Maternal, Newborn and Infant Clinical Outcome Review Programme

MBRRACE-UK
Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK

Saving Lives, Improving Mothers' Care

Lessons learned to inform maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2015-17

November 2019

HQIP Healthcare Quality Improvement Partnership
University of Leicester
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Bradford Teaching Hospitals NHS Foundation Trust
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University of Oxford

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Foreword

Cardiovascular disease remains the leading cause of women's deaths during or after pregnancy in the UK and Ireland. There has been no reduction in the maternal mortality rate from heart disease in the UK for more than 15 years. We must all become more aware that heart disease can and does affect young women, and that the additional strain that pregnancy places on the heart can reveal cardiac complications for the first time. Many of the women whose deaths were reviewed had symptoms which, if they had occurred in a non-pregnant person, would be considered highly suspicious of cardiovascular compromise. Yet they were attributed to normal symptoms of pregnancy. For these women, simply being pregnant led to compromised care and delayed diagnosis.

New European Society of Cardiology (ESC) guidelines on the management of cardiovascular diseases during pregnancy were published in 2018, and this report emphasises the importance of a number of the ESC recommendations. In particular, life-saving treatments such as electrical cardioversion should not be denied to women simply because they are pregnant or postpartum. We should above all aim to ensure that women with known cardiovascular conditions enter pregnancy fully informed with their health and medications suitably optimised. The ESC guidelines provide clear direction for pre-pregnancy considerations for women with a wide range of known cardiovascular conditions.

In particular, we should continue to be mindful of rare cardiovascular disorders which are very high risk in pregnancy. Women continue to die from pulmonary hypertension during or shortly after pregnancy, either because their pregnancy is unplanned, or because the diagnosis is never considered in a young woman. Advice on counselling, diagnosis and management is detailed in the ESC guidelines.

Nevertheless there are areas of cardiovascular care emphasised in this report for which we do not yet have clear guidance. Several women died from ischaemic heart disease after becoming pregnant following assisted reproduction. There is no evidence that their cardiovascular health prior to pregnancy was considered, even though they had a number of clear risk factors for heart disease. We urgently need the evidence to guide cardiovascular assessment and screening prior to assisted conception.

Women should be reassured that, although cardiovascular disease is the leading cause of maternal death, the number of women who die during or after pregnancy is still very small. Nevertheless, both women and their health professionals who care for them should be aware of symptoms and signs which are not normal for pregnancy, such as breathlessness when lying flat, chest pain which spreads to the back or arm or fainting during exercise, and which should prompt investigation for cardiovascular disease. By remaining aware of the possibility of heart disease and hence making the diagnosis we will make the first steps to reducing unnecessary deaths amongst young women and leaving families devastated.

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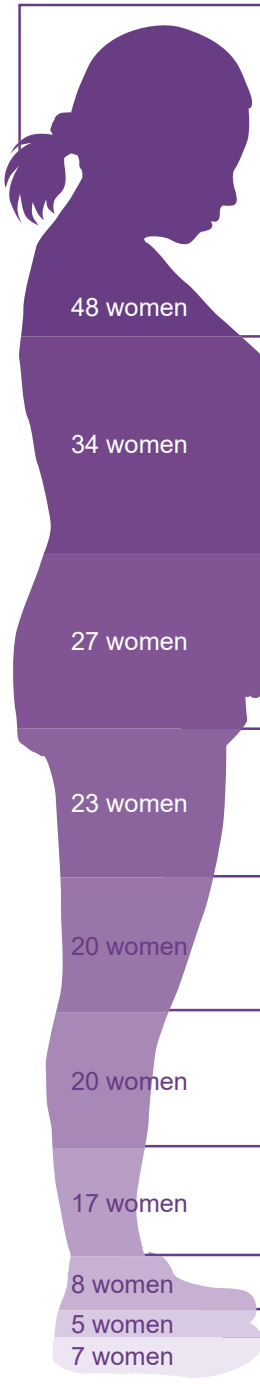
ESC
European Society of Cardiology

Key messages from the report 2019

MBRRACE-UK
Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK

In 2015-17, **209 women died** during or up to six weeks after pregnancy, from causes associated with their pregnancy, among 2,280,451 women giving birth in the UK.
9.2 women per 100,000 died during pregnancy or up to six weeks after childbirth or the end of pregnancy.

Causes of women's deaths



48 women — **Heart disease** 23%
34 women — Blood clots 16%
27 women — Epilepsy and stroke 13%
23 women — Other physical conditions 11%
20 women — Sepsis 10%
20 women — Mental health conditions 10%
17 women — Bleeding 8%
8 women — Cancer 4%
5 women — Pre-eclampsia 2%
7 women — Other 3%

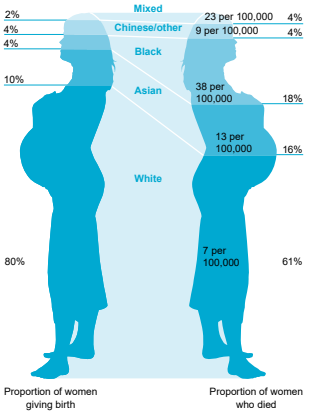
Heart disease can occur for the first time in pregnancy – severe **chest pain** is a red flag

Women who are older, obese, smoke or have diabetes or a family history may be at greater risk of heart disease

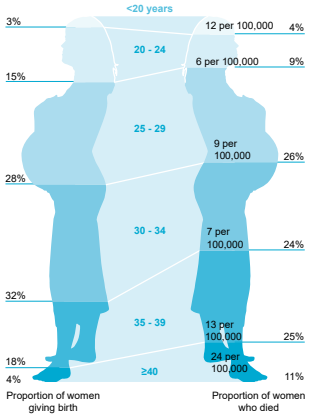
Breathlessness when resting and especially when lying flat is not normal in pregnancy and may indicate heart problems

Inequalities in maternal mortality

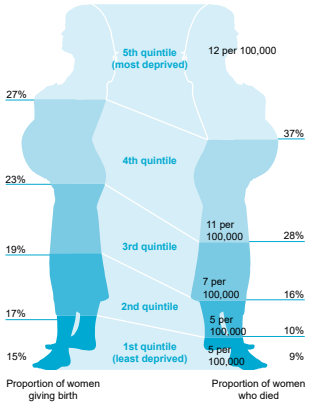
Ethnic group



Age



Living in more deprived areas



Women with risk factors for **pre-eclampsia** need **aspirin** to be prescribed from 12 weeks of pregnancy

Executive Summary

Introduction

This report, the sixth MBRRACE-UK annual report of the Confidential Enquiry into Maternal Deaths and Morbidity, includes surveillance data on women who died during or up to one year after pregnancy between 2015 and 2017 in the UK. In addition, it also includes Confidential Enquiries into the care of women who died between 2015 and 2017 in the UK and Ireland from cardiovascular causes, hypertensive disorders, early pregnancy conditions and accidents.

The report also includes a Morbidity Confidential Enquiry into the care of women with newly diagnosed breast cancer.

Surveillance information is included for 549 women who died during or up to one year after the end of pregnancy between 2015 and 2017. The care of 144 women who died and 30 with newly diagnosed breast cancer in pregnancy was reviewed in depth for the Confidential Enquiry chapters.

This report can be read as a single document; each chapter is also designed to be read as a standalone report as, although the whole report is relevant to maternity staff, service providers and policy-makers, there are specific clinicians and service providers for whom only single chapters are pertinent. There are seven different chapters which may be read independently, the topics covered are: 1. Surveillance of maternal deaths 2. Cardiovascular diseases 3. Morbidity from breast cancer 4. Hypertensive disorders 5. Early pregnancy disorders 6. Accidents 7. Critical maternal care.

Methods

Maternal deaths are reported to MBRRACE-UK, NIMACH or to MDE Ireland by the staff caring for the women concerned, or through other sources including coroners, procurators fiscal and media reports. In addition, identification of deaths is cross-checked with records from the Office for National Statistics, Information Services Division Scotland and National Records of Scotland. Full medical records are obtained for all women who die as well as those identified for the Confidential Enquiry into Maternal Morbidity, and anonymised prior to undergoing confidential review. The anonymous records are reviewed by a pathologist, together with an obstetrician or physician as required to establish a woman's cause of death. The care of each woman is then assessed by one or two obstetricians, midwives, pathologists, anaesthetists and other specialist assessors, including psychiatrists, general practitioners, physicians, emergency medicine specialists and intensive care experts. Each woman's care is thus examined by between ten and fifteen expert reviewers and assessed against current guidelines and standards (such as that produced by NICE or relevant Royal Colleges and other professional organisations). Subsequently the expert reviews of each woman's care are examined by a multidisciplinary writing group to enable the main themes for learning to be drawn out for the MBRRACE-UK report. These recommendations for future care are presented here, alongside a surveillance chapter reporting three years of UK statistical surveillance data.

NOTE: Relevant actions are addressed to all health professionals as silo working leading to compromised care is a recurring theme identified in these enquiries. Some actions may be more pertinent to specific professional groups than others but all should nonetheless be reviewed for relevance to practice by each group.

Causes and trends

There was a statistically non-significant decrease in the overall maternal death rate in the UK between 2012-14 and 2015-17, which suggests that continued focus on implementation of the recommendations of these reports is needed to achieve a reduction in maternal deaths. Assessors judged that 44% of women who died had good care. However, improvements in care which may have made a difference to the outcome were identified for 29% of women who died. **ACTION: Policy makers, service planners/commissioners, service managers, all health professionals**

Maternal deaths from direct causes are unchanged with no significant change in the rates between 2012-14 and 2015-17. Thrombosis and thromboembolism remain the leading cause of direct maternal death during or up to six weeks after the end of pregnancy.

Maternal suicide is the second largest cause of direct maternal deaths occurring during or within 42 days of the end of pregnancy and remains the leading cause of direct deaths occurring within a year after the end of pregnancy.

There remains a five-fold difference in maternal mortality rates amongst women from Black ethnic backgrounds and an almost two-fold difference amongst women from Asian ethnic backgrounds compared to white women, emphasising the need for a continued focus on actions to address these disparities. **ACTION: Policy makers, service planners/commissioners, service managers, all health professional**

Key messages to improve care

The majority of recommendations which MBRRACE-UK assessors have identified to improve care are drawn directly from existing guidance or reports and denote areas where implementation of existing guidance needs strengthening. In a small number of instances, actions are needed for which national guidelines are not available, and these are presented separately here for clarity.

New recommendations to improve care

For professional organisations:

1. Guidance is needed on maternal medical assessment and screening prior to assisted reproduction, particularly for older women who are at higher risk of co-morbidities such as cardiac disease and cancer **[ACTION: Royal Colleges of Obstetricians and Gynaecologists, Physicians].**
2. Review of the RCOG 'Responsibility of Consultant on Call' guidance is needed to ensure that deviation from the usual clinical pathway, with unexpected or unexplained symptoms, triggers consultant review **[ACTION: Royal College of Obstetricians and Gynaecologists].**
3. Guidance is needed to ensure timely staging investigations are conducted in women with breast cancer in pregnancy to guide appropriate future care **[ACTION: Royal Colleges of Obstetricians and Gynaecologists, Physicians, Radiologists].**

For policy makers, service planners/commissioners and service managers:

4. A national Patient Group Direction, including advice relating to safe, timely and cost-effective local implementation, as a solution should be explored to ensure consistent high quality care by allowing midwives to supply aspirin to eligible women in line with NICE Guidance (*MPG2*, *NG133*) **[ACTION: NHSE/I and equivalents in the devolved nations and Ireland].**
5. The new maternal medicine networks which are being developed in England and similar structures in the devolved nations should define pathways of referral for women with multiple and complex problems **[ACTION: Maternal Medicine Networks and equivalent structures in Ireland and the devolved nations].**
6. Early pregnancy assessment services should ensure processes are in place to review and act upon the results of investigations promptly **[ACTION: Hospitals/Trusts/Health Boards].**
7. Any facility performing laparoscopic surgery in pregnancy should have blood immediately available, staff should be able to perform measures to control haemorrhage prior to definitive treatment and an escalation protocol for rapid assistance should be in place **[ACTION: Hospitals/Trusts/Health Boards].**
8. Local investigations and reviews of maternal death should not be confined to a timeline of events and a clinical narrative. The strength or weakness of multi-disciplinary team working should merit specific comment **[ACTION: Hospitals/Trusts/Health Boards].**

For research organisations:

9. Development of an appropriate evidence-based early warning scoring system for pregnant and postpartum women should be a priority **[ACTION: National Institute for Health Research, Chief Scientist Office, Health and Care Research Wales, Health Research Board in consultation with Royal Colleges of Anaesthetists, Obstetricians and Gynaecologists, Physicians, Radiologists and Faculty of Intensive Care Medicine].**

For health professionals:

10. A persistent sinus tachycardia is a 'red flag' and should always be investigated, particularly when there is associated breathlessness.
11. Genetic counselling should state for women known to be carriers of any inherited condition, whether the associated genetic mutation is known or unknown, and whether they need a cardiovascular risk assessment in pregnancy. Anyone with a family history or genetic confirmation of aortopathy or channelopathy should be referred for cardiac assessment before pregnancy.
12. In general, for women with breast cancer, early delivery to avoid delays in chemotherapy should not be recommended. For women diagnosed with breast cancer in the third trimester, the risk-benefit is likely to favour both mother and baby if a woman can receive at least two cycles of chemotherapy prior to a term (39-40 week) birth.
13. Advice on appropriate contraception and postponement of pregnancy should be given to women under investigation for suspected breast cancer.
14. Women with multiple organ dysfunction need consultant involvement and there should be early consideration regarding the optimal setting for their care and whether transfer to a local or specialist critical care unit is warranted.
15. When a woman collapses out of hospital good communication should ensure senior review at admission and multidisciplinary involvement to determine the diagnosis promptly and enable rapid appropriate treatment.

16. Focused, point of care ultrasound investigations can help guide decision making in the management of maternal collapse. A limited cardiac echo study as well as a FAST scan can provide vital clues to differentiate key diagnoses and is the gold standard of care for a woman with severe cardiovascular instability or compromise.

Recommendations identified from existing guidance requiring improved implementation

Original source indicated in brackets.

Maternity Networks should work with their member organisations and professional groups to support all relevant healthcare professionals to deliver care for pregnant women in line with these recommendations.

Care of women with cardiovascular disease

Repeated presentation with pain and/or pain requiring opiates should be considered a 'red flag' and warrant a thorough assessment of the woman to establish the cause. Pain severe enough to prevent a woman caring for her baby represents a similar 'red flag' [*Saving Lives, Improving Mothers' Care 2018*]. **ACTION: All health professionals**

A raised respiratory rate, chest pain, persistent tachycardia and orthopnoea are important signs and symptoms of cardiac disease which should always be fully investigated. The emphasis should be on making a diagnosis, not simply excluding a diagnosis [*Saving Lives, Improving Mothers' Care 2016*]. **ACTION: All health professionals**

Syncope during exercise can suggest a cardiac origin, and should prompt cardiac evaluation [*ESC syncope guideline 2018*]. **ACTION: All health professionals**

ECG and measurement of troponin levels are recommended when a pregnant woman has chest pain. Echocardiography is recommended in any pregnant patient with unexplained or new cardiovascular signs or symptoms [*ESC cardiovascular diseases in pregnancy guideline 2018*]. **ACTION: All health professionals**

Following resuscitation from an arrest with a likely cardiac cause, coronary angiography ± percutaneous coronary intervention is the appropriate initial diagnostic investigation (*UK Resuscitation Council guidelines 2015*]. **ACTION: All health professionals**

Electrical cardioversion is safe in all phases of pregnancy. Immediate electrical cardioversion is recommended for any woman with a tachycardia with haemodynamic instability and for pre-excited atrial fibrillation [*ESC cardiovascular diseases in pregnancy guideline 2018*]. **ACTION: All health professionals**

Clear guidance on contraceptive choices for women with cardiac disease is available and should be consulted [*UK Medical Eligibility Criteria for Contraceptive Use 2016*]. **ACTION: All health professionals**

Care of women with breast cancer in pregnancy

Refer women using a suspected cancer pathway referral (for an appointment within 2 weeks) for breast cancer if they are aged 30 and over and have an unexplained breast lump with or without pain. Consider a suspected cancer pathway referral (for an appointment within 2 weeks) for breast cancer in women: with skin changes that suggest breast cancer or aged 30 and over with an unexplained lump in the axilla [*RCOG Green-top guideline 12*]. **ACTION: All health professionals**

The birth of the baby should be timed after discussion with the woman and the multidisciplinary team. Most women can go to full term of pregnancy and have a normal or induced birth [*RCOG Green-top guideline 12*]. **ACTION: All health professionals**

Women can be reassured that they can breastfeed from the unaffected breast. There should be a time interval of 14 days or more from the last chemotherapy session to start of breastfeeding to allow drug clearance from breast milk. If chemotherapy is restarted, breastfeeding must cease. A short period of lactation may be psychologically beneficial after a stressful pregnancy and be beneficial to the baby [*RCOG Green-top guideline 12*]. **ACTION: All health professionals**

At diagnosis, the impact of the cancer and its treatment on future fertility should be discussed between the woman diagnosed with cancer and her cancer team [*NICE CG156*]. **ACTION: All health professionals**

For women with cancer, advice on postponement of pregnancy should be individualised and based on treatment needs and prognosis over time. The risk of breast cancer recurrence is highest within the first two years after treatment. Most women with breast cancer should therefore wait at least two years after treatment [*RCOG Green-top guideline 12*]. **ACTION: All health professionals**

Care of women with pre-eclampsia and related hypertensive disorders of pregnancy

Advise women at high risk of pre-eclampsia, or with more than one moderate risk factor for pre-eclampsia, to take 75-150 mg of aspirin daily from 12 weeks until the birth of the baby [*NICE NG133*]. **ACTION: All health professionals**

Offer pharmacological treatment to women if blood pressure remains above 140/90 mmHg. Aim for a target blood pressure of 135/85 mmHg or less once on hypertensive treatment [*NICE NG133*]. **ACTION: All health professionals**

In women with severe hypertension (blood pressure of 160/110 mmHg or more) offer pharmacological treatment to all women and measure blood pressure every 15-30 minutes until BP is less than 160/110 [*NICE NG133*]. **ACTION: All health professionals**

In women with gestational hypertension who have given birth, measure blood pressure:

- daily for the first 2 days after birth
- at least once between day 3 and day 5 after birth
- as clinically indicated if antihypertensive treatment is changed after birth [*NICE NG133*]. **ACTION: All health professionals**

In women with gestational hypertension who have given birth:

- continue antihypertensive treatment if [it was] required
- advise women that the duration of their postnatal antihypertensive treatment will usually be similar to the duration of their antenatal treatment (but may be longer)
- reduce antihypertensive treatment if their blood pressure falls below 130/80 mmHg [*NICE NG133*]. **ACTION: All health professionals**

Care of women with early pregnancy disorders

A diagnosis of ectopic pregnancy should be considered in any woman of reproductive age presenting to the emergency department with collapse, acute abdominal/pelvic pain or gastrointestinal symptoms, particularly diarrhoea, vomiting and dizziness, regardless of whether or not she is known to be pregnant. A bedside pregnancy test should always be performed in these women, if necessary catheterising to obtain urine [*Saving Lives, Improving Mothers' Care 2016*]. **ACTION: All health professionals**

Women of reproductive age who present in the community in a state of shock and/or collapse with no obvious cause should be transferred urgently to a hospital Emergency Department without delay for rapid assessment and treatment [*Saving Lives, Improving Mothers' Care 2016*]. **ACTION: All health professionals**

Women of reproductive age presenting to the Emergency Department collapsed, in whom a pulmonary embolism is suspected, should have a Focused Assessment with Sonography in Trauma (FAST) scan to exclude intra-abdominal bleeding from a ruptured ectopic pregnancy especially in the presence of anaemia [*Saving Lives, Improving Mothers' Care 2016*]. **ACTION: All health professionals**

Prevention and management of accidents in pregnancy or postpartum

There is a need for practical national guidance for the management of women with multiple morbidities and social factors prior to pregnancy, and during and after pregnancy [*Saving Lives, Improving Mothers' Care 2017*]. **ACTION: Professional organisations and policy makers**

Disengagement from care should be regarded as a potential indicator of worsening mental state. All professionals involved in the woman's care should be informed of non-attendances and assertive follow-up arranged where there is already concern regarding mental state or prior evidence of risk [*Saving Lives, Improving Mothers' Care 2018*]. **ACTION: Professional organisations and policy makers**

From 20 weeks of gestation onwards, the pressure of the gravid uterus must be relieved from the inferior vena cava and aorta during maternal resuscitation [*RCOG green-top guideline 56*]. **ACTION: All health professionals**

Messages for Maternal Critical Care

Peri-mortem caesarean section (PMCS) is a vital component of advanced life support in resuscitation of a woman who is pregnant. Guidance relating to PMCS needs to be reviewed and strengthened [*Saving Lives, Improving Mothers' Care 2014*]. ACTION: Professional organisations

Pregnant or recently pregnant women should have access at all times to a healthcare professional who has enhanced maternal care competencies [*Care of the critically ill woman in childbirth 2018*]. **ACTION: Policy makers, service planners/commissioners and service managers**

The route of escalation to critical care services should be clearly defined, and include multidisciplinary discussion [*Care of the critically ill woman in childbirth 2018*]. **ACTION: Service managers and all health professionals**

Critical care outreach or an equivalent service should be available to ill women, and provide support and education to healthcare professionals delivering enhanced maternal care [*Care of the critically ill woman in childbirth 2018*]. **ACTION: Policy makers, service planners/commissioners and service managers**

Neither pregnancy, caesarean section birth or the immediate postpartum state are absolute contraindications to thrombolysis [*Saving Lives, Improving Mothers' Care 2014*]. **ACTION: All health professionals**

Where sepsis is present the source should actively be sought with appropriate imaging and consideration given to whether surgical or radiological-guided drainage is required [*RCOG Green-top guideline 64b*]. **ACTION: All health professionals**

Data gathering on maternal critical illness (including when it is managed in obstetric areas) should be re-examined and strengthened by new definitions in order to capture lessons about good care and near miss events [*NMPA 2019*]. **ACTION: Professional organisations and policy makers**

Conclusions

This report highlights once again the need for a wider focus on pre-pregnancy, pregnancy and postnatal care throughout the health service, and not solely in maternity care, in order to prevent women from dying. The inequalities observed in previous reports remain. Black women still have more than five times the risk of dying in pregnancy or up to six weeks postpartum compared to white women, women of mixed ethnicity three times the risk and Asian women almost twice the risk. Following a recommendation in the 2018 report that 'Action is needed to address these disparities' a number of research projects are in progress to explore in depth the underlying reasons for this inequality and identify specific actions to reduce this disparity. This work will be completed next year, but actions have already been put in place as part of the NHS Long Term Plan, and there are ongoing discussions at policy level about actions to address disparity. However, there are actions we can take as individuals now. Continued awareness of these inequalities within our own services and questioning whether the way we deliver care before, during and after pregnancy unconsciously disadvantages different groups of women, whether on the basis of their ethnicity, socioeconomic status or pre-existing social, mental health or physical health problems is an important immediate first step we can all take.

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Key to colour coding

Vignettes concerning the care of women who died are described in blue boxes

Vignettes concerning the care of women who had severe morbidity but survived are described in purple boxes with the character M in the corner

The majority of recommendations arise from existing national guidelines or previous reports and the source of these recommendations are cited within green boxes. Example:

Existing guidance requiring improved implementation is presented in green boxes

NICE 2345

Recommendations based on improvements in care noted by MBRRACE reviewers for which there is no current national guidance and which has not been noted in previous guidance or reports are shown in purple boxes. Example:

New recommendations are presented in purple boxes with the character N in the corner.

The recommendations identified by MBRRACE reviewers as the most frequently needed improvements are highlighted in the key messages section at the start of each chapter. The specific individuals or professional groups who need to take action are indicated alongside the key messages, where appropriate.

Glossary of terms

AFE	Amniotic Fluid Embolism
AFLP	Acute Fatty Liver of Pregnancy
AIP	Abnormally Invasive Placenta
ALSO	Advanced Life Support in Obstetrics
BMI	Body mass index
BP	Blood pressure
CEMD	Confidential Enquiries into Maternal Deaths
CEMM	Confidential Enquiries into Maternal Morbidity
CHD	Congenital Heart Disease
CI	Confidence interval
CMACE	Centre for Maternal and Child Enquiries
CPAP	Continuous positive airway pressure
CPN	Community psychiatric nurse
CPR	Cardiopulmonary resuscitation
CRHT	Crisis resolution and home treatment
CT	Computerised Tomography
CTPA	Computerised tomography pulmonary angiogram
DIC	Disseminated intravascular coagulation
DNA	Deoxyribonucleic acid
DVT	Deep venous thrombosis
ECMO	Extracorporeal membrane oxygenation
ECG	Electrocardiogram
ECT	Electroconvulsive therapy
EEA	European Economic Area
EEG	Electroencephalogram
ER	Estrogen receptor
ESC	European Society for Cardiology
EWS	Early warning scores
FAST	Focused Assessment with Sonography in Trauma
GCS	Glasgow Coma Score
GCSF	Granulocyte-colony stimulating factor
GP	General practitioner
HELLP	Haemolysis, Elevated Liver enzymes, Low Platelet count
HER2	Human epidermal growth factor receptor 2
HES	Hospital Episode Statistics
HQIP	Healthcare Quality Improvement Partnership
HSE	Health Service Executive
ICD	Implantable cardioverter defibrillator
ICD	International Classification of Diseases
ICD-MM	International Classification of Diseases – Maternal Mortality
IHP+	Health Partnership and related initiatives
IMD	Index of Multiple Deprivation
IMEWS	Irish Maternity Early Warning System
IOL	Induction Of Labour
IV	Intravenous
IVF	In vitro fertilisation
JRCALC	Joint Royal Colleges Ambulance Liaison Committee
LMWH	Low molecular weight heparin
LVH	Left ventricular hypertrophy
LQTS	Long QT syndrome
MBRRACE-UK	Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries across the UK
MBU	Mother and Baby Unit
MDE	Maternal Death Enquiry
MEmO	Medical Emergencies in Obstetrics
MEOWS	Modified Early Obstetric Warning Score
MMR	Maternal mortality ratio
mMOET	Managing Medical and Obstetric Emergencies and Trauma
MNI-CORP	Maternal Newborn and Infant Clinical Outcome Review Programme
MRI	Magnetic resonance imaging
NCAPOP	National Clinical Audit and Patient Outcomes Programme
NCEPOD	National Confidential Enquiry into Patient Outcome and Death
NCISH	National Confidential Inquiry into Suicide and Safety in Mental Health
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NIMACH	Northern Ireland Maternal and Child Health
NMCRR	National Mortality Case Record Review
NMPA	National Maternal and Perinatal Audit
PCI	Percutaneous coronary intervention
PE	Pulmonary embolism
PMCS	Perimortem caesarean section
PMCT	Post mortem Computerised Tomography
PPH	Postpartum Haemorrhage
PVA	Polyvinyl alcohol
RCOG	Royal College of Obstetricians and Gynaecologists
ROSC	Return of spontaneous circulation
RR	Rate ratio
SADS/MNH	Sudden arrhythmic cardiac deaths with a morphologically normal heart
SBP	Systolic blood pressure
SCAD	Spontaneous coronary artery dissection
SVT	Supraventricular tachycardia
vEDS	Vascular Ehlers Danlos syndrome
VF	Ventricular fibrillation
VTE	Venous thromboembolism

Contents

1. Introduction and methodology

Marian Knight

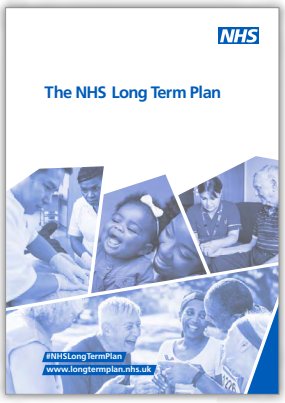
1.1 The 2019 Saving Lives, Improving Mothers' Care report

Perhaps the greatest justification for these ongoing Confidential Enquiries is evidence of a decrease in maternal deaths, and it is reassuring to note that there has been a statistically non-significant decrease in maternal mortality in the 2015-17 triennium compared with the 2014-16 triennium. Importantly, the increase in maternal deaths from haemorrhage, highlighted in the 2017 report, has almost reversed. This coincides with increased recognition of the need for specialised diagnosis and management of abnormally invasive placentation and further actions to establish expert centres (Prudhoe 2018), against the background of a continued gradual rise in caesarean birth rates (Boerma et al. 2018).

Nevertheless, this report highlights once again the need for a wider focus on pre-pregnancy, pregnancy and postnatal care throughout the health service, and not solely in maternity care, in order to prevent women from dying. Although this triennium has seen, for the first time in recent years, a statistically non-significant decrease in maternal deaths from cardiovascular disease, more than one in five of the women who died during or up to six weeks after pregnancy continue to die from heart disease. Recognition that serious symptoms and signs, such as orthopnoea, persistent tachycardia and breathlessness at rest are not normal in pregnancy, will go a long way in ensuring earlier diagnosis with the possibility of specialist treatment to prevent women from dying. The challenge is that this is not simply a message for maternity services, but for primary care, emergency departments and acute medical wards, women and families themselves. Whilst it is important that women are reassured that few women die during or after pregnancy in the UK and that many symptoms in pregnancy are unlikely to represent severe illness, raised awareness of 'red flag' symptoms will help ensure that the small number of women who are seriously ill seek care and are diagnosed early. An acute care toolkit on managing acute medical problems in pregnancy is under development by the Royal College of Physicians and Society of Acute Medicine which will highlight 'red flag' symptoms and signs in pregnancy and further similar developments raising awareness of other 'red flags' such as those for maternal mental health will be important.

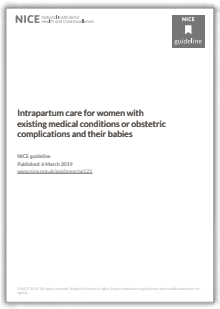
The inequalities observed in previous reports persist. This report highlights for the first time the number of women who die that have severe and multiple disadvantage. Black women still have more than five times the risk of dying in pregnancy or up to six weeks postpartum compared with white women, women of mixed ethnicity three times the risk and Asian women almost twice the risk. Following a recommendation in the 2018 report a number of research projects are in progress to explore in depth the underlying reasons for this inequality and identify specific actions to reduce this disparity. This work will be completed next year, but actions have already been put in place in the latest NHS plan, and there are ongoing discussions at policy level about actions to address disparity. However, there are actions we can take as individuals now. Continued awareness of these inequalities within our own services and questioning whether the way we deliver care before, during and after pregnancy unconsciously disadvantages different groups of women, whether on the basis of their ethnicity, socioeconomic status or pre-existing social, mental health or physical health problems is an important immediate first step we can all take.

1.2 Actions following the release of the 2014-2018 reports

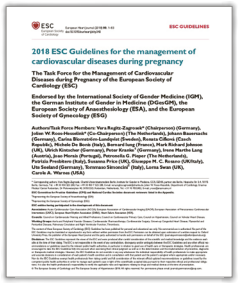


Evidence from the 2018 report was used to underpin the future strategy for England described in 'The NHS Long Term Plan' (NHS England 2019). In particular, the report reiterated the importance of establishing maternal medicine networks, and the importance of focussing on safety through programmes such as the Confidential Enquiry, noting specifically that 'the NHS will continue to improve how it learns lessons when things go wrong and minimise the chances of them happening again.'

Work is also advanced in Scotland to develop networked maternal medicine, following on from the 'Best Start' maternity review (The Scottish Government 2017) and 'Addressing the heart of the issue'. (Brennand et al. 2016).

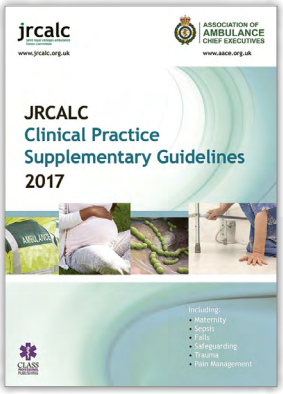


Linked to the importance of a focus on women with mental and physical co-morbidities, evidence from the Confidential Enquiry underpins multiple recommendations in the new National Institute for Health and Care Excellence (NICE) guideline NG121 'Intrapartum care for women with existing medical conditions or obstetric complications and their babies' (National Institute for Health and Care Excellence 2019a). Recommendations which reflect messages in previous MBRRACE-UK reports include particularly the involvement of a multi-disciplinary team with a named lead in the preparation of a plan for intrapartum care of pregnant women with a medical condition, early risk assessment and involvement of specialist cardiologists for women with heart disease, diagnosis and management of heart failure and fluid management.

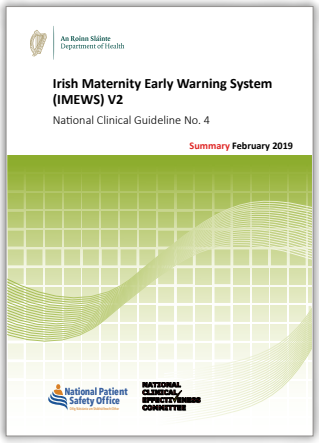


More specifically in relation to cardiac disease, the importance of the new European Society of Cardiology guidelines (Regitz-Zagrosek et al. 2018) is underpinned by the repeated finding in these Confidential Enquiries that cardiovascular disease is the most frequent cause of maternal death in the UK and a leading cause of maternal death in Ireland. Evidence from the UKOSS study of pregnant women with mechanical heart valves, which was linked to the morbidity confidential enquiry in the 2016 report (Knight et al. 2016, Vause et al. 2017) underpins the recommendations about anticoagulant regimens to prevent valve thrombosis.

The Joint Royal Colleges Ambulance Liaison Committee (JRCALC) clinical practice supplementary guidelines now have an extensive section on maternity care (Joint Royal Colleges Ambulance Liaison Committee and Association of Ambulance Chief Executives 2017), which highlights a number of key points from these Confidential Enquiries. In particular, the guidelines repeatedly emphasise that maternal safety is the key consideration, and note scenarios in which a time critical transfer to the nearest emergency department is indicated, with a pre-alert to enable the emergency department team to summon the obstetric emergency team where available.



The Scottish Patient Safety Programme (SPSP) Maternity and Children Quality Improvement Collaborative (MCQIC) supports maternity teams in Scotland to improve the quality and safety of maternity healthcare with specific aims to reduce the rate of severe postpartum haemorrhage (PPH) by 30% by 2021. The national programme focussed on PPH in 2017 highlighted issues such as reducing the number of severe haemorrhages related to atony and a rising number of cases related to trauma, particularly in relation to retained placenta and vaginal and cervical tears. As a result, MCQIC designed, tested and launched improvement measures related to these issues and other recommendations in the last MBRRACE report. A variety of mechanisms are used to deliver the national programme, one of which is the establishment of individual partnership agreements with each Health Board in Scotland to help identify and agree improvement priorities, including improving care related to severe PPH, specifically to the refreshed MCQIC measures.



