



RCSI

UNIVERSITY
OF MEDICINE
AND HEALTH
SCIENCES

Royal College of Surgeons in Ireland

repository@rcsi.com

Maternal morbidity and mortality: an iceberg phenomenon

AUTHOR(S)

S Leitao, E Manning, RA Greene, P Corcoran, Maternal Morbidity Advisory Group, Bridgette Byrne

CITATION

Leitao, S; Manning, E; Greene, RA; Corcoran, P; Group, Maternal Morbidity Advisory; Byrne, Bridgette (2022): Maternal morbidity and mortality: an iceberg phenomenon. Royal College of Surgeons in Ireland. Journal contribution. <https://hdl.handle.net/10779/rcsi.21155398.v1>

HANDLE

[10779/rcsi.21155398.v1](https://hdl.handle.net/10779/rcsi.21155398.v1)

LICENCE

CC BY-NC 4.0

This work is made available under the above open licence by RCSI and has been printed from <https://repository.rcsi.com>. For more information please contact repository@rcsi.com

URL

https://repository.rcsi.com/articles/journal_contribution/Maternal_morbidity_and_mortality_an_iceberg_phenomenon/21155398/1

Maternal morbidity and mortality: an iceberg phenomenon

S Leitao PhD,  E Manning, RA Greene, P Corcoran PhD,  the Maternal Morbidity Advisory Group*

National Perinatal Epidemiology Centre, University College Cork, Cork, Ireland

Correspondence: S Leitao, National Perinatal Epidemiology Centre, Cork University Maternity Hospital, 5th Floor, Cork, Ireland.

Email: s.leitao@ucc.ie

Accepted 22 August 2021. Published Online 23 September 2021.

Objective To apply the iceberg model, quantifying absolute and relative incidence, to the four main causes of maternal morbidity and mortality in Ireland: haemorrhage, hypertension, sepsis and thrombosis.

Design Secondary analysis of national data on maternal morbidity and mortality.

Setting Republic of Ireland.

Population or sample Approximately 715 000 maternities, 1 200 000 maternal hospitalisations, 2138 cases of severe maternal morbidity (SMM) and 54 maternal deaths.

Methods Incidence rates and case-fatality ratios were calculated.

Main outcome measures Maternal death, SMM and hospitalisation.

Results At the 'tip of the iceberg', the incidence of maternal death per 10 000 maternities was 0.09 (95% CI 0.03–0.20) due to thrombosis and 0.03 (95% CI 0–0.11) due to haemorrhage, hypertension disorders or sepsis. For one death due to thrombosis there were 35 cases of pulmonary embolism and 257 thrombosis hospitalisations. For one death due to eclampsia, there were 58 eclampsia cases, 13 040 hospitalisations with

pre-existing hypertension and 40 781 hospitalisations with gestational hypertension. For one death due to pregnancy-related sepsis, there were 92 cases of septicemic shock and 9005 hospitalisations with obstetric sepsis. For one maternal death due to haemorrhage, there were 1029 cases of major obstetric haemorrhage and 53 715 maternal hospitalisations with haemorrhage. For every 100 maternities, there were approximately 16 hospitalisations associated with haemorrhage, 12 associated with hypertension disorders, three with sepsis and 0.2 with thrombosis.

Conclusions Haemorrhage and hypertension disorders are leading causes of maternal morbidity in Ireland but they have very low case fatality. This indicates that these morbidities are managed effectively but their prevention requires more focus.

Keywords Iceberg model, maternal health, maternal mortality, obstetric/maternal hospitalisations, severe maternal morbidity.

Tweetable abstract Study shows that haemorrhage and hypertension are main causes of #maternalmorbidity in Ireland. Timely interventions for #maternalhealth and focus on prevention of severe and non-severe morbidities are needed.@NPEC #maternityservices #clinicalaudit #qualityimprovement.

Please cite this paper as: Leitao S, Manning E, Greene RA, Corcoran P; On behalf of the Maternal Morbidity Advisory Group. Maternal morbidity and mortality: an iceberg phenomenon. BJOG 2022;129:402–411.

*Bridgette Byrne (Coombe Women & Infants University Hospital, Dublin), Sharon Cooley (The Rotunda Hospital, Dublin); Dr Deirdre Daly (Trinity College Dublin); Ms Anne Fallon (School of Nursing and Midwifery, National University of Ireland, Galway); Mary Higgins (National Maternity Hospital, Dublin); Claire Jones (Patient Representative); Ms Ita Kinsella (Midland Regional Hospital Portlaoise); Cliona Murphy (Coombe Women & Infants University Hospital); Janet Murphy (University Hospital Waterford); Meabh Ni Bhuiinneain (Mayo University Hospital).

Introduction

Historically, maternal mortality has been widely used internationally as an indicator for maternal health and quality of maternal care. The most serious adverse outcome, maternal mortality, is fortunately in decline in higher-income countries with lower rates being reported in recent decades.¹ Nevertheless, reducing preventable maternal deaths is still recognised as one of the priorities in sexual and reproductive health, internationally.² Maternal deaths have often been referred to as the 'tip of the iceberg' in what relates to adverse maternal health issues.³ It has been

suggested that by focusing mainly on fatalities, other important maternal health issues might be overlooked. For each woman who loses her life due to causes related to pregnancy, many more experience life-threatening complications or long-term morbidities.^{4,5}

Maternal morbidity can be conceptualised as a spectrum ranging, at its most severe, from a 'maternal near-miss' – defined by the World Health Organization (WHO) as the near death of a woman who has survived a complication occurring during pregnancy or childbirth or within 42 days of the termination of pregnancy – to non-life-threatening morbidity, which is more common. The WHO Maternal Morbidity Working Group defined maternal morbidity and associated disability as 'any health condition attributed to and/or complicating pregnancy and childbirth that has a negative impact on the woman's wellbeing and/or functioning'.⁵

