases of renal or liver dysfunction reported in 2011-2013 gave a rate of 0.35 per 1,000 maternities. The rate of reported cases increased steadily, doubling to 0.70 per 1,000 by 2015-2017. Since then, the rate has decreased somewhat to 0.53 per 1,000 maternities in 2021 (Table 7).

Table 7: Incidence of renal or liver dysfunction in Ireland, 2011-2021

Triennium	Maternities	Renal/liver dysfunction	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011-13	196,445	69	0.35 (0.27-0.44)	1.00 (ref.)	---
2012-14	191,439	82	0.43 (0.34-0.53)	1.22 (0.89-1.68)	0.225
2013-15	186,752	104	0.56 (0.46-0.67)	1.59 (1.17-2.15)	0.003
2014-16	183,096	117	0.64 (0.53-0.77)	1.82 (1.35-2.45)	<0.001
2015-17	182,394	128	0.70 (0.59-0.83)	2.00 (1.49-2.68)	<0.001
2016-18	182,489	115	0.63 (0.52-0.76)	1.79 (1.33-2.42)	<0.001
2017-19	178,055	114	0.64 (0.53-0.77)	1.82 (1.35-2.46)	<0.001
2018-20	172,856	97	0.56 (0.46-0.68)	1.60 (1.17-2.18)	0.003
2019-21	172,217	92	0.53 (0.43-0.66)	1.52 (1.11-2.08)	0.008

Note: Rate ratios compare the rate for each triennium against the rate for the baseline triennium 2011-13. P-values assess the statistical significance of the difference between the rate for each triennium and the rate for 2011-13. Poisson 95% confidence intervals were calculated for the rate and rate ratios. Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI = confidence interval.

Trends in peripartum hysterectomy (PH)

In the early years of this national audit, there was a consistent rate of peripartum hysterectomy of approximately 0.33 per 1,000 maternities. This is equivalent to one in every 3,000 women experiencing a peripartum hysterectomy. The rate has increased in recent years and in 2019-2021 it was 42% higher than in 2011-2013, at 0.47

per 1,000. This indicates that approximately one in every 2000 women giving birth in Ireland experience a peripartum hysterectomy (Table 8).

This Irish rate is marginally higher than the rate reported in earlier studies in the United Kingdom (0.41 per 1,000 births)¹⁸ but it is lower than the rate reported in the USA and Australia (0.82 per 1,000 and 0.85 per 1,000 respectively).^{19, 20}

¹⁸ 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 (1); 97-105

¹⁹ Bateman BT, Mhyre JM, Callaghan WM, Kuklina EV. Peripartum hysterectomy in the United States: nationwide 14 year experience. *Am J Obstet Gynecol* 2012;206(1):63-8.

²⁰ Awan N, Bennett MJ, Walters WA. Emergency peripartum hysterectomy: a 10- year review at the Royal Hospital for Women, Sydney. *Aust N Z J Obstet Gynaecol* 2011;51(3):210-5.

Table 8: Incidence of peripartum hysterectomy in Ireland, 2011-2021

Triennium	Maternities (n)	Peripartum hysterectomy (n)	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011-13	196,445	65	0.33 (0.26-0.42)	1.00 (ref.)	---
2012-14	191,439	63	0.33 (0.25-0.42)	0.99 (0.70-1.41)	0.975
2013-15	186,752	57	0.31 (0.23-0.40)	0.92 (0.65-1.32)	0.656
2014-16	183,096	64	0.35 (0.27-0.45)	1.06 (0.75-1.49)	0.755
2015-17	182,394	76	0.42 (0.33-0.52)	1.26 (0.90-1.75)	0.172
2016-18	182,489	88	0.48 (0.39-0.59)	1.46 (1.06-2.01)	0.021
2017-19	178,055	89	0.50 (0.40-0.62)	1.51 (1.10-2.08)	0.011
2018-20	172,856	84	0.49 (0.38-0.60)	1.47 (1.06-2.03)	0.020
2019-21	172,217	81	0.47 (0.37-0.58)	1.42 (1.03-1.97)	0.035

Note: Rate ratios compare the rate for each triennium against the rate for the baseline triennium 2011-13. P-values assess the statistical significance of the difference between the rate for each triennium and the rate for 2011-13. Poisson 95% confidence intervals were calculated for the rate and rate ratios. Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI= confidence interval.

Of the 25 women who required a peripartum hysterectomy in 2021, 84% (n=21) occurred in 4 large tertiary referral units of which 7 were reported in women following in-utero transfer. A further 6 of the 25 PH were performed across 4 smaller maternity units.

PAS, formerly known as morbidly adherent placenta (MAP), is a recognised risk factor for peripartum hysterectomy.^{21, 22} A study conducted by the NPEC confirmed the established association between previous caesarean section (CS), MAP and PH. In this 2021 SMM audit, PAS, was the most commonly reported indication for PH (n=16/25, 64.0%), followed by MOH with a blood loss $\geq 2.500\text{ml}$ due to uterine atony (n=4/25, 16.0%) and placenta praevia (n=3/25, 12.0%). A further two cases were associated with cervical cancer.

All of the PHs in 2021 involved birth by CS (n=25) and most of the women had a previous CS (n=20, 80%).

In this SMM audit between 2018-2021, a total of 108 PHs were reported. PAS was the most reported indication for PH (82/108, 75.9%), followed by MOH with a blood loss $\geq 2.500\text{ml}$ (16/108, 14.8%). Further indications for PH included placenta praevia (n=3), infection (n=2), cervical cancer (n=1), PPH $< 2,500\text{ml}$ (n=1), a large necrotic fibroid (n=1) among others. The vast majority of PHs between 2018-2021 involved birth by CS (n=100, 92.6%) and most of the women had a previous CS (n=87, 80.6%). Considering the increasing caesarean section rate, this underscores the value of research on the incidence and risk factors associated with PAS. Research on PAS is underway and a national guideline on the diagnosis and management of 'Placenta Accreta Spectrum' was published in 2022.²³

²¹Kallianidis AF, Maraschini A, Danis J, Colmorn LB, Deneux-Tharaux C, Donati S, et al. Epidemiological analysis of peripartum hysterectomy across nine European countries. 2020; 99(10):1364-73.

²²Campbell, 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

²³Bartels H. et al. National Clinical Practice Guideline: Diagnosis and Management of Placenta Accreta Spectrum. National Women and Infants Health Programme and The Institute of Obstetricians and Gynaecologists. January 2023.

Trends in pulmonary embolism

The incidence of reported cases of pulmonary embolism (PE) has increased by 66% over the years of the SMM audit (Table 9). The rate of 0.24 per 1,000 maternities in 2011-2013 indicates that one woman in approximately 4,000 experienced PE. The rate of 0.41 per 1,000 indicates that in 2019-2021 one woman in approximately 2,500 experienced PE.

Recent reports on maternal mortality in Ireland and the UK have identified thrombosis/thromboembolism as a leading direct obstetric

cause of maternal death.^{24, 25} At 0.41 per 1,000 maternities, the incidence of PE in Ireland was approximately three times higher than the reported rate in the UK (0.14 per 1,000 maternities). Notwithstanding, we believe the Irish rate reported here may represent an underestimate as many postpartum cases of PE will be unknown to maternity units because the women would present to general hospitals in the postnatal period. Previous research has shown that thrombosis has been the main cause of direct maternal mortality in Ireland in past years with one death due to thrombosis for every 35 cases of pulmonary embolism.²⁶

Table 9: Incidence of pulmonary embolism in Ireland, 2011-2021

Triennium	Maternities (n)	Pulmonary embolism (n)	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011-13	196,445	48	0.24 (0.18-0.32)	1.00 (ref.)	---
2012-14	191,439	53	0.28 (0.21-0.36)	1.13 (0.77-1.67)	0.531
2013-15	186,752	49	0.26 (0.19-0.35)	1.07 (0.72-1.60)	0.726
2014-16	183,096	55	0.30 (0.23-0.39)	1.23 (0.83-1.81)	0.296
2015-17	182,394	63	0.35 (0.27-0.44)	1.41 (0.97-2.06)	0.071
2016-18	182,489	69	0.38 (0.29-0.48)	1.55 (1.07-2.24)	0.020
2017-19	178,055	72	0.40 (0.32-0.51)	1.65 (1.15-2.38)	0.007
2018-20	172,856	68	0.39 (0.31-0.50)	1.61 (1.11-2.33)	0.012
2019-21	172,217	70	0.41 (0.32-0.51)	1.66 (1.15-2.40)	0.007

Note: Rate ratios compare the rate for each triennium against the rate for the baseline triennium 2011-13. P-values assess the statistical significance of the difference between the rate for each triennium and the rate for 2011-13. Poisson 95% confidence intervals were calculated for the rate and rate ratios. Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI = confidence interval.

The NPEC Severe Maternal Morbidity Group have endeavoured to develop a 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 and the use of the radiology systems was investigated but did not

provide a good evidence base. As part of the NPEC triennial topic-specific audit series (2017-2019), a detailed audit of women presenting to Irish maternity units with a diagnosis of PE during pregnancy or within 42 days of the pregnancy end was carried out. Findings from this audit will be presented in a future separate report in 2023.

²⁴Knight M, Bunch K, Tuffnell D, Patel R, Shakespeare J, Kotnis R, Kenyon S, Kurinczuk JJ (Eds.) on behalf of MBRRACE-UK. Saving Lives, Improving Mothers' Care - Lessons learned to inform maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2017-19. Oxford: National Perinatal Epidemiology Unit, University of Oxford 2021.

²⁵O'Hare MF, Manning E, Corcoran P, Greene RA on behalf of MDE Ireland. Confidential Maternal Death Enquiry in Ireland, Report for 2018 - 2020. Cork: MDE Ireland, November 2022.

²⁶Leitao S, Manning E, Greene RA, Corcoran P; Maternal Morbidity Advisory Group.* Maternal morbidity and mortality: an iceberg phenomenon. BJOG. 2022 Feb;129(3):402-411. doi: 10.1111/1471-0528.16880.

Trends in septicaemic shock

The reported incidence of septicaemic shock was low at the start of the SMM audit. Eight cases were reported in the first two years but sixteen were reported in 2013. Even then, the rate for 2011-2013 was just 0.12 per 1,000 maternities. This increased rapidly and the 80 cases reported in 2014-2016 gave a rate of 0.44 per 1,000, more than three times the rate reported for 2011-2013.

The apparent increase in reported cases in this triennium may reflect an increased awareness of sepsis following the introduction of guidelines on sepsis and the implementation of the Irish Maternity Early Warning System.^{27, 28} Since then, the rate has decreased to 0.28 per 1,000 in 2019-2021 though this is still more than twice the rate reported for 2011-2013 (Table 10).