These Confidential Enquries have repeatedly emphasised the early recognition of deterioration in pregnancy, and evidence from the Maternal Death Enquiry Ireland is cited in the newly updated Irish Maternity Early Warning System (IMEWS v2) National Clinical Guideline (Department of Health 2019). Reflecting the recommendation made in the 2017 MBRRACE-UK report (Knight et al. 2017), that women's clinical condition as well as their MEOWS score should be considered, the IMEWS guideline also notes among its recommendations that "clinical concern about an individual woman warrants an escalation to medical staff irrespective of the presence or absence of IMEWS triggers. The level and speed of escalation should reflect the degree of clinical concern." In Northern Ireland the Maternity Quality Improvement Collaborative, under the direction of the Maternity Strategy Implementation group, has also designed an Obstetric Early Warning Score system which is now in use in all maternity units.

The 2018 report highlighted particularly that women from Black and other minority ethnic groups were at higher risk of dying in pregnancy compared with white women, and women from deprived areas are also at higher risk of dying compared with those from less deprived areas (Knight et al. 2018). The updated Guidelines for the Provision of Anaesthesia Services for an Obstetric Population 2019 (Bogod et al. 2019) aimed specifically "to provide recommendations that address the specific needs of these (and all) women to define a service that reduces their exposure to that risk of harm". It is very encouraging to see this focus taken when designing services and we hope that this is one of many actions with a similar aim.

Action on Pre-eclampsia (APEC), as part of a parliamentary debate on pre-eclampsia, also highlighted the ethnic disparity in maternal mortality, noting that "Black women (compared to White) are around 3 times more likely to develop pre-eclampsia in their pregnancies" and calling on the Government to prioritise care for hard to reach and at risk groups (Action on Pre-eclampsia 2019).

One of the biggest challenges to decreasing maternal mortality in the UK and Ireland is the fact that it requires joint working across specialties, and particularly with teams outside of maternity (Knight et al. 2018). In order to facilitate further the embedding of common messages for improving care across specialties, the adult national morbidity and mortality programmes (Learning Disabilities Mortality Review Programme (LeDeR), National Confidential Inquiry into Suicide and Safety in Mental Health (NCISH), Medical and Surgical Clinical Outcome Review and the Child Health Clinical Outcome Programmes (NCEPOD), National Mortality Case Record Review Programme (NMCRR) and MBRRACE-UK) have worked together to identify the key common messages to focus on. These have been drawn together in a leaflet and accompanying web summary, and formed the focus of a session at the launch of the first NMCRR report at the Royal College of Physicians (Mortality Reviews Collaborative 2018). We hope that by working together as a mortality reviews collaborative, dissemination and embedding of common recommendations will be further enhanced.

1.3 Topics covered in MBRRACE-UK maternal reports 2014-19

The programme now involves the production of annual CEMD reports. Reports were previously produced on a triennial basis, because the number of maternal deaths from individual causes is small, and three years' worth of data is required to identify consistent lessons learned for future care and to maintain anonymity and confidentiality. Clearly the need to undertake annual reporting does not change this requirement, therefore, each topic-specific chapter which appeared in the previous triennial report now appears in an annual report once every three years on a cyclical basis, alongside a surveillance chapter reporting three years of statistical data. All causes of maternal death have now been covered once in this three-year cycle; this report is the third in the second three-year cycle:

- **2014 report:** Surveillance data on maternal deaths from 2009-12. Confidential Enquiry reports on severe morbidity and deaths from sepsis, deaths from haemorrhage, amniotic fluid embolism (AFE), anaesthesia, neurological, respiratory, endocrine and other indirect causes.
- **2015 report:** Surveillance data on maternal deaths from 2011-13. Confidential Enquiry reports on deaths from psychiatric causes, deaths due to thrombosis and thromboembolism, malignancy, homicides and late deaths.
- **2016 report:** Surveillance data on maternal deaths from 2012-14. Confidential Enquiry reports on deaths and severe morbidity from cardiac causes, deaths from pre-eclampsia and eclampsia and related causes and deaths in early pregnancy, messages for critical care.
- **2017 report:** Surveillance data on maternal deaths from 2013-15. Confidential Enquiry reports on severe morbidity from psychosis, severe morbidity and deaths from epilepsy, deaths from haemorrhage, amniotic fluid embolism (AFE), anaesthesia, stroke, respiratory, endocrine and other indirect causes.
- **2018 report:** Surveillance data on maternal deaths from 2014-16. Confidential Enquiry reports on deaths from psychiatric causes, deaths due to thrombosis and thromboembolism, malignancy and homicides, and morbidity from major obstetric haemorrhage.
- **2019 (this report):** Surveillance data on maternal deaths from 2015-17. Confidential Enquiry reports on deaths from cardiac causes, deaths from pre-eclampsia and eclampsia and related causes, accidental deaths and deaths in early pregnancy, morbidity from newly diagnosed breast cancer and messages for critical care.

Alongside the confidential enquiries into maternal deaths we also conduct enquiries into maternal morbidity topics, which can be proposed by anyone. Proposals for topics are accepted annually between October and December. Further details are available at *https://www.npeu.ox.ac.uk/mbrrace-uk/topics*

1.4 The MBRRACE-UK Confidential Enquiries into Maternal Deaths and Morbidity Methods

Maternal Deaths

The methods for the Confidential Enquiry into maternal deaths remain unchanged, and readers are therefore referred to the 2016 report (Knight et al. 2016) for a full description of the methods (*https://www.npeu.ox.ac.uk/downloads/files/mbrrace-uk/reports/MBRRACE-UK%20Maternal%20Report%202016%20-%20website.pdf*).

Maternal Morbidity

Women are identified for the Confidential Enquiries into Maternal Morbidity in different ways according to the topic. The women with newly diagnosed breast cancer were identified from an existing UKOSS study of breast cancer in pregnancy, which identified women fulfilling the criteria in Box 1.1 between October 2015 and October 2017 *(https://www.npeu.ox.ac.uk/ukoss/current-surveillance/bcip)*.

All surviving women notified nationally were used as the sampling frame. A geographically representative sample of 34 women was drawn at random from this group. A full set of medical records was requested from each hospital and general practice concerned. The records then underwent expert assessment in exactly the same way as the records of the women who died. Consent was requested from women in Northern Ireland to participate, since legislation does not exist to allow inclusion of their data without consent. Hospitals provided only 30 of 34 requested sets of records; the care of these 30 women is described in Chapter 4.

Box 1.1: Case definition used in the UKOSS breast cancer in pregnancy study

Any woman meeting one of the following criteria:

Newly diagnosed case of breast cancer during pregnancy.

First pathological diagnosis of breast cancer during pregnancy.

A new confirmed diagnosis of breast cancer during pregnancy determined from the medical records.

Excluded:

Breast cancer diagnosed before pregnancy.

Recurrence of breast cancer in current pregnancy.

2. Maternal Mortality in the UK 2015-17: Surveillance and Epidemiology

Kathryn Bunch and Marian Knight

2.1 Key points

There was a statistically non-significant increase in the overall maternal death rate in the UK between 2012-14 and 2015-17, which suggests that continued focus on implementation of the recommendations of these reports is needed to achieve a reduction in maternal deaths. **ACTION: Policy makers, service planners/commissioners, service managers, all health professionals**

There remains a five-fold difference in maternal mortality rates amongst women from Black ethnic backgrounds and an almost two-fold difference amongst women from Asian ethnic backgrounds compared to white women, emphasising the need for a continued focus on action to address these disparities. **ACTION: Policy makers, service planners/commissioners, service managers, all health professionals**

Six percent of the women who died during or up to a year after pregnancy in the UK in 2015-17 were at severe and multiple disadvantage. The main elements of multiple disadvantage were a mental health diagnosis, substance use and domestic abuse.

Cardiac disease remains the largest single cause of indirect maternal deaths. Neurological causes are the second most common indirect cause of maternal death, with a statistically non-significant increase in mortality rate such that neurological causes are now the third commonest cause of death overall. This increase is due to an increase in both deaths from epilepsy and stroke.

Maternal deaths from direct causes are unchanged with no significant change in the rates between 2012-14 and 2015-17. Thrombosis and thromboembolism remain the leading cause of direct maternal death during or up to six weeks after the end of pregnancy.

Maternal suicide is the second largest cause of direct maternal deaths occurring during or within 42 days of the end of pregnancy and remains the leading cause of direct deaths occurring within a year after the end of pregnancy.

2.2 Causes and trends

Overall, 236 women died in 2015-17 during or within 42 days of the end of pregnancy in the UK. The deaths of 27 women were classified as coincidental. Thus in this triennium 209 women died from direct and indirect causes, classified using ICD-MM (World Health Organisation 2012), among 2,280,451 maternities, a maternal death rate of 9.16 per 100,000 maternities (95% CI 7.96 – 10.50). This compares to the rate of 9.78 per 100,000 maternities (95% CI 8.54 – 11.14) in 2014-16. As in previous MBRRACE-UK maternal reports, information on deaths from the Republic of Ireland is not included in this chapter and therefore rates and numbers presented here are comparable with all previous UK reports.

Table 2.1 and Figure 2.1 show rolling three-yearly maternal death rates since 2003 using ICD-MM. There remains an overall decrease in maternal death rates between 2003-05 and 2015-17 (rate ratio (RR) 0.66, 95% CI 0.55-0.79 p=0.002 for trend in rolling rates over time). The direct maternal death rate has decreased by 44% since 2003-05 with a RR of 0.56 (95% CI 0.43-0.74, p=0.012) and there was a 26% decrease in the rate of indirect maternal deaths (RR 0.74, 95% CI 0.58 to 0.95, p=0.009).

However, the rates of overall mortality, direct and indirect maternal death in the 2015-17 triennium were once again not significantly different from the rates in 2012-14, the immediately preceding triennium (RR for overall mortality = 1.07, 95% CI = 0.88 to 1.31, p=0.476; RR for direct deaths = 1.10, 95% CI = 0.81 to 1.51, p=0.527; RR for indirect deaths = 1.05, 95% CI = 0.81 to 1.37, p=0.644).

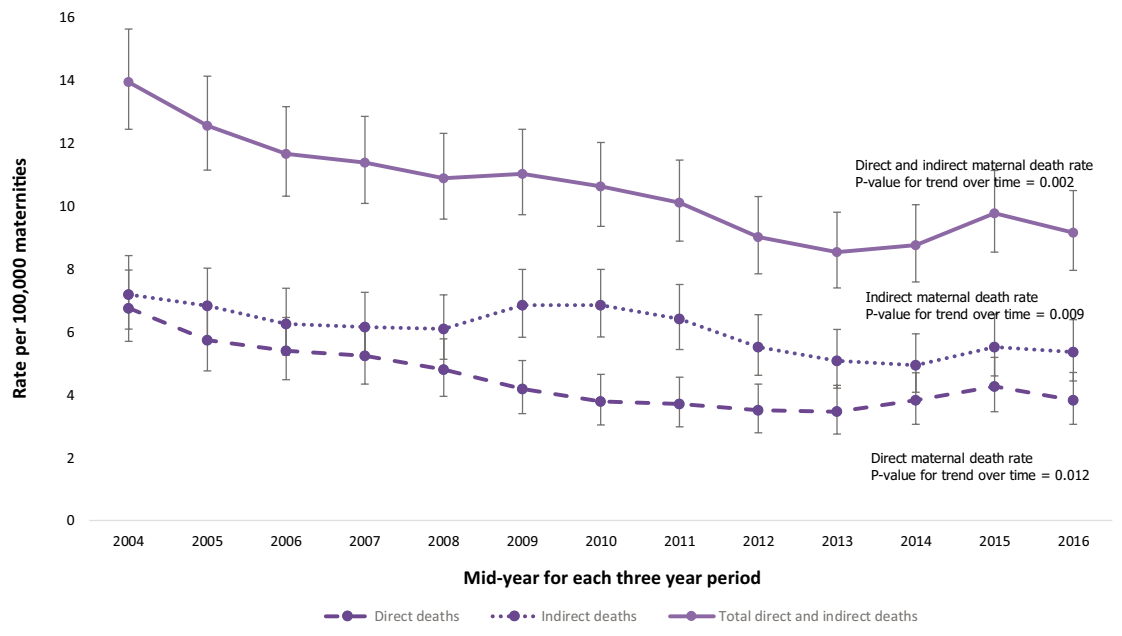
It is reassuring that there is no evidence of an increase in maternal mortality rates, either overall, direct or indirect. The statistically non-significant decrease in direct maternal deaths is predominantly due to a decrease in maternal deaths from haemorrhage and amniotic fluid embolism. Mortality rates still appear higher than the nadir in the overall UK maternal mortality rate which was observed in 2012-14, and this highlights further the challenge of achieving the Government ambition of reducing maternal deaths in England by 50% by 2025 (Department of Health 2017).

Triennial rates are shown in Table 2.2 and Figure 2.2, and suggest that the rate of decrease in maternal mortality has slowed or is static.

Table 2.1: Rolling three-year average direct and indirect maternal mortality rates per 100,000 maternities, deaths classified using ICD-MM; UK 2003-17

3-year period	Total UK maternities	Direct deaths			Indirect deaths			Total Direct and Indirect deaths		
		n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI
2003–05	2,114,004	143	6.76	5.70 – 7.97	152	7.19	6.09 – 8.43	295	13.95	12.45 – 15.64
2004–06	2,165,909	124	5.73	4.76 – 6.83	148	6.83	5.78 – 8.03	272	12.56	11.15 – 14.14
2005–07	2,220,979	120	5.40	4.48 – 6.46	139	6.26	5.26 – 7.39	259	11.66	10.32 – 13.17
2006–08	2,291,493	120	5.24	4.34 – 6.26	141	6.15	5.18 – 7.26	261	11.39	10.09 – 12.86
2007–09	2,331,835	112	4.80	3.95 – 5.78	142	6.09	5.13 – 7.18	254	10.89	9.59 – 12.32
2008–10	2,366,082	99	4.18	3.40 – 5.09	162	6.85	5.84 – 7.99	261	11.03	9.73 – 12.45
2009–11	2,379,014	90	3.78	3.04 – 4.65	163	6.85	5.84 – 7.99	253	10.63	9.36 – 12.03
2010–12	2,401,624	89	3.71	2.98 – 4.56	154	6.41	5.44 – 7.51	243	10.12	8.89 – 11.47
2011–13	2,373,213	83	3.50	2.79 – 4.34	131	5.52	4.62 – 6.55	214	9.02	7.85 – 10.31
2012–14	2,341,745	81	3.46	2.75 – 4.30	119	5.08	4.21 – 6.08	200	8.54	7.40 – 9.81
2013–15	2,305,920	88	3.82	3.06 – 4.70	114	4.94	4.08 – 5.94	202	8.76	7.59 – 10.05
2014–16	2,301,628	98	4.26	3.46 – 5.19	127	5.52	4.60 – 6.57	225	9.78	8.54 – 11.14
2015–17	2,280,451	87	3.82	3.06 – 4.71	122	5.35	4.44 – 6.39	209	9.16	7.96 – 10.50

Figure 2.1: Direct and indirect maternal mortality rates per 100,000 maternities using ICD-MM and previous UK classification systems; rolling three year average rates 2003-2017



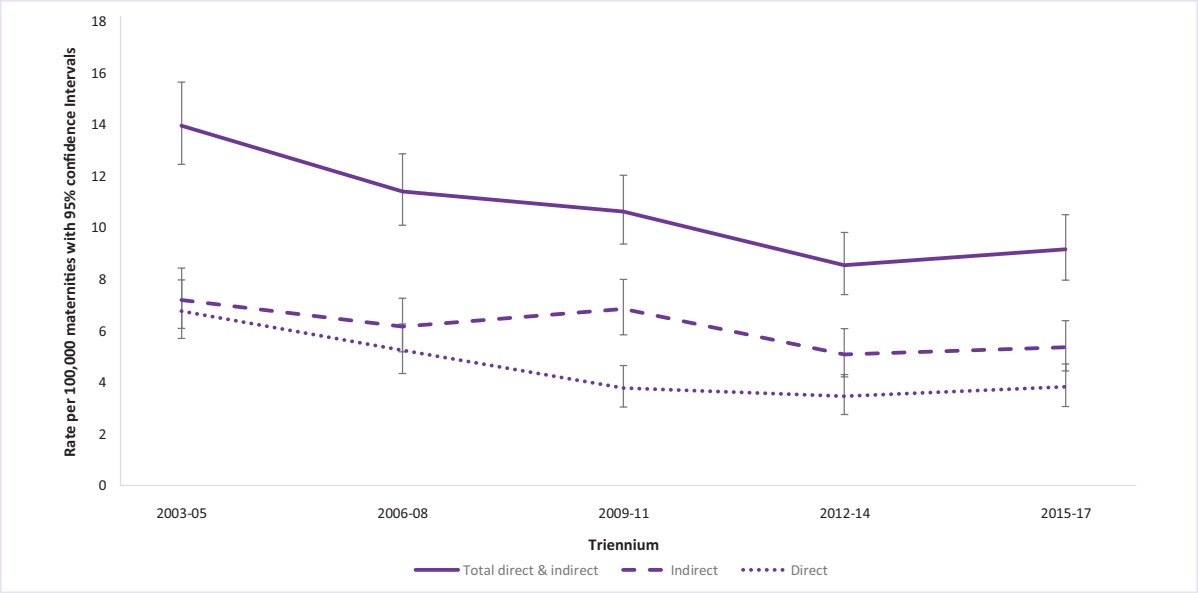
Sources: CMACE, MBRRACE-UK

Table 2.2: Direct and Indirect maternal deaths and mortality rates per 100,000 maternities by triennium, UK using ICD-MM; UK 2003-17

Triennium	Direct deaths recorded			Indirect deaths recorded			Total Direct and Indirect deaths recorded		
	n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI
2003–05	143	6.76	5.70–7.97	152	7.19	6.09–8.43	295	13.95	12.45–15.64
2006–08	120	5.24	4.34–6.26	141	6.15	5.18–7.26	261	11.39	10.09–12.86
2009–11	90	3.78	3.04–4.65	163	6.85	5.84–7.99	253	10.63	9.36–12.03
2012–14	81	3.46	2.75–4.30	119	5.08	4.21–6.08	200	8.54	7.40–9.81
2015-17	87	3.82	3.06 – 4.71	122	5.35	4.44 – 6.39	209	9.16	7.96 – 10.50

Sources: CMACE, MBRRACE-UK, Office for National Statistics, General Register Office for Scotland, Northern Ireland Statistics and Research Agency

Figure 2.2: Direct and Indirect maternal mortality rates per 100,000 maternities; UK 2003-2017 (using ICD-MM)

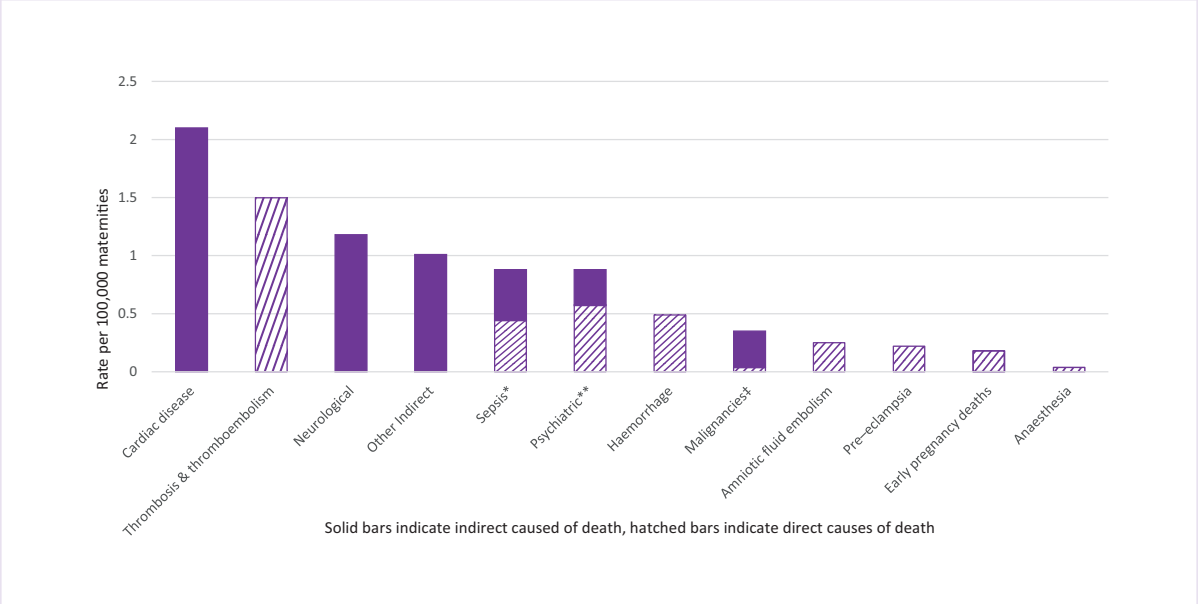


Sources: CMACE, MBRRACE-UK

Deaths due to individual causes

Maternal deaths by cause are shown in Tables 2.3 and 2.4, and Figure 2.3. Rolling three year rates for individual causes are presented for five overlapping triennial reporting periods (2011-13, 2012-14, 2013-15, 2014-16 and 2015-17) (Table 2.3 and Figure 2.3) and for non-overlapping triennial periods between 1985-7 and 2015-17 (Table 2.4). Since this is the final report in a three-year cycle, Table 2.4 is newly updated with the latest triennial figures; deaths by suicide have been included amongst indirect deaths in Table 2.4 to allow for comparability to earlier years. Three-year rolling rates for causes of death classified according to ICD-MM sub-groups are presented in Table 2.5.

Figure 2.3: Maternal mortality by cause 2015-17



Hatched bars show direct causes of death, solid bars indicate indirect causes of death;
*Rate for direct sepsis (genital tract sepsis and other pregnancy related infections) is shown in hatched and rate for indirect sepsis (influenza, pneumonia, others) in solid bar
**Rate for suicides (direct) is shown in hatched and rate for indirect psychiatric causes (drugs/alcohol) in solid bar
‡Rate for direct malignancies (choriocarcinoma) shown in hatched and rate for indirect malignancies (breast/ovary/cervix) in solid bar
Source: MBRRACE-UK

Table 2.3: Maternal mortality rates by cause, per 100,000 maternities, 2011 to 2017

	2011-13			2012-14			2013-15			2014-16			2015-17		
	n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI
All Direct and Indirect deaths	214	9.02	7.85 – 10.31	200	8.54	7.40 – 9.81	202	8.76	7.59 – 10.05	225	9.78	8.54 - 11.14	209	9.16	7.96 – 10.50
Direct deaths															
Pregnancy related infections - Sepsis*	8	0.34	0.15 – 0.66	7	0.29	0.12 – 0.61	10	0.43	0.21 – 0.79	11	0.48	0.24 – 0.86	10	0.44	0.21 – 0.81
Pre-eclampsia and eclampsia	6	0.25	0.09 – 0.55	2	0.08	0.01 – 0.31	3	0.13	0.03 – 0.38	6	0.26	0.10 – 0.57	5	0.22	0.07 – 0.51
Thrombosis and thromboembolism	24	1.01	0.65 – 1.50	20	0.85	0.52 - 1.32	26	1.13	0.74 – 1.65	32	1.39	0.95 – 1.96	34	1.49	1.03 – 2.08
Amniotic fluid embolism	10	0.42	0.20 – 0.78	16	0.68	0.39 – 1.11	8	0.35	0.15 – 0.68	9	0.39	0.18 – 0.74	6	0.26	0.10 – 0.57
Early pregnancy deaths	6	0.25	0.09 – 0.55	7	0.29	0.12 – 0.61	4	0.17	0.05 – 0.44	3	0.13	0.03 – 0.38	4	0.18	0.05 – 4.49
Haemorrhage	13	0.55	0.29 – 0.94	13	0.56	0.29 – 0.95	21	0.91	0.56 – 1.39	18	0.78	0.46 – 1.24	11	0.48	0.24 – 0.86
Anaesthesia	3	0.13	0.03 – 0.37	2	0.09	0.01 – 0.31	2	0.09	0.01 – 0.31	1	0.04	0.001 – 0.24	1	0.04	0.001 – 0.24
Psychiatric causes - Suicides	13	0.55	0.29 – 0.94	14	0.60	0.33 – 1.00	12	0.52	0.27 – 0.91	16	0.70	0.40 – 1.13	13	0.57	0.30 – 0.98
Malignancy - direct										1	0.04	0.001 – 0.24	1	0.04	0.001 – 0.24
Unascertained - direct	-	-	-	-	-	-	2	0.09	0.01 – 0.31	1	0.04	0.001 – 0.24	2	0.09	0.01 – 0.32
All direct	83	3.50	2.79 - 4.34	81	3.46	2.75 – 4.30	88	3.82	3.06 – 4.70	98	4.26	3.46 – 5.19	87	3.82	3.06 – 4.71
Indirect															
Cardiac disease	49	2.06	1.53 – 2.73	51	2.18	1.62 – 2.86	54	2.34	1.76 – 3.06	55	2.39	1.80 – 3.11	48	2.10	1.55 – 2.79
Indirect Sepsis - Influenza	9	0.38	0.17 – 0.72	1	0.04	0.001 – 0.24	1	0.04	0.001 – 0.24	2	0.09	0.01 – 0.31	1	0.04	0.001 – 0.24
Indirect Sepsis – Pneumonia/ others	20	0.84	0.52 – 1.30	14	0.60	0.33 – 1.00	3	0.13	0.03 – 0.38	6	0.26	0.10 – 0.57	9	0.39	0.18 – 0.75
Other Indirect causes	22	0.93	0.58 – 1.40	23	0.98	0.62 – 1.47	26	1.13	0.74 – 1.65	26	1.13	0.74 – 1.66	23	1.01	0.64 – 1.51
Indirect neurological conditions	24	1.01	0.65 – 1.5	22	0.94	0.59 – 1.42	19	0.82	0.49 – 1.29	24	1.04	0.67 – 1.55	27	1.18	0.78 – 1.72
Psychiatric causes – Drugs/alcohol/others	6	0.25	0.09 – 0.55	4	0.17	0.05 – 0.44	4	0.17	0.05 – 0.44	6	0.26	0.10 – 0.57	7	0.31	0.12 – 0.63
Indirect malignancies	1	0.04	0.001 – 0.24	4	0.17	0.05 – 0.44	7	0.30	0.12 – 0.63	8	0.35	0.15 – 0.69	7	0.31	0.12 – 0.63
All Indirect	131	5.52	4.62 - 6.55	119	5.08	4.21 – 6.08	114	4.94	4.08 – 5.94	127	5.52	4.60 – 6.57	122	5.35	4.44 – 6.39
Coincidental															
Homicide	8	0.34	0.15 – 0.66	9	0.38	0.18 – 0.73	9	0.39	0.18 – 0.74	10	0.43	0.21 – 0.80	7	0.31	0.12 – 0.63
Other coincidental	18	0.76	0.45 - 1.20	32	1.37	0.94 - 1.93	29	1.26	0.84 – 1.81	24	1.04	0.67 – 1.55	20	0.88	0.54 – 1.35
All coincidental	26	1.10	0.72 – 1.61	41	1.75	1.26 – 2.38	38	1.65	1.17 – 2.26	34	1.48	1.02 – 2.06	27	1.18	0.78 – 1.72
Late deaths	335	14.12	12.64 – 15.71	323	13.79	12.33 – 15.38	326	14.14	12.64 – 15.76	286	12.43	11.03 – 13.95	313	13.73	12.25 – 15.33

*Genital/ urinary tract sepsis deaths, including early pregnancy deaths as a result of genital/ urinary tract sepsis. Other deaths from infectious causes are classified under indirect causes.
Source: MBRRACE-UK, Office for National Statistics, National Records Scotland, Northern Ireland Statistics and Research Agency.

Table 2.4: UK Maternal deaths and mortality rates per 100,000 maternities by cause 1985-2017 (Maternal deaths by suicide classified as indirect for comparability)

Cause of death	Numbers										Rates per 100,000 maternities											
	1985-87	1988-90	1991-93	1994-96	1997-99	2000-02	2003-05	2006-08	2009-11	2012-14	2015-17	1985-87	1988-90	1991-93	1994-96	1997-99	2000-02	2003-05	2006-08	2009-11	2012-14	2015-17
All Direct and Indirect deaths	223	238	228	268	242	261	295	261	253	200	209	9.83	10.08	9.85	12.19	11.4	13.07	13.95	11.39	10.63	8.54	9.16
Direct deaths																						
Sepsis*	9	17	15	16	18	13	18	26	16	7	10	0.40	0.72	0.65	0.73	0.85	0.65	0.85	1.13	0.63	0.29	0.44
Pre-eclampsia and eclampsia	27	27	20	20	16	14	18	19	10	2	5	1.19	1.14	0.86	0.91	0.75	0.70	0.85	0.83	0.42	0.08	0.22
Thrombosis and thromboembolism	32	33	35	48	35	30	41	18	30	20	34	1.41	1.40	1.51	2.18	1.65	1.50	1.94	0.79	1.26	0.85	1.49
Amniotic fluid embolism	9	11	10	17	8	5	17	13	7	16	6	0.40	0.47	0.43	0.77	0.38	0.25	0.80	0.57	0.29	0.68	0.26
Early pregnancy deaths	16	24	17	15	17	15	14	11	4	7	4	0.71	1.02	0.73	0.68	0.80	0.75	0.66	0.48	0.17	0.29	0.18
Haemorrhage	10	22	15	12	7	17	14	9	14	13	11	0.44	0.93	0.65	0.55	0.33	0.85	0.66	0.39	0.59	0.56	0.48
Anaesthesia	6	4	8	1	3	6	6	7	3	2	1	0.26	0.17	0.35	0.05	0.14	0.30	0.28	0.31	0.12	0.09	0.04
Other Direct‡	27	17	14	7	7	8	4	4	0	0	3	1.19	0.72	0.60	0.32	0.33	0.40	0.19	0.17	-	-	0.13
All direct	139	145	128	134	106	106	132	107	82	67	74	6.13	6.14	5.53	6.10	4.99	5.31	6.24	4.67	3.49	2.84	3.24
Indirect deaths																						
Cardiac disease	23	18	37	39	35	44	48	53	51	51	48	1.01	0.76	1.60	1.77	1.65	2.20	2.27	2.31	2.14	2.18	2.10
Other Indirect causes	43	45	38	39	41	50	50	49	72	38	33	1.90	1.91	1.64	1.77	1.93	2.50	2.37	2.14	3.03	1.62	1.45
Indirect neurological conditions	19	30	25	47	34	40	37	36	30	22	27	0.84	1.27	1.08	2.14	1.60	2.00	1.75	1.57	1.26	0.94	1.18
Psychiatric causes	†	†	†	9	15	16	18	13	13	18	20	†	†	†	0.41	0.71	0.80	0.85	0.57	0.55	0.77	0.88
Indirect malignancies	†	†	†	†	11	5	10	3	4	4	7	†	†	†	†	0.52	0.25	0.47	0.13	0.17	0.17	0.31
All Indirect	84	93	100	134	136	155	163	154	170	133	135	3.70	3.94	4.32	6.10	6.40	7.76	7.71	6.59	7.15	5.68	5.92
Coincidental	26	39	46	36	29	36	55	50	22	41	27	1.15	1.65	1.99	1.64	1.37	1.80	2.60	2.18	0.98	1.75	1.18

*Including early pregnancy deaths as a result of sepsis

‡Acute fatty liver and genital tract trauma; included with pre-eclampsia and eclampsia and haemorrhage respectively from 2009 onwards

†Deaths from these causes not included in reports from earlier years

Sources: CMACE, MBRRACE-UK

Table 2.5: Maternal mortality rates by cause using ICD-MM classification, per 100,000 maternities, 2011 to 2017

Cause of death	2011-13			2012-14			2013-15			2014-16			2015-17		
	n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI	n	Rate	95% CI
Direct causes															
Group 1: Pregnancy with abortive outcome	6	0.25	0.09 – 0.55	7	0.29	0.12 – 0.62	4	0.17	0.05 – 0.44	3	0.13	0.03 – 0.38	4	0.18	0.05 – 4.49
Group 2: Hyper-tensive disorders	6	0.25	0.09 – 0.55	2	0.08	0.01 – 0.31	3	0.13	0.03 – 0.38	6	0.26	0.10 – 0.57	5	0.22	0.07 – 0.51
Group 3: Obstetric Haemorrhage	13	0.55	0.29 – 0.94	13	0.56	0.29 – 0.95	21	0.91	0.56 – 1.39	18	0.78	0.46 – 1.24	11	0.48	0.24 – 0.86
Group 4: Pregnancy-related infection	8	0.34	0.15 – 0.66	7	0.29	0.12 – 0.61	10	0.43	0.21 – 0.79	11	0.48	0.24 – 0.86	10	0.44	0.21 – 0.81
Group 5: Other obstetric complications	47	1.98	1.46 – 2.63	50	2.14	1.58 – 2.81	48	2.08	1.53 – 2.76	59	2.56	1.95 – 3.31	56	2.46	1.85 – 3.19
Group 6: Unanticipated complications of management	3	0.13	0.03 – 0.37	2	0.09	0.01 – 0.31	2	0.09	0.01 – 0.31	1	0.04	0.001 – 0.24	1	0.04	0.001 – 0.24
Indirect causes															
Group 7: Non-obstetric complications	131	5.52	4.62 - 6.55	119	5.08	4.21 – 6.08	114	4.94	4.08 – 5.94	127	5.52	4.60 – 6.57	122	5.35	4.44 – 6.39
Group 8: Unknown/ undetermined	0	0	-	0	0	-	0	0	-	0	-	-	0	-	-
Coincidental causes															
Group 9: Coincidental causes	26	1.10	0.72 – 1.61	41	1.75	1.26 – 2.38	38	1.65	1.17 – 2.26	34	1.48	1.02 – 2.06	27	1.18	0.78 – 1.72

Source: MBRRACE-UK, Office for National Statistics, National Records Scotland, Northern Ireland Statistics and Research Agency.

Direct deaths

There was no statistically significant change in the rate of direct maternal deaths from any cause between 2009 and 2017. Thrombosis and thromboembolism continues to be the leading cause of direct deaths occurring within 42 days of the end of pregnancy, followed by deaths by suicide and deaths due to obstetric haemorrhage (Figure 2.3). The maternal mortality rate from thrombosis and thromboembolism remains at the same level as it was in 1985-87; as there is known to be an increased prevalence of risk factors for VTE in the UK maternity population, improved detection of risk and better prevention may nevertheless underlie this static rate. Maternal death rates from suicide remain unchanged. As noted above, the rate of maternal mortality from haemorrhage reassuringly shows a statistically non-significant decrease. The maternal death rate from pre-eclampsia and eclampsia continues to be low but remains higher than the lowest observed rate, in 2012-14, and therefore the messages for prevention identified in chapter 5 remain important. Although maternal mortality rates from early pregnancy causes remain low, a number of messages to prevent future deaths are clearly identified in chapter 6.

Indirect deaths

Deaths due to indirect causes still remain the major proportion (58%) of maternal deaths in the UK. As in previous reports, cardiac disease remains the largest single cause of indirect maternal deaths (Figure 2.3) and is the focus of chapter 3 of this report. There has been no change in the maternal mortality rate from cardiac disease since enhanced case ascertainment was introduced (RR 0.90, 95% CI 0.61-1.36 when comparing 2015-17 with 2003-05). Neurological causes are the second most common indirect cause of maternal death, with a statistically non-significant increase in mortality rate such that neurological causes are now the third commonest cause of death overall. This increase is due to an increase in both deaths from epilepsy and stroke, with fourteen women dying from epilepsy during or up to six weeks after pregnancy in this triennium (compared with eight in the triennium 2013-15), a mortality rate of 0.61 per 100,000 maternities (95% CI 0.34-1.03).