It is essential to know the full extent to which women's health is affected during or shortly after pregnancy, and to identify the main causes of illness. More accurate and relevant indicators are needed to provide a clearer and broader understanding of the issues affecting maternal health. Hence, severe maternal morbidities (SMMs) have been recognised as important indicators of the broader issues affecting maternal health.⁶

Measuring morbidity can also serve as an indicator of the quality of obstetric care.⁷ By reviewing near-misses and/or SMMs affecting women, lessons can be learned about their needs, the quality of care provided and the processes in place (and their deficiencies) as well as identifying ways to improve them. This can ensure a better and more efficient response to the specific needs of these women. The study of women who survive a severe complication of pregnancy or childbirth offers the possibility of carrying out preventive actions towards the avoidance of such complications and improved care in future cases.⁸

An approach that analyses maternal deaths, together with SMMs and other pregnancy complications or adverse events, recognises that death is the extreme of a continuum of adverse pregnancy events. This facilitates a focus on the circumstance that led or contributed to an adverse outcome.^{4,9,10}

The current study aimed to quantify the incidence of the leading causes of maternal mortality, severe morbidity and hospitalisation (i.e. obstetric haemorrhage, thrombosis, hypertensive disorders and pregnancy-related sepsis) in the Republic of Ireland for 2009–19.

Methods

The iceberg model, based on the work by Mantel et al.,³ was used to represent the continuum of adverse outcomes from the extreme of maternal death, followed by SMM, then maternal hospitalisation and all maternities.

The iceberg phenomenon of health illustrates situations in which only acute or serious health events have greater visibility from healthcare services (the 'tip of the iceberg').¹¹ The deeper, wider issues or general disorders with larger incidence rates (where early intervention or prevention can be applied) may remain overlooked as the layers of the iceberg beneath the surface.

Data selection

Data from three different sources were used to obtain the frequency of the specific maternal deaths, SMMs and hospitalisations. The total number of maternities used for rate calculation referred to the total number of women who delivered in Ireland each year, as per the National Perinatal Reporting System. Table 1 outlines the sources of data used and their main characteristics. An overview of the data sources, measures and conditions included in the analyses is also included in Figure S1 in the supplementary material.

Thrombosis, obstetric haemorrhage, hypertensive disorders and pregnancy-related sepsis have been widely reported as the main causes of maternal mortalities due to obstetric complications, worldwide and, especially, in higher-income countries.^{9,12–16} Similarly, literature has shown that the main severe maternal morbidities recorded for high-income countries are severe haemorrhage, hypertensive disorders (e.g. pre-eclampsia) and sepsis.^{10,15}

The outcomes and conditions included in the analyses are described below.

Maternal mortalities

Defined as 'the death of a woman whilst pregnant or within 42 days of delivery or termination of pregnancy, from any cause related to, or aggravated by, pregnancy or its management, but excluding deaths from incidental or accidental causes' as per WHO 2010.^{12,17} For the current study, maternal deaths with direct cause due to thrombosis, obstetric haemorrhage, eclampsia or pregnancy-related sepsis occurring in Ireland for the reporting years 2009–18 were included. Data were obtained from the Maternal Death Enquiry Ireland, which records all maternal deaths occurring nationally.

Severe maternal morbidities

A case of SMM was defined as a pregnant or recently pregnant woman (i.e. up to 42 days following the end of pregnancy) who experienced any of the following four, clearly defined, maternal morbidities in the years 2011–19: pulmonary embolism (PE), major obstetric haemorrhage (MOH), eclampsia and septicæmic shock. Data on these conditions were used as recorded by the National Perinatal Epidemiology Centre (NPEC) National Audit of Severe Maternal Morbidity. Definitions for each SMM included are detailed in Table 2 and related to the criteria used by this audit, which are a further adaption of a validated

Table 1. Data Sources used in the study

Data	Data source	Years of data	Description
Maternal mortalities (i.e. mortalities linked to Haemorrhage, Hypertension/Eclampsia, Thromboembolism, Sepsis/Septicaemia or related infection)	Maternal Death Enquiry (MDE)	2009–18	MDE Ireland records all maternal deaths occurring in Ireland and carries out confidential enquiries on these, identifying the main causes of, and trends, in maternal deaths nationally
Severe maternal morbidities (i.e. Major obstetric haemorrhage, Septicaemia, Eclampsia or Pre-eclampsia, Pulmonary embolism)	NPEC National Audit of Severe Maternal Morbidity	2011–19	Audit carried out by the NPEC, which has collected maternal morbidity data from Irish maternity units. The purpose of the audit is to provide baseline evidence for reflective practice and action planning by public maternity healthcare providers, public health professionals and policy-makers in Ireland
Maternal hospitalisations (non-severe/acute conditions leading to admission to hospital, include: Hypertension; Haemorrhage; thrombosis). See Table 2 for further detail on the conditions included	Hospital InPatient Enquiry Scheme (HIPE)	2009–19	HIPE is a system that collects information on hospital day cases and inpatients in Ireland. It is a health information system designed to collect demographic, clinical and administrative information on discharges and deaths from acute hospitals nationally. (Data were extracted on the 30 July 2021)
Maternities (total number of women who delivered in Ireland each year)	National Perinatal Reporting System (NPRS)	2009–19	The NPRS collects information on approximately 70 000 birth records each year from 19 maternity units and all practicing self-employed community midwives

methodology of the Scottish Confidential Audit of Severe Maternal Morbidity.^{18–20}