Table 10: Incidence of septicaemic shock in Ireland, 2011-2021

Triennium	Maternities (n)	Septicaemic shock (n)	Rate (95% CI)	Rate ratio (95% CI)	P-value
2011-13	196,445	24	0.12 (0.08-0.18)	1.00 (ref.)	---
2012-14	191,439	41	0.21 (0.15-0.29)	1.75 (1.06-2.90)	0.029
2013-15	186,752	68	0.36 (0.28-0.46)	2.98 (1.87-4.75)	<0.001
2014-16	183,096	80	0.44 (0.35-0.54)	3.58 (2.27-5.64)	<0.001
2015-17	182,394	71	0.39 (0.30-0.49)	3.19 (2.01-5.06)	<0.001
2016-18	182,489	59	0.32 (0.25-0.42)	2.65 (1.65-4.25)	<0.001
2017-19	178,055	50	0.28 (0.21-0.37)	2.30 (1.41-3.74)	<0.001
2018-20	172,856	54	0.31 (0.23-0.41)	2.56 (1.58-4.14)	<0.001
2019-21	172,217	48	0.28 (0.21-0.37)	2.28 (1.40-3.72)	<0.001

Note: Rate ratios compare the rate for each triennium against the rate for the baseline triennium 2011-13. P-values assess the statistical significance of the difference between the rate for each triennium and the rate for 2011-13. Poisson 95% confidence intervals were calculated for the rate and rate ratios. Maternities figure is the national number of women who gave birth in hospital based on HIPE data with the maternities in one non-participating unit excluded for 2011, 2012, 2014 and 2015. CI= confidence interval.

The frequency of the specific SMMs renal or liver dysfunction, peripartum hysterectomy, PE and septicaemic shock are relatively similar and the trend in their incidence by triennium is illustrated in Figure 3. Distinctive trends are evident for each of these SMMs. This includes the significant rise and subsequent gradual decrease in the reported incidence of renal or liver dysfunction, the steady increases in the rate of both peripartum hysterectomy and of PE and the sharp increase in septicaemic shock reported at the start of the decade followed by a steady decrease.

Eclampsia, uterine rupture and intervention radiology

Trends over time cannot be assessed for the incidence of eclampsia, uterine rupture and intervention radiology given the relatively small number of cases with an annual average of 8-10 for each SMM. However, based on the most recent five-year period, 2017-2021, from a total of 292,289 maternities in the country's 19 maternity units, 50 cases of eclampsia, 51 cases of uterine rupture and 39 cases of intervention radiology were reported. This gives a rate of eclampsia of 0.17 per 1,000 maternities, which is lower than reported for the UK (0.27 per 1,000 maternities) and Netherlands (0.54 per 1,000 maternities).²⁹ The Irish rate of uterine rupture for 2017-2021 was 0.17 per 1,000. This is low considering that a recent study of nine European countries reported national rates ranging from 0.16 to 0.78 per 1,000 deliveries.³⁰

²⁷<https://www.hse.ie/eng/services/publications/clinical-strategy-and-programmes/sepsismanagement.pdf>

²⁸<https://www.hse.ie/eng/services/publications/clinical-strategy-and-programmes/imews-guidelines.pdf>

²⁹Schaap, T. P., et al. Eclampsia, a comparison within the International Network of Obstetric Survey Systems. BJOG. 2014; 121(12): 1521-1528.

³⁰Vandenberghe, G., et al. The INOSS study of uterine rupture: a descriptive multi country population based study. BJOG: Int J Obstet Gy. 2019;126:370-381.

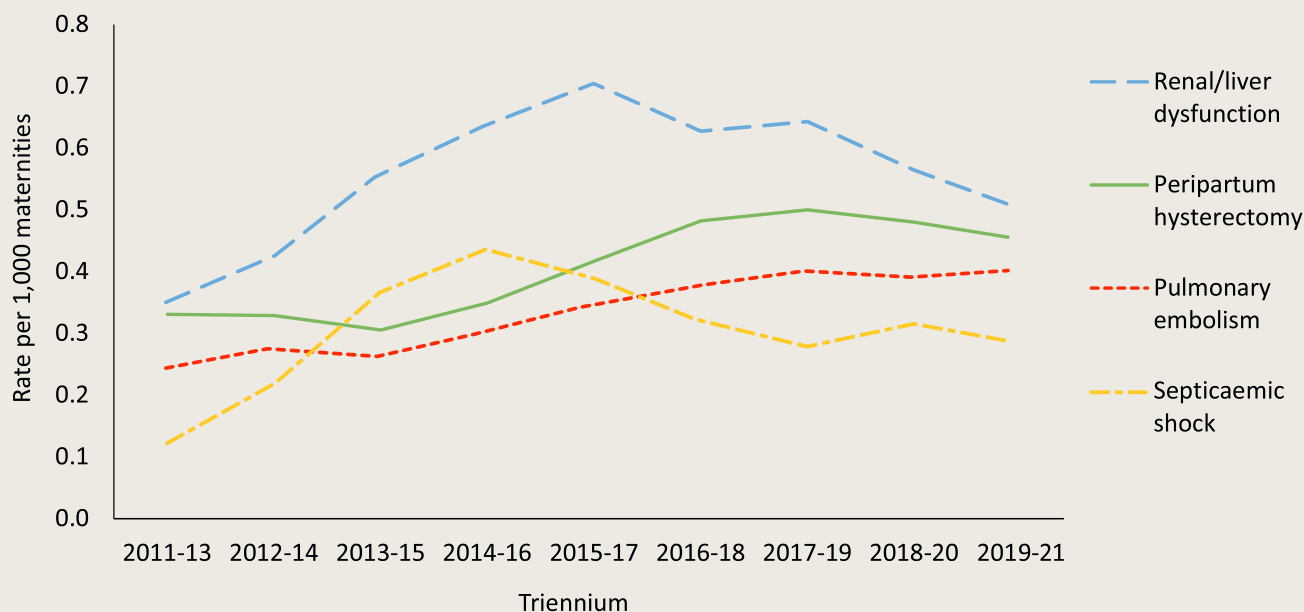


Figure 3: Trend in the rate of renal or liver dysfunction, peripartum hysterectomy, pulmonary embolism and septicaemic shock, 2011-2021

Robson Ten Group Classification System

The Robson Ten Group Classification System (TGCS) is a method of providing a common starting point for further detailed analysis within which all perinatal outcomes can be measured and compared. The system classifies all pregnant women into one of 10 groups that are mutually exclusive and, as a set, totally comprehensive (see Appendix G).³¹ The groups are based on five basic obstetric characteristics that are routinely collected for all maternities: parity, gestational age, onset of labour, fetal presentation and number of fetuses. The NPEC and the Irish Maternity Indicator System (IMIS) worked together to consolidate the data collection of Robson TGCS.

There were 58,248 maternities classified by the Robson TGCS. The incidence of MOH (due to an estimated blood loss of $\geq 2,500$ ml and/or a transfusion of five or more units of blood) is detailed in Table 11. The MOH rate was 3.29 per 1,000 maternities. Notwithstanding the relatively small numbers involved when examined by TGCS,

there was evidence of increased risk of MOH in Group 8 (women with multiple pregnancies including previous CS) and in Group 10 (all singleton, cephalic and < 37 weeks gestational age at delivery, including previous CS).

This year we examined the data by mode of delivery. We can see from the table below the break down for spontaneous vaginal delivery (SVD), CS and assisted delivery. Examining the MOH data by TGCS and mode of delivery draws one's attention to specific groups that may need additional elements for further investigation.

³¹Robson M et al. The 10-Group Classification System (Robson classification), induction of labor, and cesarean delivery. International Journal of Gynecology and Obstetrics. 2015;131: S23-S27

Table 11: Incidence of major obstetric haemorrhage (MOH) by the Ten Group Classification System (TGCS), 2021

Group	Group description	Maternities	MOH Cases*		Mode of delivery		
			N	Rate	SVD N%	Assisted Delivery N(%)	C section N(%)
All		58,248	192	3.29 (2.84-3.76)	64(33.3)	31(16.1)	97(50.4)
1	Nulliparous, singleton, cephalic, ≥ 37 spontaneous labour	8,229	21	2.55 (1.57-3.90)	7(3.6)	10(5.2)	4(2.1)
2	Nulliparous, singleton, cephalic, ≥ 37 induced or elective CS	11,648	39	3.34 (2.38-4.57)	11(5.7)	15(7.8)	13(6.8)
3	Multiparous (excluding previous CS), singleton, cephalic, ≥ 37 spontaneous labour	11,846	25	2.11 (1.36-3.11)	22(11.5)	1(0.5)	2(1.0)
4	Multiparous (excluding previous CS), singleton, cephalic, ≥ 37 induced or elective CS	10,774	28	2.59 (1.72-3.75)	16(8.3)	1(0.5)	11(5.7)
5	Previous CS, singleton, cephalic, ≥ 37 induced or elective CS	9,808	34	3.46 (2.40-4.84)	6(3.2)	2(1.0)	26(13.5)
6	All nulliparous women with a single breech pregnancy	1,183	1	0.84 (0.02-4.70)	0(0)	0(0)	1(0.5)
7	All multiparous breech (including previous CS)	1,159	7	6.03 (2.42-12.44)	1(0.5)	0(0)	6(3.1)
8	All multiple pregnancies (including previous CS)	1,059	12	11.33 (5.85-19.79)	0(0)	2(1.1)	10(5.2)
9	All women with a single pregnancy with a transverse or oblique lie, including women with previous uterine scars	256	4	15.62 (4.25-40.00)	0(0)	0(0)	4(2.1)
10	All singleton, cephalic, < 37 (including previous CS)	2,409	21	8.71 (5.39-13.32)	1(0.5)	0(0)	20(10.4)

For the total number of maternities for three units' data was used from their 2020 data submission. Note: Rate per 1,000 maternities. CI=95% confidence interval. Exact Poisson 95% confidence intervals were calculated. SVD= Spontaneous Vaginal Delivery; CS = Caesarean section. TGCS Group could not be determined for 7 women % were calculated= $n/\text{total cases}$.

Variation in rates by maternity unit

Variation in the SMM rate in 2021 across the 19 Irish maternity units is illustrated in the funnel plot in Figure 4. A diagrammatic aid outlining the interpretation of a funnel plot in the context of the findings of this audit in 19 maternity units is detailed in the methods section of this report (Figure IV; page 14). Differences in rates 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. The NPEC disseminates unit specific reports to all maternity units, thus informing them of their SMM rates with reference to the national annual rate and trend data over time.

Figure 4 shows that one unit had an SMM rate above the 99.8% upper limit, with a rate that was more than twice the national rate (15.15 vs. 6.34

per 1,000 maternities). Another unit had a rate below the 99.8% lower limit; the national rate was three times higher than the rate for this unit (6.34 vs. 2.15 per 1,000 maternities). One unit recorded an SMM rate between the upper 95% and the upper 99.8% limit at 10.83 per 1,000 maternities.