Coincidental deaths

Most women's deaths from malignancy during or after pregnancy are classified as coincidental deaths, together with deaths of women due to accidents. Many messages for improving the care of women with malignancy were identified in the 2018 report, further messages for improving care have been identified from the confidential enquiry into breast cancer morbidity and these are considered in chapter 4. Six women died due to accidents during or up to six weeks after pregnancy in the UK in 2015-17, a mortality rate of 0.26 per 100,000 maternities (95% CI 0.10-0.57). Messages to improve their care are dicussed in chapter 7.

International comparison

For international comparison, Table 2.6 has been updated to highlight the maternal mortality ratios estimated for the UK using routinely reported data. The rate estimate from routine sources of data is much lower (less than half) than the actual rates as identified through the UK CEMD, which uses multiple sources of death identification. It is important to note that not only are a number of maternal deaths not ascertained through routine data (false negatives), there is also a significant false positive rate. One hundred and sixty-one potential maternal deaths during or up to one year after the end of pregnancy were identified through routine sources of data in 2015-17, 52 (32%) of these proved to be false positives on further investigation by the MBRRACE team. This emphasises the importance of the additional case identification and checking undertaken to give an accurate maternal mortality estimate.

Table 2.6: Maternal mortality ratios* per 100,000 live births calculated based on deaths identified from routine sources of data, UK: 1985-2017

Triennium	No. of deaths identified through death certificates	Maternal mortality ratio	95% CI	Denominator number of live births
1985-87	174	7.67	6.61-8.90	2,268,766
1988-90	171	7.24	6.24-8.42	2,360,309
1991-93	150	6.48	5.52-7.60	2,315,204
1994-96	158	7.19	6.15-8.40	2,197,640
1997-99	128	6.03	5.70-7.17	2,123,614
2000-02	136	6.81	5.76-8.05	1,997,472
2003-05	149	7.05	6.00-8.27	2,114,004
2006-08	155	6.76	5.78-7.92	2,291,493
2009-11	134	5.57	4.67-6.60	2,405,251
2012-14	110	4.65	3.82-5.60	2,368,125
2015-17	95	4.10	3.32-5.01	2,317,363

Source: Office for National Statistics, General Register Office for Scotland, Northern Ireland Statistics and Research Agency *Note that, for the purposes of international comparison, this table reports the Maternal Mortality Ratio and not the rate as elsewhere in the report.

Women who died between six weeks and one year after the end of pregnancy

In the triennium 2015-17, 313 women died between six weeks and one year after the end of pregnancy, representing a mortality rate of 13.7 per 100,000 maternities (95% CI 12.3 – 15.3). There has been no change in the rate of late pregnancy-associated deaths since the first MBRRACE-UK confidential enquiry report. Rolling rates of late deaths are shown in Figure 2.4 and causes of late death in Figure 2.5. Maternal suicides continue to be the leading cause of direct deaths occurring between six weeks and one year after the end of pregnancy.

Figure 2.4: Pregnancy-associated maternal mortality rates six weeks to one year after the end of pregnancy, UK, 2009-2017

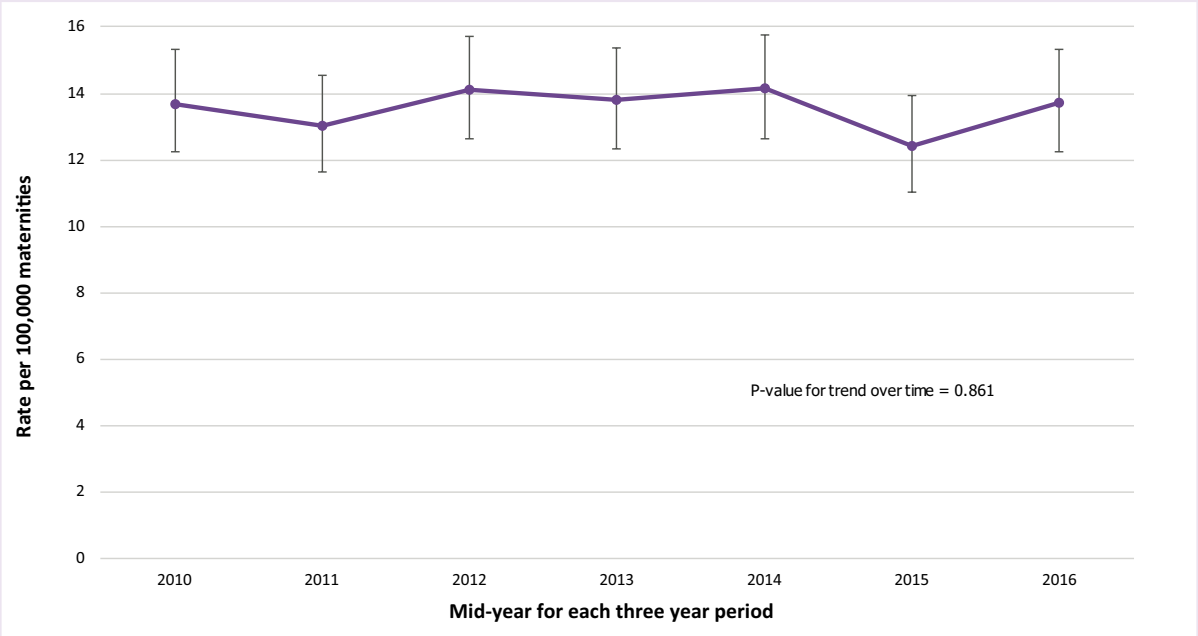
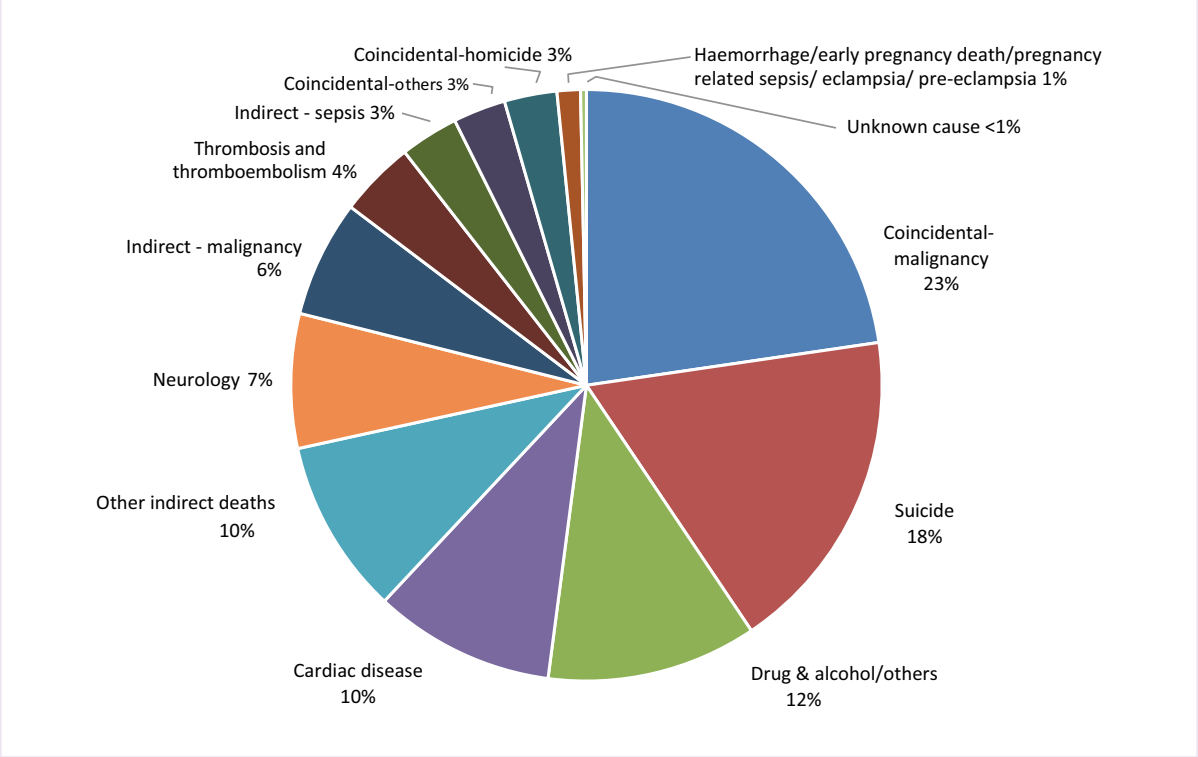


Figure 2.5: Causes of death amongst women who died between six weeks and one year after the end of pregnancy, UK 2015-17



2.3 The characteristics of women who died 2015-17

The women and babies

Of the 209 women who died from direct and indirect causes during or up to 42 days after the end of their pregnancy in 2015-17, 30% (62 women) were still pregnant at the time of their death and of these women 60% were ≤20 weeks' gestation (Table 2.7). Fifteen (7%) women had a pregnancy loss at ≤20 weeks' gestation. The remaining 132 women gave birth to a total of 144 infants, 96 (67%) survived, 48 died (40 babies were stillborn and 8 died in the neonatal period). The 208 women who died left behind a further 236 children, thus a total of 332 motherless children remain. The majority of women who gave birth did so in hospital (77%); 17% of women gave birth in an emergency department or an ambulance, and 5% at home (Table 2.8). In this triennium 94 of the women who died were delivered by caesarean section, 43% of these were performed perimortem as part of attempted resuscitation. A total of 48 babies were born by perimortem caesarean section of which 17 (35%) were born after 32 weeks of gestation. Six out of the 17 babies born after 32 weeks' gestation survived (8 were stillborn and 3 died in the neonatal period) and four out of the remaining 31 born at 32 weeks or less survived (23 were stillborn and 4 died in the neonatal period). Thus 21% of the total 48 babies delivered by perimortem caesarean section survived (65% were stillborn and 15% died in the neonatal period).

Table 2.7: Timing of maternal deaths in relation to pregnancy 2015-17

Time period of deaths in the pregnancy care pathway	Direct (n=87) Frequency (%)	Indirect (n=122) Frequency (%)	Total (n=209) Frequency (%)
Antenatal period			
≤20 weeks	12 (14)	25 (20)	37 (18)
>20 weeks	5 (6)	20 (16)	25 (12)
Postnatal on day of delivery	28 (32)	25 (20)	53 (25)
Postnatal 1–41 days after delivery	42 (48)	52 (43)	94 (45)

Table 2.8: Place of delivery amongst women >20 weeks' gestation who died after delivery 2015-17

Place of birth (for women who had a childbirth)	Direct (n=57) Frequency (%)	Indirect (n=75) Frequency (%)	Total (n=132) Frequency (%)
Home	1 (2)	5 (7)	6 (5)
Hospital (except A&E)	46 (81)	56 (75)	102 (77)
Emergency Department or ambulance	8 (14)	14 (19)	22 (17)
Not known	2 (4)	0 (0)	2 (2)

Socio-demographic characteristics

The socio-demographic characteristics of women who died in 2015-17 are shown in Table 2.9. More than half of women's records (53%) did not have information on whether they were subject to domestic abuse before or during pregnancy despite guidance that it is important to enquire about this at booking and throughout pregnancy.

The rates of maternal mortality varied by age, socioeconomic status and ethnic background of the women, which are known to be independently associated with an increased risk of maternal death in the UK (Nair et al. 2015, Nair et al. 2016). The rate of maternal mortality was higher amongst older women, those living in the most deprived areas and amongst women from particular ethnic minority groups (Table 2.10). There remain statistically significant differences in the maternal mortality rates between women living in the most deprived areas and those living in the least deprived areas. As noted in the 2016 report, we are no longer able to obtain denominator figures for the specific ethnic groups, instead aggregate rates using larger ethnicity groupings are presented in Tables 2.10 and 2.11. The risk of maternal death in 2015-17 continues to be significantly over five-fold higher among women from black ethnic minority backgrounds compared with white women (RR 5.27; 95% CI 3.44 to 7.87). Women from Asian backgrounds also continue to be at higher risk than white women (RR 1.77, 95% CI 1.10 to 2.74), as are women from mixed ethnic backgrounds (RR 3.12, 95% CI 1.22-6.64). Whilst the estimated ratios of relative risk (RRR) of maternal death in the different age, socioeconomic and ethnic groups did not show any statistically significant differences (Table 2.11), there is an overall tendency suggesting that the inequality gap is increasing. As noted in 2018, further research is needed to fully understand the reasons for these disparities and hence to develop actions to address them.

Nearly a quarter of women who died in 2015-17 (23%) were born outside the UK; 42% of these women were not UK citizens. Overall 10% of the women who died were not UK citizens. Women who died who were born abroad and who were not UK citizens had arrived in the UK a median of 3.5 years before they died (range 3 months to 18 years). Women who died who were born abroad were from Asia (30%, mainly Pakistan, India and China) and Africa (40%, mainly Nigeria, Eritrea and South Africa), Eastern Europe (17%, mostly from the Czech Republic and Romania) with the remainder from other parts of Europe, the Americas and the Caribbean. Table 2.12 shows the rates of death amongst women born in selected countries with the highest number of deaths. Similar to the previous triennium, overall there was no statistically significant difference in maternal death rate between women born in the UK and those born outside the UK in 2015-17. However, women born in certain specific countries had a significantly higher risk of death compared to women born in the UK (Table 2.12). Of the 20 women who were not UK citizens and were born outside the UK, three were refugees/asylum seekers (15%), four (20%) were recently arrived wives of UK residents, four were EU citizens (20%) and nine (45%) had another or unknown status.

It is also of note that 20% of women who died were known to social services, highlighting further the vulnerability of many women who died.

It has been increasingly noted in these enquiries that women at severe disadvantage appear to be over-represented amongst the women who die. Adopting the definition of severe and multiple disadvantage used in other work (Birthrights and Birth Companions 2019), of the 549 women who died in the UK in 2015-17 during or up to one year after pregnancy, 35 (6%) were of women considered to be at severe and multiple disadvantage (Table 2.13). The main elements of multiple disadvantage were a mental health diagnosis (either current or in the past) (33/35 women with multiple disadvantage), substance use (28/35 women with multiple disadvantage) and domestic abuse (26/35 women with multiple disadvantage). However, this must be regarded as a minimum estimate, since these three factors are amongst the most poorly recorded, with information missing on mental health diagnoses for 11% of women who died, on substance use for 4% and on domestic abuse for 53%.

Table 2.9: The socio-demographic characteristics of women who died 2015-17

Characteristics	Direct (n=87) Frequency (%)	Indirect (n=122) Frequency (%)	Total (n=209) Frequency (%)
Age (years)			
<20	3 (3)	6 (5)	9 (4)
20–24	7 (8)	12 (10)	19 (9)
25–29	21 (24)	34 (28)	55 (26)
30–34	18 (21)	33 (27)	51 (24)
35–39	27 (31)	25 (20)	52 (25)
≥ 40	11 (13)	12 (10)	23 (11)
Parity			
0	33 (38)	41 (34)	74 (36)
1 to 2	37 (43)	56 (46)	93 (45)
≥3	12 (14)	17 (14)	29 (14)
Missing	5 (6)	8 (7)	13 (6)
UK citizen			
Yes	69 (79)	103 (84)	172 (82)
No	9 (10)	12 (10)	21 (10)
Missing	9 (10)	7 (6)	16 (8)
Ethnicity			
White European	55 (63)	76 (62)	131 (63)
Indian	5 (6)	7 (6)	12 (6)
Pakistani	6 (7)	4 (3)	10 (5)
Bangladeshi	1 (1)	1 (1)	2 (1)
Other Asian	3 (3)	2 (2)	5 (2)
Black Caribbean	3 (3)	4 (3)	7 (3)
Black African	4 (5)	18 (15)	22 (11)
Others/ Mixed	5 (6)	9 (7)	14 (7)
Missing	5 (6)	1 (1)	6 (3)
Woman's region of birth			
United Kingdom	55 (63)	78 (64)	133 (64)
Eastern Europe	6 (7)	3 (2)	9 (4)
Western Europe	1 (1)	0 (0)	1 (0)
Asia	6 (7)	8 (7)	14 (7)
Africa	3 (3)	16 (13)	19 (9)
Australia and North America	0 (0)	1 (1)	1 (0)
Central & South America & Caribbean	3 (3)	1 (1)	4 (2)
Missing	13 (15)	15 (12)	28 (13)
Socioeconomic status (Index of Multiple Deprivation (IMD) of postcode of residence)			
First quintile (Least deprived)	4 (5)	11 (9)	15 (7)
Second quintile	6 (7)	13 (11)	19 (9)
Third quintile	8 (9)	17 (14)	25 (12)
Fourth quintile	21 (24)	27 (22)	48 (23)
Fifth quintile (Most deprived)	26 (30)	40 (33)	66 (32)
Missing	22 (25)	14 (11)	36 (17)
Socioeconomic status (Occupational classification)			
Employed (Either woman or partner)	52 (60)	73 (60)	125 (60)
Unemployed (Both)	18 (21)	24 (20)	42 (20)
Missing	17 (20)	25 (20)	42 (20)
Able to speak/understand English			
Yes	82 (94)	119 (98)	201 (96)
No	4 (5)	2 (2)	6 (3)
Missing	1 (1)	1 (1)	2 (1)
Living arrangements			
With partner	66 (76)	84 (69)	150 (72)
Living alone	6 (7)	19 (16)	25 (12)
With parents/extended family	9 (10)	11 (9)	20 (10)
Others	1 (1)	3 (2)	4 (2)
Missing	5 (6)	5 (4)	10 (5)
Domestic abuse (prior to pregnancy/ during pregnancy)			
Yes	12 (14)	8 (7)	20 (10)
No	30 (35)	48 (39)	78 (38)
Missing	45 (52)	66 (54)	111 (53)
Known to social services			
Yes	17 (20)	25 (20)	42 (20)
No	64 (74)	88 (72)	152 (73)
Missing	6 (7)	9 (7)	15 (7)

Table 2.10: Maternal mortality rates amongst different population groups 2015-17

	Total maternities 2015-17	Total deaths	Rate per 100,000 maternities	95% CI	Relative risk (RR)	95% CI
Age (years)						
<20	74,837	9	12.03	5.50 to 22.83	2.16	0.86 to 5.00
20–24	340,586	19	5.58	3.36 to 8.71	1 (Ref)	-
25–29	642,794	55	8.56	6.45 to 11.14	1.53	0.90 to 2.74
30–34	721,328	51	7.07	5.26 to 9.30	1.27	0.74 to 2.27
35–39	405,959	52	12.81	9.57 to 16.80	2.30	1.33 to 4.11
≥ 40	94,920	23	24.23	15.36 to 36.36	4.34	2.26 to 8.43
IMD Quintiles (England only)						
First quintile (Least deprived)	269,945	14	5.19	2.84 to 8.70	1 (Ref)	-
Second quintile	308,115	16	5.19	2.97 to 8.43	1.00	0.46 to 2.22
Third quintile	346,150	25	7.22	4.67 to 10.66	1.39	0.70 to 2.90
Fourth quintile	418,292	44	10.52	7.64 to 14.12	2.03	1.09 to 4.01
Fifth quintile (Most deprived)	500,949	58	11.58	8.79 to 14.97	2.23	1.23 to 4.33
Ethnic group (England only)						
White (inc. not known)	1,523,822	110	7.22	5.93 to 8.70	1 (Ref)	-
Asian	196,199	25	12.74	8.25 to 18.81	1.77	1.10 to 2.74
Black	84,144	32	38.03	26.01 to 53.68	5.27	3.44 to 7.87
Chinese/ others	75,442	7	9.28	3.73 to 19.12	1.29	0.50 to 2.74
Mixed	31,104	7	22.51	9.05 to 46.36	3.12	1.22 to 6.64

Table 2.11: Comparing the relative risk of maternal death among different population groups between 2012-14 and 2015-17

	2012-14		2015-17		Ratio of the relative risks (RRR) (comparing 2015-17 with 2012-14)	95% CI	P-value
	Relative risk (RR)	95% CI	Relative risk (RR)	95% C			
Age (years)							
<20	0.84	0.25 to 2.25	2.16	0.86 to 5.00	2.57	0.63 to 10.51	0.189
20–24	1 (Ref)	-	1 (Ref)	-	-	-	-
25–29	1.20	0.72 to 2.05	1.53	0.90 to 2.74	1.28	0.59 to 2.74	0.533
30–34	1.32	0.81 to 2.23	1.27	0.74 to 2.27	0.96	0.45 to 2.05	0.920
35–39	2.29	1.38 to 3.89	2.30	1.33 to 4.11	1.00	0.47 to 2.16	0.991
≥ 40	3.00	1.51 to 5.83	4.34	2.26 to 8.43	1.45	0.56 to 3.72	0.443
IMD Quintiles (England only)							
First quintile (Least deprived)	1 (Ref)	-	1 (Ref)	-	-	-	-
Second quintile	0.99	0.48 to 2.05	1.00	0.46 to 2.22	1.01	0.35 to 2.95	0.985
Third quintile	1.00	0.50 to 2.01	1.39	0.70 to 2.90	1.39	0.51 to 3.76	0.516
Fourth quintile	1.56	0.86 to 2.93	2.03	1.09 to 4.01	1.30	0.53 to 3.18	0.564
Fifth quintile (Most deprived)	1.62	0.92 to 2.99	2.23	1.23 to 4.33	1.38	0.58 to 3.26	0.468
Ethnic group (England only)							
White (inc. not known)	1 (Ref)	-	1 (Ref)	-	-	-	-
Asian	1.36	0.81 to 2.18	1.77	1.10 to 2.74	1.30	0.66 to 2.55	0.443
Black	4.19	2.69 to 6.35	5.27	3.44 to 7.87	1.26	0.69 to 2.28	0.451
Chinese/ others	0.55	0.11 to 1.66	1.29	0.50 to 2.74	2.35	0.47 to 11.64	0.297
Mixed	0.44	0.01 to 2.54	3.12	1.22 to 6.64	7.09	0.39 to 128.28	0.185

Table 2.12: Maternal mortality rates according to mother's country of birth (selected countries)

Woman's country of birth	Maternities 2015-17	Total Deaths	Rate per 100,000 maternities	95% CI	Relative risk (RR)	95% CI
UK	1,669,097*	133	7.97	6.67 to 9.44	1 (Ref)	-
Outside UK	611,354*	48	7.85	5.79 to 10.41	0.99	0.69 to 1.38
Specific countries						
China	11,203‡	3	26.78	5.52 to 78.24	3.36	0.68 to 10.04
India	42,399‡	4	9.43	2.57 to 24.15	1.18	0.32 to 3.10
Nigeria	20,469‡	10	48.85	23.43 to 89.83	6.13	2.87 to 11.63
Pakistan	53,491‡	4	7.48	2.04 to 19.15	0.94	0.25 to 2.46

*Estimates based on proportions of births to UK and non-UK born mothers applied to number of maternities

‡Estimates based on ratio of maternities to births applied to number of births recorded to mothers born in stated country

Table 2.13: Severe and multiple disadvantage among women who died 2015-17

Category of maternal death	Direct (n=87) Frequency (%)	Indirect (n=127) Frequency (%)	Coincidental (n=27) Frequency (%)	Late Deaths (n=313) Frequency (%)	Total (n=549) Frequency (%)
Severe and multiple disadvantage					
No	79 (91)	117 (96)	24 (89)	294 (94)	514 (94)
*Yes**	8 (9)	5 (4)	3 (11)	19 (6)	35 (6)

*Three or more of substance abuse, domestic abuse, abuse in childhood, arrival in UK within last 5 years, refugee or asylum seeker, mental health diagnosis, female genital mutilation, and known learning difficulties

Medical and pregnancy-related characteristics

Studies have shown that 66% of the increased risk of maternal death in the UK could be attributed to medical comorbidities (Nair et al. 2016). Two-thirds (67%) of the women who died in 2015-17 were known to have pre-existing medical problems (Table 2.14), 28% were known to have pre-existing mental health problems and 14% had pre-existing cardiac problems. Among women who died in 2017, in 11% it was reported to be unknown whether they had previous or pre-existing mental health problems, lower than the 19% observed in 2016. More than a third (34%) of the women who died in this triennium were obese and a further 24% were overweight (Table 2.14). A lack of pre-pregnancy counselling prior to assisted reproduction has been noted as a theme in both chapters 3 and 4 of this report; of note, 13 women (6%) who died during or up to six weeks after pregnancy in the UK in 2015-17 had a pregnancy as a result of an assisted conception procedure(Table 2.15), this compares to 8 women (4%) in 2014-16.

The pregnancy-related characteristics of the women who died in 2015-17 are shown in Table 2.15.

Table 2.14: Selected medical conditions and characteristics identified amongst women who died 2015-17

Medical condition/characteristic	Direct (n=87) Frequency (%)	Indirect (n=122) Frequency (%)	Total (n=209) Frequency (%)
Body mass index (BMI)			
<18	0 (0)	2 (2)	2 (1)
18 – 24	29 (34)	32 (26)	61 (29)
25 – 29	22 (25)	28 (23)	50 (24)
≥ 30	29 (33)	43 (35)	72 (34)
Missing	7 (8)	17 (14)	24 (11)
Mental health problems or psychiatric disorders			
Yes	26 (30)	32 (26)	58 (28)
No	55 (63)	73 (60)	128 (61)
Missing	6 (7)	17 (14)	23 (11)
Pre-existing cardiac problems			
Yes	12 (14)	18 (15)	30 (14)
No	71 (82)	101 (83)	172 (82)
Missing	4 (5)	3 (2)	7 (3)
Any pre-existing medical problem (excluding obesity)			
Yes	55 (63)	86 (70)	141 (67)
No	28 (32)	33 (27)	61 (29)
Missing	4 (5)	3 (2)	7 (3)

Table 2.15: Pregnancy-related characteristics of the women who died 2015-17

Medical condition/characteristic	Direct (n=87) Frequency (%)	Indirect (n=122) Frequency (%)	Total (n=209) Frequency (%)
Pregnancy known to be as a result of assisted reproductive technologies			
Yes	6 (7)	7 (6)	13 (6)
No	80 (92)	114 (93)	194 (93)
Missing	1 (1)	1 (1)	2 (1)
Multiple pregnancy			
Yes	5 (6)	4 (3)	9 (4)
No	82 (94)	118 (97)	200 (96)
Previous caesarean section			
Yes	20 (23)	19 (16)	39 (19)
No	63 (72)	96 (79)	159 (76)
Missing	4 (5)	7 (6)	11 (5)
Previous caesarean numbers (among women who had a previous caesarean section)			
1	12 (60)	18 (95)	30 (77)
≥2	8 (40)	1 (5)	9 (23)

Other characteristics of women who died

Inadequate utilisation of antenatal care services and substance misuse have been shown to be associated with increased risk of maternal death in the UK (Nair et al. 2015, Nair et al. 2016). The prevalence of these risk factors among women who died in 2015-17 did not differ from that noted in the previous reports (Table 2.16) and use of recommended levels of antenatal care still remains low. Only a third (31%) of women who received antenatal care, received the recommended level of care according to NICE antenatal care guidelines (booking at 10 weeks or less and no routine antenatal visits missed) (National Institute for Health and Care Excellence 2017a).

Table 2.16: Other characteristics of women who died in 2015-17

Characteristics	Direct (n=87) Frequency (%)	Indirect (n=122) Frequency (%)	Total (n=209) Frequency (%)
Smoking			
Smoker	26 (30)	34 (28)	60 (29)
Non-smoker	51 (59)	73 (60)	124 (59)
Missing	10 (11)	15 (12)	25 (12)
Substance user			
Yes	13 (15)	18 (15)	31 (15)
No	72 (83)	98 (80)	170 (81)
Missing	2 (2)	6 (5)	8 (4)
Received any antenatal care*			
Yes	75 (86)	104 (85)	179 (86)
No	12 (14)	17 (14)	29 (14)
Not known	0 (0)	1 (1)	1 (0)
Gestational age at booking (among women who received any antenatal care) (weeks)			
≤10	28 (38)	47 (45)	75 (42)
11 – 12	24 (32)	31 (30)	55 (31)
>12	20 (27)	22 (21)	42 (23)
Missing	3 (4)	4 (4)	7 (4)
Received *recommended* antenatal care† (among women who received any antenatal care)			
Yes	23 (31)	33 (32)	56 (31)
No	48 (64)	65 (63)	113 (63)
Missing	4 (5)	6 (6)	10 (6)
Received a minimum level of antenatal care† (among women who received any antenatal care)			
Yes	49 (65)	70 (67)	119 (66)
No	21 (28)	25 (24)	46 (26)
Missing	5 (7)	9 (9)	14 (8)

*Includes 4 women who died in early pregnancy. †NICE recommended antenatal care: booked at 10 weeks or less and no antenatal visits missed. Minimum level of care: booked at less than 13 weeks and 3 or fewer antenatal visits missed.

Classification of quality of care

This section includes information on women who died between 2015 and 2017 and are included in the confidential enquiry chapters of this report (including women who died between six weeks and a year after the end of pregnancy and women from the Republic of Ireland), along with the 30 women who were diagnosed with breast cancer but survived. Table 2.17 shows the classification of care as agreed by the assessors for the 133 women whose case notes were available with sufficient information for an in-depth review. Among the women who died, 47% were assessed to have received good care, but detailed assessment showed that for another 29% improvements in care may have made a difference to their outcome. Improvements in care were identified amongst two thirds of women with breast cancer morbidity; in only 7% was it thought that improvements may have made a difference to outcome, but of note, improvements to care which would have made no difference to outcome were identified in nearly two thirds.

Table 2.17: Classification of care received by women who died or had a new diagnosis of breast cancer and for whom case notes were available for an in-depth review and are included in the confidential enquiry chapters, UK and Ireland (2015-17)

Classification of care received	Women who died (n=103)* Number (%)	Women with newly diagnosed breast cancer (n=30) Number (%)*
Good care	47 (46)	10 (33)
Improvements to care which would have made no difference to outcome	26 (25)	18 (60)
Improvements to care which may have made a difference to outcome	30 (29)	2 (7)

*includes only women whose case notes were available with sufficient information for an in-depth review considered in chapters 3 to 7. Critical care for some of these women is reviewed separately in Chapter 8.

Local clinicians' reports

The proportion of reports received from local clinicians of those requested for the confidential enquiry remains static at around 80% (Table 2.18). Local clinicians' reports are absolutely essential to allow MBRRACE-UK assessors to fully take account of any local factors impacting on care, and we urge clinicians to return these in a timely manner.

Table 2.18: Percentages of requested local clinicians' reports received for women who died in 2016

Specialty group	Percentage of reports requested that were received
Obstetricians	68
Anaesthetists	71
Midwives	77
Critical Care Clinicians	90
Emergency Medicine Specialists	76
GPs	94
Physicians	63
Psychiatrists	100*
Total	78

*n=1

Postmortem examination

There was substantial variation in the proportion of women who had a postmortem examination, according to the cause of death. For women with records available, overall a postmortem examination was carried out in 80% (Table 2.19). However, the figure was 93% for women who died from direct causes, 83% amongst women who died from indirect causes, 71% amongst women who died from coincidental causes and only 67% amongst women who died between six weeks and one year after the end of pregnancy. As noted in previous reports, and once again in Chapter 3, establishing the cause of women's death with a high quality autopsy is essential not only to improve future care, but to ensure any family counselling or testing is appropriate.

Table 2.19: Post Mortem information for maternal deaths in the UK 2015-17

Specialty group	Direct (n=87) Frequency (%)	Indirect (n=122) Frequency (%)	Coincidental (n=27) Frequency (%)	Late Deaths (n=313) Frequency (%)	Total (n=549) Frequency (%)
No post mortem	6 (7)	21 (17)	7 (26)	77 (25)	111 (20)
Post mortem completed	81 (93)	100 (82)	17 (63)	153 (49)	351 (64)
Hospital	4 (5)	5 (5)	0	14 (9)	23 (7)
Coroner/ Procurator Fiscal	77 (95)	95 (95)	17 (100)	139 (91)	328 (93)
Records not available	0	1 (1)	3 (11)	83 (27)	87 (16)

2.4 Morbidity Enquiry - women with breast cancer newly diagnosed during pregnancy

Women with breast cancer newly diagnosed during pregnancy

A national cohort study was undertaken through the UK Obstetric Surveillance System between October 2015 and October 2017, identifying all pregnant women with a new diagnosis of breast cancer *(https://www.npeu.ox.ac.uk/ukoss/current-surveillance/bcip)*. As described in section 1.4, 30 of these women were included in the morbidity Confidential Enquiry. The characteristics of the women who survived and were selected for inclusion in the Confidential Enquiry into Maternal Morbidity are shown in Table 2.20. It is worth noting that, in contrast to the women who died, more of these women were aged over 35. Seventeen percent were pregnant following IVF and almost half had pre-existing medical or mental health problems.

Table 2.20: Characteristics of women with newly diagnosed breast cancer

Characteristics	Total (n=30) Frequency (%)
Age (years)	
25-34	8 (27)
≥35	22 (73)
Parity	
0	11 (37)
≥1	19 (63)
Previous caesarean section	
Yes	16 (47)
No	18 (53)
Ethnicity	
White European	27 (90)
Other	3 (10)
Socioeconomic status (Occupational classification)	
Employed (Either woman or partner)	24 (80)
Unemployed (Both)	3 (10)
Missing	3 (10)
Body mass index (BMI) (kg/m^2)	
18-24	12 (40)
25-29	11 (37)
≥30	7 (23)
IVF pregnancy	
Yes	5 (17)
No	25 (83)
Any pre-existing medical or mental health problem in addition to breast cancer (excluding obesity)	
Yes	14 (46)
No	16 (53)

3. Lessons on cardiovascular care

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3.1 Key messages

New recommendations

Guidance is needed on maternal medical assessment and screening prior to assisted reproduction, particularly for older women who are at higher risk of co-morbidities such as cardiac disease and cancer.

Genetic counselling should state for women known to be carriers of any inherited condition, whether the associated genetic mutation is known or unknown, and whether they need a cardiovascular risk assessment in pregnancy. Anyone with a family history or genetic confirmation of aortopathy or channelopathy should be referred for cardiac assessment before pregnancy.

Review of the RCOG 'Responsibility of Consultant on Call' guidance is needed to ensure that deviation from the usual clinical pathway, with unexpected or unexplained symptoms, triggers consultant review.

The new maternal medicine networks which are being developed in England and similar structures in the devolved nations should define pathways of referral for women with multiple and complex problems.

A persistent sinus tachycardia is a 'red flag' and should always be investigated, particularly when there is associated breathlessness.

Existing guidance and recommendations requiring improved implementation

Clear guidance on contraceptive choices for women with cardiac disease is available and should be consulted.

Repeated presentation with pain and/or pain requiring opiates should be considered a 'red flag' and warrant a thorough assessment of the woman to establish the cause. Pain severe enough to prevent a woman caring for her baby represents a similar 'red flag'.

A raised respiratory rate, chest pain, persistent tachycardia and orthopnoea are important signs and symptoms of cardiac disease which should always be fully investigated. The emphasis should be on making a diagnosis, not simply excluding a diagnosis.