Maternal hospitalisations

These were defined as the admission into hospital of a pregnant or recently pregnant woman (up to 42 days following the end of pregnancy),²¹ as recorded by the Irish Hospital In-Patient Enquiry. This can be for childbirth or due to 'any illness or disability directly related to pregnancy or childbirth. These are not necessarily life-threatening but can have a significant impact on the quality of life'.²² The number of hospitalisations for the conditions under study was obtained from all admissions with a relevant diagnosis irrespective of whether it was a delivery admission or not. Morbidities were classified using the International Classification of Diseases 10th revision. The cases of maternal hospitalisations of interest in this study included those under one of the following specific morbidities:

- Thrombosis (antenatal and postnatal venous thromboembolism cases diagnosed with any of the International Classification of Diseases 10th revision codes related to this, as per Jacobsen et al.²³)
- Obstetric haemorrhage (including early pregnancy, antepartum, intrapartum and postpartum haemorrhage and following ectopic or molar pregnancy)
- Gestational hypertension (including gestational oedema or proteinuria)

- Pre-existing hypertension (including unspecified maternal hypertension)
- Obstetric sepsis (during pregnancy or puerperium as per Say et al.).¹²

Further details on the morbidities and International Classification of Diseases 10th revision codes included are outlined in Table 3.

Analyses

Crude incidence rates with exact Poisson 95% CIs were calculated per 10 000 maternities for the four causes of maternal death, SMM and maternal hospitalisation. Maternal death rates are usually reported per 100 000; however, we report all rates per 10 000 in order to facilitate comparison of their relative incidence. The total number of maternities (i.e. women giving birth to a live or stillborn infant with a birthweight ≥ 500 g) occurring in Ireland was used as the denominator.

Case-fatality ratios were calculated to present the frequency of one maternal death due to obstetric haemorrhage, hypertension, thrombosis and sepsis relative to the rate of the corresponding type of SMM and relative to the rate of the corresponding type of maternal hospitalisation. Poisson regression was used to derive 95% CIs for these ratios.

Results

There was a total of 54 maternal deaths in Ireland in the period 2009–18, a rate of 0.82 (95% CI 0.62–1.07) per

Table 2. Definition of severe maternal morbidities included in this study

Severe maternal morbidity	
Major obstetric haemorrhage (MOH)	An estimated blood loss ≥ 2500 ml, or transfusion 5 or more units of blood or administration of treatment for coagulopathy (Fresh Frozen Plasma; Fibrinogen Concentrate Substitution Therapy; Platelets). Ectopic pregnancies meeting these criteria were also included
Eclampsia	Seizure associated with antepartum, intrapartum or postpartum symptoms and signs of pre-eclampsia
Pulmonary embolism	Venous thromboembolism can manifest during pregnancy as an isolated lower extremity deep venous thrombosis or a clot can break off from the lower extremities and travel to the lung to present as pulmonary embolus. Cases matching the following criteria were recorded: increased respiratory rate (>20 /min), tachycardia, hypotension. Diagnosed as 'high' probability on VQ scan or positive spiral chest CT scan. Treated by heparin, thrombolysis or embolectomy
Septicaemic shock	Sepsis-induced tissue hypoperfusion or hypotension persisting after resuscitation with 30 ml/kg intravenous isotonic crystalloid fluid as evidenced by: Systolic blood pressure <90 mmHg or Mean arterial pressure <65 mmHg – Decrease in systolic blood pressure by 40 mmHg from baseline and/or Lactate >4 mmol/l

Table 3. Conditions from Hospital InPatient Enquiry Scheme data and corresponding International Classification of Diseases 10th revision (ICD-10) codes included in this study

Condition	ICD-10 codes	Description
Hypertension (including gestational oedema or proteinuria)	O12	Gestational [pregnancy-induced] oedema and proteinuria without hypertension
	O13	Gestational [pregnancy-induced] hypertension without significant proteinuria
	O14	Pre-eclampsia
	O15	Eclampsia
Pre-existing hypertension (including unspecified maternal hypertension)	O10	Pre-existing hypertension complicating pregnancy, childbirth and the puerperium
	O11	Pre-existing hypertension with pre-eclampsia
	O16	Unspecified maternal hypertension
Haemorrhage	O081	Delayed or excessive haemorrhage following ectopic and molar pregnancy
	O20	Haemorrhage in early pregnancy
	O441	Complete placenta praevia with haemorrhage
	O46	Antepartum haemorrhage, not elsewhere classified
	O67	Labour and delivery complicated by intrapartum haemorrhage, not elsewhere classified
	O72	Postpartum haemorrhage
	O73	Intracranial and intraspinal phlebitis and thrombophlebitis
Thrombosis (using ICD-10 codes per Jacobsen et al., ²³ in the <i>AJOG</i> 2008)	I26	Pulmonary embolism
	I80	Phlebitis and thrombophlebitis
	I82	Other venous embolism and thrombosis
	O223	Deep phlebothrombosis in pregnancy
	O225	Cerebral venous thrombosis in pregnancy
	O228	Other venous complications in pregnancy
	O229	Venous complication in pregnancy, unspecified
	O871	Deep phlebothrombosis in the puerperium
	O873	Cerebral venous thrombosis in the puerperium
	O879	Venous complication in the puerperium, unspecified
Sepsis (as per Say et al., ¹² in the <i>Lancet</i> 2014)	O882	Obstetric thromboembolism
	A34	Obstetric tetanus
	O411	Infection of amniotic sac and membranes
	O753	Other infection during labour
	O85	Puerperal sepsis
	O86	Other puerperal infections

10 000 maternities.²⁴ Of these, 23 were classified as ‘direct’ maternal deaths (i.e. deaths due to obstetric complications) and 31 deaths were classified as ‘Indirect’ maternal deaths (i.e. deaths due to pre-existing disease or disease that developed during pregnancy, which was not the result of obstetric causes, but which was aggravated by the physiological effects of pregnancy).² Twelve of the ‘direct’ maternal deaths were due to one of the four conditions under study. Thus, these conditions caused 0.18 (95% CI 0.09–0.32) deaths per 10 000 maternities.

