National Maternity and Perinatal Audit

Maternity Admissions to Intensive Care in England, Wales and Scotland in 2015/16

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Foreword

Admission of a previously healthy woman to intensive care during pregnancy or after birth is a serious event and can have long-term consequences for the woman and her family. In this report, we are able to understand better the number of women who are affected by admission to intensive care. While this number, 1882 women over the course of pregnancy until a year after birth, seems small in comparison with the number of women giving birth each year, each one of these women and their families will never forget this experience.

In this report, we can see for the first time the demographics of these women. Those with a higher BMI, an older age at birth and with more medical conditions are more likely to require admission to intensive care. As our population demographic shifts, the number of women requiring intensive care is likely to increase. We also see that women of black ethnic origin are more likely to require admission to intensive care; we know from the 2018 MBRRACE-UK report that they are also more likely to die. This requires urgent investigation and action.

Looking after unwell women requires a multidisciplinary team who are both experts in the care of critical illness and able to maintain as far as possible the relative normality of pregnancy – meeting and caring for a new baby, feeding appropriately and planning for the future. This sort of care, where it is appropriate, is often best provided in a maternity unit where there is access to monitoring of the baby in pregnancy and support for the baby and feeding after birth, preventing separation of mothers from their babies. This report highlights that this provision of 'high dependency' or 'enhanced' care for the most unwell women is not always available in maternity units. It is only by working together with our anaesthetic , critical care and neonatal colleagues, to enhance provision both for critically unwell women on our maternity units and for those women who are admitted to intensive care, that we can provide the highest standards of care.

Edward Morris FRCOG
Vice President for Clinical Quality, Royal College of Obstetricians and Gynaecologists

Mandy Forrester
Head of Quality and Standards, Royal College of Midwives

The admission of sick pregnant or recently pregnant women to intensive care units is relatively unusual for a number of reasons. Such women are usually young with excellent physiological reserves and therefore tend to return to normal physiology quickly with appropriate resuscitation. The skills of midwives, obstetric anaesthetists and obstetricians are key to resuscitation and undoubtedly play an important role in keeping these women out of intensive care units.

In this report, which for the first time links maternity data with intensive care data, we see that the number of women admitted to intensive care is small, but there is variation due to the provision of maternal high dependency care.

Maternity high dependency units, perhaps more appropriately termed as enhanced maternal care (EMC) units, are currently a diverse collection of under-resourced units offering variable levels of care.[1] These require a standardised definition to be developed collaboratively and a defined service specification to help identify appropriate funding from commissioners.

The recently published *Care of the Critically Ill Woman in Childbirth; Enhanced Maternal Care*,[1] the development of which was led by Dr Audrey Quinn, makes a number of recommendations to improve the care of the sick mother. The most important of these is 'working in teams' to deliver the care the patient needs as effectively and efficiently as possible. Obstetrics, midwifery, obstetric anaesthesia, critical care and critical care outreach should work closely together as a cohesive team to optimise patient care. The guidance also recommends a new set of competencies – 'enhanced maternal care (EMC)' – that go some distance towards equipping healthcare professionals, particularly midwives, with the skills necessary to care for these sick patients. The guidance also covers the care of the sick mother in the general critical care service. Critical care doctors and nurses have much to learn too.

This report highlights that, while linkage to intensive care data provides the opportunity to understand the reasons for admission to intensive care units, there is more work to be done to understand what happens to the majority of critically ill women.

EMC units also need to be part of a standardised case mix programme data set to ensure performance and quality assurance. I commend the National Maternity and Perinatal Audit report for supporting these recommendations.

Dr Gary Masterton
President, Intensive Care Society (ICS)

The starting point when considering care of the critically ill obstetric patient is that the quality of that care should be of the same standard as for the nonpregnant patient. While this may seem self-evident, there are many potential obstacles to attaining this standard, including the expectation of 'normality' for a pregnant woman using maternity services and the fact that midwives are no longer required have a nursing background so their knowledge, experience and skills in caring for sick women cannot be guaranteed. Pregnant women are mostly perceived as being young and fit and thus 'low risk' in the context of health care. This has on occasion, and as demonstrated in successive MBRRACE-UK reports, resulted in evolving critical illness not being recognised and treated in a timely manner. There is growing evidence that the standard adult intensive care environment may not be the optimal one for the obstetric patient and may even pose specific risks. As the authors of this report point out, 'it is not possible to provide co-located care in an adult critical care setting'. Evidence of the long-term psychological consequences of falling critically ill in the peripartum period and particularly when this involves separation of the woman from her baby is growing and well illustrated by some of the quotes included in this report. As critical care has evolved into a standalone specialty separate from anaesthesia, an increasing proportion of intensive care clinicians will be unfamiliar with the physiological changes of pregnancy and presentation of pathological states and this will also have implications for the critically ill pregnant or postnatal woman.