It is important to be mindful of the possibility of a cardiac diagnosis when repeated attempts are made to access medical care, particularly when extreme anxiety and breathlessness are prominent symptoms.

Syncope during exercise can suggest a cardiac origin, and should prompt cardiac evaluation.

ECG and measurement of troponin levels are recommended when a pregnant woman has chest pain. Echocardiography is recommended in any pregnant patient with unexplained or new cardiovascular signs or symptoms.

Following resuscitation from an arrest with a likely cardiac cause, coronary angiography ± percutaneous coronary intervention is the appropriate initial diagnostic investigation.

Electrical cardioversion is safe in all phases of pregnancy. Immediate electrical cardioversion is recommended for any tachycardia with haemodynamic instability and for pre-excited atrial fibrillation.

When aortic dissection occurs in a young woman, the underlying diagnosis should be assumed to be an inherited aortopathy until proven otherwise.

If there are concerns about patient compliance or access to diagnostic testing then there should be a low threshold for admission to hospital for for implementation of changes to the anticoagulation regimen during pregnancy or postpartum as per ESC guidelines.

3.2 Background

Cardiovascular disease has been the single leading cause of maternal death in the UK since the 2000-02 triennium, and has been the leading cause of maternal death in Ireland since the inception of MDE Ireland (O'Hare et al. 2018). This may be partly attributable to the changing maternity population, with increasing numbers of women deferring pregnancy until they are older, and hence at greater risk of cardiovascular disease, and additionally higher numbers of women with known cardiovascular risk factors such as hypertension and obesity becoming pregnant. The predominance of cardiovascular deaths is also partly a reflection of successful prevention of maternal deaths from obstetric causes. Nevertheless, the maternal mortality rate from cardiovascular disease has now been static with little evidence of change since the beginning of this century. More women die from cardiovascular disease in pregnancy than from all the direct causes added together, with the exception of thrombosis and thromboembolism. There is clear evidence, nevertheless, from the care of the women examined for the purposes of this chapter, that the possibility of cardiovascular disease in a woman of reproductive age is still frequently not considered at presentation.

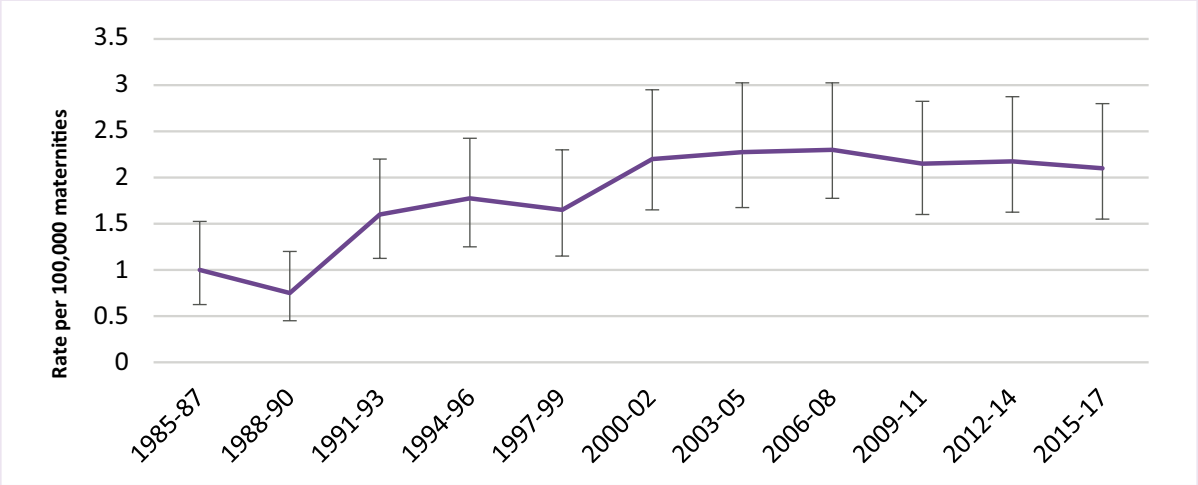
3.3 The women who died

Between 2015-17 the deaths of 82 women from heart disease associated with, or aggravated by, pregnancy were reported to the Enquiry. Of these, 48 occurred in the UK during pregnancy or within 42 days of delivery (Table 3.1). This represents a maternal mortality rate from cardiac disease in the UK of 2.10 per 100,000 maternities which is lower, but not significantly so, than the rate for 2012-14 (2.39 per 100,000 maternities). Cardiac disease therefore remains the commonest cause of indirect maternal death and the commonest cause of maternal death overall. There has been no statistically significant change in the maternal mortality rate from cardiovascular disease in the UK since enhanced case ascertainment commenced in 2000-02 (Figure 3.1)

Table 3.1: Timing of maternal deaths due to cardiac causes in relation to pregnancy, UK and Ireland, 2015-17

Time period of deaths in the pregnancy care pathway	Total (n=82) Frequency (%)
Antenatal period/ still pregnant	19 (23)
Postnatal on day of delivery	12 (15)
Postnatal 1 to 42 days after delivery	20 (24)
Postnatal 43-91days	5 (6)
Postnatal 92-182 days	8 (10)
Postnatal 183-273 days	10 (12)
Postnatal 274-364 days	8 (10)

Figure 3.1: Maternal mortality rate from cardiovascular causes, UK 1985-2017



Sources: CMACE, MBRRACE-UK

NOTE: Enhanced surveillance (and therefore more complete case ascertainment) commenced in 2000-02

Almost a quarter of women (22%) who died from cardiovascular causes were recognised to have a pre-existing cardiac problem (Table 3.2), although some, as noted in section 3.4, had clear symptoms and signs of cardiac disease which were not recognised. Maternal mortality rates from cardiovascular disease increased with age, with women aged 35-39 at three times higher risk of death compared with women aged 20-24 (Table 3.3).

Table 3.2: Medical, demographic and pregnancy related characteristics of women who died from a cardiac cause, UK and Ireland, 2015-17

Characteristics	Total (n=82) Frequency (%)
Age	
<20	2 (2)
20-24	6 (7)
25-29	21 (26)
30-34	25 (30)
35-39	24 (29)
≥40	4 (5)
Pre-existing cardiac problems	
Yes	18 (22)
No	60 (73)
Missing	4 (5)
Pre-existing health problems (excluding obesity)	
Yes	51 (62)
No	27 (33)
Missing	4 (5)
Ethnicity	
White European	56 (68)
Black African	10 (12)
Other & mixed ethnicity	13 (17)
Missing	3 (4)
Woman's region of birth	
United Kingdom/Ireland	53 (65)
Outside UK/Ireland	17 (21)
Missing	12 (15)
Socioeconomic status (Index of Multiple Deprivation)	
First quintile (Least deprived/ highest 20%)	11 (13)
Second quintile	10 (12)
Third quintile	13 (16)
Fourth quintile	15 (18)
Fifth quintile (Most deprived/ lowest 20%)	20 (24)
Missing	13 (16)
Body mass index (BMI)	
<18	3 (4)
18-24	20 (24)
25-29	16 (20)
≥30	29 (35)
Missing	14 (17)
Living arrangements	
With partner	49 (69)
Living alone	13 (18)
With parents/extended family	2 (3)
Others	1 (1)
Missing	6 (8)
IVF pregnancy	
Yes	6 (7)
No	72 (88)
Missing	4 (5)
Multiple pregnancy	
Yes	4 (5)
No	75 (91)
Missing	3 (4)
Previous caesarean section	
Yes	15 (18)
No	64 (78)
Missing	3 (4)
Previous caesarean numbers (among women who had a previous caesarean section)	
1	11 (73)
≥2	4 (27)

Table 3.3: Maternal mortality rates by age from cardiovascular causes, UK and Ireland 2015-17

	Total maternities 2015-17	Total deaths	Rate per 100,000 maternities	95% CI	Relative risk (RR)	95% CI
Age						
<20	78,227	2	2.56	0.31 to 9.24	1.52	0.15 to 8.50
20 – 24	356,591	6	1.68	0.62 to 4.74	1 (Ref)	-
25 – 29	677,597	21	3.10	1.92 to 4.56	1.84	0.72 to 5.58
30 – 34	790,025	25	3.16	2.05 to 4.67	1.88	0.75 to 5.61
35 – 39	460,830	24	5.21	3.34 to 7.75	3.10	1.23 to 9.26
≥ 40	107,511	4	3.72	1.01 to 9.53	2.21	0.46 to 9.32

Overall, a quarter of women (24%) died from ischaemic causes, and almost one third from myocardial disease/ cardiomyopathy (27%) (Table 3.4 and Figure 3.2). Although there has been an apparent decrease in the proportion of women dying from sudden arrhythmic cardiac deaths with a morphologically normal heart (SADS/MNH) amongst those dying from cardiovascular causes, there is no statistically significant decrease in the mortality rate from SADS/ MNH between 2009-14 and 2015-17.

Figure 3.2: Causes of cardiovascular deaths, UK and Ireland 2015-17

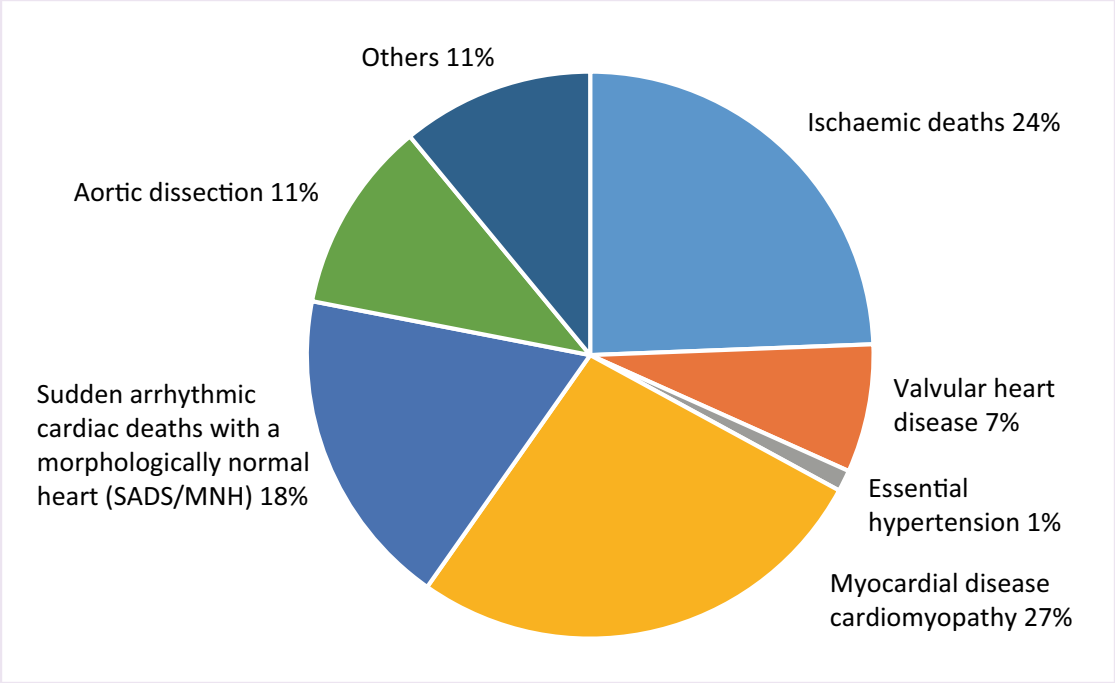


Table 3.4: Sub-classification of cardiac deaths for whom information was available for an in-depth review, UK and Ireland, 2015-17

Sub-classification	Number of deaths	Percentage of total (n=82)*
Ischaemic deaths	**20**	**24**
Atherosclerosis	14	
Coronary artery dissection	6	
Valvular heart disease	**6**	**7**
Valve disease	3	
Endocarditis	3	
Essential hypertension	**1**	**1**
Myocardial disease/ cardiomyopathy	**22**	**27**
Dilated cardiomyopathy	4	
Left ventricular hypertrophy (LVH) with or without fibrosis	2	
Left ventricular hypertrophy (LVH) in morbid obesity	2	
Myocarditis	2	
Peripartum cardiomyopathy	3	
Defined cardiomyopathy		
Hypertrophic cardiomyopathy	0	
Arrhythmogenic right ventricular cardiomyopathy	2	
Ventricular disease (not otherwise specified)	7	
Sudden arrhythmic cardiac deaths with a morphologically normal heart (SADS/MNH)	**15**	**18**
Aortic dissection	**9**	**11**
Others	**9**	**11**
Pulmonary arterial hypertension	4	
Undetermined cardiovascular disease	5	
TOTAL	**82**	
Women with Congenital Heart Disease (CHD) (included in figures above)		
Deaths from aortic dissection	1	
Deaths from valvular heart disease	1	
Deaths from arrhythmia	1	
Deaths from ischaemia	1	

3.4 Overview of care and lessons to be learned

Overall messages

New NICE guidance NG121 on intrapartum care for women with existing medical conditions or obstetric complications has recently been published, (National Institute for Health and Care Excellence 2019a), and many of the recommendations are directly relevant to the care of the women described here.

Contraception and pre-pregnancy counselling

Several of the women who died from cardiac causes reviewed in this report had unplanned pregnancies despite being known to have high risk cardiac conditions. In some instances, there was no evidence they had ever received pre-pregnancy counselling, despite this being a recurrent message of these reports. One woman discovered her unplanned pregnancy the day before she was due to have urgent cardiac surgery. She discussed this with her surgeon, but was advised to go ahead with surgery. There was no evidence that any multidisciplinary conversation including an obstetrician took place before the decision to proceed with the operation was made. Whilst it was correct not to delay her surgery, she should have seen an obstetrician and an urgent multidisciplinary team discussion convened. No consideration of even a brief delay was entertained to allow for proper counselling and discussion. She died shortly afterwards from complications of the surgery.

Pre-pregnancy counselling should be available both within the paediatric cardiology transition service and to women of child bearing age with known cardiac disease. This should include provision of appropriate contraceptive advice.

Saving Lives, Improving Mothers' Care 2016 (Knight et al. 2016)

Clear guidance on contraceptive choices for women with cardiac disease is available and should be consulted *(https://www.fsrh.org/standards-and-guidance/documents/ukmec-2016-summary-sheets/)*

Cardiac risk assessment prior to assisted reproduction

Six of the 82 women who died from cardiac causes and whose care was reviewed in this chapter conceived following in vitro fertilisation. There was no evidence that any of them had any assessment of their cardiovascular health prior to their assisted reproduction treatment.

> An older obese diabetic woman with a family history of cardiac disease underwent IVF with multiple embryo replacement. Her pregnancy was complicated by pre-eclampsia and she had an extremely preterm delivery. In the postnatal period she developed arm and hand pain which did not resolve. She was found collapsed the following day and could not be resuscitated. There was evidence of coronary atheroma and acute infarction at postmortem.

Although she had multiple risk factors, there is no evidence that this woman had any discussion of the implications of her risk factors prior to her IVF treatment, and no evidence of cardiac assessment. Additionally, the significance of her arm pain was not recognised by her or her family at the time, emphasising the importance of raising the awareness of symptoms in women with cardiac risk factors.

A number of women had their IVF abroad, but some who subsequently died from cardiac disease underwent assisted reproduction in the UK. It was noted in the 2016 report that older women with clear risk factors for cardiac disease, such as diabetes, hypertension or smoking underwent assisted reproduction without any evidence that underlying cardiac disease was considered. The European Society of Cardiology (ESC) Guidelines for the management of cardiovascular diseases during pregnancy (Regitz-Zagrosek et al. 2018) state that 'pregnancy, and consequently fertility treatment, is contraindicated in women with the [modified WHO classification of maternal risk] class IV'. In women with [modified] WHO class III or those who are anticoagulated, the risk of superovulation is very high and the alternative of natural cycle in vitro fertilisation should be considered.' It therefore follows that assessment of maternal cardiovascular risk should be undertaken. Evidence of maternal medical comorbidity that had not been considered prior to assisted reproduction has been noted in other chapters of previous reports, and notably was also identified as a theme amongst women with new diagnoses of breast cancer whose care was reviewed in Chapter 4 of this report. There is an urgent need for guidance to be developed on assessment of women, particularly older women, prior to undergoing IVF. Noting that such guidance would only be applicable in the UK, staff in maternity services need to be particularly aware of the potential for undiagnosed co-morbidities among older women who have undergone IVF abroad.

Women with cardiac risk factors should have a cardiac assessment prior to receiving assisted reproductive technology or other infertility treatment.

Saving Lives, Improving Mothers' Care 2016 (Knight et al. 2016)

Women should have the opportunity to make informed decisions regarding their care and treatment [for fertility problems] via access to evidence-based information. These choices should be recognised as an integral part of the decision-making process. Verbal information should be supplemented with written information or audio-visual media.

NICE CG156 Fertility problems: assessment and treatment (National Institute for Health and Care Excellence 2013)

Guidance is needed on maternal medical assessment and screening prior to assisted reproduction, particularly for older women who are at higher risk of co-morbidities such as cardiac disease and cancer. N

Family history

> A woman reported a family history of aortic dissection at booking, but the significance of this was not recognised, partly because of confusion in interpretation of a prior genetic assessment which had excluded known genetic aortopathies but had noted there was still a 50% risk of an unknown inherited aortopathy. In the late stages of pregnancy, she developed severe back pain and systolic hypertension and was assumed to have pre-eclampsia. She subsequently developed abdominal and lower limb symptoms at which time the aortic dissection from which she died was diagnosed.

A family history of sudden death of young relatives is important. In this instance, it indicated the likelihood of an inherited, albeit unknown, aortopathy. Similar histories of sudden death of young family members were seen among women who died from SADS/MNH, indicating the possibility of an inherited long QT syndrome or other conduction defect, and among women who died from ischaemic heart disease, indicating the possibility of familial hypercholesterolaemia. Recent assessments have shown that there are clinically relevant cardiac gene mutations detectable in at least a quarter of children and young adults who died from sudden unexplained cardiac death (Bagnall et al. 2016). A family history of sudden death of young relatives must be elicited at booking, potentially by inclusion within booking checklists, its significance should be recognised and appropriate referral for further assessment made.

A family history of sudden death of a young relative (aged less than 40) is important and may be an indication of inherited cardiac conditions. **N**

When aortic dissection occurs in a young woman, the underlying diagnosis should be assumed to be an inherited aortopathy until proven otherwise.

Saving Lives, Improving Mothers' Care 2016 (Knight et al. 2016)

In the vignette above, the significance of this woman's family history was not recognised, nor the significance of her symptoms. New genetic aortopathies are regularly discovered, but it seems likely that there are many more still to be found (Regitz-Zagrosek et al. 2018). Therefore, the exclusion of known aortopathies or genetic mutations does not exclude the possibility of a genetic syndrome. This woman was advised she had a 50% risk of an undiagnosed inherited aortopathy and should have been managed as if she had Marfan or a similar syndrome. The genetic advice could have been clearer in this instance. Her back pain should have led to the consideration of aortic dissection; subsequent abdominal and neurological symptoms are also recognised presentations of aortic dissection.

Genetic counselling should state for women known to be carriers of any inherited condition, whether the associated genetic mutation is known or unknown, and whether they need a cardiovascular risk assessment in pregnancy. Anyone with a family history or genetic confirmation of aortopathy or channelopathy should be referred for cardiac assessment before pregnancy. **N**

Cardiovascular manifestations of associated conditions

Several women who died had conditions known to have cardiovascular manifestations, including Ehlers Danlos type IV (Vascular Ehlers Danlos syndrome) and Turner syndrome. Women with Vascular Ehlers-Danlos syndrome are at high risk of dissection of major arteries and veins during pregnancy. Turner syndrome is associated with an increased risk of aortic dilatation, and, notably, aortic dissection is six times more common than in the general population (Regitz-Zagrosek et al. 2018). Many conditions which are uncommonly encountered in obstetric practice have cardiovascular manifestations, and expert advice should always be sought to guide management during pregnancy. Documenting the presence of a syndrome is not a substitute for finding out whether there are particular cardiovascular considerations in pregnancy and making appropriate referral. Specific guidance on lifetime cardiovascular screening for women and girls with Turner syndrome is available (Mortensen et al. 2018), and the European Society of Cardiology provides advice on cardiovascular management of pregnant women with Turner syndrome (Regitz-Zagrosek et al. 2018).

Always consider possible cardiovascular manifestations of unusual conditions. **N**

Transfer to hospital

A woman collapsed in the third trimester of pregnancy. Bystander cardiopulmonary resuscitation was undertaken for 20 minutes until the arrival of paramedic staff. Resuscitation continued for a further hour before transport to hospital. On arrival at hospital, perimortem caesarean section was not undertaken because of the prolonged resuscitation time. The woman's aortic dissection was diagnosed at postmortem.

A 'time critical transfer' policy is the best approach for women who are visibly pregnant, as perimortem caesarean section (PMCS) is an essential part of resuscitation in all women of 20 weeks or greater gestation, irrespective of whether the baby is considered viable. Resuscitation of this woman and several other women continued for a significant time in the community prior to transfer, thus delaying PMCS which may have enabled successful resuscitation.

Perimortem caesarean section is an important part of the resuscitation of a pregnant woman. Ambulance crews should not delay this by prolonged attempts at resuscitation in the community before transferring the woman to hospital.

Saving Lives, Improving Mothers' Care 2016 (Knight et al. 2016)

In maternal resuscitation, if there is no response to CPR after 5 minutes, undertake a TIME CRITICAL transfer to the nearest Emergency Department, ideally with an obstetric unit attached. Place a pre-alert as soon as possible to enable the Emergency Department team to organize a maternity team, as an immediate perimortem caesarean section (resuscitative hysterotomy) may be performed.

JRCALC Clinical Practice Supplementary Guidelines 2017 (Joint Royal Colleges Ambulance Liaison Committee and Association of Ambulance Chief Executives 2017)

Senior review

A primiparous woman became hypertensive after a caesarean birth at term for fetal distress. Over the following few days she had severe abdominal pain, a numb foot, diarrhoea and an ongoing need for analgesia including opiates. Staff were aware of her pain but interpreted it as normal post caesarean discomfort and she was not seen by a consultant. She was discharged but was in too much pain to interact with her baby and family. Two days later, she was seen by the community midwife, her pain was worse, her abdomen was bruised and her foot numb. After a phone call to the GP, more analgesia was prescribed but the GP did not review her. Later that day she had copious bloody diarrhoea and collapsed. She was taken to labour ward, where she was in extremis with rectal bleeding, a grossly distended and bruised abdomen, hypotension and acidosis. She was taken straight to theatre for emergency surgery but died from complications of her extensive aortic dissection.

This woman's aortic dissection is likely to have occurred when she became hypertensive in the postpartum period, and was the cause of her severe postpartum pain. Had the diagnosis been made earlier, it is possible that she might have survived.

Her symptoms were typical of a descending aortic dissection, but not of the more common ascending aortic dissection, with severe pain, neurological features and symptoms of an ischaemic bowel. Escalation for senior review did not take place during her postnatal hospital care despite unexpected and unexplained severe symptoms. These enquiries have emphasised repeatedly the importance of senior review, and recognition that severe pain requiring opiates is a 'red flag'. The 2009 RCOG good practice guide no 8 (Responsibility of Consultant On-Call) specifies that consultants should attend 'when requested' but does not specify that consultant review should take place when women experience deviation from the usual clinical pathway, with unexpected or unexplained symptoms (Royal College of Obstetricians and Gynaecologists 2009). Given the increasing complexity of the maternity population, revision of this guidance is warranted to ensure that consultant review is appropriately triggered.

Review of the RCOG 'Responsibility of Consultant on Call' guidance is needed to ensure that deviation from the usual clinical pathway, with unexpected or unexplained symptoms, triggers consultant review. **N**

Repeated presentation with pain and/or pain requiring opiates should be considered a 'red flag' and warrant a thorough assessment of the woman to establish the cause.

Saving Lives, Improving Mothers' Care 2018 (Knight et al. 2018)

Pain severe enough to prevent a woman caring for her baby represents a similar 'red flag'. **N**

Multiple pathology and integration of care

A hypertensive obese multiparous woman booked late in her current pregnancy. She was an asylum seeker and engaged with care sporadically due to childcare issues. Follow-up care for her blood pressure was fragmented. She had proteinuria noted on several occasions in the second trimester and received a single dose of methyldopa. She collapsed in the third trimester. Out of hospital resuscitation was stopped until it was realised she was pregnant, when it was recommenced. Obstetric staff were not alerted that she was being transported to hospital. On arrival in the emergency department no scalpel was available, there was disagreement over the need for a perimortem caesarean section, and obstetric staff were delayed. No neonatal resuscitation equipment was available and both mother and baby died. Coronary atheroma and evidence of hypertensive heart disease were evident at postmortem.

This woman had multiple problems, including multiple medical pathologies, social issues and sole responsibility for child care. There was a clear need for someone to integrate her care during pregnancy. The reasons for her non-attendance and discharge against medical advice were never explored and the impact of her social situation was therefore not considered. When she collapsed, resuscitation was chaotic, and although it is unlikely to have affected the outcome for either her or her baby, there was a worrying lack of awareness of the importance of PMCS for maternal resuscitation, and of the need for equipment to be available, in this instance a scalpel and neonatal resuscitation equipment. Ensuring obstetric staff were in the Emergency Department when she arrived would have helped.

All local maternity systems should ensure that there are defined pathways of referral for women with multiple and complex problems, both medical and social. The majority of women who died from cardiac conditions had multiple pathologies, and there should be a role for providing integrated advice on their care within new maternal medicine networks in England (Department of Health 2017) and similar services in the devolved nations.

The new maternal medicine networks being developed in England and similar structures in the devolved nations should define pathways of referral for women with multiple and complex problems. N

Charging overseas visitors

There was a suggestion that this woman and two others whose deaths are considered in this chapter may have been reluctant to access care because of concerns over the costs of care and the impact of their immigration status. Within England, free NHS hospital treatment is provided on the basis of someone being ordinarily resident (Department of Health and Social Care 2018). Although no woman will be refused emergency treatment, this may not be commonly known. The importance of maternity care is recognised and is the only service explicitly classed as being 'immediately necessary' in the regulations, meaning it cannot be withheld even if a woman has no means to pay. However, women may believe they will be asked to pay in advance for planned treatment and this may act as a disincentive to seeking care.

Aortic dissection

Most aortic dissections in women of reproductive age occur in and around pregnancy, thus awareness of the spectrum of clinical presentations and a low threshold for considering the diagnosis is important. Dissection occurs most often in the last trimester of pregnancy (50%) or the early post-partum period (33%) (Regitz-Zagrosek et al. 2018).

Recognition of risk

As noted above in the section relating to family history, with the currently evolving state of knowledge, ruling out known genetic mutations does not rule out an inherited aortopathy. Recognition of the risk of dissection will allow the significance of symptoms to be recognised.

A woman with Ehlers Danlos type IV attended the emergency department with chest and left arm pain the day after discharge following first trimester loss of an unplanned pregnancy. She had received tertiary care at a different hospital, but as her aortic root was not dilated she was not thought to be at risk of aortic dissection. No discussion of contraception is recorded. Shortly after arrival in the emergency department she had a cardiac arrest due to an aortic dissection from which she could not be resuscitated.

Vascular Ehlers Danlos syndrome (vEDS, EDS IV) is a very high-risk condition and women should be advised to avoid pregnancy because of the risk of vascular dissection and uterine rupture (Regitz-Zagrosek et al. 2018). Although this woman was seen regularly by a vEDS service, discussions appear to have focused solely on her cardiac medication and the importance of not conceiving while taking angiotensin receptor blockers. However, as with other women discussed in this chapter, there is no mention of a discussion about adequate contraception. Importantly, this woman's death illustrates that aortic dissection can occur without aortic dilation in individuals with an underlying aortopathy.

Consideration of the diagnosis

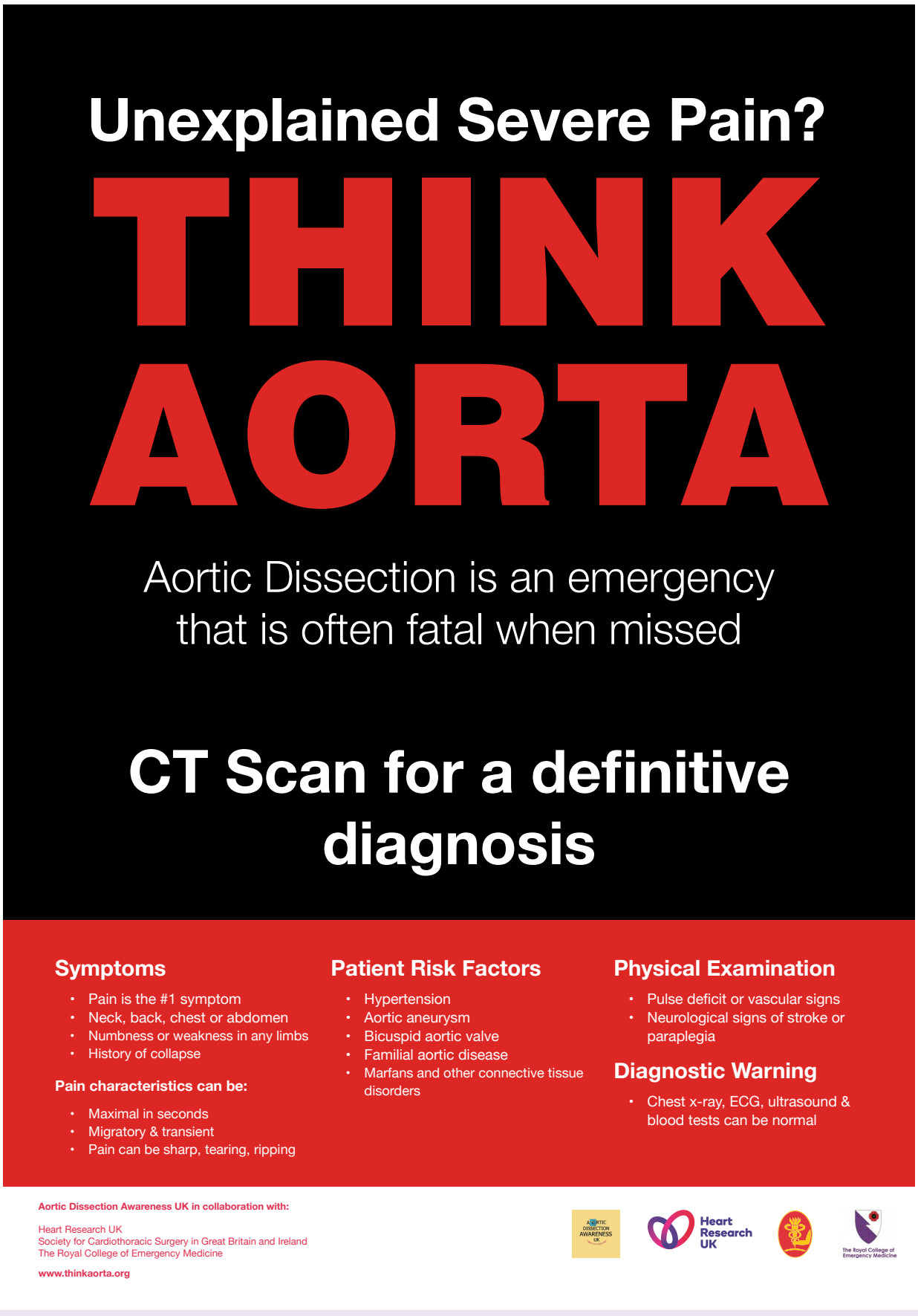
Aortic dissection classically presents with severe sudden onset pain in the chest, back, neck or abdomen. The pain may be tearing in nature, and typically between the shoulder blades. However, a dissection extending into the abdominal aorta or head and neck vessels may cause additional symptoms and signs. Depending on the organs affected by the dissection, there may be neurological symptoms, haematuria or rectal bleeding. Agitation is a common feature. Collapse or syncope may occur. The combination of severe sudden onset pain and neurological symptoms should always raise the possibility of dissection. Underdiagnosis of aortic dissection is an important issue in the wider population and the subject of the current "Think Aorta" campaign to increase identification and early diagnosis.

Posters for raising awareness (Figure 3.3) and other information are available from *www.thinkaorta.org*.

> A postnatal woman with known poorly controlled hypertension presented to the emergency department with sudden onset severe central chest pain and collapse. PE and aortic dissection were considered and, on this basis, a CTPA was performed demonstrating that the ascending aorta was dilated at 41mm diameter with some features of aortic syndrome such as oedema in the aortic wall, together with left ventricular hypertrophy, but no PE and no dissection flap. The woman declined further investigations. The following day she was found unresponsive at home and despite all attempts to resuscitate her she died from an aortic dissection and associated cardiac tamponade.

The assessment of this woman when she attended the emergency department was very thorough, but aortic dissection could have been higher in the differential diagnosis given her symptoms. An aortic CT (rather than CTPA) would then have been performed which may have identified the incipient dissection. A specific indication on the request to radiology that aortic dissection is a likely differential diagnosis will lead to different consideration of which imaging is most appropriate in pregnant or postpartum women with chest pain. Triple rule-out CT has been suggested to be beneficial in assessing patients in whom additional diagnoses such as pulmonary embolism and aortic dissection are part of the differential diagnostic list along with acute coronary syndrome, because it simultaneously examines the coronary arteries, thoracic aorta and pulmonary arteries (Hiratzka et al. 2010, Burris et al. 2015). However, this requires a slightly higher radiation dose and contrast load compared to dedicated coronary CT angiography, may not be readily available, particularly out of hours, and there is currently no guidance on its use in pregnancy.

Figure 3.3: 'Think Aorta'



Myocardial ischaemia

Diagnosis

A morbidly obese woman who had recently given up smoking was admitted twice in the third trimester of pregnancy with chest pain and breathlessness. On the second occasion she associated these symptoms with exertion. A family history of heart disease was documented at her booking visit. On both occasions she was investigated for presumed pulmonary embolism and discharged when investigations were negative. A cardiac cause for her symptoms was never considered. She collapsed at home a few days after her caesarean birth at which time the ischaemic heart disease from which she died was diagnosed.

This woman had several risk factors for ischaemic heart disease and a strong family history, but no-one recognised their relevance. At the time of her admissions no-one considered an ischaemia test, for example ECG and measurement of troponin levels, echocardiography, or potentially coronary angiography, which would have revealed her critical coronary stenosis, allowing for management which may have prevented her death. Women with established coronary artery disease are known to be at increased risk of adverse events during pregnancy (Regitz-Zagrosek et al. 2018).

ECG and measurement of troponin levels are recommended when a pregnant woman has chest pain.

Echocardiography is recommended in any pregnant patient with unexplained or new cardiovascular signs or symptoms. (Regitz-Zagrosek et al. 2018)

Box 3.2: Risk factors for ischaemic heart disease

Older maternal age	Hypertension
Smoking	Family history of premature vascular disease
Obesity	Hypercholesterolaemia
Diabetes	

An obese woman who smoked consulted her GP in the second trimester with severe central anterior chest pain radiating to the jaw and left arm and associated with sweating, nausea and dry retching. The pain came on at rest and lasted an hour. It was different from her pregnancy-related heartburn. The GP referred her to the emergency department. Cardiovascular examination was normal and two ECGs showed no ischaemic changes. Differential diagnoses included indigestion, acute coronary syndrome and PE. She was admitted and given aspirin pending test results. Her D Dimer was normal, but serum troponin was raised on two separate samples. She was discussed with a locum emergency medicine consultant and sent home with a diagnosis of reflux oesophagitis. She sought medical help from her GP for the same chest pain on two further occasions over the next three days, but no further action was taken. She was found dead in bed the morning after a further episode of pain. Postmortem revealed acute myocardial infarction and a single vessel coronary artery thrombosis.