Between the years 2011 and 2019, 2138 cases of the studied SMMs (MOH, eclampsia, PE, septicaemic shock) were recorded, equivalent to a rate of 39.10 (95% CI 37.46–40.80) cases per 10 000 maternities.

During 2009–19, there were 714 698 maternities in Ireland for which there were 763 675 maternal hospitalisations due to complications (i.e. excluding hospitalisations for women to give birth). In the same time period, there were 255 520 maternal hospitalisations associated with obstetric haemorrhage, hypertension, thrombosis or sepsis, a rate of 3575.22 (95% CI 3561.37–3589.11) per 10 000 maternities.

Maternal mortality rates

Thrombosis had the highest maternal mortality rate, 0.09 (95% CI 0.03–0.20) per 10 000. This was followed by obstetric haemorrhage, eclampsia and sepsis, each with a mortality rate of 0.03 (95% CI 0–0.11) per 10 000 maternities (Table 4).

Severe maternal morbidity incidence

As shown in Table 4, MOH was the most frequent SMM at 31.35 (95% CI 29.88–32.87) per 10 000 maternities, approximately ten times more common than PE at 3.18 (95% CI 2.73–3.69) per 10 000 and septicaemic shock at

2.82 (95% CI 2.39–3.3) per 10 000, whereas the lowest incidence rate among the four SMMs studied was registered for eclampsia with 1.76 (95% CI 1.42–2.14) per 10 000 maternities.

Maternal hospitalisation incidence

As observed with the SMMs, obstetric haemorrhage was the commonest cause of maternal hospitalisation at 1637.03 (95% CI 1627.66–1646.44) per 10 000, showing that a high proportion of women, approximately 16%, had a hospital admission associated with haemorrhage during pregnancy, delivery or in the postpartum period (Table 4). Hospitalisations related to hypertension recorded a similar incidence rate, with 1242.86 (95% CI 1234.70–1251.06) per 10 000 associated with gestational hypertension and 397.40 (95% CI 392.79–402.05) per 10 000 associated with pre-existing hypertension. Hospitalisations associated with sepsis were far less common, though its incidence of 274.45 (95% CI 270.62–278.32) per 10 000 maternities was at least ten times more common than hospitalisations associated with thrombosis, which had a rate of 23.48 (95% CI 22.37–24.63) per 10 000.

Case-fatality ratios

Case-fatality ratios are displayed as an iceberg demonstrating the number of cases of each SMM or type of maternal hospitalisation that occurred relative to one maternal death due to the corresponding cause. One fatality is represented at the top and the number of cases of the corresponding SMM or maternal hospitalisation is then displayed in the layers below (Figure 1).

When examining the case-fatality ratios for each of the studied SMMs, PE stands out because there was one death for every 35 cases of this condition (95% CI 15–79; Figure 1; Table 4). Among the severe morbidities, eclampsia recorded

Table 4. Selected maternal mortalities and morbidities recorded in Ireland

	Thrombosis /PE			Haemorrhage			Hypertension			Sepsis			
	<i>n</i>	Rate (per 10 000)	CFR	<i>n</i>	Rate (per 10 000)	CFR	<i>n</i>		Rate (per 10 000)	CFR	<i>n</i>	Rate (per 10 000)	CFR
Mortality*	6	0.09	1	2	0.03	1	2		0.03	1	2	0.03	1
Severe morbidity**	174	3.18	35	1714	31.35	1029	96		1.76	58	154	2.82	92
Maternal hospitalisation***	1678	23.48	257	116 998	1637.03	53 715	Gestational Pre-existing	88 827 28 402	1242.86 397.40	40 781 13 040	19 615	274.45	9005

CFR, case fatality ratio; PE, pulmonary embolism.

**n* maternities (2009–18) = 656 248.

***n* maternities (2011–19) = 546 749.

****n* maternities (2009–19) = 714 698.

the second highest fatality level. For 58 cases with this diagnosis (95% CI 14–234), one death occurred. There was one fatality due to sepsis per 92 cases of septicaemic shock (95% CI 23–373) whereas MOH had the lowest fatality risk with one death for every 1029 cases (95% CI 257–4116).

Among the studied maternal hospitalisations, there were 257 admissions related to thrombosis (95% CI 115–572) for each death due to thrombosis. This highlights the far higher fatality risk associated with hospitalisation due to thrombosis. In contrast, there were 9005 maternal hospitalisations associated with sepsis (95% CI 2252–36 010) and 13 040 (95% CI 3261–52 141) associated with obstetric haemorrhage for each death due to these conditions. However, there were more than 50 000 maternal hospitalisations associated with hypertension – 40 781 (95% CI 10 199–163 064) associated with gestational hypertension and 13 040 (95% CI 3261–52 141) associated with pre-existing hypertension – for each maternal death due to eclampsia (Table 4).