The funnel plot in Figure 5 illustrates the variation in the SMM rate by maternity unit after exclusion of the 61 cases admitted to an ICU/CCU with no other SMM experienced as defined in this audit. Variation in SMM rate across the maternity units was reduced after this adjustment. The adjusted national SMM rate was 5.31 per 1,000 maternities.

The plot shows that one unit had an adjusted SMM rate just above the upper 99.8% limit, which makes this unit a statistical outlier according to the criteria for the National Office of Clinical Audit (NOCA) escalation.³² The rate of another unit was between the upper 95% and 99.8%

³²NOCA (2021) PRO 18 Monitoring of statistical outliers in national clinical audit and registries. Available on request.

limits, however, this was not a statistical outlier according to the NOCA criteria because it was not in this range in the previous year. One unit had a rate between the lower 95% and 99.8% for the

reporting years 2021 and 2020. In line with the NOCA escalation policy, senior management in this unit has been informed that it is a statistical outlier for SMM.

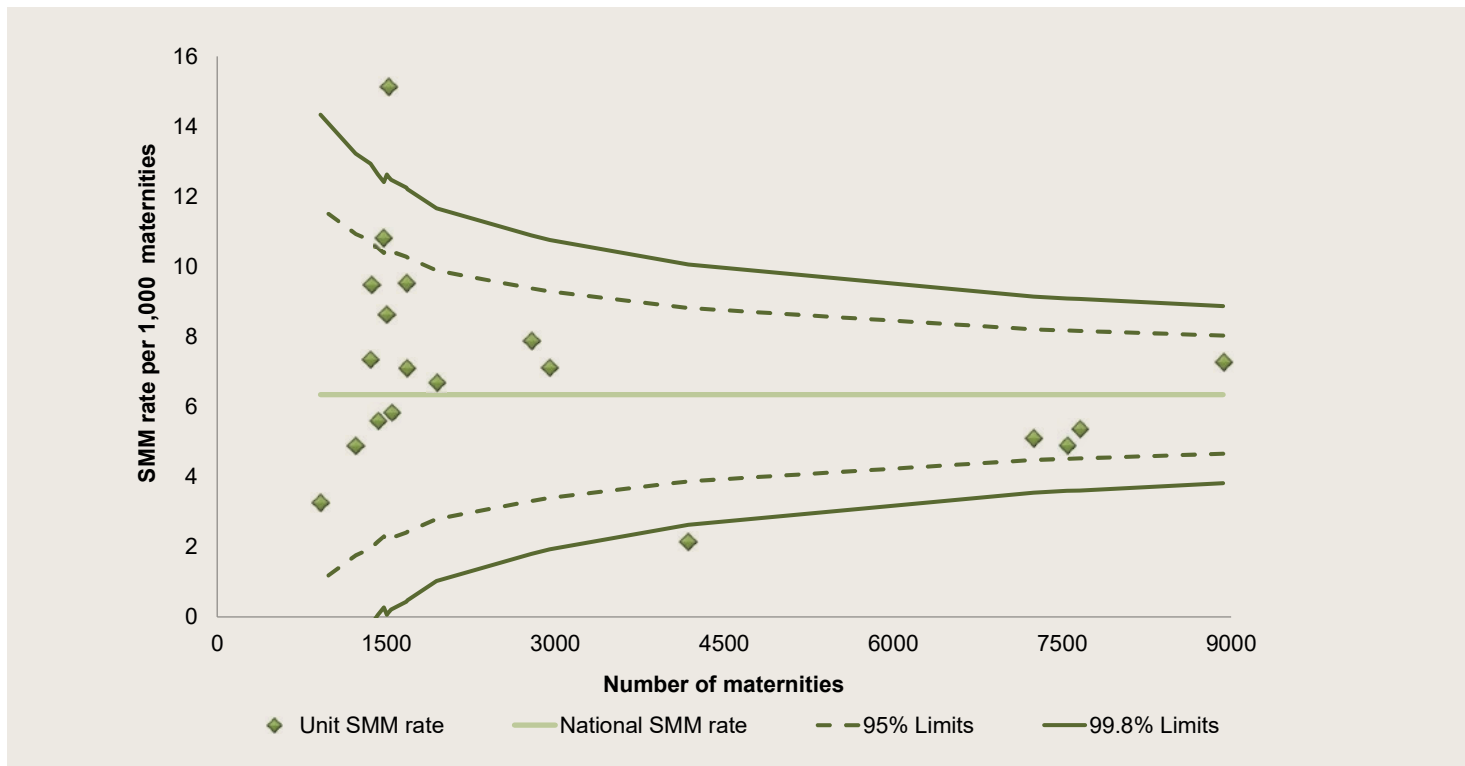
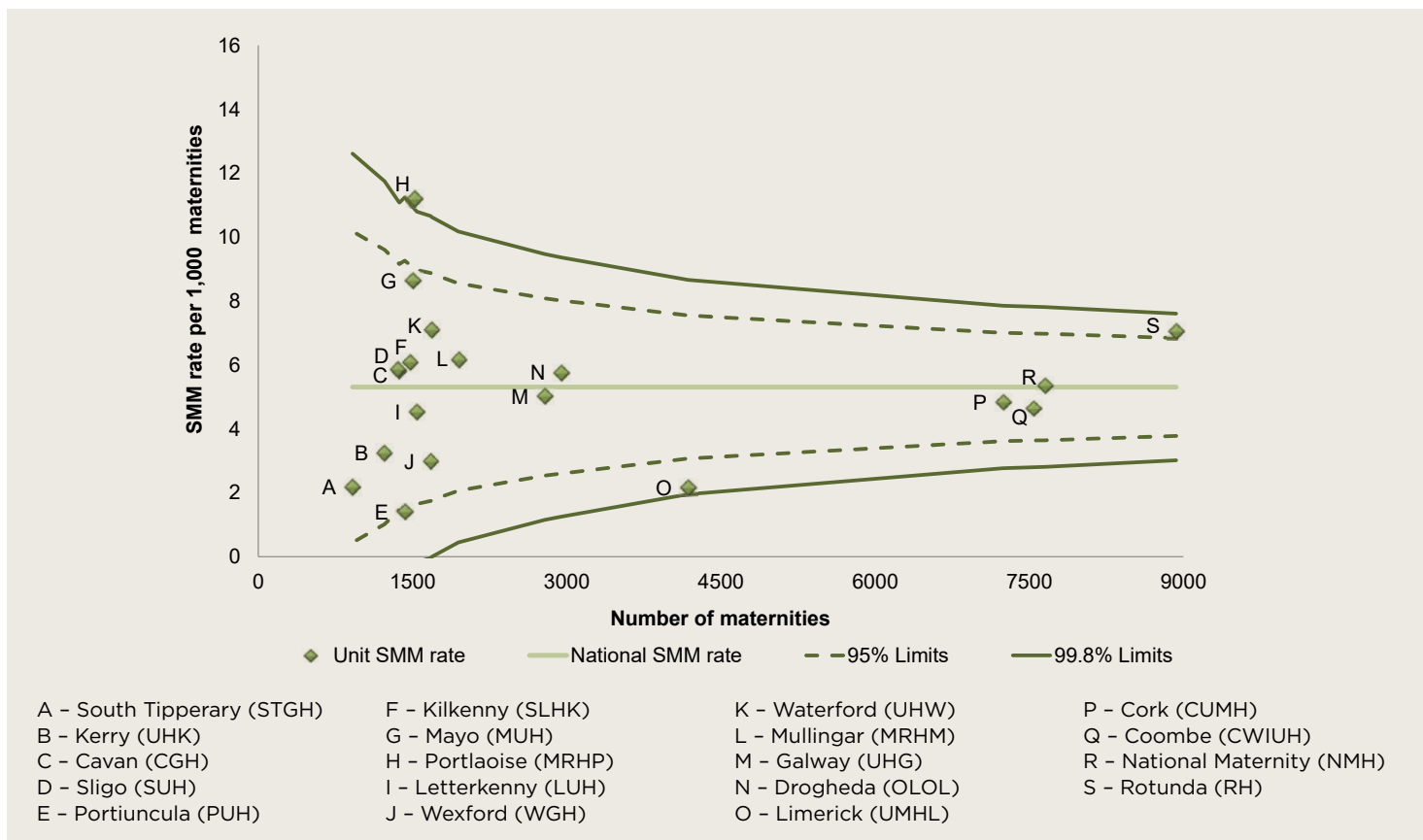


Figure 4: Funnel plot of the rate of severe maternal morbidity (SMM) by maternity unit, 2021



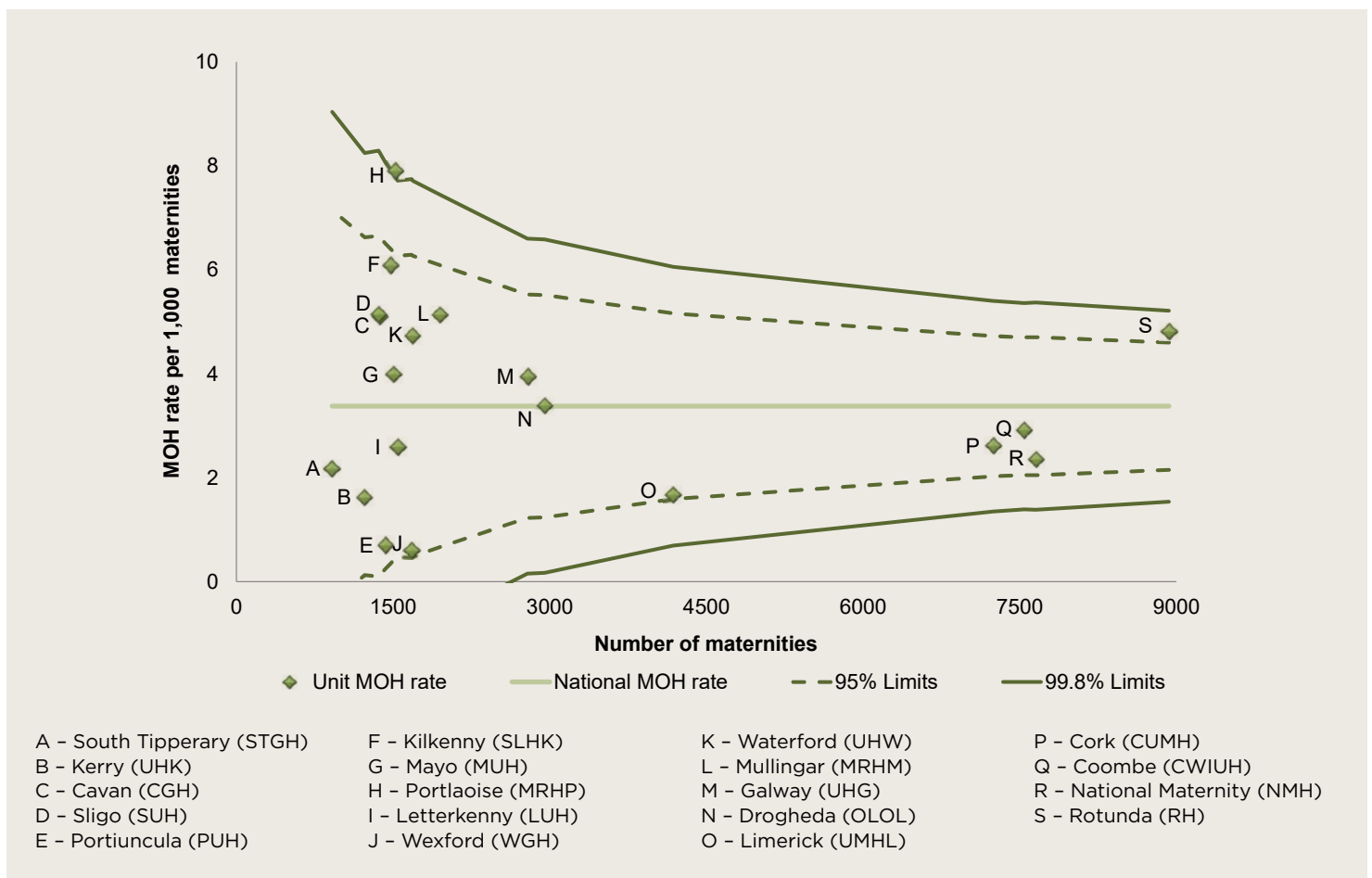
*Please see full hospital names in Appendix I