GP reflection provided to MBRRACE-UK stated ‘bad outcomes cannot be prevented no matter how careful you are. No change in practice.’ There was no evidence of a hospital review.

This woman clearly had an acute coronary syndrome - she had classical symptoms of angina and a raised troponin. A normal ECG does not exclude ischaemia. There were at least four opportunities to make a diagnosis and provide life-saving treatment.

The message repeated in previous maternal mortality reports did not reach the medical staff who cared for this woman:

- Severe chest pain needs a positive diagnosis
- Women of child-bearing age can have coronary disease
- Chest pain at rest radiating to the jaw and left arm, associated with sweating and nausea represents an acute coronary syndrome (Box 3.3) until proven otherwise and requires urgent definitive investigation and treatment.
- Elevated troponin should be interpreted in the same way for pregnant and non-pregnant women and in this instance should have triggered urgent review.

It is extremely disappointing that there is no medical report or evidence of reflection from the hospital team on the care this this woman received. The GP report shows a lack of insight into the fact that this woman's death might have been prevented.

Box 3.3: Chest pain 'red flags' to be aware of:

Pain requiring opioids
Pain radiating to arm, shoulder, back or jaw
Sudden onset, tearing or exertional chest pain
Associated with haemoptysis, breathlessness, syncope or abnormal neurology
Abnormal observations
RCP Toolkit: Care for the acutely Ill pregnant woman 2019 (Royal College of Physicians 2019)

Pregnant and postpartum women presenting to the emergency department with medical problems should be discussed with a member of the maternity medical team. (Knight et al. 2015)

A raised respiratory rate, chest pain, persistent tachycardia and orthopnoea are important signs and symptoms of cardiac disease which should always be fully investigated. The emphasis should be on making a diagnosis, not simply excluding a diagnosis. (Knight et al. 2016)

Third stage management

A morbidly obese woman who smoked had a major postpartum haemorrhage following delayed delivery of the placenta. She was given syntometrine and intravenous access achieved. During her ongoing haemorrhage she developed symptoms of acute myocardial infarction. She was treated with carboprost and transferred to theatre for management of her haemorrhage. Her condition worsened but she died despite angiography during resuscitation. Postmortem revealed atherosclerotic coronary arteries with no evidence of thrombus.

The team caring for this woman managed well with a very difficult situation. However, planning ahead for the third stage of labour is important in any woman with BMI >40kg/m^2. This woman would have benefitted from early active management, which may have prevented her PPH, and from having venous access established early in labour, which would have facilitated more rapid treatment when haemorrhage occurred. Once venous access was established, the team quickly and appropriately managed her severe haemorrhage. However, carboprost is known to raise blood pressure and this may have worsened her cardiac ischaemia. Although this woman was not known to have cardiac disease, she had several risk factors for premature coronary disease, and in this instance, given her chest pain at the time, there should have been careful consideration before administering carboprost.

Women with a BMI 40 kg/m^2 or greater should have venous access established early in labour and consideration should be given to the siting of a second cannula.

Although active management of the third stage of labour is advised for all women, the increased risk of PPH in those with a BMI greater than 30 kg/m^2 makes this even more important.

RCOG Green-top Guideline 72: Care of Women with Obesity in Pregnancy (Royal College of Obstetricians and Gynecologists 2018)

Post-resuscitation care

An older obese multiparous woman who smoked had reported chest pain for a few weeks in the second trimester of pregnancy. She reported further chest pain and breathlessness before she collapsed at home. She had bystander CPR and an ambulance was called. She was found to be in ventricular fibrillation and paramedics therefore attempted resuscitation and transferred her to the emergency department. She regained output and an ECG showed evidence of an old myocardial infarct and sinus tachycardia. A chest x-ray was reported as showing signs of pulmonary oedema. The differential diagnosis was pulmonary embolus. Despite presenting with chest pain and breathlessness, she nevertheless then underwent a head CT scan that

was normal. The plan was for a CTPA to exclude a pulmonary embolus; however she had a further episode of ventricular tachycardia and could not be resuscitated. Postmortem showed triple vessel coronary atherosclerosis with a single thrombosed vessel.

UK Resuscitation Council guidelines are clear that following return of spontaneous circulation, if a cardiac cause for arrest is likely, coronary angiography should be considered as the first investigation, with recourse to CT if no cause for cardiac arrest is identified (UK Resuscitation Council 2015) (Figure 3.4). The decision to undertake a head CT led to a delay of over an hour during which percutaneous coronary intervention may have prevented her death.

Following resuscitation from an arrest with a likely cardiac cause, coronary angiography ± percutaneous coronary intervention is the appropriate initial diagnostic investigation.

Resuscitation guidelines 2015 (UK Resuscitation Council 2015)

Spontaneous Coronary Artery Dissection (SCAD)

Six of twenty women who died from myocardial ischaemia (30%) had SCAD, which reflects previous estimates (Adlam et al. 2019). SCAD tends to occur in young and middle-aged women, and is known to be associated with pregnancy. The causes of SCAD are not well understood; women with SCAD do not typically have the cardiovascular risk factors evident in women with atherosclerotic disease. However, recent analyses have started to identify some genetic associations which may help illuminate the pathogenesis (Adlam et al. 2019). In the absence of means of prevention or prediction, the mainstay of treatment remains rapid recognition and early intervention.

A postpartum woman in her mid 30s collapsed at home after experiencing chest pain and breathlessness the day beforehand. She had no overt risk factors for cardiac disease. Paramedic staff arrived very promptly. She had a cardiac arrest after their arrival and was resuscitated and transported to hospital within 30 minutes. She had a further cardiac arrest on arrival in hospital requiring resuscitation. She had good immediate care in hospital with an early cardiology review, bedside echocardiography and coronary angiography which revealed a spontaneous coronary artery dissection. She died a few days later from hypoxic brain injury. Postmortem examination suggested two areas of myocardial infarction possibly consistent with her history of previous chest pain.

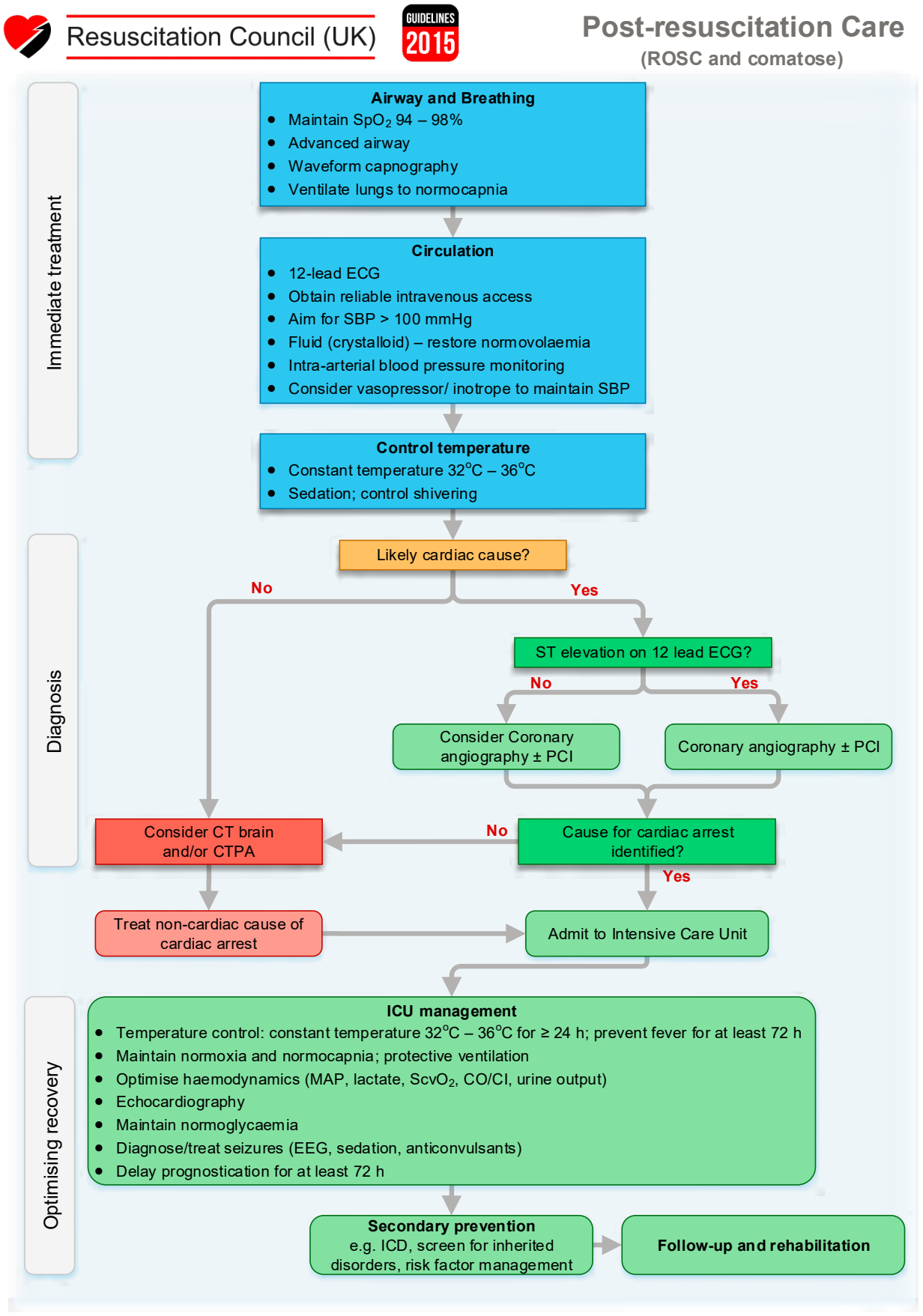
This woman had good urgent care including early angiography. Resuscitation closely followed UK Resuscitation Council guidelines with appropriate intervention. The woman had some symptoms on the day before her collapse which emphasises the importance of awareness of cardiac symptoms and the possibility of conditions such as SCAD. SCAD, although rare, predominantly affects reproductive age women and an association has been described with pregnancy and the postpartum period.

Myocardial disease

Cardiomyopathies are diseases of the heart muscle; the heart may be affected in isolation (primary) or the disease process may involve other organs and be part of a systemic disorder. Some primary cardiomyopathies which are genetically determined are included in the group of inherited cardiovascular conditions such as aortopathies and ion channel diseases. Others are acquired however, even non genetic forms of cardiomyopathy may be shaped by an individual's genetic profile and a family history of early onset cardiomyopathy is important.

Twenty-two women died from myocardial disease (Table 3.4) between 2015 and 2017 in the UK and Ireland. Women died suddenly from cardiac arrest or in heart failure. In a number of cases the symptoms and signs of heart failure were not appreciated. One woman, with multiple co-morbidities, died despite having been counselled against a further pregnancy. Notably, in this enquiry only three women died from peripartum cardiomyopathy. In addition, four women died from a dilated cardiomyopathy, two from arrhythmogenic right ventricular cardiomyopathy and one from Danon cardiomyopathy. A further three women had an unspecified cardiomyopathy; the autopsy was not of sufficient quality to determine the type (see section 3.5). No women died in this triennium from hypertrophic cardiomyopathy. Four women died with left ventricular hypertrophy; in two of these women it was associated with morbid obesity. A further two women died from myocarditis, two dysrhythmias with structural heart disease, and one from post-heart transplant heart failure.

Figure 3.4: Post-resuscitation Care (Reproduced with permission) (UK Resuscitation Council 2015)



A woman who was an asylum seeker presented a few weeks after an uneventful caesarean birth at term with vomiting, abdominal and chest pain. She was initially admitted to a surgical ward and investigated for a gastrointestinal cause and then a small pulmonary embolus, but her severe left ventricular dysfunction was diagnosed quickly and treated appropriately. She was unsuitable for transplant or a left ventricular assist device and was managed palliatively. She died surrounded by her family.

Presentation of heart failure may be with abdominal symptoms such as distension and discomfort, as well as pain and breathlessness. The cardiac cause for this woman's symptoms was rapidly recognised, she was fully assessed for possible transplant and a Left Ventricular Assist Device but was not considered suitable. She was discharged to a hospice where she received excellent palliative care.

A woman with a complex social situation and previous mental health problems attended three times in late pregnancy with different concerns, and on each occasion was noted to have a tachycardia. She was reported to be very anxious. She attended in labour and was again noted to be tachycardic. She remained tachycardic postpartum and was thought to have signs of sepsis. She had a raised CRP. Her anxiety was causing concern and she had two mental health reviews. After 6 days of IV antibiotics she remained tachycardic. She was discussed with but not reviewed by the medical registrar in view of the tachycardia and it was assumed to be due to sepsis. She subsequently took her own discharge. She remained tachycardic at each post-natal visit. Three weeks later she was admitted with acute breathlessness at which point the peripartum cardiomyopathy from which she subsequently died was diagnosed.

The importance of investigation of persistent tachycardia has been highlighted previously in these reports (Knight et al. 2016). This woman was significantly and persistently tachycardic postpartum, which continued after leaving hospital, with the additional development of breathlessness (Box 3.4). Unfortunately, due to her history of raised inflammatory markers and mental health problems, a cardiac cause was not considered and her symptoms were attributed to anxiety. Women with mental health problems can and often do have physical health problems.

A persistent sinus tachycardia is a 'red flag' and should always be investigated, particularly when there is associated breathlessness. **N**

Take a cardiac-specific history and suspect heart failure if there is not another likely cause of any of the following symptoms:

- **Breathlessness when lying down (ruling out aortocaval compression) or at rest**
- **Unexplained cough, particularly when lying down or which produces frothy pink sputum**
- **Paroxysmal nocturnal dyspnoea – being woken from sleep by severe breathlessness and coughing, which may produce pink frothy sputum and is improved by moving to an upright position**
- **Palpitation (awareness of persistent fast heart rate at rest).**

(National Institute for Health and Care Excellence 2019a)

Box 3.4: Breathlessness 'red flags' to be aware of:

Sudden onset breathlessness

Orthopnoea

Breathlessness with chest pain or syncope

Respiratory rate >20 breaths/min

Oxygen saturations < 94% or fall to < 94% on exertion

Breathlessness with associated tachycardia (heart rate can be elevated by 10-15% in a normal pregnancy-refer to pre-pregnancy observations/ECG)

RCP Toolkit: Care for the acutely Ill pregnant woman 2019 (Royal College of Physicians 2019)

Exercise syncope

Two women died from myocardial disease after recurrent exercise syncope. Both experienced initial symptoms in the first trimester which then recurred. One woman's symptoms were attributed to her pregnancy, the other woman was investigated and referred to cardiology but was given the more benign diagnosis of right ventricular outflow tract ventricular tachycardia instead of the arrhythmogenic right ventricular cardiomyopathy from which she died.

Both these women could potentially have been saved by an implantable cardioverter defibrillator (ICD). Although a reluctance to place an ICD during pregnancy is reasonable (symptoms may have stopped after pregnancy, and ICDs carry a high risk of long-term complications in young people), a wearable shock vest should have been considered. In women of reproductive age, exertional syncope may be the first indication of a variety of cardiac conditions and should be considered a 'red flag' and always prompt cardiac evaluation (Brignole et al. 2018).

Syncope during exercise can suggest a cardiac origin, and should prompt cardiac evaluation.

ESC Guidelines for the diagnosis and management of syncope 2018 (Brignole et al. 2018)

Good care

There were several examples of extremely good care, prompt recognition of cardiac disease and prompt resuscitation.

A woman in the third trimester awoke in the early hours complaining of shortness of breath. The ambulance was called and arrived rapidly. She was noted to be hypertensive and hypoxic. However, she deteriorated markedly during transfer and arrived at hospital in extremis. The multi-professional team were in attendance for her arrival and early recognition of the severity of her illness activated escalation for senior input, who attended promptly. She was intubated immediately, and copious pulmonary oedema noted and treated. Her condition deteriorated further and CPR was commenced. There was a timely peri-mortem caesarean section undertaken by the surgical registrar, guided on the telephone by the obstetric registrar whilst the obstetric consultant was en-route. Full resuscitation continued for 60 minutes, with consideration for causes made. Cardiac echo showed a completely akinetic heart with no identifiable reversible causes. Her hypertensive heart disease was diagnosed at post-mortem.

Arrhythmic deaths

Four women died following acute arrhythmias.

Delayed cardioversion

Two women died following acute narrow complex tachycardias which were managed with intravenous metoprolol prescribed over the telephone. In both instances cardioversion was delayed.

A woman presented to the emergency department with breathlessness and palpitations in the third trimester. She described orthopnoea which she attributed to pregnancy. She was tachycardic on presentation with a narrow complex tachycardia >200 bpm. There were no physical signs of heart failure but she did not have a chest X-ray or echocardiogram despite the history of orthopnoea. It was difficult to obtain an accurate blood pressure. She was given adenosine with fetal monitoring in increasing doses. When this was unsuccessful in restoring sinus rhythm, the cardiology registrar was contacted and IV metoprolol was advised. After this she had collapse of her circulation and was transferred to theatre for a caesarean section. It was noted on arrival that she was agitated and had saturations of 60%. She was still in supraventricular tachycardia with a heart rate 230-250 bpm. As the placenta was delivered, she arrested and could not be revived. Her cause of death was her atrio-ventricular nodal re-entrant tachycardia.

When this woman presented to the emergency department she was treated for an acute SVT but the importance of her history of breathlessness, and particularly orthopnoea, appear to have been overlooked along with the signs of cardiac compromise. The woman had poor left ventricular function and mitral regurgitation on echo but no abnormality was demonstrated on physical examination in the emergency department. Furthermore, it had been difficult to obtain her blood pressure at times and this should have alerted staff to her compromise. The intravenous beta-blocker was recommended over the phone and it is possible the cardiology registrar was unaware of the history of breathlessness and orthopnoea. This was sufficient to render the woman haemodynamically compromised and by the time she arrived in theatre she was peri-arrest with agitation and very low oxygen saturation. Had the extent of maternal compromise not been overlooked both in the emergency department and on arrival in theatre, an urgent DC cardioversion may have saved her life.

A second woman died in very similar circumstances. In both instances, intravenous metoprolol was prescribed over the phone, the women then became extremely haemodynamically compromised, leading to a fetal bradycardia. In both instances, the woman was rushed to theatre for emergency surgery for fetal reasons, when in fact an urgent cardioversion would have corrected the maternal compromise and therefore also the fetal compromise. Improving the condition of the mother in these circumstances will improve the condition of the baby. The European Society of Cardiology (ESC) guidelines for the management of cardiovascular diseases during pregnancy are clear that cardioversion is the next line management after failure of adenosine, and the fact of pregnancy should not prevent this (Regitz-Zagrosek et al. 2018).

[Electrical] cardioversion is safe in all phases of pregnancy.

Immediate electrical cardioversion is recommended for any tachycardia with haemodynamic instability and for pre-excited atrial fibrillation.

In the event of maternal cardiac arrest, resuscitation (and delivery) should be performed according to existing guidelines.

In case of emergency, drugs that are not recommended by international agencies for use during pregnancy and breastfeeding should not be withheld from the mother.

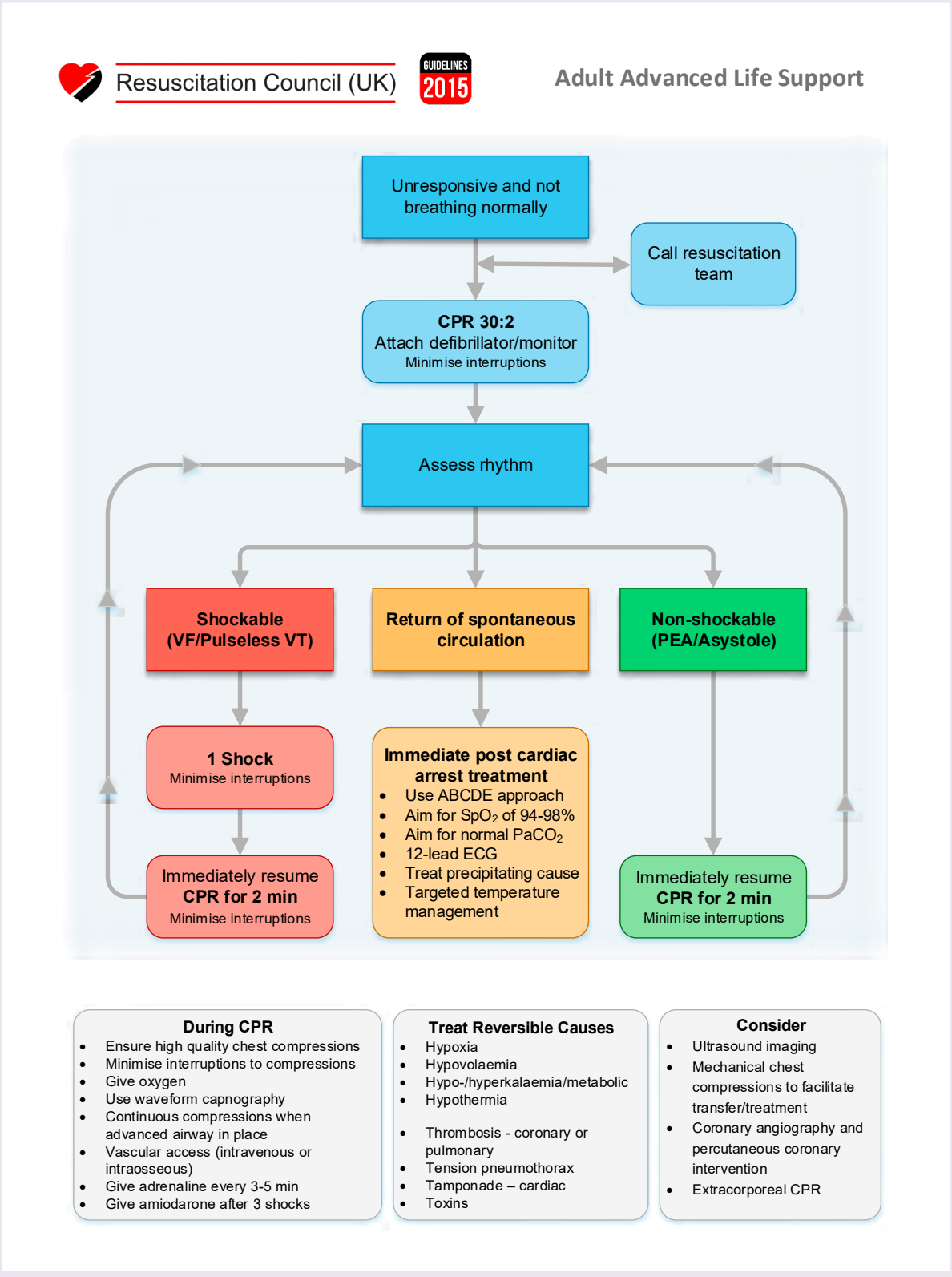
ESC guidelines for the management of cardiovascular diseases during pregnancy 2018 (Regitz-Zagrosek et al. 2018)

A woman with a history of repaired congenital heart disease and thyroid disease was booked for low risk pregnancy care. Both carbimazole and propranolol had been discontinued at the beginning of the pregnancy. She was reviewed by a cardiologist at 17 weeks with palpitations. 24hr ECG monitoring was arranged for almost two months later, by which time she had died. She was not given a follow up cardiology appointment during pregnancy and it appears she was due for cardiology review in two years. Four weeks later she presented to the emergency department with palpitations but symptoms were assumed to be thyroid-related and she was discharged home with no change in therapy and no obstetric or obstetric medical review.

Two days after discharge from ED she felt her heart racing at home and was found by the ambulance team to have a supraventricular tachycardia. During transfer to the ambulance the woman collapsed and developed ventricular fibrillation. It is not clear whether she received cardioversion before arrival in the emergency department. After a prolonged cardiac arrest and a very late perimortem section, due to confusion over which hospital she was taken to, both mother and baby died.

This woman's pregnancy was clearly not low risk. The potential impact of changing physiology in pregnancy on her heart disease did not appear to have been considered. She was not reviewed by an obstetric medical team at the time of her first admission to the emergency department, when the significance of her symptoms might have been recognised. Cardioversion is indicated in pregnant women with SVT and haemodynamic instability, as in this woman. At the time of her collapse, cardioversion was clearly indicated according to UK Resuscitation Council peri-arrest algorithms (Figure 3.5), but it is not clear whether this was carried out in a timely manner.

Figure 3.5: Adult Advanced Life Support algorithm (Reproduced with permission) (UK Resuscitation Council 2015).



Sudden arrhythmic cardiac death with a morphologically normal heart (SADS/MNH)

Fifteen women died from SADS/MNH during 2015-17 in the UK and Ireland, a statistically non-significant decrease in the mortality rate compared with 2009-14. SADS/MNH deaths are presumed to be due to cardiac arrest resulting from a primary abnormality of cardiac rhythm. A proportion of these arrhythmias result from genetic alteration in cardiac ion channels, so called channelopathies. Such conditions include long QT and Brugada syndrome. A history of unexplained sudden death in the family should raise the suspicion of an inherited channelopathy.

Women with long QT syndrome are particularly at risk of ventricular arrhythmia and sudden death in the postnatal period. This increased risk extends for nine months postpartum and is reduced by beta-blocker use. One woman who died had known long QT syndrome-2 (LQTS2). Women with this LQTS type appear to be at the highest risk of sudden death in this postpartum period (Seth et al. 2007).

Several key channelopathy genes have been identified allowing the identification of individuals at risk and clinical intervention, and it is possible that other inherited conditions will be discovered. In almost half of deaths in this enquiry, splenic tissue was retained which can be used for subsequent analysis and potential family screening but this is recommended for all women.

> A woman with known Long QT syndrome was advised by her cardiologist to stop her beta-blocker during pregnancy. This erroneous advice was not followed and she gave birth uneventfully. However, she discontinued the beta blocker postnatally and although advised to restart after admission for an episode of syncope, she was found dead a few months later. No beta blocker was detected in blood assays at post-mortem.

Although the initial advice to stop her beta blocker during pregnancy was correctly recognised as inappropriate, it is unclear what advice this woman received immediately postpartum. Conflicting advice about medication during pregnancy may have contributed to her decision to cease medication at this point. There is no evidence that she was advised that the elevated risk of sudden death associated with pregnancy continues for at least nine months postpartum (Rashba et al. 1998, Seth et al. 2007).

Nonselective beta-blockers should be continued throughout pregnancy and during the post-partum period (at least 40 weeks after delivery) in patients with congenital LQTS

ESC guidelines for the management of cardiovascular diseases during pregnancy 2018 (Regitz-Zagrosek et al. 2018)

Nonselective beta blockers are safe and recommended during pregnancy for women with LQTS. Some medications, however, are known to further prolong the QT interval and are relatively contra-indicated.

> One woman who subsequently died from SADS/MNH was managed for an unrelated condition with quetiapine, which has the potential to cause lengthening of the QT interval and therefore sudden death. There was no ECG in her records, so reviewers were unable to assess whether she had any evidence of prolongation.

Details of drugs to be avoided, and those with relative contraindications in congenital LQTS and other inherited channelopathies such as Brugada syndrome may be found at Brugadadrugs.org and crediblemeds.org.

Always check the cardiac contraindications of any medication in women with a history of cardiac disease.
N

One other woman who died from SADS had a history of fainting, which was not further investigated. One had a family history of early sudden death, which was not recognised as significant. None of the remaining 11 women who died had any recorded prodromal indications or relevant family history.

Valve disease

Six women died with complications of heart valve disease. One had thrombosis of her mechanical mitral valve, one died of post operative complications after planned urgent aortic valve replacement in the very early stages of pregnancy, three had native valve endocarditis, and one died with undiagnosed severe rheumatic mitral stenosis.

Undiagnosed valve disease

A young African woman had a normal birth followed by a one litre PPH. Her blood results were delayed and she was discharged home on day 1 before staff became aware of her low haemoglobin. The following day she was readmitted via the emergency department with breathlessness when lying down, palpitations and dizziness which was attributed to her anaemia. She was transfused two units of blood, but although she remained tachycardic, orthopneic and breathlessness post-transfusion, she was discharged home. She contacted the hospital again that night feeling breathless but was advised to remain at home. She collapsed and died shortly afterwards. Her severe rheumatic mitral valve disease was diagnosed at post-mortem.

This woman was discharged home by a junior doctor after blood transfusion despite persistent tachycardia, breathlessness and orthopnoea. No senior review took place before discharge. The importance of orthopnoea as a symptom needs to be emphasised once again. If her symptoms had been recognised as cardiac, balloon dilatation of her stenosed mitral valve may have prevented her death. The possible diagnosis of covert rheumatic heart disease should always be considered, especially in immigrant women of African or Asian backgrounds. At childbearing age, valvular heart disease is often due to rheumatic heart disease, particularly in low and middle-income countries (Regitz-Zagrosek et al. 2018).

It is important to be mindful of the possibility of a cardiac diagnosis when repeated attempts are made to access medical care, particularly when extreme anxiety and breathlessness are prominent symptoms.

Saving Lives, Improving Mothers' Care 2016 (Knight et al. 2016)

Valve thrombosis

A woman with a mechanical mitral valve replacement was admitted in the first trimester with dehydration secondary to hyperemesis. She developed chest pain and pulmonary oedema following four litres of intravenous fluid, requiring treatment with diuretics. An echocardiogram demonstrated an increased trans-mitral gradient and a transoesophageal echo confirmed an abnormal appearance of her prosthetic valve. Thrombus was considered but the woman was discharged home on the same anticoagulation regime for review in a combined cardiac obstetric clinic. A diagnosis of iatrogenic pulmonary oedema was made.

The woman attended the emergency department in the second trimester. She had become acutely unwell, experiencing breathlessness on minimal exertion and not being able to sleep. She had pink frothy sputum, a systolic murmur and pulmonary oedema on a chest x-ray but was presumed to have a PE. However, her LMWH was initially withheld as her anti-Xa levels were therapeutic. A cardiology registrar recognised the signs of valve thrombosis but she died despite thrombolysis.

When this woman presented with hyperemesis in the first trimester, her increased risk of thrombosis was not recognised. The importance of a significantly elevated trans-mitral gradient in an abnormally moving mitral valve prosthesis was not appreciated, and was attributed to the haemodynamic changes of pregnancy. Her pulmonary oedema was described as iatrogenic. When she was admitted in the second trimester with a history consistent with pulmonary oedema which was confirmed on chest X-ray, her symptoms were initially attributed to a PE. The finding of a systolic murmur with a mechanical mitral valve replacement was not recognised. Withholding LMWH at this stage was not appropriate. As has been observed in previous reports, the significance of cardiac symptoms and abnormal signs was not appreciated and a pregnancy-related PE was considered as the initial diagnosis. Throughout her care, there was a lack of recognition of how unwell this woman was. Assessors felt her life may have been saved if she had been diagnosed and referred earlier to a cardiothoracic unit for intervention to the thrombosed valve.

New onset of cardiorespiratory symptoms and/or absence of valve clicks in women with prosthetic heart valves should prompt careful echocardiography and early review by a senior cardiologist to exclude the possibility of valve thrombosis.

Saving Lives, Improving Mothers' Care 2016 (Knight et al. 2016)

A young woman with complex congenital heart disease had a mechanical valve replacement as a child. She was subsequently lost to follow-up by cardiology services, and presented to the GP in the second trimester of pregnancy having stopped her warfarin. This was an unplanned pregnancy as she had understood from a doctor that she should not take any form of oral contraception. At booking she was assumed to have a bioprosthetic valve and was converted to sub-therapeutic levels of low molecular weight heparin. She first saw a specialist obstetric cardiologist in the late third trimester when her dose was increased. She had a normal birth and was discharged home with a supply of warfarin to start taking on day four and to arrange her own anticoagulation testing. She attended her GP several weeks later at which time it was noted she was not taking warfarin and only then did the GP become aware that she had not attended multiple planned follow-up visits. She became unwell shortly afterwards at which time the valve thrombosis and impaired ventricular function from which she eventually died was diagnosed.

This woman's care was clearly complex. She had been lost to follow up since her operation as a teenager and had not received (or at least not understood) appropriate contraceptive advice. She had not received pre-pregnancy counselling. Her lack of follow up also meant that opportunities to emphasise the importance of anticoagulation compliance. She had probably been poorly compliant with anticoagulation for some years before becoming pregnant, but this does not seen to have been recognised. Although she was converted to dose adjusted LMWH after her late booking, her anti Xa levels were sub therapeutic throughout the pregnancy since she appears to have been assumed to have a bioprosthetic valve until late in the 3rd trimester.

Although her peripartum inpatient anticoagulation care was appropriate, her conversion to warfarin should have been more closely supervised in view of her history, preferably as an inpatient. It appears that she did not restart regular warfarin at all after giving birth. After her death, the teams caring for her recognised the importance of strengthening communication between primary, secondary and tertiary care for women with multiple problems, but it is not clear that anyone other than her GP attempted to find ways that she could have engaged with health care professionals better.

If there are concerns about patient compliance or access to diagnostic testing then there should be a low threshold for admission to hospital for for implementation of changes to the anticoagulation regimen during pregnancy or postpartum as per ESC guidelines. (Regitz-Zagrosek et al. 2018).

The implications for a future pregnancy are an important consideration in choice of heart valve replacement in a girl or woman of childbearing potential and the woman and/or family should be given the opportunity to discuss this with a cardiac obstetric specialist prior to surgery. The balance of risk needs to be weighed between a lower risk pregnancy but the inevitable need for redo surgery with a bioprosthetic valve, versus the longevity of a mechanical prosthesis but the need for anticoagulation resulting in a high risk pregnancy.

Endocarditis

A young woman with a complex social history including previous substance misuse had a normal birth. She had multiple postnatal visits but no maternal observations were documented at any point, even after she complained of feeling sweaty with aches and chest pain. She was advised to see her GP within two days but attended almost two weeks later at which point she was in extremis from sepsis in association with infective endocarditis. She died shortly afterwards.

When maternal well-being is reported to have changed in the postnatal period, routine physical observations should be performed. Any abnormalities should be referred for medical advice and investigation, and in a vulnerable woman such as this with multiple problems, it should be facilitated rather than left to the woman herself. Although this woman did not have a known history of intravenous drug use, her past history could have triggered consideration of the possibility of endocarditis given her symptoms. Earlier recognition of her condition would have allowed for timely antibiotic treatment with the possibility of valve surgery.

All women with any symptoms or signs of ill health, including those who are postnatal, should have a full set of basic observations taken (temperature, pulse rate, respiratory rate and blood pressure), and the results documented and acted upon.

Saving Lives, Improving Mothers' Care 2014 (Knight et al. 2014)

'Think Sepsis' at an early stage when presented with an unwell pregnant or recently pregnant woman, take all appropriate observations and act on them.

Saving Lives, Improving Mothers' Care 2014 (Knight et al. 2014)

Pulmonary arterial hypertension

Pulmonary arterial hypertension carries a very high risk of maternal mortality, even with care in a specialist centre and the use of selective pulmonary vasodilators. Four women died from pulmonary arterial hypertension in the UK and Ireland in 2015-17. One woman whose condition was known received pre-pregnancy counselling explaining her risks but died in early pregnancy. A second woman's pulmonary hypertension was previously undiagnosed.