Discussion

Main findings

Of the studied conditions, thrombosis, although having the second highest crude incidence rate (3.18 per 10 000), was

the highest cause of maternal death due to obstetric complications. At the ‘tip of the iceberg’, the incidence of maternal death per 10 000 maternities was 0.09 due to thrombosis, but 0.03 due to haemorrhage, due to hypertension disorders or due to sepsis.

There is a significant group of women affected by maternal morbidities in Ireland, as evidenced by the high number of maternal hospitalisations due to complications exceeding the number of maternities in the same period.

For one death due to thrombosis there were 35 cases of pulmonary embolism and 257 thrombosis hospitalisations. For one death due to eclampsia, there were 58 eclampsia cases, 13 040 hospitalisations with pre-existing hypertension and 40 781 hospitalisations with gestational hypertension. For one death due to pregnancy-related sepsis, there were 92 cases of septicaemic shock and 9005 hospitalisations with obstetric sepsis. For one maternal death due to haemorrhage, there were 1029 cases of major obstetric haemorrhage and 53 715 maternal hospitalisations with haemorrhage. For every 100 maternities, there were approximately 16 hospitalisations associated with haemorrhage, 12 associated with hypertension disorders, three with sepsis and 0.2 with thrombosis.

MOH and obstetric haemorrhage were the main maternal conditions affecting women in Ireland; showing, by far,

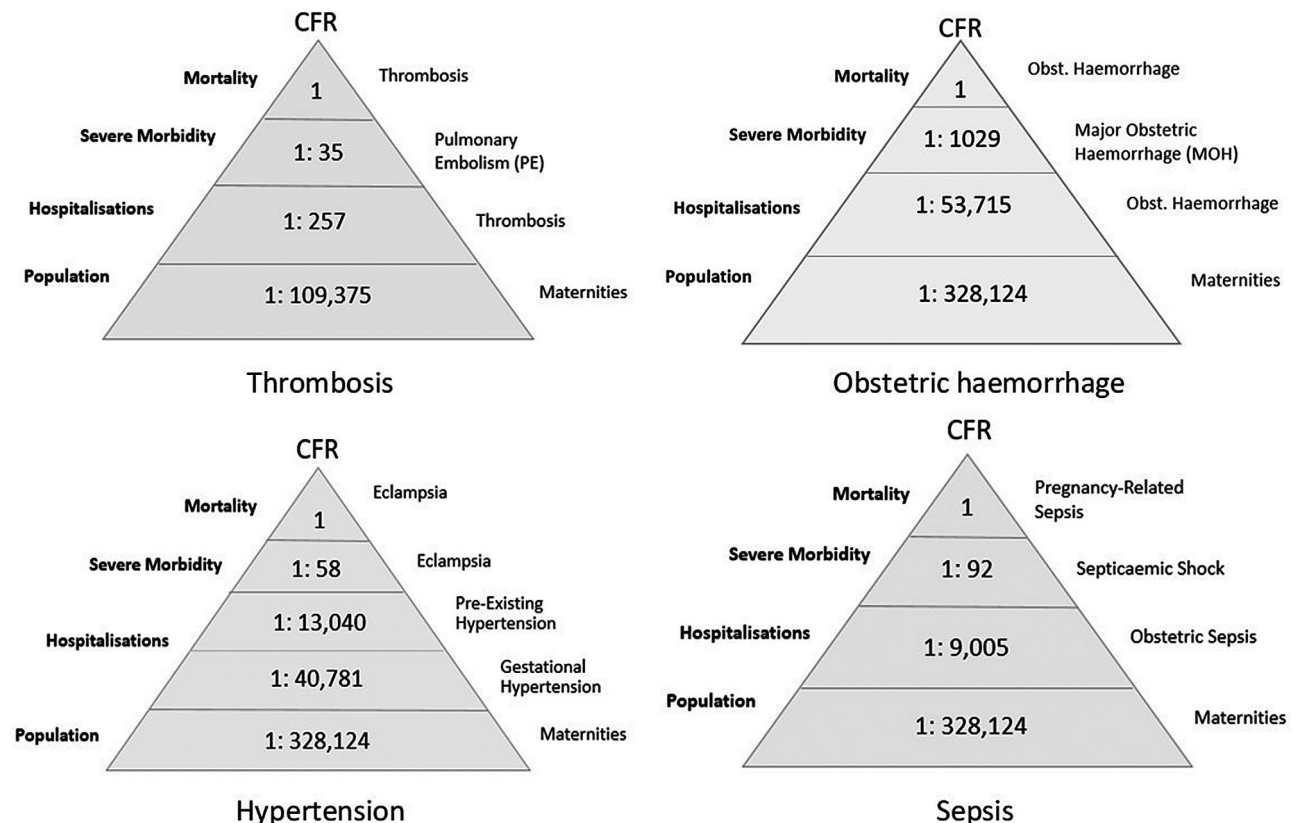


Figure 1. Case-fatality ratios (CFRs) for thrombosis, obstetric haemorrhage, hypertension and sepsis in Ireland, 2009–19.

the highest crude incidence among all the morbidities and hospitalisations studied (31.35 and 1637.03 per 10 000, respectively). Gestational hypertension recorded the second highest crude incidence rate (1242.86 per 10 000) among all the conditions studied. The incidence of PE during pregnancy or postpartum was 3.18 per 10 000 and of thrombosis hospitalisations was 23.48 per 10 000.

Interpretation

Maternal mortality is declining in high-income countries, recording encouragingly low values in Ireland.²⁵ However, in recent reports²⁶ SMMs show increasing incidence rates, highlighting the need for further attention to these potentially life-threatening conditions.²⁷

Thrombosis was the highest cause of maternal death in Ireland, similar to the UK⁹ and EU.¹³ Eclampsia also recorded a high fatality level, but the mortality rate associated with this condition (0.03 per 10 000) was below the European rate in 2010 (0.07 per 10 000).¹³

Previous studies found incidence rates for thrombosis between 8.50 and 13.0 per 10 000 pregnancies.²⁸ The incidence of thrombosis in Ireland is high in comparison to these.