Figure 5: 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, 2021

Figure 6 illustrates the variation across the country's 19 maternity units in the rate of MOH due to an estimated blood loss of at least 2,500ml and/or a transfusion of five or more units of blood. In 2021, all but two of the maternity hospitals had an MOH rate within the 95% confidence limits. One exception had a rate just above the upper 99.8% confidence limit and was therefore considered a statistical outlier and the other had an MOH rate between the upper 95% and 99.8% confidence limits but this unit's MOH rate was not in this range in 2020 and, consequently, was not deemed to be an outlier. In line with the NOCA escalation policy, senior management in the outlying unit has been informed that it is a statistical outlier for MOH

and are working with the NPEC and NWIHP through the Post partum Haemorrhage Quality Improvement Initiative (PPHQII) in developing a toolkit for reviewing their PPH cases.

Variances in rates of MOH between units may reflect variances in practices of estimating blood loss. We have previously recommended that a standardised quantitative approach, involving volume and weight assessment to estimate blood loss, should be considered for use in all maternity units and that development of a national toolkit would assist standardisation of such an approach.^{33, 34} This is currently being addressed by the national PPHQII which aims to evaluate and standardise the management of PPH.³⁵



*Please see full hospital names in Appendix I

Figure 6: Funnel plot of the rate of major obstetric haemorrhage (MOH) by maternity unit, 2021

³³Manning E, Leitao S, Corcoran P, McKernan J, de Foubert P, Greene RA, on behalf of the Severe Maternal Morbidity Group. Severe Maternal Morbidity in Ireland Annual Report 2016. Cork: National Perinatal Epidemiology Centre, 2018

³⁴Leitao S, Manning E, Corcoran P, Greene RA on behalf of the Severe Maternal Morbidity Group. Severe Maternal Morbidity in Ireland Annual Report 2017. Cork: 2019.

³⁵Post Partum Haemorrhage Quality Improvement Initiative (PPHQII), Available at: pphqii@ucc.ie

Maternal characteristics

Age

Maternal age was recorded for all the 374 cases of severe maternal morbidity (SMM) in 2021 and ranged from 15 to 48 years (mean=33.8 years, SD=5.6 years). The age distribution of women who experienced SMM in 2018-2021 is detailed in Table 12. In 2021, the women's age profile was

broadly similar to the population of women who gave birth. However, women in the younger age groups were under-represented among those who experienced SMM (47.6% of SMM cases were aged <35 years vs. 59.4% of all maternities) so women aged at least 35 years were over-represented (52.4% vs. 40.6%).

Table 12: Age distribution of women who experienced severe maternal morbidity (SMM), 2018-2021

Age group	SMM 2018 (N=401)	SMM 2019 (N=375)	SMM 2020 (N=329)	SMM 2021 (N=374)	All maternities 2021**
<20yrs	7(1.7)	5(1.3)	3(0.9)	7(1.9)	1.2%
20-24yrs	30(7.5)	22(5.9)	20(6.1)	18(4.8)	7.1%
<25yrs*	37 (9.2)	27 (7.2)	23 (7.0)	25 (6.7)	8.3%
25-29yrs	47(11.7)	66(17.6)	42(12.8)	47(12.6)	16.3%
30-34yrs	123(30.6)	108(28.8)	103(31.3)	106(28.3)	34.8%
35-39yrs	137(34.1)	120(32.0)	116(35.3)	148(39.6)	32.3%
≥40yrs	57(14.2)	54(14.4)	45(13.7)	48(12.8)	8.3%

Note: Values are shown as n (%) unless otherwise stated. *Represents the sum of the data detailed in the two rows above (<20yrs and 20-24yrs). **Data for all maternities based on Hospital In-Patient Enquiry data provided by the Healthcare Pricing Office.

Previous pregnancy

Previous early pregnancy loss was reported for over one-third of the women who experienced SMM in 2021 (37.5%, 140 of 373, unknown for one woman). Twenty one women (5.6%) had previously experienced three or more pregnancies that ended before 24 weeks' gestation.

Thirty eight percent (n=142) of the women who experienced an SMM in 2021 were nulliparous

which is similar to previous years and similar to the percentage of nulliparous women among all maternities in 2021 (Table 13). Women with one previous completed pregnancy were under-represented among SMM cases relative to the population of women who gave birth in 2021 (30% vs. 35%) whereas women with at least three previous completed pregnancies were over-represented among those who experienced SMM (12% vs. 9%).

Table 13: Parity for women who experienced severe maternal morbidity (SMM), 2018-2021

Parity	SMM 2018 (N=401)	SMM 2019 (N=375)	SMM 2020 (N=329)	SMM 2021 (N=374)	All maternities 2021*
Nulliparous	152(37.9)	159(42.4)	133(40.4)	142(38.0)	38.2%
Para 1	113(28.2)	102(27.2)	84(25.5)	112(29.9)	35.2%
Para 2	72(18.0)	59(15.7)	58(17.6)	75(20.1)	18.0%
Para 3+	64(16.0)	55(14.7)	54(16.4)	45(12.0)	8.6%

Note: Values are shown as n (%) unless otherwise stated. *Data for all maternities based on Hospital In-Patient Enquiry data provided by the Healthcare Pricing Office.

Body mass index

Body mass index (BMI) for the women who experienced SMM in 2021 ranged from 17.9 to 53.1 kg/m². BMI was not known for 19 (5.8%) of the women.

Approximately one third of the women who experienced SMM in 2021 had a BMI in the healthy range (35%), 27% were overweight and 36% had obesity (Table 14). In comparison to data from previous years, this represented an increase in the proportion of women with SMM who suffered from obesity: from 24.9% in 2019 to 33.2% in 2020 and 35.8% in 2021. A slight decrease was noticed in the proportion of women experiencing a SMM

who were overweight (from 32.9% in 2019 to 30% in 2020 and 26.8% in 2021) and who had a healthy BMI (from 40.5% in 2019 to 36.5% in 2020 and 34.6% in 2021).

It was also observed that of the total number of women experiencing two or more SMMs in 2021, a higher proportion (65.7%) were overweight or had obesity.

As shown in Table 14, women in the lean and overweight BMI category were underrepresented among SMM cases and women in the obese category were over represented relative to the population of women who gave birth in 2021 (35.8% with SMM vs 21.1% in population).

Table 14: Body mass index (BMI) for women who experienced SMM, 2021

BMI category (kg/m ²)	SMM 2019 (N=353)*	SMM 2020 (N=310)*	SMM 2021 (N=355)*	Maternities (2021)
Underweight (<18.5)	6(1.7)	1(0.3)	10(2.8)	-
Healthy (18.5-24.9)	143(40.5)	113(36.5)	123(34.6)	-
*Lean (<25)	149(42.2)	114(36.8)	133(37.4)	48.2%
Overweight (25.0-29.9)	116(32.9)	93(30.0)	95(26.8)	30.7%
Obese (≥30.0)	88(24.9)	103(33.2)	127(35.8)	21.1%

Note: BMI was not known for 22 women who experienced SMM in 2019, 19 women in 2020 and 19 women in 2021. Data on maternities by BMI were obtained for 31,476 women who gave birth or booked to give birth in one of the country's four large maternity hospitals. This is 54.3% of the 57,983 women who gave birth in hospital in 2019, according to HIPE data. We multiplied the BMI data on 31,476 women by 1.84 (i.e. 100%/54.3%) in order to estimate the national number of maternities by BMI category.

*Represents the sum of the data detailed in the two rows above (Underweight and Healthy).

BMI associated with specific SMMs

High BMI has been associated with maternal mortality and morbidity, in particular, morbidities such as pulmonary embolism, kidney disease and complications of anaesthetics.^{36, 37, 38, 39} The four most recent years of this clinical audit, 2018-2021, provide a sufficient number of cases to compare the risk of seven specific SMMs among women with high BMI compared to women with low BMI.

Women with a high BMI were at higher risk of all but one of the most common seven SMMs: major obstetric haemorrhage (MOH), ICU/CCU admission, renal or liver dysfunction, peripartum hysterectomy, pulmonary embolism, septic shock and acute respiratory disease (Table 15). Women with high BMI had approximately 50% higher risk of MOH, ICU/CCU admission and renal or liver dysfunction, almost twice the risk of peripartum hysterectomy and pulmonary embolism and more than twice the risk of acute respiratory dysfunction.

³⁶Rosenberg E, Sergienko R, Abu-Ghanem S, Wiznitzer A, Romanowsky I, Neulander EZ, Sheiner E. "Nephrolithiasis during pregnancy: characteristics, complications, and pregnancy outcome", *World journal of urology* 29, no 6 (2011): 743-7.