An obese woman had a normal birth at term but required suturing of a perineal tear under spinal anaesthesia. Oxygen was required to maintain a saturation above 96% and her oxygen requirements persisted into recovery. She had recurrent desaturation for several hours with saturation over 90% when awake but dropping to 88-90% when sleeping. She was investigated for suspected PE, an ECG showed right axis deviation and blood gases revealed a compensated metabolic acidosis, but the significance of these was not recognised. Her symptoms were attributed to possible obstructive sleep apnoea. She was discharged home and reported feeling light headed on several occasions to her midwife. The severity of her condition was only recognised by her GP when she attended two weeks postnatally and was noted to be breathless, tachycardic and with bilateral leg swelling. She was admitted to hospital but deteriorated and died rapidly from her pulmonary arterial hypertension and associated right heart failure.

Whilst it is unlikely that earlier diagnosis would have prevented this woman's death given the very high risk of mortality from the condition in the peripartum period, there were several opportunities to diagnose her condition immediately postnatally. Recurrent desaturation, not otherwise explained by a respiratory cause should have raised suspicions of a possible underlying cardiac cause. In this instance, as seen elsewhere in this report, the presence of maternal obesity potentially detracted from consideration of other causes of her symptoms.

Congenital cardiac disease

Four women with congenital heart disease died; messages from the reviews of their care are reported in other sections within this chapter. One died with a thrombosed mechanical mitral valve and one died with a tachyarrhythmia. A further woman died post partum with an acute myocardial infarction and was found at post mortem to have a coarctation of the aorta and normal coronary arteries; coarctation-associated hypertension may have contributed to her death. A fourth woman had Ebstein anomaly associated with an interatrial communication. She had a lower limb deep vein thrombosis and subsequently died from a paradoxical embolism.

3.5 Pathology in maternal cardiac deaths

Esther Youd and Sebastian Lucas

Given its importance in all adult autopsy work, it is expected that all pathologists would perform heart examinations well. Review of the reports from the postmortems conducted for the 77 women included in this chapter for whom records were available suggests that this is not the case. In 14/77 (18%) reports were lacking in essential detail and/or essential examinations/tests had not been carried out. In five women where the clinical picture was clearly of a cardiovascular death, the underlying cardiac cause could not be ascertained due to the inadequacy of the autopsy.

The highest quality of autopsies overall were seen in women who died from dissection of the aorta, and ischaemic heart disease, where the coronary atherosclerosis versus coronary artery dissection discriminations were clear (notwithstanding some unusual non-UK-standard nomenclature such as "glandular myocardial cells" in the histology).

The improving appreciation of sudden arrhythmic cardiac death syndrome (SADS/MNH) as a major issue in maternal death was evident, with an increasing number of women's deaths referred to cardiac pathologists for evaluation. Retention of splenic tissue for the potential for genetic studies is improving but remains lower than ideal; material which was necessary to help surviving family members was not retained after the deaths of 13 women (17%).

Careful gross examination of the heart, histopathology and clinico-pathological correlation are vital to ascribe the true cause of cardiac death in women who died from non-ischaemic and non-valvular myocardial disease/cardiomyopathy, and yet the autopsies of these women were most in need of improvement.

> A woman died in hospital after a second trimester loss. A full forensic examination followed, documenting a flaccid heart with biventricular dilatation (enlarged, weighing 0.76% of total body weight), normal coronary arteries, further examination by a cardiac pathologist with full histopathology (interstitial fibrosis), a negative toxicology screen, and no evident external trauma. The report's discussion clearly made the case for the diagnosis of long-standing dilated cardiomyopathy (DCM).

This autopsy was clearly excellent. However, expert clinical and pathological review of the maternal autopsies overall proved essential for more accurate categorisation of causes of death. To arrive at the final confirmed number of 22 myocardial disease/cardiomyopathy deaths, three women's deaths were reclassified from other causes, two having originally been diagnosed as valve disease, one as ischaemic heart disease; and two women's deaths were reclassified as SADS/MNH.

Of the 22 women who died from myocardial disease/cardiomyopathy, six (27%) had no autopsy: two of these were women with peripartum cardiomyopathy which fulfilled the clinical case definition; one had post-transplant heart failure; but the other three women's deaths would certainly have benefitted from an autopsy to provide positive and negative pathological features and in particular to guide family counselling. For one of these three women, the specific cardiac disease she had remains entirely unclear, and the other two were considered to have 'ventricular disease not otherwise specified'. One woman who died had no heart histology performed and thus assessors were only able to ascribe her death to 'undetermined cardiovascular disease'. This uncertainty would be reduced by better and more consistent gross and histopathological examinations.

Half the cardiac autopsy reports included the BMI of the woman, but only five calculated the heart/body weight ratio (a metric useful in determining whether the heart is truly enlarged and potentially pathological). None presented coronary artery stenosis measurements absolutely in millimetres.

> A postpartum woman died following an out of hospital collapse, with a reported history of recent headache. The autopsy examined only her heart and lungs, did not weigh her (her booking BMI was 32), and despite finding a heart weighing 594g, did no histopathology and concluded that her death was from acute cardiac failure due to left ventricular hypertrophy.

This woman had clear neurological symptoms prior to her death and the reason that her brain was not examined is very difficult to understand. Examining the brain in cases of death in the community is essential in nearly all instances. This woman's death highlights the problem that pathologists can have in categorising apparently enlarged hearts into cardiomyopathy, hypertension, idiopathic hypertrophy with or without fibrosis, related diagnoses – and normal heart. This woman's death was one of three women included in the category of 'unascertained cause of death' in the period 2015-2017, predominantly because of the quality of her autopsy.

Box 3.5: Specific points for improving autopsy reports following cardiovascular maternal deaths:

The woman's body's height, weight and BMI should be stated

The heart/body weight ratio (normal = <0.5%) should be stated – a useful metric in assessing whether the heart is enlarged. (Gaitskell et al. 2011)

In all cases, the aortic valve cusp should be stated as either tri- or bicuspid – to clarify the pathogenesis of dissection of the aorta and of infective endocarditis.

In all cases, the potential atrial patent foramen ovale should be inspected – several reviewed maternal deaths had paradoxical pulmonary thromboembolism as a possibility not excluded.

Coronary artery lumens should be assessed according to the Davies criteria with particular attention if 1mm or less (Davies 1999) –pathologists are discouraged from grading stenoses as a %, since that is subjective.

All maternal cardiac deaths require histopathology of, at least, the right and left ventricular heart muscle (following standard sampling guidance (UK Cardiac Pathology Network 2008, Sheppard and Suvarna 2015)) and kidney. Histology of the aorta should be examined in cases of aortic dissection (Halushka et al. 2016) – to determine if there is an underlying inheritable connective tissue disorder.

In cases where the mother had hypertension, pre-eclampsia or an enlarged heart, the essential kidney histology should indicate whether hyaline arteriolopathy (in systemic hypertension) and glomerular endotheliosis (in pre-eclampsia) are present or absent.

Premature coronary artery disease should be recognised as such and recommendations made for family members to be referred to their GP for screening for familial hypercholesterolaemia (National Institute for Health and Care Excellence 2016).

It is extremely important to accurately categorise maternal cardiac deaths, therefore pathologists should follow standard cardiac pathology guidelines when performing such autopsies and seek appropriate expert help, particularly when the diagnosis is unclear. **N**

3.6 Conclusions

Pre-pregnancy planning and contraception continue to be important themes to improve the care of women with known cardiovascular disorders. However, several women died who had risk factors for disease but did not have known cardiac conditions until the acute event that precipitated their death. Public health and preventive actions aimed at reducing risk factors such as obesity and inactivity will therefore be of benefit even among women of reproductive age, who may be considered relatively young and less likely to have cardiovascular disease. The importance of considering a cardiac cause for symptoms is very evident from the reviews of these women's care. Despite cardiovascular disease being the leading cause of maternal death in both the UK and Ireland for almost 20 years, assessors still noted that it was not considered when women presented with typical symptoms. This chapter highlights once again that pregnant women with medical co-morbidities should be treated the same as non-pregnant women unless there is a clear reason not to, in this triennium, one of the clearest messages concerned the utility of cardioversion in pregnancy. Assessors considered that in almost one third of instances, different care may have prevented women's deaths (Table 3.5).

Table 3.5: Classification of care received by women who died from cardiovascular causes, UK and Ireland, 2015-17

Classification of care received	Women who died Number (%) N=82
Good care	35 (43)
Improvements to care which would have made no difference to outcome	17 (21)
Improvements to care which may have made a difference to outcome	22 (27)
Records unavailable	8 (10)

4. Caring for women with breast cancer in pregnancy

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4.1 Key messages

New recommendations

Guidance is needed to ensure timely staging investigations are conducted in women with breast cancer in pregnancy to guide appropriate future care.

In general, early delivery to avoid delays in chemotherapy should not be recommended. For women diagnosed with breast cancer in the third trimester, the risk-benefit is likely to favour both mother and baby if a woman can receive at least two cycles of chemotherapy prior to a term (39-40 week) birth.

Advice on appropriate contraception and postponement of pregnancy should be given to women under investigation for suspected breast cancer.

Guidance is needed on maternal medical assessment and screening prior to assisted reproduction, particularly for older women who are at higher risk of co-morbidities such as cardiac disease and cancer.

Existing guidance and recommendations requiring improved implementation

Refer women using a suspected cancer pathway referral (for an appointment within 2 weeks) for breast cancer if they are aged 30 and over and have an unexplained breast lump with or without pain. Consider a suspected cancer pathway referral (for an appointment within 2 weeks) for breast cancer in women: with skin changes that suggest breast cancer, or aged 30 and over with an unexplained lump in the axilla.

With few exceptions, radiation exposure through radiography, computed tomography (CT) scan, or nuclear medicine imaging techniques is at a dose much lower than the exposure associated with fetal harm. If these techniques are necessary in addition to ultrasonography or MRI, or are more readily available for the diagnosis in question, they should not be withheld from a pregnant patient.

The birth of the baby should be timed after discussion with the woman and the multidisciplinary team. Most women can go to full term of pregnancy and have a normal or induced delivery.

Women can be reassured that they can breastfeed from the unaffected breast. There should be a time interval of 14 days or more from the last chemotherapy session to start of breastfeeding to allow drug clearance from breast milk. If chemotherapy is restarted, breastfeeding must cease. A short period of lactation may be psychologically beneficial after a stressful pregnancy and be beneficial to the baby.

At diagnosis, the impact of the cancer and its treatment on future fertility should be discussed between the woman diagnosed with cancer and her cancer team.

For women with cancer, advice on postponement of pregnancy should be individualised and based on treatment needs and prognosis over time. The risk of breast cancer recurrence is highest within the first two years after treatment. Most women with breast cancer should therefore wait at least two years after treatment(Royal College of Obstetricians and Gynaecologists 2015a).

Non-hormonal methods of contraception are recommended for women wishing to avoid pregnancy after treatment of breast cancer.

4.2 Background

Breast cancer is the most common cancer affecting women of reproductive age. There is a transient increase in risk of breast cancer after pregnancy although pregnancy has a protective effect in the longer term (Ruiz et al. 2017). Pregnancy-associated breast cancer, defined as breast cancer diagnosed during or up to one year after pregnancy, is estimated to occur in one in 3,000 to one in 10,000 pregnant women, with a third of diagnoses made during pregnancy and two thirds postnatally (Ruiz et al. 2017). Pregnancy-associated breast cancer is more common in older women having their first baby (Ruiz et al. 2017), and with current trends in age at first childbirth, the incidence is likely to increase. Studies in other high income countries have already shown an increasing incidence (Andersson et al. 2009). Studies have also shown that pregnancy-associated breast cancer is associated with a poorer prognosis, but whether this is due to biological differences in the disease, or later presentation and diagnosis due to pregnancy and lactation, is unclear (Ruiz et al. 2017).

4.3 The women who died

As noted in chapter 2, the 30 women whose care was examined for the purposes of this chapter were a sample of women identified in a UKOSS study of women with newly diagnosed breast cancer during pregnancy conducted between 1st October 2015 and 30th September 2017. All the women whose care was reviewed were from the UK; women from the Republic of Ireland were not included. All the women were alive at the time of their inclusion in the UKOSS study and did not die in the year following the end of pregnancy, but some have died subsequently.

Table 4.1: Characteristics of women with newly-diagnosed breast cancer in pregnancy whose care was reviewed for the purposes of this chapter

Characteristics	Total (n=30) Frequency (%)
Age (years)	
25-34	8 (27)
≥35	22 (73)
Pre-existing cardiac problems	
Yes	18 (22)
No	60 (73)
Missing	4 (5)
Parity	
0	11 (37)
≥1	19 (63)
Ethnicity	
White European	27 (90)
Other	3 (10)
Socioeconomic status (Occupational classification)	
Employed (Either woman or partner)	24 (80)
Unemployed (Both)	3 (10)
Missing	3 (10)
Body mass index (BMI) (kg/m$^{2)}$	
18-24	12 (40)
25-29	11 (37)
≥30	7 (23)
IVF pregnancy	
Yes	5 (17)
No	25 (83)
Any pre-existing medical or mental health problem (excluding obesity)	
Yes	14 (47)
No	16 (53)

4.4 Overview of care and lessons to be learned

Pregnancy planning

Contraception

A woman stopped the oral contraceptive pill due to breast pain. She consulted her GP and was referred for further investigation, but by the time of diagnosis of her invasive breast cancer she had a positive pregnancy test. M

As has been noted repeatedly in these enquiries in relation to other medical or mental health diagnoses, consideration of contraception in women of reproductive age is often omitted. There were a number of women with a new diagnosis of breast cancer during pregnancy whose pregnancies were unplanned or occurred around the time of diagnosis. The diagnosis of pregnancy clearly impacted on decision-making around their subsequent treatment. In this instance the woman had stopped her oral contraceptive pill due to her breast symptoms, but alternatives were not discussed while she awaited investigation. The key messages regarding contraception from the RCOG guidance on pregnancy and breast cancer deserve reiteration, with an emphasis that these apply equally when women are under investigation as well as receiving treatment for malignancy.

For women with cancer, advice on postponement of pregnancy should be individualised and based on treatment needs and prognosis over time. The risk of breast cancer recurrence is highest within the first two years after treatment. Most women with breast cancer should therefore wait at least two years after treatment (Royal College of Obstetricians and Gynaecologists 2015a).

Non-hormonal methods of contraception are recommended for women wishing to avoid pregnancy after treatment of breast cancer (Royal College of Obstetricians and Gynaecologists 2015a).

Clear guidance on contraceptive choices for women with breast cancer or suspected breast cancer is available and should be consulted *(https://www.fsrh.org/standards-and-guidance/documents/ukmec-2016-summary-sheets/)*

Advice on appropriate contraception and postponement of pregnancy should be given to women under investigation for suspected breast cancer. N

The risk of recurrence after a diagnosis of breast cancer will vary according to the subtype of the disease. For example, in oestrogen receptor (ER) positive breast cancer only 50% of recurrences happen within the first 5 years of diagnosis (Pan et al. 2017). In contrast, for ER negative, progesterone receptor (PR) negative and HER2 (human epidermal growth factor 2) negative (triple negative) disease, late recurrences, after 5 years, are much rarer (Malorni et al. 2012). In addition, for ER positive disease there is evidence of benefit of two years of adjuvant endocrine therapy with tamoxifen (Early Breast Cancer Trialists' Collaborative Group 1998, Early Breast Cancer Trialists' Collaborative Group 2005) before it needs to be stopped for subsequent conception. The 'two years post treatment' recommendation allows women time to get over many of the physical and psychological effects of the cancer therapy before embarking on pregnancy. Clearly, therefore, the discussion of contraception and postponement of pregnancy will always need to be an individualised one with each woman.

A woman in the late third trimester of pregnancy found a breast lump. She saw her GP the next day, had a fast track referral and was seen in the breast clinic within ten days. After diagnosis of her cancer she underwent induction of labour and had a normal term birth. She was discharged with extended postpartum thromboprophylaxis (6 weeks). Because she could not take hormonal contraception, she had a copper T intrauterine device inserted by her GP, who followed her up during her pre-operative chemotherapy. She subsequently underwent a wide local excision and axillary clearance with adjuvant radiotherapy with no evidence of recurrent disease at further follow-up. M

This woman received optimal care, with prompt referral, diagnosis and treatment, a normal birth at term, appropriate postnatal thromboprophylaxis and good communication between the teams involved in her care. Importantly, her GP considered her need for non-hormonal contraception during her postnatal treatment.

Assisted reproduction

Five of the women whose care was examined for the purposes of this chapter were pregnant following in vitro fertilisation (IVF). Whilst most women were diagnosed later in pregnancy and it is possible that their cancers were not evident at the time of treatment, one had a breast lump which likely pre-dated pregnancy. Whilst IVF per se is not a risk factor for breast cancer, all were older women and therefore at higher risk of breast cancer because of its known association with age. NICE guidance (National Institute for Health and Care Excellence 2013) on Assessment and treatment for people with fertility problems does not make any recommendation concerning health assessment or pre-treatment counselling amongst women with or at increased risk of medical co-morbidities, although it does recommend provision of evidence-based information for all women. The NICE guidance recommends that women aged 40-42 years should have a discussion of the additional implications of IVF at this age, although the additional implications are not specified. However, women should have high quality pre-pregnancy advice before IVF, which would normally include as a minimum checks of smear history, breast examination and advice about self examination (see below) and consideration of symptoms or signs of other cancers. This is even more important in women over 40 years of age.

People should have the opportunity to make informed decisions regarding their care and treatment via access to evidence-based information. These choices should be recognised as an integral part of the decision-making process. Verbal information should be supplemented with written information or audio-visual media.

In women aged 40–42 years offer IVF provided there has been a discussion of the additional implications of IVF and pregnancy at this age.

NICE CG156 (National Institute for Health and Care Excellence 2013)

Guidance is needed on maternal medical assessment and screening prior to assisted reproduction, particularly for older women who are at higher risk of co-morbidities such as cardiac disease and cancer. N

Diagnosis

Rapid referral

In most instances women were referred and diagnosed very rapidly after presenting to their GP. Most were referred via the two week wait pathway and diagnosis was timely once they reached breast cancer services. However, for two women diagnosis was delayed when the initial presumed diagnosis was mastitis.

A woman presented with a swelling in her breast in the second trimester and was given antibiotics by her GP for a presumed breast abscess. She was not examined. Her symptoms did not resolve and she was seen again two and a half weeks later when she was referred to the urgent breast clinic. Her breast cancer was then diagnosed and treated appropriately. M

A woman in her 30s presented to her GP in the second trimester with an acutely tender discrete breast lump that had inflammatory but no suspicious features. She was given antibiotics and reviewed a month later when she was referred as it had not resolved. She was not referred via the two week wait pathway. The following month (two months after first discovering the lump) she then saw a breast surgeon who thought it was likely to be a fibroadenoma but performed a biopsy. This showed an aggressive invasive ductal carcinoma. She had steroids for fetal lung maturation prior to induction of labour at 36 weeks and a normal birth. She was subsequently treated with chemotherapy, mastectomy and radiotherapy. She next saw her GP more than a year after giving birth. She never had a postnatal check. M

Both these women presented with what was presumed to be mastitis. In such circumstances, if examination supports the diagnosis, a one-week course of antibiotics followed by a review is a reasonable course of action, but there should be a low threshold for referral if symptoms do not resolve. One of these women was not examined at her first presentation, when the suspicious features of her lump would have been evident and hence she could have been referred earlier. The second woman was not seen for review for over a month, and was not then referred rapidly, overall leading to a delay of more than two months and as a consequence a late preterm delivery to expedite treatment. Earlier referral and diagnosis would have allowed her to commence chemotherapy during pregnancy with a planned term birth.

Refer women using a suspected cancer pathway referral (for an appointment within 2 weeks) for breast cancer if they are aged 30 and over and have an unexplained breast lump with or without pain

Consider a suspected cancer pathway referral (for an appointment within 2 weeks) for breast cancer in women:

- **with skin changes that suggest breast cancer or**
- **aged 30 and over with an unexplained lump in the axilla.**

NICE NG12 (National Institute for Health and Care Excellence 2015)

Breast self-examination in pregnancy

Several women presented late with relatively large tumours who had noticed a lump for several months. Some, but not all, of these women had noticed the lump prior to pregnancy. Although breast self-examination during pregnancy may be difficult due to breast changes, women should be advised that breast awareness continues to be important in pregnancy and that medical help should be sought for any new lump during pregnancy. Such lumps should not be assumed to be a 'blocked duct'. Guidance on breast self-examination is available at *https://www.nhs.uk/common-health-questions/womens-health/how-should-i-check-my-breasts/* or *https://www.breastcancercare.org.uk/information-support/have-i-got-breast-cancer/checking-your-breasts*.

Staging

An older woman booked with her GP at 13 weeks of pregnancy and reported a three-month history of a breast lump. She was rapidly referred and her cancer diagnosed, but no staging investigations, including chest X-ray or CT, were carried out. She underwent wide local excision and axillary node clearance and was started on chemotherapy. In her third trimester she developed chest pain and underwent CTPA for investigation of presumed pulmonary embolism, at which point her thoracic spinal metastases were diagnosed. Her baby was noted to be small for gestational age and she underwent elective caesarean delivery at 37 weeks under general anaesthetic following administration of steroids. Her baby developed respiratory distress syndrome and required neonatal intensive care. M

Thirteen (43%) of the 30 women whose care was examined for the purposes of this chapter should have had, but did not have, staging investigations, as knowledge of the presence of distant disease may have changed their planned management. The remaining 57% either had staging undertaken, or assessors felt that their treatment would have been identical regardless of the presence of metastatic disease. In the vignette described above, this woman had unnecessary surgery as full staging at the time of her diagnosis would have diagnosed her as having incurable disease. Of note, she could have given birth under regional anaesthetic as her spinal metastases were not a contraindication to spinal or epidural anaesthesia. Several other women had unnecessary, sometimes extensive, surgery as a consequence of incomplete staging investigations. In some instances, staging may have led to a different chemotherapeutic regimen, and/or led to changed decisions about whether or not to continue with the pregnancy or may have impacted on maintenance therapy or the post-treatment surveillance schedule. In some instances, the requirement to give signed consent for radiological investigations, in a manner not required for non-pregnant women, clearly influenced decisions about staging investigations by both women and their clinicians.

As with other medical conditions in pregnancy, the recurring message of these Enquiries is that pregnant women should be treated the same as non-pregnant women unless there are good reasons not to. Chest x-ray and chest CT are both safe in pregnancy, as is MRI without gadolinium contrast enhancement (American College of Radiology Committee on Drugs and Contrast Media 2016).

With few exceptions, radiation exposure through radiography, computed tomography (CT) scan, or nuclear medicine imaging techniques is at a dose much lower than the exposure associated with fetal harm. If these techniques are necessary in addition to ultrasonography or MRI or are more readily available for the diagnosis in question, they should not be withheld from a pregnant patient.

American College of Obstetricians and Gynecologists Committee Opinion No. 723: Guidelines for Diagnostic Imaging During Pregnancy and Lactation (Committee on Obstetric Practice 2017)

If a woman's breast cancer is not considered low risk for metastatic disease and if staging would be considered beneficial in a non-pregnant woman with a similar breast cancer, it should be carried out in a pregnant woman with breast cancer in the same circumstances. Staging would be considered beneficial, for example, if knowledge of the baseline stage of disease is important, or may change management, or if a woman is unwell with unexplained symptoms.

There is no clear guidance on when to conduct staging investigations, either within or outside pregnancy in the UK, and such guidance would be useful.

Guidance is needed for breast oncologists to ensure timely staging investigations are conducted in women with breast cancer in pregnancy to guide appropriate future care. **N**

Chemotherapy and timing of birth

A woman had breast cancer diagnosed in the first trimester of pregnancy, following which she had a wide local excision and lymph node biopsy. In the second trimester she commenced chemotherapy and thromboprophylaxis. A multi-disciplinary team meeting in the late second trimester included the consultant oncologist, paediatrician, obstetrician, midwifery matron and lead cancer nurse where a plan for pregnancy and birth was put in place. As she had a previous caesarean birth the decision was made for an elective caesarean birth under spinal anaesthesia at 39 weeks. Postnatally she was seen by a breastfeeding advisor to discuss the pros and cons of feeding from the unaffected breast. She made the decision to breastfeed for the first few days, then to switch to formula. Adjuvant radiotherapy was undertaken in the postnatal period and Tamoxifen was prescribed. M

This woman received exemplary care. Chemotherapy was appropriately initiated in the second trimester without delay, she had good multidisciplinary team care and gave birth at 39 weeks. Her baby was well and required no additional care.

In general, assessors felt that decisions around initiation of chemotherapy for women who were diagnosed in the first or second trimesters were good. In contrast, women who were diagnosed in the third trimester almost universally experienced inappropriate delay in initiation of chemotherapy, the clear pattern being to delay chemotherapy and deliver electively at around 34-35 weeks following steroids administration for fetal lung maturation. Previous studies have shown clearly that chemotherapy in pregnancy and delivery at term leads to better baby outcomes than early delivery followed by postnatal chemotherapy (Loibl et al. 2012).

A woman was diagnosed with breast cancer at 30 weeks gestation and two weeks later she underwent a mastectomy. Chemotherapy was delayed in favour of planned induction at 35 weeks and postnatal treatment. Induction was unsuccessful and she had an emergency caesarean section following which her baby was admitted to neonatal intensive care with respiratory distress syndrome. She commenced chemotherapy three weeks after giving birth. M

Twelve women whose care was reviewed for the purposes of this chapter were diagnosed in the third trimester, and could have received at least two cycles of chemotherapy prior to elective birth at term. Only one of these women did (8%). The woman described above could have started her chemotherapy at least a month earlier while still pregnant and could have undergone induction of labour at 39-40 weeks when the risk of failed induction would have been lower and the likelihood is that her baby would have avoided the need for intensive care.

Beyond the immediate neonatal complications of preterm birth, evidence is very clear that both late pre-term and early term birth confers a disadvantage in terms of cognitive and school performance (Chan and Quigley 2014, Chan et al. 2016). Whilst beneficial in terms of lung maturation, the long-term effects of steroid administration are still to be fully established (Steer 2005), but there are suggested impacts on neurodevelopment, dependent on timing and multiplicity of administration, and observational evidence of impact on cardiovascular risk (Murray et al. 2017).

Caring for women whose cancer is diagnosed in the third trimester requires close working between oncologist and obstetrician to minimise delays in starting chemotherapy. In general, early delivery to avoid delays in chemotherapy should not be recommended. The risk-benefit is likely to favour both mother and baby if a woman can receive at least two cycles of chemotherapy prior to a term (39-40 week) birth. Birth should be more than 2–3 weeks after the last chemotherapy session to allow maternal bone marrow recovery and to minimise problems with neutropenia (Royal College of Obstetricians and Gynaecologists 2015a), noting that the type of chemotherapy used in pregnancy has

minimal impact on maternal platelet count. It is also worth bearing in mind that vaginal delivery allows for more rapid recovery and potentially an earlier start date for postnatal chemotherapy. Women can also be referred urgently for an early start date for antenatal chemotherapy if this allows for planning of a term birth.

If the woman is diagnosed later in the third trimester, such that it may only be possible for her to receive one cycle of chemotherapy, an individualised discussion of risks and benefits needs to take place, but again, noting that early delivery to avoid delays in chemotherapy in general should not be recommended. A 1-2 week delay in starting chemotherapy for a mother is likely to have little impact on the outcome of her breast cancer, whereas a two-week delay in timing of birth may have substantial benefit for the baby in terms of reducing the risk of neonatal complications and improving future cognitive performance.

In general, for women with breast cancer, early delivery to avoid delays in chemotherapy should not be recommended. For women diagnosed with breast cancer in the third trimester, the risk-benefit is likely to favour both mother and baby if a woman can receive at least two cycles of chemotherapy prior to a term (39-40 week) birth. **N**

The birth of the baby should be timed after discussion with the woman and the multidisciplinary team. Most women can go to full term of pregnancy and have a normal or induced delivery.

GTG 12 Pregnancy and breast cancer (Royal College of Obstetricians and Gynaecologists 2015a)

There was very little evidence in any of the records reviewed of a detailed nuanced discussion covering the risks and benefits of early delivery versus antenatal chemotherapy.

Granulocyte-colony stimulating factor (GCSF) was used in a few women whose care was reviewed for the purposes of this chapter, but there was evidence of variation in practice. The risk of neutropenia with standard chemotherapeutic regimens used in pregnancy is low, hence GCSF is not usually necessary. However, evidence does suggest it is safe if needed in the second and third trimesters (Pessach et al. 2013). As with other medications, GCSF should therefore be used in pregnancy as it would outside pregnancy in women who are in their second or third trimesters. If any chemotherapeutic agent with a risk of neutropenia is used antenatally within three weeks of delivery, the baby's blood count should be monitored as they may also be at risk of neutropenia.

Multidisciplinary team working

A woman was diagnosed with breast cancer in the first trimester of pregnancy. She received good multidisciplinary care between obstetric, midwifery and oncology teams and had a mastectomy with sentinel node biopsy and chemotherapy during pregnancy. Her GP, however, only received updates by directly telephoning the woman to find out how she was progressing with both treatment and pregnancy. The GP was only formally involved with her care several months postpartum when her care became palliative. M

Assessors felt that most women received good multidisciplinary care, although, as in the vignette described above, the GP was rarely involved in the multidisciplinary team. RCOG guidance emphasises the importance of involving both the obstetric team and the GP in multidisciplinary communication. Multidisciplinary care was successfully delivered across split sites in several instances, with inclusion of obstetricians and midwives in multidisciplinary review meetings by telephone if necessary. Assessors observed that multidisciplinary care worked particularly well when the oncology team had access to a named obstetrician and midwife.

The multidisciplinary team review outcome should be forwarded to the obstetric team *and family doctor.*

GTG 12 Pregnancy and breast cancer (Royal College of Obstetricians and Gynaecologists 2015a)

A woman was diagnosed with breast cancer in the second trimester of pregnancy. She underwent four cycles of chemotherapy antenatally, receiving pertussis vaccination between cycles. Breastfeeding was discussed antenatally and she was advised that she could breastfeed initially. She had an elective caesarean birth at 38 weeks and breastfed until recommencing chemotherapy one week later. She had a subsequent wide local excision with axillary clearance and radiotherapy. M

Documented discussion of breastfeeding and managing expectations in the context of breast cancer in pregnancy is important. Assessors noted that most women had documented discussion of breastfeeding. Women received appropriate advice to feed from the contralateral breast, or to feed initially postnatally prior to (re-)starting chemotherapy. Assessors did note, however, that some women struggled to attend radiotherapy with their baby. Attendance for breast cancer radiotherapy by women with a newborn, which may require appointments for as many as five days a week for five to six weeks, can be challenging without family or financial resources for childcare.

Women can be reassured that they can breastfeed from the unaffected breast.

There should be a time interval of 14 days or more from the last chemotherapy session to start of breastfeeding to allow drug clearance from breast milk. If chemotherapy is restarted, breastfeeding must cease.

A short period of lactation may be psychologically beneficial after a stressful pregnancy and be beneficial to the baby.

GTG 12 Pregnancy and breast cancer (Royal College of Obstetricians and Gynaecologists 2015a)

Thromboprophylaxis

Although none of the women whose care was reviewed for the purposes of this chapter had a thrombotic or thromboembolic event, very few had thromboprophylaxis considered. Thrombosis and thromboembolism remains the leading cause of direct maternal deaths. Cancer is a recognised risk factor for thromboembolic disease (Royal College of Obstetricians and Gynaecologists 2015b), and women should be considered for antenatal thromboprophylaxis from 28 weeks. Surgery is also a risk factor for thromboembolism and if breast surgery (mastectomy or wide local excision) is carried out before 28 weeks, women should have thromboprophylaxis for at least 10 days following the operation. All should receive at least 10 days of postnatal thromboprophylaxis and should be considered for thromboprophylaxis for six weeks if they have two or more other risk factors, such as caesarean section, obesity or surgery in the puerperium.

Cancer is a recognised risk factor for thromboembolic disease and women should be prescribed thromboprophylaxis in accordance with RCOG guidelines.

RCOG Green-top Guideline 37a 2015 (Royal College of Obstetricians and Gynaecologists 2015b)

Discussion of future fertility

A young woman presented to her GP with a breast lump in the second trimester of pregnancy. She was rapidly referred and diagnosis of breast cancer was made a week later. She underwent a wide local excision and sentinel node biopsy and was referred for discussion with the fertility team prior to commencing chemotherapy three weeks later. She had an elective caesarean section at term for an obstetric indication. She was seen again several months postnatally by the fertility team for advice on future fertility and the possibility of egg donation. M

This was the only woman who had documented evidence of referral for discussion around future fertility. Whilst this may reflect that many women with breast cancer were older and may therefore have been assumed to have completed their family, consideration of the impact of cancer treatment on future fertility is known to be a major concern for young women (Royal College of Obstetricians and Gynaecologists 2015a).

At diagnosis, the impact of the cancer and its treatment on future fertility should be discussed between the woman diagnosed with cancer and her cancer team.

NICE CG156 (National Institute for Health and Care Excellence 2013)

Pathology

In some instances, women's placentas were sent for pathological examination to determine whether metastatic disease was present. There are very few documented instances of metastatic cancer in placental tissue of women with breast cancer, and no instances of fetal transmission. Most instances of mother to child transmission of metastatic disease relate to melanoma, leukaemia or lymphoma (Pavlidis 2002). Placental pathology is therefore unlikely to be informative and is hence unnecessary.

4.5 Conclusions

Although improvements in care were noted for two thirds of women, in only two women was it considered that different care may have made a difference to their outcome (Table 4.3). Nevertheless, this morbidity enquiry highlighted a number of areas in which care could be improved, particularly around staging, and which may, for example, have meant that women avoided unnecessary extensive surgery. There was also evidence of a need for reiterating the importance of both contraception advice and thromboprophylaxis. The enquiry clearly showed the very wide ranging impacts of a diagnosis of breast cancer in pregnancy. A number of women were followed up to a year postnatally and remained very anxious, emphasising the importance of the support that the GP and organisations such as Mummy's Star (https://www.mummysstar.org) can provide. This enquiry did not assess whether different care may have made a difference to the baby's outcome, yet this may be the biggest potential impact of changing practice in the care of women diagnosed with breast cancer during pregnancy. Chemotherapeutic regimens used in pregnancy are not associated with adverse fetal outcomes, in contrast to iatrogenic preterm birth which does have adverse consequences. Baby outcomes will be improved by an increased focus on facilitating chemotherapy during pregnancy rather than early delivery.

Table 4.2: Classification of care received by women who had newly diagnosed breast cancer in pregnancy

Classification of care received	Number of women (%) N=30
Good care	10 (33)
Improvements to care which would have made no difference to outcome	18 (60)
Improvements to care which may have made a difference to outcome	2 (7)

5. Lessons on prevention and treatment of hypertensive disorders

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5.1 Key messages

New recommendations

A national Patient Group Direction, including advice relating to safe, timely and cost-effective local implementation, as a solution should be explored to ensure consistent high quality care by allowing midwives to supply aspirin to eligible women in line with NICE Guidance (MPG2, NG133).