Findings for sepsis and septic shock demonstrate how these are also among the main conditions affecting maternal health in Ireland, as previously highlighted in the literature for high-income countries.^{6,9,11}

The current study highlights the need to look further into the continuum of severity of maternal outcomes, focusing not only on severe maternal morbidities but also on the non-severe morbidities. Many women survive maternal health complications but suffer from lifelong disabilities. These have a significant impact on women, their families, infant health, the wider community and an already overburdened healthcare service with limited resources.^{10,27,29}

Maternal morbidities are a significant issue affecting women in Ireland. Although this might be partially due to an increasing number of women entering pregnancy with chronic medical conditions, older age, obesity and increasing caesarean rates, other preventable factors related to the care provided might also contribute to this phenomenon.

MOH and sepsis are two conditions with high impact on maternal health in Ireland, as shown in our findings, and these are among the most common conditions considered preventable.³⁰ This demonstrates the potential for prevention and reduction of the rates and ratios reported in the current study. Previous studies found that the majority of preventable SMM cases were linked to healthcare provider-related issues,^{4,30} indicating that maternal morbidities can be prevented through reduction of risk factors by creating and implementing adequate health policies, establishing best-practice guidelines, adequate healthcare

practitioner training and public health education and interventions.^{4,31} Our findings, by identifying significant morbidities such as those outlined, can also become an important tool as guidance to direct the focus of quality improvement initiatives.

The findings highlight a high incidence of SMMs in Ireland. Numerous women surviving life-threatening maternal morbidities suffer altered functioning and hampered well-being, and many more endure long-lasting health outcomes linked to maternal conditions. Guida et al.³² demonstrated that SMMs can have an impact on maternal functioning up to 5 years postpartum. Hypertension headed the list of conditions associated with this. In our study, the incidence of hypertension-related hospitalisations was among the highest from the conditions studied.³²

Our study emphasises the importance of preventing a woman's progression along the continuum of severity. This can also improve delivery outcomes and newborn health.¹⁰ It was estimated that, in 2019, maternal disorders contributed to 299.8 disability-adjusted life-years (DALYs), including morbidity from haemorrhage (53.8 DALYs), sepsis and other maternal infections (30 DALYs), hypertensive disorders (44.2 DALYs), obstructed labour and uterine rupture (42.0 DALYs) and ectopic pregnancy (9.7 DALYs), among others (e.g. late and indirect maternal deaths, deaths aggravated by HIV/AIDS and abortion complications or miscarriage).^{33,34}

As per previous literature,^{4-7,10,29,35,36} this study's findings support the need for greater focus on maternal morbidities (both severe and non-severe) as conditions that also significantly impact on the health and wellbeing of mothers. The WHO has recommended that countries with low maternal mortality (high-income countries) review and analyse SMMs to identify systems failures and intervention priorities.¹² Dedicating further attention to SMM would allow us to establish quality improvement initiatives and address possible shortcomings in care and/or significant risk factors associated with it. Many countries or maternity hospitals have established SMM case reviews to examine preventability of severe morbidities and learn lessons towards improved care.^{9,30,37} Through this, cases determined to be preventable can be addressed, reviewed through a multidisciplinary discussion, and areas for improvement can be identified.³¹

National clinical audit has had an essential role in the recording and monitoring of severe maternal morbidities. This is an important step towards identification of issues, defining priorities, implementing measures to address these and establishing quality improvement. In Ireland, annual SMM clinical audits have been carried out by the NPEC since 2011.³⁸ The current findings highlight the relevance of audit and review of SMMs, near-misses and important events from which lessons can be learned for improved

care. These also demonstrate the importance of adhering to guidelines and best-practices, and of implementation of adequate risk management systems (e.g. MOH pro-forma, sepsis care bundles, maternity early warning systems and venous thromboembolism assessments).

Though current data do not provide clear evidence of the impact of access to care on maternal mortality, in the latest Maternal Death Enquiry report,²⁵ 30% of deaths from direct and indirect causes in 2009–18 occurred in women born outside Ireland. Similarly, in the UK, a more than four-fold difference in maternal mortality rates among women from Black ethnic backgrounds was reported and an almost two-fold difference among women from Asian ethnic backgrounds compared with White women.³⁹ Furthermore, in the SMM reports in Ireland 2017–19,^{18,26,40} an overrepresentation of women from Black, Asian and Irish-traveller ethnicities has been noticed. Further and more thorough studies on this issue are needed to clearly understand how access, or the quality of care provided, impact on maternal morbidities or mortalities.

The findings on case-fatality ratios associated with obstetric haemorrhage, eclampsia and pregnancy-related sepsis may also be evidence of ever-improving clinical care. These conditions' low fatality rate in Ireland suggest that women with potential life-threatening conditions are being identified and managed, although there is no room for complacency.

By applying the iceberg effect model to maternal mortalities and morbidities, it was possible to reveal further relevant issues affecting obstetric women's health. Further analyses on additional conditions and relevant maternal health issues would also be valuable. This approach has been applied to a limited number of clinical areas. Analysing these different data together in further clinical fields has the potential to clarify and inform healthcare services and providers on important issues affecting individuals.

Strengths and limitations

This study provided an important overview of the prevalence and fatality of some of the main maternal morbidities in Ireland in recent years. This is the first piece of research using some of the main national data available on these conditions, allowing for the identification of maternal health issues beyond fatalities and offering opportunities for improved care.