³⁷Knight M, UKOSS. Antenatal pulmonary embolism: risk factors, management and outcomes. *BJOG* 2008; 115 (4):453-461

³⁸Malinowski AK, Bomba-Opoń D et al. Venous thromboembolism in obese pregnant women: approach to diagnosis and management. *Polish Gynaecology*; 2017, vol. 88, Issue 8: 453-459

³⁹Beckett 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 15: Risk of specific severe maternal morbidities (SMMs) for women with high and low body mass index (BMI), 2018-2021

Morbidity	High BMI* n(%)	Low BMI** n(%)	High BMI* SMM risk (95% CI)	Low BMI** SMM risk (95% CI)	Rate ratio (95% CI)
Major obstetric haemorrhage	434(61.8)	268(38.2)	3.65 (3.31-4.01)	2.38 (2.10-2.68)	1.53 (1.32-1.79)
ICU/CCU admission	344(63.6)	197(36.4)	2.89 (2.59-3.21)	1.75 (1.51-2.01)	1.65 (1.39-1.97)
Renal or liver dysfunction	70(59.3)	48(40.7)	0.59 (0.46-0.74)	0.43 (0.31-0.56)	1.38 (0.96-2.00)
Peripartum hysterectomy	61(67.0)	30(33.0)	0.51 (0.39-0.66)	0.27 (0.18-0.38)	1.93 (1.24-2.98)
Pulmonary embolism	55(65.5)	29(34.5)	0.46 (0.35-0.60)	0.26 (0.17-0.37)	1.80 (1.15-2.82)
Septicaemic shock	24(43.6)	31(56.4)	0.20 (0.13-0.30)	0.27 (0.19-0.39)	0.73 (0.43-1.25)
Acute respiratory dysfunction	36(73.5)	13(26.5)	0.30 (0.21-0.42)	0.12 (0.06-0.20)	2.62 (1.39-4.95)

Note: *BMI in the overweight (25.0-29.9) or obese (≥ 30.0) category; **BMI in the underweight (<18.5) or healthy (18.5-24.9) category; ICU/CCU=Intensive care unit/Coronary care unit; SMM risk is per 1,000 maternities; Data on maternities by BMI were obtained for 33,221 women who gave birth or booked to give birth in seven of the country's 19 maternity hospitals/units in 2021, extrapolated to represent all maternities in 2018-2021; Risk ratio compares the risk of SMM among high BMI women relative to the risk among low BMI women.

Age, parity and body mass index

Below, the risk of SMM is examined separately by age, parity and BMI. Then the three factors are considered together to assess their mutually independent influence on the risk of SMM.

Advanced maternal age was associated with increased risk of SMM. Compared to women in their early thirties, risk of SMM was 40% higher among 35-39-year-olds and 66% higher among women aged at least 40 years after accounting for the influence of parity and BMI (Table 16).

Regarding parity, women with one previous completed pregnancy had the lowest risk of SMM. Compared to them, the risk was marginally higher among nulliparous women and women with two previous completed pregnancies but the risk was twice as high among women with three or more previous deliveries. After adjustment for age and BMI, women with three or more previous deliveries had a 64% higher risk than women with one previous delivery.

With respect to BMI, women with a BMI in the lean category were at low risk. Compared to them, the risk was only slightly higher for women in the overweight BMI category but women in the obese BMI category had more than twice the risk, even after accounting for age and parity.

The crude and adjusted risk ratios for maternal age, parity and BMI in Table 16 were broadly similar, indicating that they operate as independent risk factors for SMM. Therefore, an accumulated risk is experienced by women with the combination of advanced maternal age, increased parity and high BMI, which is relevant for risk assessment at booking.

Table 16: Risk of severe maternal morbidity (SMM) by age, parity and BMI, 2021

		Maternities N (%)	SMM cases N (%)	SMM risk (95% CI)	Crude risk ratio (95% CI)	Adjusted risk ratio (95% CI)
Age group	<25yrs	4,286 (7.3)	25 (6.7)	5.83 (3.77-8.61)	1.13 (0.73-1.74)	1.08 (0.69-1.71)
	25-29yrs	8,935 (15.2)	47 (12.6)	5.26 (3.87-7.00)	1.02 (0.72-1.43)	1.00 (0.71-1.42)
	30-34yrs	20,459 (34.7)	106 (28.3)	5.18 (4.24-6.27)	1.00 (Ref.)	1.00 (Ref.)
	35-39yrs	20,038 (34.0)	148 (39.6)	7.39 (6.24-8.68)	1.43 (1.11-1.83)	1.40 (1.08-1.82)
	≥40yrs	5,235 (8.9)	48 (12.8)	9.17 (6.76-12.16)	1.77 (1.26-2.49)	1.66 (1.17-2.38)
Parity	Nulliparous	23,378 (39.7)	142 (38.0)	6.07 (5.12-7.16)	1.16 (0.91-1.49)	1.22 (0.95-1.58)
	Para 1	21,437 (36.4)	112 (29.9)	5.22 (4.30-6.29)	1.00 (Ref.)	1.00 (Ref.)
	Para 2	10,067 (17.1)	75 (20.1)	7.45 (5.86-9.34)	1.43 (1.06-1.91)	1.26 (0.93-1.70)
	Para 3+	4,071 (6.9)	45 (12.0)	11.05 (8.06-14.79)	2.12 (1.50-2.99)	1.64 (1.14-2.37)
BMI (kg/m²)	Lean (<25)	28,682 (48.7)	133 (37.5)	4.64 (3.88-5.50)	1.00 (Ref.)	1.00 (Ref.)
	Overweight (25<30)	17,960 (30.5)	95 (26.8)	5.29 (4.28-6.47)	1.14 (0.88-1.48)	1.12 (0.86-1.46)
	Obese (≥30)	12,310 (20.9)	127 (35.8)	10.32 (8.60-12.28)	2.23 (1.74-2.84)	2.19 (1.72-2.80)

Note: BMI was not known for 19 women who experienced SMM in 2021. Data on maternities by age, parity and BMI were obtained for 33,221 women who gave birth or booked to give birth in seven of the country's 19 maternity hospitals/units. This is 56.4% of the 58,953 women who gave birth in hospital in 2021, according to HIPE data. We multiplied the maternity data on 33,221 women by 1.77 (i.e. 58,953/33,221) in order to estimate the national number of maternities across the 19 hospitals/units by age, parity and BMI category. The estimated number of maternities were tabulated above and used to calculate the risk of SMM per 1,000 maternities and the risk ratios. Exact Poisson 95% confidence intervals were calculated for the risk and risk ratio. Risk ratios compare the rate for each age/parity/BMI group against the rate for the reference group (25-29yrs/Para 1/Lean). Ref. = Reference group.

Ethnicity

There are no national data available on ethnicity for the pregnant population in Ireland which impedes the calculation of SMM risk per ethnic group. The distribution by ethnic group of the women who experienced SMM in 2021 broadly reflected that of the general population of women aged 15-49 years as reported from the most proximal national census with available data (Table 17).⁴⁰

In those who experienced SMM, there was an over-representation of women whose ethnicity was described as Asian as they made up 6.7% of SMM cases compared to 2.7% of the population aged 15-49 years in this ethnic group. Similarly, women of Black ethnicity (3.2%) and Irish traveller (1.6%) were over-represented in experiencing SMM when compared to the percentage of women aged 15-49 years of that ethnic group in the Irish population.

Table 17: Ethnicity of women who experienced severe maternal morbidity (SMM), 2021

Ethnicity	SMM 2021 (N=374)	15-49-year-old female population 2016* (%)
White Irish	261(69.8)	77.1
Irish Traveller	6(1.6)	0.7
Other white background	55(14.7)	13.3
Asian/Asian Irish	25(6.7)	2.7
Black/Black Irish	12(3.2)	1.6
Other/mixed	4(1.1)	1.8
Not recorded	11(2.9)	2.7

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

⁴⁰Central Statistics Office. (2018). Census 2016.

Pathway of maternity care

The Maternity and Infant Care Scheme provides free care for pregnant women residing in Ireland.⁴¹ This may include a shared care pathway provided by General Practitioners (GPs), maternity units and hospital obstetricians (includes antenatal visits, labour, and postnatal care). Most women opt for this latter type of care, while some choose a private, fee paying, care pathway provided by a selected consultant obstetrician or an independent Self-Employed Community Midwife (SECM).

Eighty-six percent of the women who experienced SMM in 2021 availed of maternity care in the

public scheme (Table 18), which is slightly more than the 82% of all women who gave birth in hospital in 2021 as public patients. At 4.94 per 1,000 maternities, the SMM rate for women who attended private care was 26% lower than the rate of 6.66 per 1,000 for women who attended public maternity care, a statistically significant difference.

Various socio-economic factors and health determinants have a significant role in determining the risk profile of women who access the different types of maternity care. These should be taken into consideration when interpreting the above findings.

Table 18: Risk of severe maternal morbidity (SMM) by type of maternity care, 2021

Maternity care	Maternities	SMM cases (N=374)	SMM rate (95% CI)	Rate ratio (95% CI)
Public	48,223 (81.8%)	321 (85.8%)	6.66 (5.95-7.43)	1.00(ref.)
Private	10,730 (18.2%)	53 (14.2%)	4.94 (3.70-6.46)	0.74 (0.55-0.99)

Note: Total maternities by type of maternity care were derived from Hospital In-Patient Enquiry (HIPE) data.

Smoking, alcohol and drug misuse

Smoking status at the time of the first hospital booking appointment was known for 93% of the 374 women. Of these, 7.8% (n=27 of 346) 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%, 14%, 17% and 16% have been reported for England, Northern Ireland, Wales and Scotland, respectively.⁴²

The quantity smoked was recorded for 25 of the 27 women who were smokers at the time of the first hospital booking appointment. Most commonly, these women smoked 10 cigarettes per day (Mean=8.76; SD=0.9). Of these 27 women,

only one was reported to have given up smoking during pregnancy (3.7%, unknown for eight women).

Alcohol drinking status at the time of the first hospital booking appointment was not known for 12.6% of the women (n=47). Of the 327 women with available data on this, only 0.6% (n=2) self-reported alcohol consumption at the time of their first booking appointment.

One woman was recorded as having a documented history of drug abuse or attendance at a drug rehabilitation unit prior to the pregnancy (0.3%, n=1 of 373, unknown for one case). One additional woman was reported as using drugs during the pregnancy (n=1 of 373, 0.3%).

⁴¹Maternity and Infant Care Scheme. Available at <https://www.hse.ie/eng/services/list/3/maternity/combinedcare.html>

⁴²Euro-Peristat Project. European Perinatal Health Report. Core indicators of the health and care of pregnant women and babies in Europe in 2015. November 2018. Available: www.europenperistat.com

Recommendations:

- Internationally, social inequalities have been shown to impact on risk of SMM. There is a need to establish the evidence in this regard in Ireland. This requires improved maternity data at national level and more research in order to establish this evidence.
- There is an opportunity with the Maternal Newborn Clinical Management System (MN_CMS) data from Irish maternity units to mine data at national level. These data could be collated to identify the influence of risk factors for SMM in Ireland including ethnicity,

maternal age, body mass index (BMI), smoking, employment status and other socio-economic factors. This should overcome the current deficit in the pregnant population data.*

- In the interim, work is being carried out by the NPEC and the NWIHP on facilitating 'real time data' in units who do not have an IT system.