Women with multiple organ dysfunction need consultant involvement and there should be early consideration regarding the optimal setting for their care and whether transfer to a local or specialist ICU is warranted.

Existing guidance requiring improved implementation

Advise women at high risk of pre-eclampsia to take 75-150 mg of aspirin daily from 12 weeks until the birth of the baby. Women at high risk are those with any of the following:

- hypertensive disease during a previous pregnancy
- chronic kidney disease
- autoimmune disease such as systemic lupus erythematosis or antiphospholipid syndrome
- type 1 or type 2 diabetes
- chronic hypertension.

Advise women with more than one moderate risk factor for pre-eclampsia to take 75-150 mg of aspirin daily from 12 weeks until the birth of the baby. Factors indicating moderate risk are:

- first pregnancy
- age 40 years or older
- pregnancy interval of more than 10 years
- body mass index (BMI) of 35 kg/m^2 or more at first visit
- family history of pre-eclampsia
- multi-fetal pregnancy.

Offer pharmacological treatment to women if blood pressure remains above 140/90 mmHg. Aim for a target blood pressure of 135/85 mmHg or less once on hypertensive treatment.

In women with severe hypertension (blood pressure of 160/110 mmHg or more) offer pharmacological treatment to all women and measure blood pressure every 15-30 minutes until BP is less than 160/110.

In women with gestational hypertension who have given birth, measure blood pressure:

- daily for the first 2 days after birth
- at least once between day 3 and day 5 after birth
- as clinically indicated if antihypertensive treatment is changed after birth.

In women with gestational hypertension who have given birth:

- continue antihypertensive treatment if [it was] required
- advise women that the duration of their postnatal antihypertensive treatment will usually be similar to the duration of their antenatal treatment (but may be longer)
- reduce antihypertensive treatment if their blood pressure falls below 130/80 mmHg.

5.2 Background

The number of women who die from hypertensive disorders of pregnancy has reduced markedly in the United Kingdom from around 200 in three years in 1952-54 to single figures in the last two triennia. Whilst the number of women dying from hypertensive disorders is reducing around the world, the drop has been greater in the UK. However lessons learnt from these few women's deaths carry important messages for reducing morbidity in all women with severe hypertensive disorders.

5.3 The women who died

In 2015-2017 six women died from hypertensive disorders of pregnancy in the UK and Ireland. One of these was a late death. The mortality rate remains low (0.24/100,000, 95% CI 0.09-0.53) but is higher than in the 2012-14 triennium (0.11/100,000 maternities, 95% CI 0.02-0.34). One woman was found dead at home in the antenatal period and after a postmortem the cause of death was ascribed to hypertensive disease. She had had gestational hypertension. It is not thought that changes in care would have altered her outcome.

Two women died of fulminant liver failure (HELLP, Acute Fatty Liver of Pregnancy (AFLP)), and three died of cerebral or subarachnoid haemorrhage (one also had HELLP liver pathology) (Table 5.1). No women died following eclampsia or hepatic rupture. The continued absences of deaths from pulmonary oedema or renal failure, which were common in the past, are a testament to the care which is now taken with the management of fluids in severe pre-eclampsia.

It should also be noted that of the nine women who died from aortic dissection, and whose deaths are considered in Chapter 3, five were hypertensive and two had pre-eclampsia, which may have played a role in their deaths.

Table 5.1: Causes of death among women who died from hypertensive disorders of pregnancy (1997-2017)

	1997- 2002§	2003-08§	2009-14¶	2015-17¶
Intracranial haemorrhage	16	18	7*	3*
Eclampsia or cerebral oedema	0	6	3	1
Pulmonary oedema	3	0	0	0
Hepatic rupture	2	1	0	0
Hepatic necrosis/HELLP	9	5	4*	2*
AFLP	7	7	1	1
Total	37	37	14	6

*One woman in each triennium died due to both intracranial bleed and HELLP syndrome. § Figures for UK only, ¶ Figures for UK and Ireland

Three of the women who died were aged 35 or over and one woman was obese, with a BMI of over 40 kg/m^2 (Table 5.2). One woman died from a hypertensive disorder of pregnancy following IVF. Both of the women with twin pregnancies died from liver problems; multiple pregnancy is known to be associated with both AFLP and HELLP syndrome (Knight et al. 2008, Fitzpatrick et al. 2014). The majority of women died in the immediate postnatal period (Table 5.3).

Table 5.2: The socio-demographic characteristics of women who died from hypertensive disorders of pregnancy, UK and Ireland, 2015-17

Characteristics	Total (n=6) Frequency (%)
Age (years)	Median=32.5, range 26 to 43
<35	3 (50)
≥ 35	3 (50)
BMI at booking (kg/m^2)	
18-24	4 (67)
≥25	2 (33)
Parity	
Nulliparous	4 (67)
Multiparous	2 (33)
Multiple pregnancy	
Singleton	4 (67)
Twin	2 (33)
Ethnicity	
White	4 (67)
Black or other minority ethnic group	2 (33)
Woman's region of birth	
United Kingdom/ Ireland	4 (67)
Outside UK/Ireland	2 (33)
Socioeconomic status (Index of Multiple Deprivation)	
First - third quintile (Least deprived)	3 (50)
Fourth/ fifth quintile	2 (33)
Missing	1 (17)

Table 5.3: Timing of maternal deaths from hypertensive disorders of pregnancy, UK and Ireland, 2015-17

Time period of deaths in the pregnancy care pathway	Number (%) N=6
Antenatal period or on day of delivery	1 (17)
Postnatal 1 to 42 days after delivery	4 (67)
Postnatal >42 days after delivery	1 (17)

5.4 Overview of care and lessons to be learned

Aspirin for preventing hypertensive disorders of pregnancy

There is clear evidence that low dose aspirin for women at risk reduces the incidence of pre-eclampsia as well as reducing preterm birth, fetal or neonatal death and small for gestational age babies (Duley et al. 2007). Four of the six women who died had indications to commence aspirin at the beginning of pregnancy. Only one woman received aspirin at the correct gestation and in one woman it was started late (after 20 weeks' gestation). Two women were never prescribed aspirin despite clear indications. It was noted by reviewers that even when aspirin was commenced women experienced difficulties with obtaining aspirin; there was evidence of a reluctance to prescribe by general practitioners and pharmacists were not allowed to give aspirin to pregnant women. Reduction of the barriers to women obtaining aspirin in a timely way and to ensure continuing supply are therefore important. Whilst Patient Group Directions are only currently used in hospitals, an approach that allows community midwives to prescribe aspirin, in line with NICE guidance, would significantly reduce the barriers to the availability of aspirin for women who are advised to take it. The prescription of aspirin to prevent pre-eclampsia is an off-label indication and needs specialist supervision. Off-label use of a licensed medicine can be included in a Patient Group Direction when clearly justified by best clinical practice (National Institute for Health and Care Excellence 2017b) noting that some organisations have additional policies with reference to off label use.

Advise women at high risk of pre-eclampsia to take 75-150mg of aspirin daily from 12 weeks until the birth of the baby. Women at high risk are those with any of the following:

- **hypertensive disease during a previous pregnancy**
- **chronic kidney disease**
- **autoimmune disease such as systemic lupus erythematosis or antiphospholipid**
- **syndrome**
- **type 1 or type 2 diabetes**
- **chronic hypertension**

Advise women with more than one moderate risk factor for pre-eclampsia to take 75-150 mg of aspirin daily from 12 weeks until the birth of the baby. Factors indicating moderate risk are:

- **first pregnancy**
- **age 40 years or older**
- **pregnancy interval of more than 10 years**
- **body mass index (BMI) of 35 kg/m^2 or more at first visit**
- **family history of pre-eclampsia**
- **multi-fetal pregnancy**

NICE Guideline NG133 Hypertension in pregnancy: diagnosis and management (National Institute for Health and Care Excellence 2019b)

A national Patient Group Direction, including advice relating to safe, timely and cost-effective local implementation, as a solution should be explored to ensure consistent high quality care by allowing midwives to supply aspirin to eligible women in line with NICE Guidance (MPG2, NG133). N

Following up women who do not attend

Two women who had developed hypertension did not attend for planned antenatal checks. There did not seem to be a clear process in place for ensuring further appointments and review. It is important, particularly in high risk women, to ensure follow up, noting that this may need additional home visits.

Managing hypertension

A woman had raised blood pressure in labour and was given a single dose of oral therapy. She went home shortly after the birth, without treatment and had no postnatal checks of her blood pressure. She had a cerebral haemorrhage at home.

Appropriate management of hypertension requires an urgent response to episodes of severe hypertension together with a need to ensure that there is a documented plan for blood pressure surveillance and antihypertensive maintenance treatment to prevent further episodes of significant hypertension.

Any woman treated with antihypertensives in the antenatal or intrapartum period, even if only a single dose, requires additional postnatal blood pressure checks and continuing preventive antihypertensive treatment until it is certain that the hypertension was solely related to pregnancy and has completely resolved. There is a risk of 'rebound hypertension' and so there is a need to have repeated checks of the blood pressure at home. Every woman who has had hypertension in pregnancy should have a documented plan for postnatal blood pressure surveillance and antihypertensive treatment and this plan should be included in the postnatal discharge notes and communicated to the woman's general practitioner and community midwife.

Offer pharmacological treatment to women if blood pressure remains above 140/90 mmHg. Aim for a target blood pressure of 135/85 mmHg or less once on hypertensive treatment.

In women with severe hypertension (blood pressure of 160/110 mmHg or more) offer pharmacological treatment to all women and measure blood pressure every 15-30 minutes until BP is less than 160/110.

In women with gestational hypertension who have given birth, measure blood pressure:

- **daily for the first 2 days after birth**
- **at least once between day 3 and day 5 after birth**
- **as clinically indicated if antihypertensive treatment is changed after birth.**

In women with gestational hypertension who have given birth:

- **continue antihypertensive treatment if [it was] required**
- **advise women that the duration of their postnatal antihypertensive treatment will usually be similar to the duration of their antenatal treatment (but may be longer)**
- **reduce antihypertensive treatment if their blood pressure falls below 130/80 mmHg.**

NICE Guideline NG133 Hypertension in pregnancy: diagnosis and management (National Institute for Health and Care Excellence 2019b)

Senior decision-making and escalation

A woman with risk factors for pre-eclampsia presented at term with an abnormal fetal heart rate trace. She had an emergency caesarean birth. Postnatally she had significantly abnormal renal, liver and clotting function but there was no direct consultant obstetric involvement and the severity of her illness was not recognised until very late. There were differing opinions about transfer to intensive care and despite multiorgan problems she remained in the obstetric HDU. She continued to deteriorate with markedly abnormal liver function, but at no point was a gastroenterology or hepatology opinion sought. She eventually died from her liver failure several days after giving birth. There was no postmortem or serious incident review carried out. At all stages the severity of her underlying pathology was underestimated and opportunities to escalate her care were missed.

Women in maternity care who are unwell require an assessment by senior clinicians to ensure that the most appropriate level of support and expertise is provided for the care of these women. Senior clinicians are best placed to coordinate care and identify the need for input from other teams within the hospital. Young women can often seem

less ill than they are, but experienced clinicians should be able to recognise the need to undertake appropriate review, investigations and continued monitoring to allow interventions that can improve the chances of a good outcome. Those women who have multiple organ dysfunction need consultant appraisal of what level of care is required and where it is best provided, and these needs should be regularly re-assessed. The advice of the intensive care team should be sought early in any women with organ dysfunction and particularly in any woman who does not show a general trend towards clinical improvement and recovery after giving birth. Women should expect to be given the same best standard of care for their severity of illness as that provided to non-pregnant patients.

Women with multiple organ dysfunction need consultant involvement and there should be early consideration regarding the optimal setting for their care and whether transfer to a local or specialist ICU is warranted. N

5.5 Conclusions

Whilst the number of women dying from hypertensive disorders of pregnancy remains low there are still important lessons to be learned and opportunities to further improve care. This may avoid deaths but importantly may also reduce morbidity. Easier availability of aspirin at the appropriate gestation in pregnancy could reduce the incidence of pre-eclampsia. Prompt treatment of severe hypertension and continuing treatment and monitoring should avoid neurological problems in particular. There should be early consultant involvement in the care of women with severe disease to optimise the assessment and management, ensuring a coordinated approach to the involvement of a multidisciplinary senior team.

Table 5.4: Classification of care received by women who died from hypertensive disorders of pregnancy, UK and Ireland, 2015-17

Classification of care received	Women who died Number (%) N=6
Good care	0
Improvements to care which would have made no difference to outcome	2 (33)
Improvements to care which may have made a difference to outcome	4 (67)

6. Lessons on caring for women with early pregnancy disorders

Derek Tuffnell, Lucy Mackillop, Judy Shakespeare, David Churchill, Annette Lobo, Samantha Holden, Carole Bell, Jenny Kurinczuk and Marian Knight on behalf of the MBRRACE-UK early pregnancy chapter-writing group

Chapter writing group members: Carole Bell, Kathryn Bunch, David Churchill, Lisa Elliott, Bill Fawcett, Samantha Holden, Marian Knight, Jenny Kurinczuk, Annette Lobo, Lucy MacKillop, Sheila Macphail, Judy Shakespeare, Derek Tuffnell

6.1 Key messages

New recommendations

When a woman collapses out of hospital good communication should ensure senior review at admission and multidisciplinary involvement to determine the diagnosis promptly and enable rapid appropriate treatment.

Early pregnancy assessment services should ensure processes are in place to review and act upon the results of investigations promptly.

Any facility performing laparoscopic surgery in pregnancy should have blood immediately available, staff should be able to perform measures to control haemorrhage prior to definitive treatment and an escalation protocol for rapid assistance should be in place.

Existing guidance and recommendations requiring improved implementation

A diagnosis of ectopic pregnancy should be considered in any woman of reproductive age presenting to the emergency department with collapse, acute abdominal/pelvic pain or gastrointestinal symptoms, particularly diarrhoea, vomiting and dizziness, regardless of whether or not she is known to be pregnant. A bedside pregnancy test should always be performed in these women, if necessary catheterising to obtain urine.

Women of reproductive age presenting to the Emergency Department collapsed, in whom a pulmonary embolism is suspected, should have a Focused Assessment with Sonography in Trauma (FAST) scan to exclude intra-abdominal bleeding from a ruptured ectopic pregnancy especially in the presence of anaemia.

Women of reproductive age who present in the community in a state of shock and/or collapse with no obvious cause should be transferred urgently to a hospital Emergency Department without delay for rapid assessment and treatment.

6.2 Background

Early pregnancy problems include all types of miscarriage, trophoblastic disease and complications from termination of pregnancy as well as ectopic pregnancy. Miscarriage, termination of pregnancy and ectopic pregnancy generate a significant number of presentations to primary and secondary care; a few of these women will have serious morbidity and a small number will die.

6.3 The women who died

In 2015-2017, 99 women died whilst less than 24 weeks gestation or after a pregnancy that ended at less than 24 weeks in the United Kingdom and Ireland. Their causes of death are shown in Table 6.1, and reviews of the care of the majority are considered in different chapters of this and other reports. Six of these women died from early pregnancy problems and their care is considered here. One woman died from complications of a self-induced termination of pregnancy. She had had no medical care whilst being pregnant. The remaining five women who died had ectopic pregnancies. All five of them died within 48 hours of presentation with their ectopic pregnancy. Three of the six women who died were from Black or other ethnic minority groups and four were aged over 35 (Table 6.2).

Table 6.1: Causes of death amongst women who died at less than 24 weeks' gestation whilst still pregnant or after their pregnancy ended at less than 24 weeks (2015-17), UK and Ireland

Cause of Death	Number of women	Percentage of women
Sepsis	10	10
Thrombosis and thromboembolism	13	13
Cardiac disease	18	18
Mental Health problems	21	21
Early pregnancy-related causes	6	6
Haemorrhage	1	1
Neurology	11	11
Other indirect causes	7	7
Unascertained	1	1
Coincidental deaths	11	11
Total	99	100

Table 6.2: The socio-demographic characteristics of women who died from early pregnancy complications, UK and Ireland, 2015-17

Characteristics	N=6 Number (%)
Age (in Years)	Median=36, Range 31 to 37
<35	2 (33)
≥ 35	4 (67)
Parity	
Nulliparous	2 (33)
Multiparous	2 (33)
Missing	2 (33)
UK/Irish citizen	
Yes	2 (33)
No	1 (17)
Missing	3 (50)
Ethnicity	
White European	1 (17)
Black or other minority ethnic group	3 (50)
Missing	2 (33)
Woman's region of birth	
United Kingdom/Ireland	3 (50)
Outside UK/Ireland	2 (33)
Missing	1 (17)

6.4 Overview of care and lessons to be learned

The lessons described here all relate to the five women who had ectopic pregnancies, four of whom had tubal pregnancies and one of whom had a cornual pregnancy.

Transfer to hospital following collapse

In three of the women who collapsed out of hospital there were delays in the ambulance being available and/or delays in facilitating transfer to the hospital. In one instance this was, at least in part, due to difficulties with access as the woman was morbidly obese. In another instance the delay arose due to service pressures.

Massive intraperitoneal haemorrhage from ectopic pregnancy leads to a presentation with collapse and unless the haemorrhage is stopped surgically the woman will die. This is an important consideration in terms of both emergency management in the community and immediate management on arrival in hospital. If a woman of reproductive age

collapses in the community and there is no obvious cause, urgent transfer to hospital will allow for rapid assessment of the possibility of ectopic pregnancy. Once the woman arrives in the Emergency Department resuscitation should be carried out during assessment and diagnosis but the definitive treatment will always be surgical intervention.

Women of reproductive age who present in the community in a state of shock and/or collapse with no obvious cause should be transferred urgently to a hospital Emergency Department without delay for rapid assessment and treatment. (Knight et al. 2016)

In maternal resuscitation, if there is no response to CPR after 5 minutes, undertake a TIME CRITICAL transfer to the nearest Emergency Department, ideally with an obstetric unit attached.

In the event of collapse in the community in early pregnancy, if TIME CRITICAL features are present, transfer to the nearest appropriate destination, which may be the emergency department or early pregnancy unit, with a pre-alert stating the emergency. If significant shock or compromise, consider the emergency department in the first instance.

JRCALC Clinical Practice Supplementary Guidelines 2017 (Joint Royal Colleges Ambulance Liaison Committee and Association of Ambulance Chief Executives 2017)

Considering the diagnosis of ectopic pregnancy at time of collapse

An obese woman presented in cardiac arrest at the Emergency Department. After cardiopulmonary resuscitation was commenced she was thrombolysed. Her haemoglobin was 50g/l. Shortly afterwards an abdominal scan identified significant free fluid, and then a catheter specimen of urine was obtained and a pregnancy test was positive. Despite massive transfusion and surgery she died a few hours later.

Four of the five women who died from an ectopic pregnancy collapsed prior to surgery and one woman collapsed during surgery, as a result of a surgical complication. When a woman presents with collapse it is important to consider the differential diagnosis, which will include pulmonary embolism and intraperitoneal haemorrhage. As previously recommended a pregnancy test and a Focused Assessment with Sonography in Trauma (FAST scan) should be undertaken before thrombolysis in all women of reproductive age. Shock or collapse is an unusual presentation of pulmonary embolism (Stein et al. 2007).

Women of reproductive age presenting to the Emergency Department collapsed, in whom a pulmonary embolism is suspected, should have a Focused Assessment with Sonography in Trauma (FAST) scan to exclude intra-abdominal bleeding from a ruptured ectopic pregnancy especially in the presence of anaemia.

A diagnosis of ectopic pregnancy should be considered in any woman of reproductive age presenting to the emergency department with collapse, acute abdominal/pelvic pain or gastrointestinal symptoms, particularly diarrhoea, vomiting and dizziness, regardless of whether or not she is known to be pregnant. A bedside pregnancy test should always be performed in these women, if necessary catheterising to obtain urine.

Saving Lives, Improving Mothers' Care 2016 (Knight et al. 2016)

A woman had had an ultrasound scan reported as normal at nineteen weeks of pregnancy but then presented with collapse a few days later. There were delays in transfer to hospital but even after admission there was no senior emergency medicine or gynaecological input for some time. The gynaecology registrar left the Emergency Department suggesting the woman did not have a gynaecological problem. There was subsequent delay in performing a laparotomy and she died from her ruptured cornual ectopic pregnancy.

When a woman collapses out of hospital good communication should ensure senior review at admission and multidisciplinary involvement to determine the diagnosis promptly and enable rapid appropriate treatment. **N**

Following up results in early pregnancy units

The increasing use of early pregnancy assessment units provides the opportunity for high quality care. However, the high level of activity means that processes have to be in place to ensure the results of investigations are available rapidly and acted on promptly, especially when women go home.

> A woman presented in early pregnancy. An abdominal scan did not show an intrauterine pregnancy. She declined a vaginal scan. A serum HCG was performed, but she took her own discharge before the result was available as she had no childcare. When the result was found to be elevated she was not contacted to return. She collapsed at home. There were delays in the ambulance arrival and she had a cardiac arrest before reaching the emergency department. She could not be resuscitated.

Early pregnancy assessment services should ensure processes are in place to review and act upon the results of investigations promptly. **N**

Management of surgical complications

> A woman with a known ectopic pregnancy was taken for laparoscopic surgery by a trainee. After trocar entry she collapsed. The assumption was that the ectopic had ruptured. A low transverse incision was performed. No-one took overall leadership in the management of her aortic tear, resulting in delayed diagnosis and resuscitation and she died from the resulting haemorrhage.

Whilst a single woman's death cannot lead to recommendations regarding surgical techniques it is clear that anyone performing independent surgery should have an understanding of the immediate management of a surgical catastrophe. Any facility performing laparoscopic surgery should have blood immediately available, staff should be able to perform measures to control haemorrhage prior to definitive treatment and an escalation protocol for rapid assistance should be in place. Surgical access is best achieved through a midline incision to allow compression of the injury and of the great vessels during resuscitation.

Any facility performing laparoscopic surgery in pregnancy should have blood immediately available, staff should be able to perform measure to control haemorrhage prior to definitive treatment and an escalation protocol for rapid assistance should be in place. **N**

6.5 Conclusions

The assessors considered that for all five women with ectopic pregnancy, care could have been improved and that in four of the women improved care may have made a difference to outcome. Whilst the numbers of women of reproductive age who present with collapse are small, there should be rapid transfer to hospital. At hospital there should be early senior involvement, pregnancy must be considered in women of reproductive age, and a rapid assessment of the differential diagnosis made before commencing treatment. Bedside pregnancy tests and abdominal scans before thrombolysis will avoid inappropriate treatment when there is intraperitoneal haemorrhage. Only surgical treatment can arrest the bleeding in ectopic pregnancy and save lives.

Table 6.3: Classification of care received by women who died from early pregnancy disorders, UK and Ireland, 2015-17

Classification of care received	Women who died Number (%) N=6
Good care	1 (17)
Improvements to care which would have made no difference to outcome	1 (17)
Improvements to care which may have made a difference to outcome	4 (67)

7. Lessons from accidental deaths in pregnancy and the postpartum period

Marian Knight, Malcolm Griffiths, Judy Shakespeare, Samantha Holden, Carole Bell and Derek Tuffnell on behalf of the MBRRACE-UK accidental death chapter-writing group

Chapter writing group members: Carole Bell, Kathryn Bunch, David Churchill, Lisa Elliott, Bill Fawcett, Samantha Holden, Marian Knight, Jenny Kurinczuk, Annette Lobo, Lucy MacKillop, Sheila Macphail, Judy Shakespeare, Derek Tuffnell

7.1 Key messages

Existing guidance and recommendations requiring improved implementation

From 20 weeks of gestation onwards, the pressure of the gravid uterus must be relieved from the inferior vena cava and aorta during maternal resuscitation.

There is a need for practical national guidance for the management of women with multiple morbidities and social factors prior to pregnancy, and during and after pregnancy.

In women facing multiple adversity, changes in frequency or nature of presentations may reflect worsening mental state or the emergence of new complications (such as alcohol or substance misuse or interpersonal violence), and should prompt renewed attempts at engagement, diagnosis and care co-ordination.

Disengagement from care should be regarded as a potential indicator of worsening mental state. All professionals involved in the woman's care should be informed of non-attendances and assertive follow-up arranged where there is already concern regarding mental state or prior evidence of risk.

Loss of a child, either by miscarriage, stillbirth and neonatal death or by the child being taken into care increases vulnerability to mental illness for the mother and she should receive additional monitoring and support.

7.2 Background

Thirteen percent of deaths in women of reproductive age are due to road traffic accidents or fires, an estimated mortality rate of 2.5 per 100,000. Proportionately, the majority of those deaths (97%) are due to road traffic accidents. Important messages for preventive care, such as correct seatbelt positioning, have arisen from the review of the outcomes of pregnant women involved in road traffic accidents. However, accidental maternal deaths in pregnancy are classified as 'coincidental' (World Health Organisation 2012), and excluded from maternal mortality figures, and therefore typically also excluded from Confidential Enquiries. The National Confidential Enquiry into Patient Outcome and Death (NCEPOD) conducted a review of trauma care in 2007 (National Confidential Enquiry into Patient Outcome and Death 2007), following which trauma care has undergone major re-organisation. However, issues specifically related to pregnancy and pregnant women were not assessed. This chapter therefore includes reviews of the care of all women who died due to accidental causes in the UK and Ireland in 2015-17.

7.3 The women who died

Overall, 17 women died from accidental causes in the UK and Ireland between 2015 and 2017, a mortality rate of 0.69 per 100,000 women giving birth (95% CI 0.40-1.10). The majority of women who died in accidents were vulnerable women with multiple problems. Of note, a third of women were known to have mental health problems, a third were known to social services and almost one in five were known to have been subject to domestic abuse (Table 7.1), although with considerable missing data (71%) the real proportion subject to domestic abuse may have been higher.

Table 7.1: The characteristics of women who died from accidental causes, UK and Ireland 2015-17

Characteristics	Total (N=17) Frequency (%)
Age (years)	
<25	6 (35)
25 – 34	8 (47)
≥ 35	3 (18)
Parity	
0	2 (12)
1 or more	6 (35)
Missing	9 (53)
Ethnicity	
White European	12 (71)
Others/ Mixed	3 (18)
Missing	2 (12)
Woman's region of birth	
United Kingdom	11 (65)
Outside UK	3 (18)
Missing	3 (18)
Socioeconomic status (Index of Multiple Deprivation (IMD) of postcode of residence)	
First to fourth quintiles	6 (35)
Fifth quintile (Most deprived)	6 (35)
Missing	5 (29)
Domestic abuse (prior to pregnancy/ during pregnancy)	
Yes	3 (18)
No	2 (12)
Missing	12 (71)
Known to social services	
Yes	5 (29)
No	10 (59)
Missing	2 (12)
Mental health problems or psychiatric disorders	
Yes	5 (29)
No	8 (47)
Missing	4 (24)
Substance user	
Yes	4 (24)
No	11 (65)
Missing	2 (12)

Of the seventeen women whose deaths were classed as accidental, five women were undelivered at the time of death or were delivered by perimortem caesarean section. Two died in the early postnatal period and the remainder died between two and eleven months after giving birth. Five women died in fires, one following a fall and eleven as the result of road traffic accidents. All the women who were pregnant at the time of their road traffic accident were wearing seatbelts, although one woman who died postnatally was unrestrained.

7.4 Overview of care and lessons to be learned

Uncertain intent

A woman died in the second trimester as a result of multiple fatal injuries sustained in a road traffic accident two days before a planned social services parenting assessment. She was the driver and sole occupant of a car. She had a history of mental health problems and substance abuse. She underwent intensive resuscitation but died from her injuries. No local review of her care was carried out.

A second woman with a history of substance abuse and late booking died in a road traffic accident while her baby was in the special care baby unit. She was the driver and sole occupant of a car. No assessment of her mental health was documented.

It was unclear whether any suicidal intent was involved in either of these women's deaths. No toxicology was carried out at the first woman's post-mortem examination so it is unclear whether she was under the influence of drugs or alcohol, or had therapeutic levels of medication. The possibility of suicide does not appear to have been considered in either instance, yet both had multiple adversities and evidence of disengagement with care. Additionally one of these women died around the time of a case conference; this may have increased her vulnerability.

In women facing multiple adversity, changes in frequency or nature of presentations may reflect worsening mental state or the emergence of new complications (such as alcohol or substance misuse or interpersonal violence), and should prompt renewed attempts at engagement, diagnosis and care co-ordination.

Disengagement from care should be regarded as a potential indicator of worsening mental state. All professionals involved in the woman's care should be informed of non-attendances and assertive follow-up arranged where there is already concern regarding mental state or prior evidence of risk.

Saving Lives, Improving Mothers' Care 2018 (Knight et al. 2018)

Loss of a child, either by miscarriage, stillbirth and neonatal death or by the child being taken into care increases vulnerability to mental illness for the mother and she should receive additional monitoring and support.

Saving Lives, Improving Mothers' Care 2015 (Knight et al. 2015)

Safeguarding issues

A teenage mother with a long history of complex social, psychological and behavioural problems throughout her childhood as well as domestic abuse died in a fire a few months after giving birth. She had significant input from her GP, mental health services, social services, maternity and paediatric services up until her discharge from hospital with her newborn baby. It is unclear how much support was given to this new mother and baby and whether extra input from external sources could have prevented her death. The community midwife correctly identified that she was exceptionally vulnerable and referred her for additional support with the family nurse partnership, unfortunately the referral was refused as her problems were considered too complex.

There seems to have been little recognition that this mother was herself under 18, and that safeguarding issues applied equally to both her and her baby. The fact that she was considered too complex for help from the family nurse partnership highlights the ongoing need for guidance about how these woman can be appropriately cared for.

There is a need for practical national guidance for the management of women with multiple morbidities and social factors prior to pregnancy, and during and after pregnancy (Knight et al. 2017).

Resuscitation

A woman in the early second trimester of pregnancy was involved in a road traffic accident. Paramedics transported her rapidly to the Emergency Department where a number of consultants were already in attendance: anaesthetists, accident and emergency, intensive care and gynaecology. She had intraosseous access already inserted and central venous access was established very soon after arrival. She was resuscitated and a CT identified chest injuries following which she was transferred immediately to theatre. However, despite protracted resuscitation her bleeding could not be controlled and she died.

At all stages of her care this woman was managed appropriately and rapidly and with senior involvement but the severity of her injuries led to her ultimate death. There were several other instances of exemplary resuscitation attempts which were ultimately unsuccessful. However, in a few instances some of the key elements of resuscitation of pregnant women were not considered.

A woman involved in a road traffic accident during the third trimester of pregnancy underwent resuscitation at the scene. No pregnancy specific interventions were used such as uterine displacement or modified CPR (higher hand placement on sternum). On arrival at the emergency department a rapid perimortem caesarean section was carried out prior to further surgery but she did not survive her multiple injuries.

This woman had multiple sites of injury. Her precise cause of death is not clear but the hypovolaemia caused by her haemothorax would have had a greater effect if her inferior vena caval compression was unrelieved by uterine displacement.

From 20 weeks of gestation onwards, the pressure of the gravid uterus must be relieved from the inferior vena cava and aorta.

A left lateral tilt of 15° on a firm surface will relieve aortocaval compression in the majority of pregnant women and still allow effective chest compressions to be performed.

A left lateral tilt of 15° can be achieved on an operating table using a Cardiff wedge or by having someone kneel on the right side of the woman with their knees under the woman's thorax.

In cases of major trauma, the wedge should be placed under the spinal board. In the absence of a spinal board, manual displacement of the uterus should be used. Using soft surfaces such as a bed or objects such as pillows or blankets is not nearly as effective and compromises effective chest compressions, but is better than leaving the woman supine.

RCOG Green-top Guideline 56: Maternal Collapse in Pregnancy and the Puerperium 2011 (Royal College of Obstetricians and Gynaecologists 2011)

Although the woman noted above had a timely perimortem caesarean section, for two women there was evidence of delay, following diagnosis of an intrauterine death. In one instance the perimortem caesarean section was not carried out at the request of her family, although the woman was still unstable following return of spontaneous circulation. Caesarean section and delivery of fetus and placenta will still aid maternal resuscitation in this situation, and it must be remembered that perimortem caesarean section is a resuscitative procedure to be performed primarily in the interests of maternal, not fetal, survival (Royal College of Obstetricians and Gynaecologists 2011, Chu et al. 2018).

Local review/local unit awareness

When MBRRACE-UK contacted several maternity units to obtain their medical records for review as part of this enquiry, they were unaware that the woman had died, even though her death had occurred at most a few months after she gave birth. In most instances this was because a local review had not taken place, or had not involved the maternity services where the majority of her care was delivered, even when women had died during or shortly after pregnancy. As this chapter illustrates, messages for care are still evident when women have died during or after pregnancy from accidental causes, and local review should not be neglected.

Minimally invasive post-mortem

At least two of the women whose care was examined for the purposes of this chapter had minimally invasive post-mortem examinations. Whilst this may be appropriate, the reason for this choice of investigation should be documented. Assessors were unclear whether these decisions were made for clinical or family reasons.

7.5 Conclusions

It is reassuring that the mortality rate from accidental causes does not appear to be higher amongst pregnant or postpartum women compared to women of reproductive age. Nevertheless, women who died in fires are possibly over-represented in the pregnant and postpartum population, emphasising the importance of preventive measures such as smoke alarms in households with young children. Review of these women's deaths showed areas where care could be improved, particularly in relation to resuscitation, focussing on the use of lateral tilt and perimortem caesarean section to aid resuscitation. It was not felt that these improvements would have made a difference to the women's outcomes.

Table 7.2: Classification of care received by women who died from accidental causes, UK and Ireland, 2015-17

Classification of care received	Women who died Number (%) N=17
Good care	11 (65)
Improvements to care which would have made no difference to outcome	6 (35)
Improvements in care which may have made a difference to outcome	0

8. Messages for critical care

Rupert Gauntlett and Marian Knight on behalf of the MBRRACE-UK critical care chapter writing group

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8.1 Key messages

New recommendations

Focused, point-of-care ultrasound investigations can help guide decision-making in the management of maternal collapse. A limited cardiac echo study as well as a FAST scan can provide vital clues to differentiate key diagnoses and is the gold standard of care for a woman with severe cardiovascular instability or compromise.

Development of a national, evidence-based, early warning scoring system for pregnant and postpartum women should be a priority.

Multi-disciplinary team working should not end at the point of death. Any disputes and disagreements amongst members of the clinical team should be settled and information from post-mortem examinations and inquests should be considered to ensure that team members have a shared understanding of the lessons to be learned. Local investigations and reviews of maternal death should not be confined to a timeline of events and a clinical narrative. The strength or weakness of multi-disciplinary team working should merit specific comment.

Existing guidance and recommendations requiring improved implementation

Peri-mortem caesarean section (PMCS) is a vital component of advanced life support in resuscitation of a woman who is pregnant. Guidance relating to PMCS needs to be reviewed and strengthened.

Pregnant or recently pregnant women should have access at all times to a healthcare professional who has enhanced maternal care competencies.

The route of escalation to critical care services should be clearly defined, and include multidisciplinary discussion.

Critical care outreach or an equivalent service should be available to ill women, and provide support and education to healthcare professionals delivering enhanced maternal care.