Data on all SMMs in Ireland between 2009 and 2010 are not available as the NPEC audit on SMM was only launched in 2011. SMM data were collected in maternity units only, hence, any postnatal cases who presented to a general hospital were not captured. Additionally, for a complete understanding of the issues affecting maternal health, the study of incidence of conditions that did not require admission to hospital (e.g. cases managed in

primary care) would be relevant. These data are not available at national level.

The three national data sets used in this study allowed comparison of the relative incidence of morbidity and mortality associated with four categories of obstetric complications. Ideally, the case definition criteria would have been harmonised across the data sets but this was not always possible and some variation was present.

Conclusion

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. Haemorrhage and hypertension are leading causes of maternal morbidity in Ireland but they have very low case fatality. This indicates that these morbidities are managed effectively but their prevention requires more focus.

This study highlights the need to prioritise and implement timely interventions to tackle critical pregnancy and maternal health issues. Valuable lessons can be learned about the requirements, care and interventions necessary to ensure a better and more efficient response to the specific needs of these women.

Disclosure of interests

None declared. Completed disclosure of interests form available to view online as supporting information.

Contribution to authorship

SL contributed to conceptualising the study, acquiring, analysing and interpreting data and preparation of the manuscript. EM contributed to conceptualising the study, acquiring and interpreting data, and assisted in preparation of manuscript, revised drafts and final manuscript. RAG contributed to conceptualising the study, interpreting data and revised drafts and the final manuscript. PC contributed to conceptualising the study, acquiring, analysing and interpreting data, and revised drafts and the final manuscript.

Details of ethics approval

Study did not require ethical approval as it carried out secondary analyses of anonymous data.

Acknowledgements

We thank the patients and staff of the maternity units in Ireland who have contributed data to the NPEC. We are grateful to the individual units for their participation in the NPEC national clinical audits and to the data coordinators at unit level who facilitate data submission. We thank the NPEC, the NPEC Governance Committee and

the NPEC Maternal Morbidity Group, which facilitate this work. Open access funding provided by IReL.

Data availability statement

The data that support the findings of this study are available from the Hospital In-Patient Enquiry and the National Perinatal Epidemiology Centre. Restrictions apply to the availability of these data, which were used under license for this study.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure S1. Diagram with type of data sources and years of data included in the analyses. ■