There is no doubt that the need for 'levels of care' above the routine is increasing. The number of women entering pregnancy with comorbidities and at increased risk of complications is increasing every year. Approximately 75% of women who die in childbirth in the UK have coexisting morbidities.[2,3] More than 60% of women receiving maternity care in the UK require anaesthetic input at some point during birth.[4] Arguably it is time to urgently consider the resources necessary for this growing cohort of 'non-normal' women, including the provision of critical care.

This audit provides important data on the current rate of obstetric admissions to adult intensive care, on risk factors for admission and on the pathology prompting the need for admission. It is a good starting point. Where do we go from here?

The audit did not consider women receiving what is defined as level 2 care outside of general adult intensive care settings as the data were not available, and yet 67% of units reported providing such care in their obstetric unit. Further work should look at the type of care offered on the labour ward and at who delivers this care and aim to compare outcomes with those of women transferred to an adult intensive care setting. Recently the competencies required by those looking after critically ill women have been defined.[1] In the current report, the definition given in the introduction seems to suggest the opposite. Clarity and agreement is needed. Above all, care of the critically ill pregnant or recently pregnant woman must be provided in a spirit of cooperation by an appropriately trained and skilled multidisciplinary team, in a location where mother and babies can, whenever possible, be kept together.

Dr Felicity Plaat
President, Obstetric Anaesthetists' Association (OAA)

Executive summary

Introduction

The National Maternity and Perinatal Audit (NMPA) is a national audit of the NHS maternity services across England, Scotland and Wales, commissioned in July 2016 by the Healthcare Quality Improvement Partnership (HQIP) on behalf of NHS England, the Welsh Government and the Health Department of the Scottish Government. The NMPA is led by the Royal College of Obstetricians and Gynaecologists (RCOG) in partnership with the Royal College of Midwives (RCM), the Royal College of Paediatrics and Child Health (RCPCH) and the London School of Hygiene & Tropical Medicine (LSHTM).

The overarching objective of the NMPA is to produce high-quality information about NHS maternity and neonatal services that can be used by providers, commissioners and users of the services to benchmark against national standards and recommendations where these exist, and to identify good practice and areas for improvement in the care of women and babies.

This report focuses on maternal admissions to intensive care in England, Wales and Scotland. The NMPA, and the data it holds, offers a unique opportunity to link maternity data, which contain information about the mother, her pregnancy and her baby, to data from national data sets for intensive care admissions.

The purpose of this report is to describe the feasibility of linking the NMPA's maternity data to intensive care data and to evaluate the suitability of rates of maternal admission to intensive care as an indicator of care quality. It also describes the demographics of women admitted to intensive care and the reasons for admission.

Methods

The NMPA holds data for 696 738 births in NHS maternity services in England, Wales and Scotland between 1 April 2015 and 31 March 2016. Intensive care data for admissions between 1 April 2014 and 31 March 2017 were available from the Intensive Care National Audit & Research Centre (ICNARC) for England and Wales and the Scottish Intensive Care Society Audit Group (SIGSAG) in Scotland. The NMPA's maternity data were linked to intensive care data using identifiers including the NHS number in England and Wales or Community Health Index (CHI) number in Scotland, date of birth, and postcode.

Data were not available for women admitted to higher dependency settings on maternity units ('maternal' or 'obstetric' high dependency units (HDUs)).

The project is estimated to have captured approximately 88% of all admissions to intensive care that occurred between conception and a year after pregnancy for women who had a registrable birth in England, Scotland or Wales between 1 April 2015 and 31 March 2016. Reasons for non-capture include non-inclusion in the NMPA data set (which contains information on an estimated 92% of births) and admission to a specialist intensive care unit, not all of which are captured by ICNARC in England and Wales.

The measures considered in this report were arrived at through consultation with external stake-holders, including a Clinical Reference Group and an advisory group for this intensive care linkage project. The central measure under consideration was admission to intensive care as a quality indicator.

Key findings

It is possible to link routinely collected data from NHS maternity care to those collected by ICNARC and SIGSAG and use this linked data set to gain insight into the characteristics of women admitted to intensive care and the reasons for admission. However, the linked data set does not identify women who received high dependency care within maternity settings.