A multidisciplinary team led by a named healthcare professional should involve the pregnant woman with a medical condition in preparing an individualised plan for intrapartum care. The plan should be:

- formulated by following the principles of shared decision making outlined in the NICE guideline on patient experience in adult NHS services
- reviewed with the woman and her birth companion(s) as early as possible throughout pregnancy and on admission for birth
- updated with the woman if her medical condition changes during pregnancy
- shared with the woman's GP and teams providing her antenatal and intrapartum care.

For pregnant women with a medical condition, the multidisciplinary team may include, as appropriate: a midwife, an obstetrician, an obstetric anaesthetist, an obstetric physician or clinician with expertise in caring for pregnant women with the medical condition, a clinician with expertise in the medical condition, a specialty surgeon, a critical care specialist, a neonatologist, the woman's GP, allied health professionals.

In maternal [out of hospital] resuscitation, if there is no response to CPR after 5 minutes, undertake a time critical transfer to the nearest Emergency Department, ideally with an obstetric unit attached.

In the event of collapse in the community in pregnancy, if time critical features are present, transfer to the nearest appropriate destination, with a pre-alert stating the emergency. If significant shock or compromise, consider the emergency department in the first instance.

Neither pregnancy, caesarean section birth or the immediate postpartum state are absolute contraindications to thrombolysis.

Where sepsis is present the source should actively be sought with appropriate imaging and consideration given to whether surgical or radiological-guided drainage is required.

8.2 Background

The care of women who become critically ill during pregnancy or after childbirth is only a small part of the work of intensive care doctors in the UK and Ireland. This chapter examines the lessons that can be learnt from 41 women who died and who had contact with critical care services at the end of their lives. The case records have been scrutinised by assessors with expertise in critical care medicine who had no involvement in the treatment and can provide an independent review of the care the women received. It contains recommendation relevant to intensive care medicine specialists, emergency physicians, obstetricians, midwives, nurses and primary responders (paramedics and ambulance technicians).

Issues that have been highlighted in previous reports recurred in this series of maternal deaths and this chapter should be read alongside previous recommendations. The importance of early recognition of the critically ill mother and prompt involvement of senior clinicians needs to be repeated as does the need to re-evaluate how we work in multidisciplinary teams.

The chapter begins with recommendations about maternal collapse/cardiac arrest both in the community and in the hospital setting. It goes on to comment on aspects of clinical assessment and critical care management of the sick mother. Finally there are comments about the recording and audit of clinical data for this group of patients and advice on the investigation and discussions that should take place after a maternal death.

8.3 The women who died

For the purposes of this chapter, the critical care of 41 women was reviewed. Unsurprisingly, their causes of death mirror the overall causes of maternal death (Table 8.1), with the largest numbers of women who died following critical care reflecting the leading cause of indirect deaths (cardiac disease) and the leading cause of direct death (thrombosis and thromboembolism). The patterns seen in Chapter 2 which describes all women who die are also reflected amongst the characteristics of these women; more than half were overweight or obese, women living in deprived areas are over-represented, and more than two thirds had pre-existing medical problems (Table 8.2). The majority of women who received critical care were postnatal at the time of their deaths (Table 8.3), but in many instances women became unwell before giving birth, and delivery was part of their management.

Table 8.1: Causes of death of women whose critical care was assessed, UK and Ireland, 2015-17

Cause of death	Total (n=41) Frequency (%)
Amniotic fluid embolism	2 (5)
Early pregnancy death	1 (2)
Pre-eclampsia and eclampsia	3 (7)
Neurological	2 (5)
Thrombosis and thromboembolism	9 (22)
Sepsis	2 (5)
Deaths from psychiatric cause	3 (7)
Cardiac disease	11 (27)
Other indirect deaths	2 (5)
Coincidental	4 (10)
Unascertained	2 (5)

Table 8.2: The sociodemographic characteristics of women whose critical care was assessed, UK and Ireland, 2015-17

Characteristics	Total (N=17) Frequency (%)
Socio-demographic	
Age	Median=36, Range 31 to 37
20 – 24	3 (7)
25 – 29	12 (29)
30 – 34	13 (32)
35 – 39	11 (27)
≥ 40	2 (5)
Parity	
0	16 (39)
1 to 2	13 (32)
≥3	9 (22)
Missing	3 (7)
Ethnicity	
White European	31 (76)
Asian	2 (5)
African/Caribbean	6 (15)
Others	1 (2)
Missing	1 (2)
Socioeconomic status (Index of Multiple Deprivation (IMD) of postcode of residence)	
First quintile (Least deprived)	5 (12)
Second quintile	4 (10)
Third quintile	3 (7)
Fourth quintile	8 (20)
Fifth quintile (Most deprived)	15 (37)
Missing	6 (15)
Known to social services	
Yes	11 (27)
No	29 (71)
Missing	1 (2)
Body mass index (kg/m2)	
18-24	13 (32)
25-29	9 (22)
≥30	14 (34)
Missing	5 (12)
Any pre-existing medical problem (excluding obesity)	
Yes	28 (68)
No	12 (29)
Missing	1 (2)

Table 8.3: Causes of death of women whose critical care was assessed, UK and Ireland, 2015-17

	Total (n=41) Frequency (%)
Antenatal period/still pregnant	3 (7)
Postnatal on day of delivery	3 (7)
Postnatal 1-42 days after delivery	19 (46)
Postnatal 43-364 days after delivery	16 (39)

8.4 Overview of care and lessons to be learned

Out of hospital cardiac arrest

When a maternal cardiac arrest occurs in the community, paramedics and ambulance technicians are usually the first medical responders on the scene. Resuscitation algorithms continue to evolve and for adults in cardiac arrest a 'chain of survival' is described where quality basic life support (BLS) and early defibrillation are the first links in the treatment algorithm. Ambulance staff understand that the best chance of a good outcome in most adult cardiac arrests is to achieve return of spontaneous circulation with early defibrillation and first responders will often work hard to achieve this before attempting a transfer to hospital.

Whilst this approach is appropriate for many adult cardiac arrests, such a delay is unlikely to be in the best interests of a woman who is visibly pregnant and in cardiac arrest because of the central role of perimortem caesarean section in maternal resuscitation during pregnancy.

> An older woman awoke with acute shortness of breath. Paramedics were called but she deteriorated into cardiac arrest soon after their arrival. Return of spontaneous circulation was achieved after around 10 minutes but she remained very unstable and there was a further delay before moving her to the ambulance. She arrived into the emergency department 55 minutes after the crew had first arrived on scene having had further episodes of cardiac arrest en route. A pre-alert was triggered and an appropriate team received her in the hospital. A perimortem caesarean section was performed at 12 minutes after her arrival into the emergency department. After a period of time in intensive care she was found to have sustained a severe hypoxic-ischaemic brain injury from which she died. A postmortem examination found evidence of a massive pulmonary embolism.

This woman received a high standard of resuscitation care including peri-mortem caesarean section and rescue thrombolysis. However, a more rapid transfer to hospital may have allowed for these advanced treatments to be initiated earlier. Perimortem caesarean section is the most crucial resuscitation tool in pregnant women and which is only likely to be available in hospital. Urgent access to perimortem caesarean section can be a life-saving reason for ambulance teams to undertake a 'time critical' transfer for pregnant women in cardiac arrest and is therefore recommended, especially if an Emergency Department, ideally with an obstetric unit attached, can be reached in a relatively short time, such as in urban areas. Note that local geography may require urgent transfer to a nearby Emergency Department which may not have an obstetric unit attached, but a perimortem caesarean section can be performed by non-obstetric staff.

Other advanced diagnostics and treatment (even whilst chest compressions are underway) may also be helpful such as focused echocardiography. The earliest possible access to these elements was not achieved for several of the women whose care was reviewed, not solely because of the clinical scenario but also due to location; in some areas of the UK and Ireland transfer times are so long that an early transfer is unlikely to make a difference.

In maternal resuscitation, if there is no response to CPR after 5 minutes, undertake a TIME CRITICAL transfer to the nearest Emergency Department, ideally with an obstetric unit attached.

In the event of collapse in the community in early pregnancy, if TIME CRITICAL features are present, transfer to the nearest appropriate destination, with a pre-alert stating the emergency. If significant shock or compromise, consider the emergency department in the first instance.

JRCALC Clinical Practice Supplementary Guidelines 2017 (Joint Royal Colleges Ambulance Liaison Committee and Association of Ambulance Chief Executives 2017)

In hospital maternal cardiac arrest

When maternal death occurs suddenly, after an unheralded collapse or abrupt cardiac arrest, critical care specialists are often involved as part of the hospital resuscitation team. UK and European Advanced Life Support guidelines recognise the 'special circumstance' of pregnancy and the vital importance of perimortem caesarean section to improve the chance of return of spontaneous circulation in the mother.

A recent review of perimortem caesarean section reiterated advice that in healthcare settings, this technique should be performed where the collapse occurs, requires only minimal equipment and is directed at improving the chances of maternal survival and not at fetal survival (Chu et al. 2018).

A pregnant woman had a traumatic injury in the third trimester and was deeply unconscious. She was breathing and had a pulse present initially at the scene but deteriorated quickly into cardiac arrest. Return of spontaneous circulation was achieved and she was transferred into hospital. An obstetrician was summoned to the emergency department as part of the resuscitation team where the woman remained very unstable. An ultrasound scan performed by the obstetric team diagnosed fetal death; a perimortem caesarean section was not therefore performed and the woman was transferred to an intensive care unit but deteriorated and died.

In this instance, even though return of spontaneous circulation had been temporarily achieved, the woman remained in a peri-arrest state and the decision making of the obstetric team seems to have been unduly influenced by the diagnosis of fetal death. A perimortem caesarean section (sometimes referred to as a resuscitative hysterotomy) should still have been considered with the aim of improving maternal haemodynamics and respiratory function while she was unstable.

An emergency department received a pre-alert about a woman in the third trimester of pregnancy who had an out of hospital cardiac arrest. A bespoke resuscitation team was assembled; however the on-call obstetricians were slightly delayed by not being able to gain access to the emergency department resuscitation room and then could not locate the delivery pack which included a scalpel. Perimortem caesarean section was performed using a trauma thoracotomy tray.

Senior trainees, non-training grade specialists and consultants in obstetrics should all be aware how to access the resuscitation areas of their hospital emergency departments rapidly. They should also know what equipment is available for perimortem CS (only a scalpel is necessary in the first instance).

The emphasis on maintaining quality chest compressions with minimal interruption has led to the promotion of manual uterine displacement (as opposed to left lateral tilt) as the preferred means of avoiding aorto-caval compression in maternal cardiac arrest. It is unclear how well this recommendation has been adopted as accounts of resuscitation still mention lateral tilt and resuscitation team members may not be aware of how to perform effective manual uterine displacement.

In some hospitals, the implementation of early warning systems, coupled with a more pro-active approach to decision making about resuscitation status and the appropriateness of aggressive therapy at the end of life has led to a significant decrease in the number of cardiac arrest calls and a change in the composition of resuscitation teams. A practitioner with advanced airway skills may no longer be routinely included.

A resuscitation team called to a maternal collapse or cardiac arrest should always include a doctor with advanced airway management skills and an obstetrician or other surgeon who can perform a perimortem caesarean section. The team should also be able to access a critical care specialist, midwife and a team to resuscitate the newborn if it becomes clear that neonatal resuscitation is a possibility.

It has been noted in several previous reports that peri-mortem caesarean section (PMCS) is a vital component in the advanced life support of a pregnant woman in cardiac arrest. Even if return of spontaneous circulation has been achieved, PMCS may still be indicated as part of the resuscitation process.

Peri-mortem caesarean section (PMCS) is a vital component of advanced life support in resuscitation of a woman who is pregnant. Guidance relating to PMCS needs to be reviewed and strengthened.

Early identification of critical illness

In most of the women whose care was reviewed for this chapter, death was not an abrupt event but occurred in the context of critical illness. The early identification of serious maternal morbidity has been a recurrent focus of previous critical care chapters (Knight et al. 2016).

The majority of pregnant women are young and fit. The robust physiology that adapted to the demands of pregnancy, has further capacity to compensate against the early signs of critical illness. Early warning systems rely on being able to detect a window of deterioration which can be reversed by treatment interventions ahead of catastrophic collapse. In pregnant women this window may be very small.

All of this is well known and yet it continues to catch-out clinicians and the implications for the design of early warning systems specific to pregnancy is not fully recognised.

Obstetric specific early warning scores became widespread in the UK after a top 10 key recommendation made in the CEMACH report published in 2007. While the recommendation was for a national early warning system, progress towards the development of a national evidence-based system has been slow. A recent guideline document, Care of the critically ill woman in childbirth; enhanced maternal care 2018 (Maternal Critical Care/Enhanced Maternity Care Standards Development Working Group 2018) identifies key components for obstetric early warning systems. If these recommendations are adopted it would represent a step towards a national system. Early warning scores for use in pregnancy and around the time of childbirth have fallen behind the systems in place for general medical and surgical patients for whom a national early warning system is widely used and already in its second iteration (Royal College of Physicians 2017). It is not acceptable for there to be inequity between the quality of early warning system in place for general patients and those available to mothers.

Development of a national, evidence-based, early warning scoring system for pregnant and postpartum women should be a priority. **N**

A woman was readmitted with sepsis and retained products after a first trimester miscarriage. She was commenced on antibiotics but deteriorated over the next five days with a tachycardia, tachypnoea, raised temperature and low blood pressure. Her antibiotics were changed, but critical care input was not sought for a further two days and source control was not considered despite evidence of uterine abscess formation. At this stage, although she was clearly unwell, the critical care registrar, following a discussion with the consultant, did not feel a transfer to ITU was warranted. The severity of her illness was underestimated at all stages. She collapsed the following day when a point of care echocardiogram suggested a pulmonary embolism. However, despite emergency cardiopulmonary bypass and thrombolysis she could not be resuscitated. Thromboprophylaxis had not been considered at any point during her admission.

The decision not to admit a woman to critical care should only be made after careful consideration by a senior clinician. When admission is not thought to be necessary, it is vital that a 'safety net' is put in place. This would usually include a scheduled plan for reassessment and clear instructions about who to contact if the woman's condition deteriorates. Critical care outreach nurses may be part of this review process. The guideline 'Care of the critically ill woman in childbirth 2018' (Maternal Critical Care/Enhanced Maternity Care Standards Development Working Group 2018) defines a new standard of care 'Enhanced maternal care' which lies between normal midwifery care and admission to a dedicated critical care unit. This care will often require collaborative working between midwives and other healthcare professionals with skills and knowledge of critical illness.

Pregnant or recently pregnant women should have access at all times to a healthcare professional who has enhanced maternal care competencies.

The route of escalation to critical care services should be clearly defined, and include multidisciplinary discussion.

Critical care outreach or an equivalent service should be available to ill women, and provide support and education to healthcare professionals delivering enhanced maternal care.

Care of the critically ill woman in childbirth; enhanced maternal care 2018 (Maternal Critical Care/Enhanced Maternity Care Standards Development Working Group 2018)

General critical care management and specific therapies

The outcome for most women admitted to intensive care during pregnancy or after childbirth is good and provides clear reassurance that modern critical care practice (including care bundles, high-quality nursing care, meticulous organ support and frequent senior medical review) works well for this group of patients. Even for those women who died, there were many examples of high standards in critical care.

A woman developed pre-eclampsia in the third trimester and had an early caesarean birth. In the postnatal period her condition rapidly deteriorated with acute liver failure. She received full critical care support, including consideration of liver transplantation. She survived this episode but deteriorated again and despite a second period of intensive multi-organ support she developed further complications and died.

A woman had a cardiac arrest a few minutes after the birth of her baby by elective caesarean section. She received prompt advanced life support but developed a severe coagulopathy. Full supportive treatment was given for presumed amniotic fluid embolism. Despite the initial success of resuscitation over the next days she developed multi-organ failure which could not be reversed.

In both these examples the care the women received was of a very high standard. The full resources of modern critical care were deployed and it is hard to imagine what more could have been done.

Multi-disciplinary team working

When a pregnant or postpartum woman develops a critical illness, no single specialist has all the skill and knowledge that the woman will need if she is to recover. Effective multidisciplinary team (MDT) working is a pre-requisite of high quality maternal critical care. Labour ward teams engage in multidisciplinary skills drills and specialists in obstetrics and gynaecology will have experience of cancer MDTs but the way specialist doctors come together for clinical decision-making in acute situations is not well studied. In addition, women present with such a range of conditions that the particular speciality teams that need to cooperate may have no previous experience of working together. In several of the situations examined reviewers were left with the impression that smooth team working had not been achieved. A new NICE guideline (National Institute for Health and Care Excellence 2019a) makes recommendations about multi-disciplinary team working for the intrapartum care of women with pre-existing medical conditions.

A multidisciplinary team led by a named healthcare professional should involve the pregnant woman with a medical condition in preparing an individualised plan for intrapartum care. The plan should be:

- **formulated by following the principles of shared decision making outlined in the NICE guideline on patient experience in adult NHS services**
- **reviewed with the woman and her birth companion(s) as early as possible throughout pregnancy and on admission for birth**
- **updated with the woman if her medical condition changes during pregnancy**
- **shared with the woman's GP and teams providing her antenatal and intrapartum care.**

For pregnant women with a medical condition, the multidisciplinary team may include, as appropriate:

a midwife, an obstetrician, an obstetric anaesthetist, an obstetric physician or clinician with expertise in caring for pregnant women with the medical condition, a clinician with expertise in the medical condition, a specialty surgeon, a critical care specialist, a neonatologist, the woman's GP, allied health professionals.

NICE NG121 (National Institute for Health and Care Excellence 2019a))

Rescue thrombolysis and point of care echocardiography

Systemic thrombolysis is recommended in international consensus guidelines for the treatment of pulmonary embolism with haemodynamic instability. However, the decision to thrombolyse a pregnant woman, or a woman who has recently given birth, has to be balanced with the risk of causing an obstetric haemorrhage, and in early pregnancy it assumes that ectopic pregnancy has been excluded. Formulating a differential diagnosis can be particularly challenging in the context of a collapsed or rapidly deteriorating woman.

The gold standard of care should be to use, where possible, emergency focused point-of-care ultrasonography to gain more clinical information, for example, to detect signs of right ventricular strain or even visualise a thrombus, or identify fluid in the peritoneal cavity. While it is still unrealistic to expect this in all clinical settings, the number of clinicians with ultrasound and focused echocardiography skills is rising; an ultrasound investigation of the abdomen, the heart (and possibly the lungs) should always be considered and should be recognised as the gold standard when an urgent decision is required. When considering high risk therapies such as systemic thrombolysis for presumed massive pulmonary embolism there may be no time for definitive investigations but emergency focused point of care ultrasound can be an option. Previous confidential enquiry reports have highlighted that recent childbirth, including caesarean birth, should not be regarded as an absolute contraindication to thrombolysis.

Neither pregnancy, caesarean section birth or the immediate postpartum state are absolute contraindications to thrombolysis. (Knight et al. 2014)

Focused, point-of-care ultrasound investigations can help guide decision making in the management of maternal collapse. A limited cardiac echo study as well as a FAST scan can provide vital clues to differentiate key diagnoses and is the gold standard of care for a woman with severe cardiovascular instability or compromise. **N**

Sepsis - source control

Sepsis is well recognised by critical care physicians who are at the centre of work to update definitions (Singer et al. 2016), formulate clinical guidelines and support awareness campaigns aimed at other medical professionals and the public. The UK Sepsis Trust has produced an in-patient maternal sepsis tool (UK Sepsis Trust 2016) which lists red flag symptoms and signs that, if present, should prompt initiation of the sepsis pathway which includes measurement of lactate, appropriate cultures and early antibiotics. The importance of sepsis source control is also identified. The case of a pregnant woman who died of E. coli sepsis after premature rupture of membranes was used in the successful campaign to change abortion law in the Republic of Ireland. Delay to evacuation of the uterus was identified as a key area of care to be improved (Health Service Executive 2013) and is a reminder that prompt source control, which may have to include termination of pregnancy, induction of labour or caesarean section, is a fundamental part of the sepsis treatment pathway.

Where sepsis is present the source should actively be sought with appropriate imaging and consideration given to whether surgical or radiological-guided drainage is required (Royal College of Obstetricians and Gynaecologists 2012)

Extra-corporeal membrane oxygenation (ECMO)

A woman with a known cardiac condition was admitted with worsening heart failure, and, following a caesarean birth was transferred to critical care. She remained unstable and was referred for ECMO, which improved her condition. Her heart failure was later managed with a biventricular assist device, however she died despite extensive support.

A second woman collapsed with right heart failure immediately postpartum, and although she was managed on critical care, there is no evidence that the possibility of referral for ECMO was ever considered.

ECMO was either considered or used in several women whose care was reviewed for this chapter. The successful use of ECMO in pregnant women with influenza A/H1N1, including when the pregnancy continued and women went on to childbirth, demonstrated that this treatment can be effective in maternal critical care. Clinicians should consider pregnant women who meet referral criteria for ECMO in the same way as other patients and in addition ECMO should also be contemplated as a salvage treatment or a bridge to transplant in advanced resuscitation.

Most UK ECMO centres are not co-located with obstetric services and it is vital that women should continue to receive appropriate maternity care as well as their critical care. Critical care teams and consultants should be aware of the referral pathways for their nearest ECMO centre. Ensuring such pathways exist may be an important part of the programme of the new maternal medicine networks in England, and similar developments in the devolved UK nations and Ireland.

Care and process after a maternal death

Maternal death is an event which devastates families but also has a profound impact on all involved members of the clinical team. Medical and midwifery care should not end at the point of death. Caring for families and taking all possible opportunities to learn from a death are important tasks which should be carefully followed through.

Whenever possible obstetric patients who become brain stem dead or in whom life sustaining treatment becomes inappropriate should have the opportunity to become organ donors especially if that was their known wish and no objection is raised by the Coroner or Procurator Fiscal. As with other patients, critical care doctors working in conjunction with specialist nurses in organ donation should do all they can to facilitate this process. Specialist nurses in organ donation are frequent visitors to the intensive care unit and are always available to help with information, advice and approaching families about this possibility.

A woman in the third trimester of pregnancy collapsed at home with an intracerebral haemorrhage. She arrived at hospital unconscious and a CT scan confirmed a large intra-parenchymal bleed. Neurosurgical intervention was judged to be futile, her baby was delivered by caesarean section and she was ventilated in an intensive care unit. Her conscious level did not improve and her on-going neurological state suggested no realistic hope of recovery. Her family agreed to organ donation after cardiac death and this was successfully achieved.

Post-mortem learning

An obese woman died following an out of hospital cardiac arrest in the postpartum period. She had two antenatal admissions with chest pain and shortness of breath and at her caesarean section the anaesthetist noted frequent multifocal ectopics. She was admitted to critical care in the early postpartum period with sepsis. She received multi-organ support including ventilation and vasopressors. An echocardiogram revealed a dilated left ventricle and global hypokinesia and there was also a documented troponin rise. In the reports produced after her death there was a clear discordance between the views of different specialists about the circumstances and cause of her death and this did not appear to have been investigated or resolved.

When a woman has died, clinicians should do all they can to learn from the death so that care can be improved in the future. In the last chapter on critical care there was a recommendation asking for involvement of critical care doctors in the investigation and reports following a maternal death (Knight et al. 2016). There was little evidence that this recommendation has been adopted. It was particularly disappointing to review cases where different teams appeared to be in dispute over the cause of women's deaths. This represents a failure of multidisciplinary learning. Investigations should focus not just on the clinical management but should specifically address whether multidisciplinary team working was effectively achieved both before and after the death occurred.

When critical care staff have any involvement in a maternal death, it is imperative that they are included in case reviews, root cause analysis and serious incident investigations.

Saving Lives, Improving Mothers' Care 2016 (Knight et al. 2016)

Multidisciplinary team working should not end at the point of death. Disputes and disagreements amongst members of the clinical team should be settled and information from post-mortem examinations and inquests should be considered to ensure that team members have a shared understanding of the lessons to be learned. N

Local investigations and reviews of maternal death should not be confined to a timeline of events and a clinical narrative. The strength or weakness of multidisciplinary team working should merit specific comment. N

Critical care audit and data gathering

The confidential enquiries relate to women who died during and after pregnancy, however to fully understand these deaths it is important to appreciate the stories of women who became critically unwell, received support from intensive care services and survived. The UK is home to extensive clinical databases of obstetric admissions to critical care units. In England, Wales and Northern Ireland this is run by the Intensive Care National Audit and Research Centre (ICNARC) and in Scotland by the Scottish Intensive Care Society Audit Group (SICSAG). It is disappointing that the data relating to obstetric patients have not been collated and reported recently. The last comprehensive report to be produced from the ICNARC case-mix program data 'Female admissions (aged 16-50 years) to adult, general critical care units in England, Wales and Northern Ireland reported as 'currently pregnant' or 'recently pregnant' was published in December 2013 (Intensive Care National Audit and Research Centre 2013). Data from 2015-16 has been shared with the National Maternity and Perinatal Audit for the purposes of their sprint audit and other research projects have been undertaken but it would be beneficial if there were wider access to this resource or a regular programme of publication of its findings.

The NMPA produced a sprint audit entitled 'Maternity Admissions to Intensive Care in England, Wales and Scotland in 2015/16' (Jardine and NMPA Project Team 2019). This project set out to link routinely collected maternity data with the critical care data sets maintained by ICNARC and SICSAG. When data sets are linked together the qual-

ity and authority of findings can be enhanced and new insights emerge. There is also an opportunity to reassess the quality and comprehensiveness of data sets by analysis of those women who are captured in one data set but missed from another.

The key findings of the NMPA sprint audit are broadly consistent with previously published data in this area, they report an admission rate to intensive care units of women in pregnancy, birth and the first six postnatal weeks of 2.24 per 1000 maternities. Admission was more common among women of black ethnic origin, older age or with a BMI of over 35kg/m^2 (Jardine and NMPA Project Team 2019).

The leading causes of admission to critical care were obstetric haemorrhage and infections but there was a very broad range of reasons for admission.

New findings included a higher rate of admission amongst women who have had three or more previous births and a clear appreciation that rates of admission cannot be used to compare hospitals, trusts or boards because of the 'heterogeneity in the organisation of care for critically ill women'.

Amongst other factors the NMPA report recommends that

- National professional bodies should agree definitions of maternal 'high dependency' care (perhaps more appropriately termed as enhanced maternal care) to facilitate data collection.
- All high dependency and intensive care units should submit data to national data sets, such as the ICNARC and SIGSAG data sets, in order to enable the monitoring of maternal admissions.
- Developers of maternity record standards and national data sets should include the facility to collect information about women receiving high dependency and intensive care and the setting in which this care is provided.

Lessons drawn from maternal deaths are more authoritative when they can be set in the context of an understanding of the care of the majority of women who survive following an episode of critical care. In the context of 'critical care without walls' it is important to have systems to collect data on those women who receive critical care outwith critical care units. There is a place for the Intensive Care Society and the Faculty of Intensive Care Medicine to ensure that data concerning pregnant and postpartum women receiving critical care, irrespective of the setting, are reported regularly.

Data gathering on maternal critical illness (including when it is managed in obstetric areas) should be re-examined and strengthened by new definitions in order to capture lessons about good care and near miss events.

(Jardine and NMPA Project Team 2019)

8.5 Conclusions

Research in obstetric critical care is sparse and in order to improve care in the future we should learn the lessons from maternal deaths and understand the clinical course of women who survive. Overall, the critical care received by women whose deaths were reviewed for this chapter was considered to be of a high standard, with more than three quarters of women receiving good critical care, with no improvements identified. Assessors felt that improved critical care for only one woman might have made a difference to her outcome. Nevertheless, there are still a number of lessons to be learned. These include a clear understanding of the importance of peri-mortem caesarean section in managing an obstetric cardiac arrest, on-going efforts for the accurate early detection of developing critical illness, greater scrutiny of multidisciplinary team working and the use of point of care ultrasound to aid the diagnosis in maternal collapse. MBRRACE-UK will be working with the Obstetric Anaesthetists' Association and relevant intensive care organisations to ensure that these lessons, and the lessons highlighted in previous reports, are disseminated to all stakeholders, and thereby acknowledge the women who died by learning from their deaths to improve the care for other women.

Table 8.4: Classification of care received by women who died from accidental causes, UK and Ireland, 2015-17

Classification of care received	Women who died Number (%) N=41
Good care	31 (76)
Improvements to care which would have made no difference to outcome	9 (22)
Improvements in care which may have made a difference to outcome	1 (2)

9. Key indicators for audit to assess implementation of recommendations

Marian Knight

9.1 Background

The reviews of women's care contained within this report have identified 16 new recommendations for care and noted many existing guideline recommendations where implementation could be improved to change or enhance current practice and care for pregnant and postpartum women. In order to assist local units and professional organisations/policy makers this chapter contains key indicators which could be used in audits and surveys to assist with evaluation of implementation of the new recommendations.

9.2 Identification of indicators

In order to identify the indicators, we developed a simplified framework for assessment of the implementation status of recommendations. The framework was developed using the Donabedian model for the assessment of the quality of care and the International Health Partnership and related initiatives (IHP+) framework adopted by the World Health Organisation for monitoring and evaluation of health system performance (Donabedian 2005, World Health Organisation 2010). From the potential indicators identified using the framework, key output and outcome indicators were selected for regular monitoring based on the new recommendations of each topic-specific chapter. The selection was based on simplicity, availability of information at the local level and measurability.

9.3 Anticipated local use

The MBRRACE-UK Independent Advisory Group suggest that individual units should audit compliance with at least one indicator from within each theme. This should be undertaken as a quality improvement activity (The King's Fund and The Health Foundation 2017); following initial audit, units should further investigate the care of women for whom the indicator is not met in order to identify changes needed and implement actions to drive improvement. Re-audit after the actions have been implemented is essential.

For ease, where appropriate, suggested denominator and numerator groups are provided to allow calculation of the appropriate percentages.

9.4 Key audit indicators

National

Guidance produced on maternal medical assessment and screening prior to assisted reproduction, particularly for older women who are at higher risk of co-morbidities such as cardiac disease and cancer.

Review of the RCOG 'Responsibility of Consultant on Call' guidance to ensure that deviation from the usual clinical pathway, with unexpected or unexplained symptoms, triggers consultant review.

Guidance produced about when staging investigations should be conducted in women with breast cancer in pregnancy.

A national community Patient Group Direction established to allow community midwives to prescribe aspirin to women in line with NICE Guidance.

New maternal medicine networks which are being developed in England and similar structures in the devolved nations include pathways of referral for women with multiple and complex problems.

Data gathering on maternal critical illness (including when it is managed in obstetric areas) has been re-examined and strengthened by new definitions and is reported regularly.

Local

Note some indicators concerning women with uncommon medical conditions may be better audited at network rather than hospital level.

Maternal collapse

The percentage of pregnant women who collapse out of hospital for whom a pre-alert is made to ensure senior review at admission and multidisciplinary involvement in diagnosis. *Denominator: total number of pregnant women who collapsed out of hospital cared for in a particular unit in a specified time period. Numerator: number of these women for whom a pre-alert was made.*

The percentage of women who collapse out of hospital who undergo senior review at admission and multidisciplinary involvement in diagnosis. *Denominator: total number of pregnant women who collapsed out of hospital cared for in a particular unit in a specified time period. Numerator: number of these women who underwent senior review at admission and multidisciplinary involvement in diagnosis.*

Cardiovascular disorders

The percentage of women with persistent sinus tachycardia in pregnancy who have been appropriately investigated. *Denominator: total number of women with persistent tachycardia in pregnancy cared for in a particular unit in a specified time period. Numerator: number of these women whose investigations have been appropriately carried out.*

The percentage of women undergoing genetic counselling for an inherited cardiovascular condition who have documentation of whether they need a cardiovascular risk assessment in pregnancy. *Denominator: total number of women of reproductive age undergoing genetic counselling for an inherited cardiovascular condition in a particular unit in a specified time period. Numerator: number of these women with documentation of whether they need a cardiovascular risk assessment in pregnancy.*

The percentage of women undergoing genetic counselling for an inherited cardiovascular condition who have documentation of whether they are carriers of any inherited condition and whether the associated genetic mutation is known or unknown. *Denominator: total number of women of reproductive age undergoing genetic counselling for an inherited cardiovascular condition in a particular unit in a specified time period. Numerator: number of these women with documentation of whether they are carriers of any inherited condition and whether the associated genetic mutation is known or unknown.*

The percentage of women with a family history or genetic confirmation of aortopathy or channelopathy and a positive genotype who are referred for cardiac assessment before pregnancy. *Denominator: total number of women with a family history or genetic confirmation of aortopathy or channelopathy and a positive genotype cared for in a particular unit in a specified time period. Numerator: number of these women referred for cardiac assessment before pregnancy.*

Breast cancer in pregnancy

The percentage of women with a new diagnosis of breast cancer in pregnancy who give birth at term. *Denominator: total number of women with a new diagnosis of breast cancer in pregnancy cared for in a particular unit in a specified time period. Numerator: number of these women who give birth at term.*

The percentage of women with a new diagnosis of breast cancer at 28-36 weeks of pregnancy and judged to need chemotherapy who receive chemotherapy in pregnancy. *Denominator: total number of women with a new diagnosis of breast cancer in pregnancy at 28-36 weeks of pregnancy and judged to need chemotherapy cared for in a particular unit in a specified time period. Numerator: number of these women who receive chemotherapy in pregnancy.*

The percentage of women under investigation for suspected breast cancer given advice on postponement of pregnancy. *Denominator: total number of women of reproductive age under investigation for suspected breast cancer in a particular unit in a specified time period. Numerator: number of these women with documentation of whether they received advice on postponement of pregnancy.*

Hypertensive disorders of pregnancy

The percentage of women with multiple organ dysfunction who have a documented multidisciplinary consultant discussion of the optimal setting for their care at the time of diagnosis and whether transfer to a local or specialist critical care unit is warranted. *Denominator: total number of women with multiple organ dysfunction cared for in a particular unit in a specified time period. Numerator: number of these women with a documented multidisciplinary consultant discussion of the optimal setting for their care at the time of diagnosis and whether transfer to a local or specialist critical care unit is warranted.*

Early pregnancy disorders

The percentage of investigations reviewed and acted on in early pregnancy assessment services. *Denominator: total number of women cared for in a particular unit in a specified time period. Numerator: number of these women whose investigations have been reviewed and appropriately acted on.*

The availability of blood immediately in any facility performing laparoscopic surgery in pregnancy.

The percentage of staff trained to perform measures to control haemorrhage prior to definitive treatment in the event of haemorrhage in women undergoing laparoscopic surgery in early pregnancy. *Denominator: total number of staff undertaking laparoscopic surgery in early pregnancy at a specified time point. Numerator: number of those staff who have completed appropriate training.*

The availability of an escalation protocol for rapid assistance to control haemorrhage in women undergoing laparoscopic surgery in early pregnancy.

Critical care

The availability of a critical care outreach or equivalent service which provides support and education to health-care professionals delivering enhanced maternal care.

The proportion of reviews of the deaths of pregnant or postpartum women who have received critical care which have involved an intensive care specialist. *Denominator: total number of deaths of pregnant or post-partum women during a specified time period. Numerator: number of those women who have had a review of care involving an intensive care specialist.*

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