Recommendations:

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

Obstetric factors associated with the severe maternal morbidity event

For 10.7 % of the women who experienced SMM in 2021, their pregnancy was the result of infertility treatment (n=40 of 374 10.7%). In the majority of these cases the method of infertility treatment was in vitro fertilisation, IVF, (n=32, 80.0%). Of these 32 IVF cases, two cases involved Intracytoplasmic sperm injection (ICSI), five were with egg donation and two were with sperm donation.

Other methods reported include intrauterine insemination (n=2, 5.0 %), ovulation induction (n=1) and follicle tracking (n=1). In four cases, the method of fertility treatment was not specified.

The prevalence of a previous caesarean section was 50% among the women who had previously given birth (n=117 of 232, 50.4%).

Gestation at pregnancy-end for women who experienced a SMM ranged from 7 to 42 weeks. For over 65% of the women affected in 2021, their pregnancy went full term, i.e. 37-41 weeks gestation (n=251, 67%) (Table 19). For a further 21% of women, their pregnancy ended at moderate-to-late pre-term gestation (32-36 weeks), whereas for 3%, the end of pregnancy occurred before 22 weeks of gestation (Table 18).

Table 19: Gestation at pregnancy-end for women who experienced severe maternal morbidity, 2018-2021

	2018 (N= 398)*	2019 (N=375)	2020 (N=329)	2021 (N=373)*
Pre-viable (<22wks)	15(3.7)	24(6.4)	15(4.6)	12(3.2)
Extremely pre-term (22-27wks)	9(2.3)	10(2.7)	6(1.8)	9(2.4)
Very pre-term (28-31wks)	26(6.5)	16(4.3)	21(6.4)	22(5.9)
Moderate/late pre-term (32-36wks)	77(19.3)	69(18.4)	70(21.3)	78(20.9)
Term (37-41wks)	267(67.1)	253(67.5)	217(66)	251(67.3)
Post-term (42wks+)	4(1)	3(0.8)	0(0)	1(0.3)

Note: Values are shown as n (%) unless otherwise stated; *Gestation at pregnancy-end was not known for three women in 2018 and for one woman in 2021.

Severe maternal morbidity associated with early pregnancy loss

Early pregnancy loss (i.e. before 24 weeks of gestation and birthweight less than 500g) was experienced by 15 of the 374 women (4%). Nine of these 15 women (60%) suffered a miscarriage (n=4 early miscarriage, n=5 late miscarriage), one (6.6%) experienced an ectopic pregnancy and five underwent a termination of pregnancy (33.3%).

Nine of the early pregnancy losses were diagnosed with one SMM (two early miscarriages, one ectopic pregnancy, three late miscarriages and three terminations of pregnancy) and five women were diagnosed with two SMMs (two early miscarriages, a late miscarriage and two terminations of pregnancy). One further woman, who suffered a late miscarriage, experienced three SMMs.

MOH was the most frequently reported SMM associated with six cases of the 15 early pregnancy losses (four miscarriages, one ectopic pregnancy and two terminations of pregnancy).

Nine women met the criteria for admission to ICU. Of these, two women were admitted due to complications related to MOH and two due to septic shock.

Severe maternal morbidity associated with multiple pregnancy

Of the 374 women who experienced SMM in 2021, 359 had a pregnancy that resulted in the delivery of at least one live baby. As shown in Table 20, 27 of these women had a multiple birth (n=27 of 359, 7.5%), all involving twins. In Ireland in 2021, 1.8% of all women delivering in hospital had a multiple birth (n=1,046 of 58,953). This indicates that multiple birth was approximately four times more common in cases of SMM than in all maternities (7.5% versus 1.8%), a reflection of the increased risk of SMM associated with multiple birth. The national SMM rate associated with single birth was 5.73 per 1,000 maternities in 2021 whereas the SMM rate associated with multiple birth was 4.5 times higher at 25.81 per 1,000 maternities, a highly statistically significant difference (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%).⁴³

Table 20: Single and multiple births for women who experienced severe maternal morbidity (SMM) but who did not experience early pregnancy loss, 2018-2021

	SMM 2018 (N=388)	SMM 2019 (N=350)	SMM 2020 (N=315)	SMM 2021 (N=359)	All maternities 2021	SMM rate (95% CI)	Rate ratio (95% CI)
Single	358 (92.3)	331 (94.6)	297 (94.3)	332 (92.5)	98.1%	5.73 (5.13-6.38)	1.00 (Ref.)
Multiple	30 (7.7)	19 (5.4)	18 (5.7)	27 (7.5)	1.8%	25.81 (17.01-37.56)	4.50 (3.04-6.66)

Note: Values are shown as n (%) unless otherwise stated. SMM rate per 1,000 maternities. Exact Poisson 95% confidence intervals were calculated for the rate and rate ratio. Ref. =Reference group.

⁴³Scottish 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 associated with severe maternal morbidity

The mode of delivery for nearly two thirds of the 359 women giving birth in 2021 was caesarean section (65%; Table 21). The majority of caesarean sections in cases of SMM were

carried out prior to labour (a total of 163; n=79 elective CS and n=84 Emergency CS) which may reflect the clinical complexity of the pregnancy rather than indicating that mode of delivery may be influencing the risk of SMM. Thirty five percent of women had a vaginal delivery, usually spontaneously (23% of all deliveries).

Table 21: Primary mode of delivery (excluding those who experienced early pregnancy loss) for women who experienced severe maternal morbidity, 2017-2021

	2017 (N=375)*	2018 (N=383)*	2019 (N=338)*	2020 (N=315)	2021 (N=359)
Vaginal	120(32)	128(33.4)	115(34)	91(28.9)	126(35.1)
Spontaneous	74(19.7)	80(20.9)	77(22.8)	60(19)	84(23.4)
Assisted breech	4(1.1)	3(0.8)	2(0.6)	1(0.3)	1(0.3)
Ventouse	22(5.9)	26(6.8)	17(5)	19(6)	20(5.6)
Non-rotational forceps	19(5.1)	15(3.9)	18(5.3)	9(2.9)	19(5.3)
Rotational forceps	1(0.3)	4(1)	1(0.3)	2(0.6)	2(0.6)
Caesarean section	255(68)	255(66.6)	223(66)	224(71.1)	233(64.9)
Elective CS	88(23.5)	88(23)	85(25.2)	69(21.9)	79(22)
Emergency CS	165(44)	167(43.6)	133(39.4)	143(45.4)	154(42.9)
Classical CS	2(0.5)	-	5(1.5)	12(3.8)	-

Note: Data excludes 12, 14, 24, 14 and 15 cases of early pregnancy loss in 2017, 2018, 2019, 2020 and 2021 respectively. Values shown are n (%) unless otherwise stated; *Mode of delivery was not known for two cases in 2017, five cases in 2018 and 12 cases in 2019. For cases of multiple births when the mode of delivery differed for the babies, the more complex mode of delivery was taken as the primary mode. LSCS=Lower segment caesarean section.

Audit findings and the associated risk factors (some of these modifiable) for SMM identified in recent years have been reviewed by the multidisciplinary advisory group. This has

generated concern among educators and clinicians within the group of the need to raise public awareness of these risk factors through enhanced education and ante-natal preparation.

Recommendation:

• Antenatal education:

(a) Antenatal education/information should be provided by the multidisciplinary team to women to ensure an understanding of maternal morbidity and complication awareness.

(b) When a pregnant woman is identified as high risk for significant morbidity, specific education should be available during antenatal care and birth preparation.

(c) The national standards on antenatal education should provide guidance on specific education for maternal morbidity awareness.

Maternal care details

Practically all the women who experienced SMM in 2021 required an increased level of support/critical care (Table 22). Nearly half of the women required

Level 1 care (45%) and over one third (40%) needed Level 2 Care. A further 13% of women experiencing an SMM required Level 3 Care.

Table 22: Level of maternal care provided to women during clinical SMM events in Ireland, 2021 (N= 373)

Level of Care	Definition	n(%)
Level 0: Normal ward care	Care of low-risk pregnant women	12(3.2)
Level 1: Additional monitoring or intervention, or step down from a 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	166(44.5)
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)	148(39.7)
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 the support of at least one additional organ	47(12.6)

Note: Level of care unknown for one woman.

Of all women requiring ICU/CCU admission (n=151), 36% required Level 1 Care, 33% required Level 2 Care and 31% required Level 3 Care in 2021. This highlights that admission to an ICU/CCU does not infer that a woman has a requirement for Level 3 Care. As such it should be considered that within the Irish context, ICU/CCU admission may not be a proxy indicator for SMM. This mirrors findings in the NPEC audit on Care of the Critically Ill Woman in Obstetrics in Ireland (2014-2016).⁴⁴

As previously mentioned, admissions to intensive care can reflect resource issues in cases where women required a higher level of monitoring in small maternity units without HDU facilities. Figure 7 details the ICU and HDU facilities available across maternity units in Ireland. Approximately 54% of the 54 women admitted to an ICU/CCU requiring Level 1 Care did not experience another SMM as defined by this audit (n=29, 53.7%) in 2021.

⁴⁴Bovbjerg, M L, Leitao S, Corcoran P, O'Regan L, Greene R A, Manning E. Critical care in obstetrics: Clinical audit in the Republic of Ireland, 2014-2016, European Journal of Obstetrics & Gynecology and Reproductive Biology, 2022; 279; 183-190