In the linked data set, the findings were:

- Admission to adult intensive care during and after pregnancy is uncommon, with a rate of:
  - 2.24 per 1000 women in pregnancy, birth and the postnatal period up to 6 weeks
  - 2.75 per 1000 women in pregnancy, birth and the extended postnatal period up to 1 year.
- Admission is more common among women over the age of 35, women of black ethnic origin, and women who have had three or more previous births.
- The most common reasons for admission are obstetric haemorrhage and infection, but there is a broad range of indications.
- The most common infectious cause for admission is pneumonia.
- Most admissions during the postnatal period are for reasons unrelated to pregnancy.

NHS organisations differ in their configuration of care for women who are critically ill during pregnancy, birth or the postnatal period, resulting in variation in criteria for admission to intensive care. The meaning of the term 'high dependency unit' may differ across maternity settings within NHS organisations.

Admission to intensive care as captured in the linked data set is not suitable as an indicator of maternity care quality. Owing to heterogeneity in the organisation of care for critically ill women, equally unwell women may or may not be admitted to intensive care in different NHS organisations.

Admission to intensive care is traumatic for women and their families, is usually associated with severe morbidity, and is associated with high healthcare costs. Therefore, the rate of admission to intensive care continues to warrant local and national monitoring.

There is currently no method in England and Wales of identifying women who received high dependency care within maternity settings from routinely collected national data sets, but this information is collected in Scotland.

Recommendations

1. National professional bodies specialising in maternity and intensive care, including the RCOG, the RCM, the Obstetric Anaesthetists' Association (OAA) and the Intensive Care Society (ICS), should jointly agree definitions of maternal 'high dependency' care to facilitate data collection.
2. 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.
3. 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. Maternity information system suppliers should implement this in their systems. The NMPA endorses the recommendations of the Maternity Critical Care Standards Working Group about the collection of such data.[1]

4 The NMPA, in collaboration with ICNARC and SIGSAG, NHS Digital, ISD Scotland and NHS Wales Informatics Service (NWIS), should undertake further work to understand methods and sources of information for identifying critically unwell women in routinely collected maternity data sets.

5 Maternity service providers should investigate and monitor maternal admissions to high dependency and intensive care units locally and across their regional networks. Admission counts based on routinely collected data could be supplemented with case reviews to improve insight into who gets admitted and why.

6 The NHS should monitor the overall national maternal high dependency and intensive care admission rate using routinely collected linked data sets, where possible supplemented by insight from national reviews as established through the UK Obstetric Surveillance System.

7 NHS maternity service providers, commissioners, policymakers and regulators should not use the rate of maternal intensive care admissions identified through linkage with ICNARC or SIGSAG data as an outcome indicator of maternity care to compare hospitals, trusts or boards.

Conclusions

Admission of a woman to intensive care during pregnancy, birth or the postnatal period is a significant event and is worthy of monitoring on a local and national level. The linkage of maternity data to intensive care data offers the potential to understand in more detail the demographic factors underlying admission to intensive care, and the timing of intensive care admission relative to birth.

However, NHS organisations differ in their configuration of care for women who are critically ill during pregnancy, birth or the postnatal period, resulting in variation in criteria for admission to intensive care. Therefore, admissions to intensive care do not reliably indicate severe maternal morbidity: in different hospitals women with the same clinical condition may be cared for in different settings. Therefore, admission to intensive care is not a suitable outcome indicator of maternity care. Further investigation of methods to identify and monitor the number of women who become critically unwell in pregnancy, birth or the postnatal period is required.

Abbreviations and glossary

Amniotic fluid	Fluid surrounding the baby. A number of maternal and fetal conditions are associated with abnormal amniotic fluid volume.
AMU	Alongside midwifery unit; a maternity unit where midwives have primary responsibility for care during labour in women at low risk of complications and which is located on the same site as an obstetric unit so it has access to the same medical facilities if needed.
APACHE II score	A case mix adjustment system for scoring clinical risk in patients admitted to an intensive care unit.
BMI	Body mass index, defined as the individual's weight in kilograms divided by the square of their height in metres.
Case ascertainment	The proportion of cases identified (e.g. women admitted to intensive care during pregnancy) out of the maximum that could be identified.
Case mix	The demographic characteristics and state of health of the people using a particular health service.
Case Mix Programme (CMP) data set	A data set collected by ICNARC on a voluntary basis about all patients admitted to general intensive care units in England and Wales.
Critical care	Multidisciplinary, specialised care provided to patients who have a serious but treatable medical condition, requiring a higher ratio of staff to patients than is usually provided in a hospital, close observation and/or specialised treatments that replace the function of one or more organs. Care is sometimes described by 'levels', with level 0 representing normal hospital ward-based care, level 1 representing more frequent observations or other concerns, level 2 representing support of a single organ and level 3 representing multi-organ support or mechanical ventilation.
Deterministic linkage	Matching records between databases by comparing one or more fields that uniquely identify an individual (e.g. an individual's study ID) between the records; a link is made if they all agree.
FMU	Freestanding midwifery unit; a maternity unit where midwives have primary responsibility for care during labour in women at low risk of complications and which is not located on the same site as an obstetric unit.
HES	Hospital Episode Statistics (administered by NHS Digital), a data set containing details of admissions to all NHS hospitals in England (as well as outpatient appointments and accident & emergency attendances).
HDU	High dependency unit (see 'Critical care'); a unit that predominantly provides level 2 critical care. The term is sometimes used in maternity settings to denote an area where unwell patients can be provided with some, but not all, features of level 2 critical care.
HQIP	Healthcare Quality Improvement Partnership
ICNARC	Intensive Care National Audit & Research Centre
ICS	Intensive Care Society
ICU/ITU	intensive care unit/intensive therapy unit
Intrapartum	During labour and birth
Index of Multiple Deprivation (IMD)	A within-country measure of socio-economic status.