References

- World Health Organization. *Trends in Maternal Mortality: 2000 to 2017: Estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division*. World Health Organization, editor. Geneva: WHO; 2019.
- Butler J, Erken A, Hurskin I, Passanisi D, Said R, Smith P, editors. *Accelerating the promise – the report on the Nairobi Summit on ICPD25*. New York, NY: United Nations Population Fund; 2020.
- Mantel GD, Buchmann E, Rees H, Pattinson RC. Severe acute maternal morbidity: a pilot study of a definition for a near-miss. *Br J Obstet Gynaecol* 1998;105:985–90.
- Geller SE, Cox SM, Callaghan WM, Berg CJ. Morbidity and mortality in pregnancy: laying the groundwork for safe motherhood. *Womens Health Issues* 2006;16:176–88.
- Firoz T, Chou D, von Dadelszen P, Agrawal P, Vanderkruik R, Tunçalp O, et al. Lale say measuring maternal health: focus on maternal morbidity. *Bull World Health Organisation* 2013;93:794–6.
- Chhabra P. Maternal near miss: an indicator for maternal health and maternal care. *Indian J Community Med* 2014;39:132–7.
- Chou D, Tunçalp Ö, Firoz T, Barreix M, Filippi V, von Dadelszen P, et al. Constructing maternal morbidity – towards a standard tool to measure and monitor maternal health beyond mortality. *BMC Pregnancy Childbirth* 2016;16:45.
- Sousa MH, Cecatti JG, Hardy EE, Serruya SJ. Severe maternal morbidity (near miss) as a sentinel event of maternal death. An attempt to use routine data for surveillance. *Reprod Health* 2008;5:6.
- Knight MBK, Tuffnell D, Jayakody H, Shakespeare J, Kotnis R, Kenyon S, et al., *Saving Lives, Improving Mothers' Care – Lessons Learned to Inform Maternity Care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2014–16*. Oxford: University of Oxford; 2018.
- Geller SE, Koch AR, Garland CE, MacDonald EJ, Storey F, Lawton B. A global view of severe maternal morbidity: moving beyond maternal mortality. *Reprod Health* 2018;15 (Suppl 1):98.
- Oxford Reference iceberg phenomenon. 2021 [www.oxfordreference.com/view/10.1093/oi/authority.20110803095955847]. Accessed 11 August 2021.
- Say L, Chou D, Gemmill A, Tunçalp Ö, Moller A-B, Daniels J, et al. Global causes of maternal death: a WHO systematic analysis. *Lancet Global Health* 2014;2:e323–33.
- Zeitlin J, Mohangoo A, Delnord M, Alexander S, Blondel B, Bouvier-Colle M-H et al. *The European Perinatal Health Report: health and care of pregnant women and babies in Europe in 2010*. Paris: Euro-Peristat; 2013.
- Kassebaum NJ, Barber RM, Bhutta ZA, Dandona L, Gething PW, Hay SI, et al. Global, regional, and national levels of maternal mortality, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016;388:1775–812.
- Zhang WH, Alexander S, Bouvier-Colle MH, Macfarlane A. Incidence of severe pre-eclampsia, postpartum haemorrhage and sepsis as a surrogate marker for severe maternal morbidity in a European population-based study: the MOMS-B survey. *BJOG* 2005;112:89–96.
- O'Hare MF, Manning E, Corcoran P, Greene RA, on behalf of MDE Ireland. *Confidential Maternal Death Enquiry in Ireland*. Cork: Maternal Death Enquiry (MED) Ireland; 2018.
- O'Hare MF, Manning E, Corcoran P, Greene RA, on behalf of MDE Ireland. Confidential maternal death enquiry in Ireland, report for 2013 – 2015. Cork: Maternal Death Enquiry (MDE) Ireland; 2017.
- Leitao S, Manning E, Corcoran P, Campillo I, Cutcliffe A, Greene RA et al. *Severe maternal morbidity in Ireland annual report 2018*. Cork: National Perinatal Epidemiology Centre (NPEC); 2020.
- Lennox C, Marr L. *Scottish Confidential Audit of Severe Maternal Morbidity*. Edinburgh: Healthcare Improvement Scotland; 2014.
- National Perinatal Epidemiology Centre. Severe maternal morbidity in Ireland annual report 2011. Cork: National Perinatal Epidemiology Centre; 2013.
- Healthcare Pricing Office. *H.I.P.E. Hospital In-Patient Enquiry 2019 Instruction Manual*. Dublin: Healthcare Pricing Office; 2019.
- Koblinsky M, Chowdhury ME, Moran A, Ronsmans C. Maternal morbidity and disability and their consequences: neglected agenda in maternal health. *J Health Popul Nutr* 2012;30:124–30.
- Jacobsen AF, Skjeldestad FE, Sandset PM. Incidence and risk patterns of venous thromboembolism in pregnancy and puerperium – a register-based case-control study. *Am J Obstet Gynecol* 2008;198:233.e1–7.
- O'Hare MF, Manning E, Corcoran P, Ireland GROBOM. *Confidential Maternal Death Enquiry in Ireland*. Cork: Maternal Death Enquiry (MED) Ireland; 2019.
- O'Hare MF, Manning E, Corcoran P, Greene RA, on behalf of MDE Ireland. Confidential maternal death enquiry in Ireland, report for 2016 – 2018. Cork: Maternal Death Enquiry (MDE) Ireland; 2020.
- Leitao S, Manning E, Corcoran P, Campillo I, Greene RA, on behalf of the Severe Maternal Morbidity Group. *Severe maternal morbidity in Ireland annual report 2019*. Cork: National Perinatal Epidemiology Centre; 2021.
- Health Information and Quality Authority (HIQA). Overview report of HIQA's monitoring programme against the National Standards for Safer Better Maternity Services, with a focus on obstetric emergencies. Dublin: HIQA; 2020.
- Jang MJ, Bang S-M, Oh D. Incidence of pregnancy-associated venous thromboembolism in Korea: from the Health Insurance Review and Assessment Service database. *J Thromb Haemost* 2011;9:2519–21.
- Kalhan M, Singh S, Punia A, Prakash J. Maternal near-miss audit: lessons to be learnt. *Int J Appl Basic Med Res* 2017;7:85–7.
- Lawton B, MacDonald EJ, Brown SA, Wilson L, Stanley J, Tait JD, et al. Preventability of severe acute maternal morbidity. *Am J Obstet Gynecol* 2014;210:557.e1–6.
- Hirshberg A, Srinivas SK. Epidemiology of maternal morbidity and mortality. *Semin Perinatol* 2017;41:332–7.
- Guida JP, Costa ML, Parpinelli MA, Pacagnella RC, Ferreira EC, Mayrink J, et al. The impact of hypertension, hemorrhage, and

- other maternal morbidities on functioning in the postpartum period as assessed by the WHODAS 2.0 36-item tool. *Int J Gynecol Obstet* 2018;141 (Suppl 1):55–60.
- 33 Kyu HH, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 2018;392:1859–922.
 - 34 Institute for Health Metrics and Evaluation (IHME). Global burden of disease study 2019 (GBD 2019) results [Internet]. 2020 [http://ghdx.healthdata.org/gbd-results-tool]. Accessed 25 January 2021.
 - 35 Gon G, Leite A, Calvert C, Woodd S, Graham WJ, Filippi V. The frequency of maternal morbidity: a systematic review of systematic reviews. *Int J Gynecol Obstet* 2018;141 (Suppl 1):20–38.
 - 36 Souza JP, Cecatti JG, Parpinelli MA, Sousa MH, Lago TG, Pacagnella RC, et al. Maternal morbidity and near miss in the community: findings from the 2006 Brazilian demographic health survey. *BJOG* 2010;117:1586–92.
 - 37 van Dillen J, Mesman J, Zwart J, Bloemenkamp K, van Roosmalen J. Introducing maternal morbidity audit in the Netherlands. *BJOG* 2010;117:416–21.
 - 38 National Perinatal Epidemiology Centre. NPEC national audit of severe maternal morbidity UCC; 2020 [Page of the NPEC SMM audits] [www.ucc.ie/en/npec/npec-clinical-audits/severematernalmoribidity/severematernalmoribidityreportsandforms/]. Accessed 2 August 2021.
 - 39 Knight MBK, Tuffnell D, Shakespeare J, Kotnis R, Kenyon S, Kurinczuk JJ, editors., et al. *Saving Lives, Improving Mothers' Care – Lessons Learned to Inform Maternity Care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2016–18*. Oxford: University of Oxford; 2020.
 - 40 Leitao S, Manning E, Corcoran P, Greene RA, on behalf of the Severe Maternal Morbidity Group. *Severe maternal morbidity in Ireland annual report 2017*. Cork: National Perinatal Epidemiology Centre; 2019.