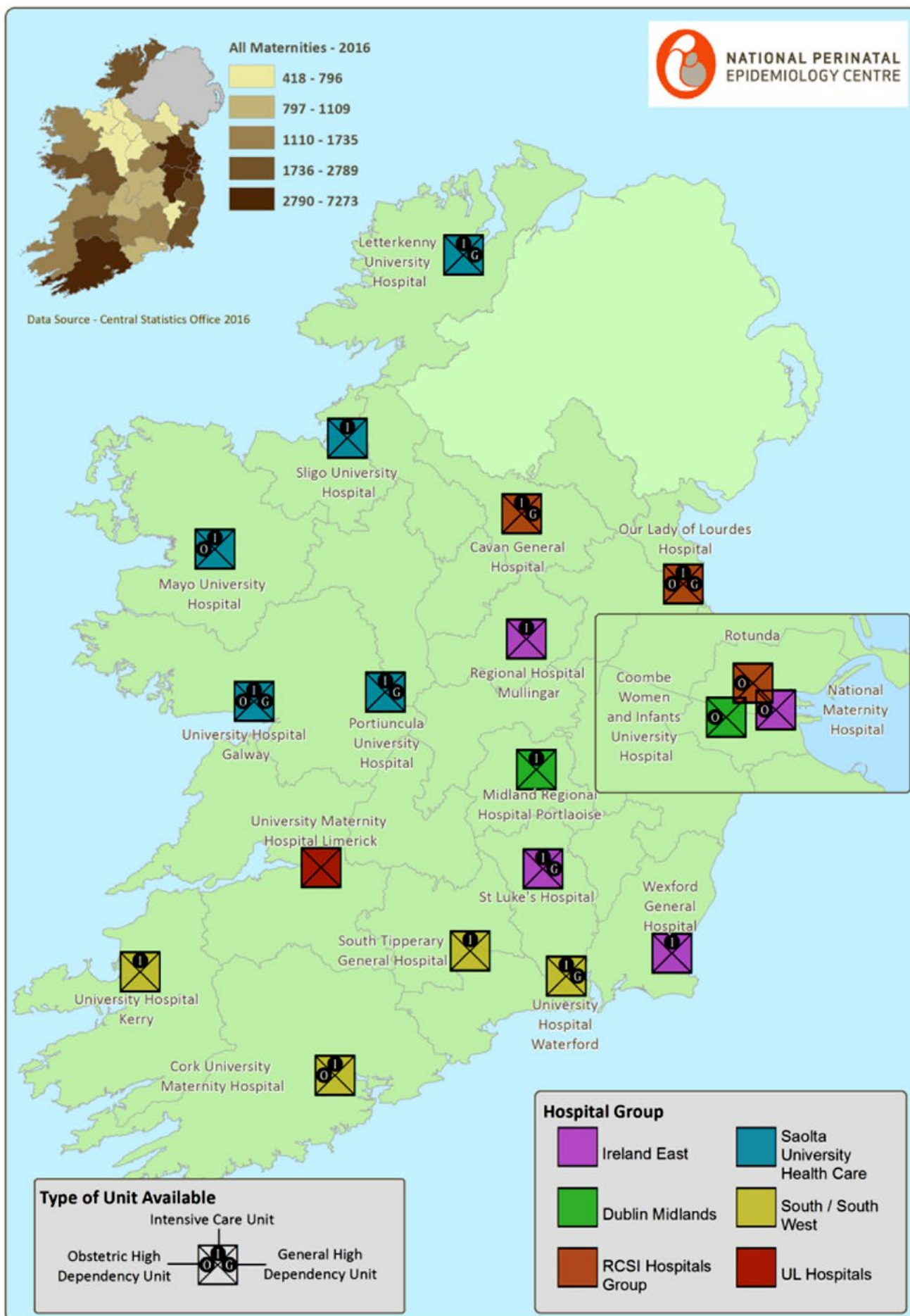


Figure 7: Map of maternity units and hospital groups in the Republic of Ireland according to the type of unit of care available in 2021

Of the major obstetric haemorrhage cases recorded in 2021, over half required Level 2 Care (53%) while 38% required Level 1 Care and 6% required Level 3 Care (Table 23). As expected clinically, higher levels of critical care/monitoring were required for the women experiencing life-threatening maternal morbidities, e.g. all women

experiencing acute respiratory dysfunction (defined in this audit as requiring advanced respiratory ventilation) received Level 3 care, as did 66.7% of women experiencing cardiac arrest. In the event of women experiencing septic shock, (n=13), all but two required either Level 2 or Level 3 care.

Table 23: Level of maternal care provided to women during specific clinical SMM events in Ireland, 2021

	Total n (%)	Level 0 n (%)	Level 1 n (%)	Level 2 n (%)	Level 3 n (%)
All SMM cases	374(100)	12(3.2)	166(44.5)	148(39.7)	47(12.6)
Major obstetric haemorrhage	199(53.4)	6(3)	76(38.2)	105(52.8)	12(6)
ICU/CCU admission	151(40.4)	-	54(35.8)	50(33.1)	47(31.1)
Renal or liver dysfunction	26(7)	1(3.8)	17(65.4)	4(15.4)	4(15.4)
Septicaemic shock	13(3.5)	-	2(15.4)	9(69.2)	2(15.4)
Peripartum hysterectomy	25(6.7)	-	8(32)	15(60)	2(8)
Pulmonary embolism	22(5.9)	5(22.7)	11(50)	2(9.1)	4(18.2)
Uterine rupture	16(4.3)	-	9(56.3)	5(31.3)	2(12.5)
Pulmonary oedema	7(1.9)	-	6(85.7)	1(14.3)	-
Eclampsia	7(1.9)	-	4(57.1)	3(42.9)	-
Interventional radiology	5(1.3)	-	4(80)	1(20)	-
Acute respiratory dysfunction	28(7.5)	-	-	-	28(100)
Cerebrovascular event	6(1.6)*	-	3(60)	1(20)	1(20)
Status epilepticus	1(0.3)	-	1(100)	-	-
Cardiac arrest	3(0.8)	-	1(33.3)	-	2(66.7)
Coma	-	-	-	-	-
Anaesthetic problem	5(1.3)	-	3(60)	1(20)	1(20)

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

Neonatal outcomes

Of the 359 SMM cases associated with the birth of a baby, a total of 386 babies were born: 332 singleton births and 27 twin births (54 babies).

Information on neonatal outcome, regarding perinatal death, was available for all of these infants. Of the 386 infants, there were 13 perinatal deaths (with a birthweight of ≥ 500 g or a gestational age ≥ 24 weeks at delivery): 11 stillbirths, one early neonatal death and one late neonatal death.

Two of the 13 perinatal deaths occurred in multiple pregnancies (one stillbirth and one early neonatal death).

Three of the 13 perinatal deaths (23%) were born at a gestation between 22 and 27 weeks: one late neonatal death and two stillbirths. Two stillbirths (15%) were born at 28-31 weeks of gestation (very pre-term) and two further infants (15%) were stillborn at the gestation of 32-36 weeks. One early neonatal death was also born at 32-36 weeks of gestation. Additionally, five stillbirths (39%) were born at full term (37-41 weeks).

Over one third of the 13 women affected by perinatal deaths experienced major obstetric haemorrhage (n=5, 38.5%), this represents a decrease from the values recorded in previous years: 50% in 2018, 60% in 2019 and 80% in 2020.

The perinatal mortality rate (PMR) based on the 11 stillbirths and one early neonatal death, (with a birthweight of ≥ 500 g or a gestational age ≥ 24 weeks at delivery), among the 386 infants was 31.09 per 1,000 births, i.e. 3.1% or one in 32 of the infants died. This rate was five times the PMR observed for all births in Ireland in 2020, the most

recent year with available data (p-value < 0.001 ; Table 24). However, the rate is in line with the perinatal mortality rate among infants born to women with SMM in previous years in Ireland and over several years up to 2012 in Scotland, which ranged from 17 to 64 per 1,000 maternities.⁴⁵

Table 24: Perinatal mortality among infants born to women with SMM in Ireland in 2021 compared to perinatal mortality among all infants born in Ireland

	Perinatal deaths (n)	Births (n)	PMR (95% CI)	Rate ratio (95% CI)
All births 2020*	357	57,114	6.25 (5.62-6.93)	1.00 (Ref.)
SMM 2021	12	386	31.09 (16.06-54.3)	4.97 (2.8-8.84)

Note: PMR=perinatal mortality rate per 1,000 births; Perinatal deaths include infants with a birthweight of ≥ 500 g or a gestational age ≥ 24 weeks at delivery. Poisson 95% confidence intervals were calculated for the rate and rate ratio. Ref. = Reference group. *Most current data available from: San Lazaro Campillo I, Manning E, Corcoran P, Keane J, O'Farrell IB, McKernan J, White E, Greene RA, on behalf of the Perinatal Mortality National Clinical Audit Governance Committee. Perinatal Mortality National Clinical Audit in Ireland Annual Report 2020. Cork: National Perinatal Epidemiology Centre, 2022.

Of the 375 liveborn infants, 5.9% (n=22) were intubated following birth in 2021 and nearly half (n=173, 46%) were transferred to the Special Care Baby Unit (SCBU) or Neonatal Intensive Care Unit (NICU; Table 25).

Table 25: Selected neonatal outcomes in livebirths, 2021

	n=375*
Intubation following delivery	22(5.9)
Transfer to SCBU/NICU	173(46.1)

Note: SCBU=Special Care Baby Unit; NICU=Neonatal Intensive Care Unit.*n=total number of live births.

⁴⁵Scottish 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

In summary

The rate of severe maternal morbidity (SMM) in Ireland in 2021 was 6.34 per 1,000 maternities, 3% lower than in 2019 but 65% higher than in 2011, the first year of this national clinical audit.

Although increasing SMM rates may reflect complexity of the pregnant population, it also acts as a surrogate measure of quality of care in the maternity services. Further, increasing numbers of women, during or shortly after pregnancy, require higher Levels of Care. This highlights increasing demands on the maternity services.

Risk of SMM was twice as high among women with three or more previous pregnancies. Multiple pregnancy was 4.5 times more common in cases of SMM than in all maternities.

Increasing national rates of MOH, and variations in rates of MOH between units, continues to be identified in this SMM audit. These issues have underscored recommendations in previous NPEC SMM reports. The development of a national quality improvement initiative to evaluate postpartum haemorrhage, in a joint NWIHP NPEC collaboration, highlights the value of on-going SMM audit in order to identify quality improvement initiatives to improve care for women in the Irish maternity services.

The rate of peripartum hysterectomy (PH) has increased in recent years (2019-2021). Similar to national and international studies, this audit has identified the strong association between PH and Placental Accreta Spectrum (PAS).

In 2021, variants of COVID-19 impacting on maternal and fetal wellbeing affected Ireland. Among the 34 pregnant or recently pregnant women admitted to ICU with COVID-19, over half (n=23, 67.6%) required advanced respiratory support and 4 (11.4%) required ECMO thus indicating the severity of illness among this cohort and the requirement for higher levels of care.