ISD Scotland	The Information Services Division in NHS Scotland
Levels of critical care	See 'Critical care' and Table 1.
Linkage	The joining of two or more separate data sets to enrich the information on the individuals in the data sets. Data sets can be joined using (pseudo) identifiers and/or a combination of other fields to match the records from the separate data sets.
LSHTM	The London School of Hygiene & Tropical Medicine
MBRRACE-UK	Mothers and Babies: Reducing Risk through Audits and Confidential Enquiries. A collaboration appointed by the Healthcare Quality Improvement Partnership (HQIP) to run the national programme of work conducting surveillance and investigating the causes of maternal deaths, stillbirths and infant deaths.
MIds	Maternity Indicators data set, managed by the NHS Wales Informatics Service (NWIS). This captures a selected subset of data items from the maternity IT systems in Welsh health boards.
Miscarriage	The spontaneous loss of a pregnancy before 24 weeks of gestation.
NHS board/local health board	In Scotland and Wales, NHS services are provided by 14 NHS boards and seven local health boards, respectively, which each include a number of hospitals and community services.
NHS trust	In England, NHS services are provided by NHS trusts (commissioned by clinical commissioning groups).
NMPA	National Maternity and Perinatal Audit.
NPEU	National Perinatal Epidemiology Unit.
NWIS	NHS Wales Informatics Service.
OAA	Obstetric Anaesthetists' Association.
Obstetric haemorrhage	Heavy bleeding from the genital tract before, during, or after birth.
OU	Obstetric unit; a maternity unit where care is provided by a team of midwives and doctors to women at low and at higher risk of complications. All women will be cared for by midwives during pregnancy, birth and after the birth. Midwives have primary responsibility for providing care during and after labour to women at low risk of complications, while obstetricians have primary responsibility for women who are at increased risk of, or who develop complications. Diagnostic and medical treatment services – including obstetric, neonatal and anaesthetic care – are available on site.
PEDW	Patient Episode Database for Wales, a data set that records all inpatient and day-case activity in NHS hospitals in Wales, managed by NWIS.
Perinatal	Related to events around the time of birth; may be used in general or in relation to pregnant women and new mothers, as in perinatal mental health, or to unborn and newborn babies, as in perinatal mortality and in the National Maternity and Perinatal Audit.
Probabilistic linkage	Matching records between databases by comparing multiple fields that may not uniquely identify an individual (e.g. an individual's first and last name). See also 'Linkage'.
RCM	Royal College of Midwives.
RCOG	Royal College of Obstetricians and Gynaecologists.
RCPCH	Royal College of Paediatrics and Child Health.
Registrable birth	In the UK, a 'registrable birth' is a live birth at any gestation, or a stillbirth occurring at or after 24 weeks gestation.
Sensitivity	The likelihood of identifying a true positive from a test, i.e. the proportion of true positives that are identified by the test.
Specificity	The likelihood of identifying a true negative from a test, i.e. the proportion of true negatives that are identified by the test.

SICSAG	Scottish Intensive Care Society Audit Group.
Stillbirth	The birth of a baby without signs of life on or after 24 weeks of gestation.

Introduction

The National Maternity and Perinatal Audit

The National Maternity and Perinatal Audit (NMPA) is a national audit of NHS maternity services across England, Scotland and Wales, commissioned in July 2016 by the Healthcare Quality Improvement Partnership (HQIP) on behalf of NHS England, the Welsh Government and the Health Department of the Scottish Government. The NMPA is led by the Royal College of Obstetricians and Gynaecologists (RCOG) in partnership with the Royal College of Midwives (RCM), the Royal College of Paediatrics and Child Health (RCPCH) and the London School of Hygiene & Tropical Medicine (LSHTM).