Appendices

Appendix A: Hospital co-ordinators and contributors 2021

Hospital	Co-ordinators	Additional contributors
Cavan General Hospital	Dr Tabassum Aman	Ms Karen Malocca
Coombe Hospital	Ms Julie Sloan	Dr Bridgette Byrne
Cork University Maternity Hospital	Ms Clare Buckley	Professor Richard Greene Dr Aoife Morris Ms Ciara Archer Ms Doireann Cuddihy
University Hospital Kerry	Ms Mary Stack Courtney	Ms Sandra O'Connor
University Maternity Hospital Limerick	Dr Mendinaro Imcha Dr Nyan Chin Liew	Dr Consol Plans Dr Clare Crowley Ms Fiona Sampson
Letterkenny University Hospital	Ms Mary Lynch	Ms Evelyn Smith Ms Marion Doogan Ms Lorna Sweeney
Mayo University Hospital, Castlebar	Ms Mary Devers	Dr Hilary Ikele Ms Andrea McGrail
Regional Hospital, Mullingar	Ms Marie Corbett Ms Kathryn Woods	
Midland Regional Hospital, Portlaoise	Ms Emma Mullins Ms Ita Kinsella	
National Maternity Hospital	Professor Mary Higgins	Ms Eve Blake Mr Philip Mulvey Ms Fionnuala Byrne
Our Lady of Lourdes Hospital, Drogheda	Ms Laura Muckian	
Portiuncula University Hospital, Ballinasloe	Ms Sheila Melvin	Ms Melinda O'Rourke
Rotunda Hospital, Dublin	Dr Maria Kennelly Ms Ruth Richie	
Sligo University Hospital	Ms Geraldine O'Brien	Ms Juliana Henry
South Tipperary General Hospital	Ms Mary O'Donnell Ms Maggie Dowling	
St Luke's Hospital, Kilkenny	Ms Kayla Thornton Ms Anne Margaret Hogan	
University Hospital Galway	Ms Louise Fitzpatrick Ms Sadhlóg Ní Chualáin	
University Hospital Waterford	Ms Janet Murphy	
Wexford General Hospital	Ms Emily Moffatt	Ms Helen McLoughlin

Appendix B: Severe Maternal Morbidity Group Members

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

- **Dr Miriam Brennan**, Lecturer in Midwifery, School of Nursing and Midwifery, University of Galway.

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

- **Siobhan Canny**, Group Director of Midwifery, Saolta Group.
Nominated by Lead Midwife NWIHP

- **Catriona Carr**, Advocacy Team Lead, Patient Advocacy Service.

- **Alexandria Collins**, Advocacy Team Lead, Patient Advocacy Service.

- **Paul Corcoran** PhD, Epidemiologist, National Perinatal Epidemiology Centre.

- **Georgina Crowe**, Director of Midwifery, Cavan General Hospital.
Nominated by Lead Midwife NWIHP

- **Deirdre Daly PhD**, Associate Professor in Midwifery, Trinity College Dublin.
Nominated by Deputy Nursing Services Director, HSE

- **Professor 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.

- **Dr Maria Kennelly**, Consultant Obstetrician & Gynaecologist, Rotunda Hospital.

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

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

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

- **Dr Terry Tan**, Consultant Anaesthetist, Coombe Women & Infants University Hospital.
Nominated by The College of Anaesthesiologists

Appendix C: NPEC Governance Committee Members

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

- **Dr Linda Biesty**, Senior lecturer in Midwifery at the School of Nursing & Midwifery, University of Galway.

- **Marie Cregan**, Patient Representative, University College Cork Georgina Cruise, Patient Representative, Patient Advocacy Service.

- **Marina Cronin**, NOCA Head of Quality & Development, National Office of Clinical Audit.

- **Professor Sean Daly**, Master, The Rotunda Hospital;
Angela Dunne, National Lead Midwife, National and Infants Health Programme (NWIHP).

- **Faye Ferris**, Student Midwifery Representative.

- **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.

- **Professor Shane Higgins**, Master, The National Maternity Hospital.

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

- **Professor Eleanor Molloy**, Professor of Paediatrics & Child Health, TCD, Faculty of Paediatrics Representative.

- **Dr Cliona Murphy**, Clinical Director, National and Infants Health Programme (NWIHP).

- **Denise Malone/ Ms Jo Delaney** co-chairs of the national Designated Midwifery Officer Group - Home Births.

- **Lilian Mudoti**, Post Grad Student, Midwifery Representative.

- **Dr Oladayo Oduola**, JOGS Committee Member Dr Michael O'Connell, Master, Coombe Women & Infants University Hospital.

- **Dr Mary O'Mahony**, Specialist in Public Health Medicine, HSE Margaret Quigley, National Lead for Midwifery ONMSD, HSE.

Appendix D: National Office of Clinical Audit Governance Board endorsement of the Severe Maternal Morbidity in Ireland Annual Report 2021



Prof Richard Greene,
Director,
National Perinatal Epidemiology Centre (NPEC),
5th Floor, Cork University Maternity Hospital,
Wilton,
Cork.

23/06/2023

Dear Prof Greene,

I wish to acknowledge receipt of the Severe Maternal Morbidity (SMM) in Ireland Annual Report 2021 and presentation to the NOCA Quality Assurance Committee on the 23 June 2023.

On behalf of the NOCA Governance Board, I wish to acknowledge the work of NPEC and participating maternity units on producing an excellent SMM report. This audit and continues to provide valuable information on the quality of care and is a focus for improvement in maternal healthcare services. This report provides tangible information on SMM events experienced by women during childbirth in 2021 and previous years, including a focus Covid-19 pandemic. We want to particularly acknowledge the valuable insights from Ms Claire Jones Patient Representative NPEC Severe Maternal Morbidity Group to this report.

Please accept this as formal endorsement from the NOCA Governance Board.

Yours sincerely,

A handwritten signature in black ink, appearing to read 'Brian Creedon', is written over a light blue horizontal line.

Dr Brian Creedon
Clinical Director
National Office of Clinical Audit

Appendix E: Postpartum Haemorrhage Quality Improvement Initiative (PPHQII)

Postpartum Haemorrhage Quality Improvement Initiative(PPHQII)

*Standardisation, Sharing ideas, Learning from one another
All 19 maternity units working together*

What we are trying to achieve

- Reduce the number of women having a MOH/LTH
- Reduce the number of women requiring ICU level 3 care due to PPH
- To reduce the morbidity associated with PPH in ROI in 3 years:
- Reduce the number of women requiring ≥ 5 units of red blood cells
- Achieve a reduction in Fresh Frozen Plasma (FFP) Coagulation transfusion
- Ensure PPH/MOH are discussed at risk management meetings
- Encourage staff and patient debriefing following a PPH/MOH
- Reduce the women receiving hysterectomy due to PPH

Thank you to all the PPHQII local champions and national steering committee.



Areas, staff want to address

- Evaluating blood loss
- Standardising local policies and protocols
- Standard checklist
- Review of PPH and MOH cases at risk management meetings
- Patient debriefing
- Training Drills
- Documentation
- Staff debriefing

Next Steps

- Continue to build the PPHQII network
- PPHQII website
- PPH awareness social media day
- Patient engagement
- Training events
- Continue international links
- Homebirth procedures
- Unit led projects

Unit led projects

Projects will be led by units and each unit will develop a toolkit that will be available for all to use.

Examples of projects

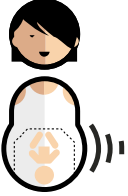



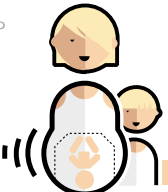
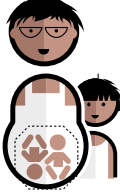
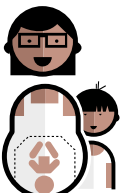
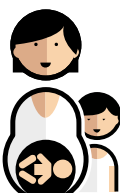
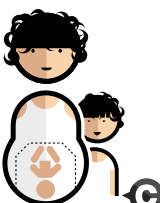

- Measurement of blood loss
- Use of checklist
- Algorithms
- Medication Protocol
- Multidisciplinary Meetings
- Real time drills
- Communication for drills/organising drills
- MN-CMS documentation
- Patient Debrief
- Staff debrief
- Risk Factors
- Communication with patient during the event
- Review of HIPE Data
- Chart review of PPH cases
- PPH poster
- PPH Guideline - Template

For further information on the PPHQII please contact pphqii@ucc.ie

Appendix F: NPEC Severe Maternal Morbidity Definitions 2021

Maternal Morbidity Definitions		
1	Major obstetric haemorrhage	Estimated blood loss \geq 2500ml and/or transfused 5 or more units of blood (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	Sepsis induced tissue hypoperfusion or hypotension persisting after resuscitation with 30mls/kg intravenous isotonic crystalloid fluid as evidenced by: - Systolic blood pressure $<$ 90 mmHg or MAP $<$ 65 mmHg - Decrease in systolic blood pressure by 40mmHg from baseline and/or - Lactate $>$ 4 mmol/l.
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.

Appendix G: The Ten Group Classification System (TGCS)⁴⁶

GROUP 1		Nulliparous women with a single cephalic pregnancy, ≥ 37 weeks gestation in spontaneous labour	GROUP 6		All nulliparous women with a single breech pregnancy
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 7		All multiparous women with a single breech pregnancy, including women with previous uterine scars
GROUP 3		Multiparous women without a previous uterine scar, with a single cephalic pregnancy, ≥ 37 weeks gestation in spontaneous labour	GROUP 8		All women with multiple pregnancies, including women with previous uterine scars
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 9		All women with a single pregnancy with a transverse or oblique lie, including women with previous uterine scars
GROUP 5		All multiparous women with at least one previous uterine scar, with a single cephalic pregnancy, ≥ 37 weeks gestation	GROUP 10		All women with a single cephalic pregnancy < 37 weeks gestation, including women with previous scars

⁴⁶Robson Classification: Implementation Manual. Geneva: World Health Organization; 2017. Licence: CCBY-NC-SA3.0/IGO.

Appendix H: Definitions on Levels of Care⁴⁷

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	<ul style="list-style-type: none"> • Risk of haemorrhage • Oxytocin infusion • Mild preeclampsia 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	<p>Basic Respiratory Support (BRS)</p> <ul style="list-style-type: none"> • 50% or more oxygen via face-mask to maintain oxygen saturation • Continuous Positive Airway Pressure (CPAP), Bi-Level Positive Airway Pressure (BIPAP) <p>Basic Cardiovascular Support (BCVS)</p> <ul style="list-style-type: none"> • 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 <p>Advanced Cardiovascular Support (ACVS)</p> <ul style="list-style-type: none"> • 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 <p>Neurological Support</p> <ul style="list-style-type: none"> • 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	<p>Advanced Respiratory Support</p> <ul style="list-style-type: none"> • Invasive mechanical ventilation <p>Support of two or more organ systems</p> <ul style="list-style-type: none"> • Renal support and BRS • BRS/BCVS and an additional organ supported • Intracranial ressure monitorin

⁴⁷Clinical 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 I: Hospital names listed in funnel plots (Figures 5 and 6)

- A - Tipperary University Hospital
- B - University Hospital Kerry
- C - Cavan General Hospital
- D - Sligo University Hospital
- E - Portiuncula University Hospital, Ballinasloe
- F - St Luke's Hospital, Kilkenny
- G - Mayo University Hospital, Castlebar
- H - Midland Regional Hospital, Portlaoise
- I - Letterkenny General Hospital
- J - Wexford General Hospital
- K - University Hospital Waterford
- L - Regional Hospital, Mullingar
- M - University Hospital Galway
- N - Our Lady of Lourdes Hospital, Drogheda
- O - Limerick University Maternity Hospital
- P - Cork University Maternity Hospital
- Q - Coombe Women and Infants University Hospital
- R - National Maternity Hospital
- S - Rotunda Hospital, Dublin.



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