The overarching aim of the NMPA is to produce high-quality information about NHS maternity and neonatal services that can be used by providers, commissioners and users of the services to benchmark against national standards and recommendations where these exist, and to identify good practice and areas for improvement in the care of women and babies. The NMPA consists of three separate but related elements:

- an organisational survey of maternity and neonatal care in England, Scotland and Wales providing an overview of care provision and of services and options available to women
- a continuous clinical audit of a number of key measures to identify unexpected variation between service providers or regions
- a programme of periodic 'sprint' audits to evaluate the feasibility of linkage of the NMPA data set to other information sources for specific topics; the linkage of intensive care and maternity data discussed in this report is one of these feasibility studies.

Maternity admissions to intensive care in England, Wales and Scotland

Intensive care admission is usually the result of critical illness and carries a significant associated risk of mortality as well as long-term physical and psychological consequences.[5] It is a rare and challenging event at all times of life, but for a young, previously healthy woman who is pregnant or has a newborn baby it has particular significance.

Previous reports have sought to understand the reasons for admission to intensive care units.[6] The NMPA and the data it holds offer a unique opportunity to link maternity data, which contain information about the mother, her pregnancy and her baby, to intensive care data. This linkage can contribute to gaining a better understanding of the characteristics of women admitted to intensive care and the reasons for admission, and it can also help to evaluate the usability of rates of maternal admission to intensive care as an outcome indicator of maternity care.

What does this report cover?

The primary objectives of this report are to evaluate the feasibility of linking the data collected and used by the NMPA to routinely collected intensive care data sets in order to derive the rate of maternal admission to intensive care settings, and to evaluate the usability of maternal intensive care admission rate as an outcome indicator of maternity care.

The secondary objectives are to describe as far as possible the prevalence of and reasons for admissions to intensive care in pregnancy, birth and the postnatal period, and to evaluate the availability of information about women who are critically unwell in pregnancy and after birth.

This feasibility study is, to our knowledge, unique in its ability to relate information about pregnancy and birth to that about admissions to critical or intensive care settings. It is important to note that it does not include women admitted to high dependency settings situated within maternity units.

The impact of intensive care admission on women and their families

Pregnancy is expected to be a positive, life-affirming experience.[7] Critical illness associated with pregnancy and childbirth is unexpected and traumatic, and can be overwhelming for women and their families.[8,9] In qualitative studies, women describe fear, a sense of grief and loss, and difficulties adjusting to motherhood. This is due both to separation from their baby, if they are critically unwell, and to the longer physical and mental recovery associated with life-threatening illness.

An intensive care unit is set up to ensure that attention is devoted to the critically unwell patient, with a high ratio of staff to patients. Women admitted to intensive care are almost always separated from their babies, either because their baby is also unwell and requires specialist care in a neonatal unit or because they are too unwell to care for the baby and it is not possible to provide co-located care in an adult critical care setting.[9] Women express feeling loss at missing moments around their baby's birth and first days of life. They also report difficulties with breastfeeding and caring for their babies, and with short- and long-term adjustment after being discharged home.[9]

Families, particularly new fathers, are also affected. They may be separated from both their partner and their new baby, or left to care for a baby alone, with an uncertain prognosis for the mother.[9]

Caring for a new baby is a physical and mental challenge for all parents. Doing this while recovering from serious illness requires additional support and understanding; women report that they found it helpful to be followed up by intensive care staff who understood what they had been through.[8,9]

Respect for the principle of integrated, customised care for women who experience intensive care admission is essential to ensure the best possible experience for these women and their families.

"My husband, mother and sister were quite keen to have counselling – I think they took . . . I think they took the brunt of it obviously because I was knocked out . . . I didn't know . . . I didn't have any anticipation sitting waiting to hear if I was going to come out of it . . . I was none the wiser . . . they thought they were going to lose me . . . and they were sitting holding this brand new little life not knowing."

*Joanne**

"I waited and remember every hour watching the clock and no one came and told me where [the baby] *was. My husband didn't come down. He was told from that side that he wasn't allowed to come back to me . . . but no one communicated that to me . . . that first night was awful because I just kept wondering where is she? . . . is she OK? . . . Who's she with? . . . Is she safe?"*

*Claire**

"I didn't expect to live . . . I just kept thinking I was going to die, I didn't think I would be here today . . . at that point I really didn't think I would survive . . . I just didn't know. I can say that probably until [the baby] *was four months/five months I still thought I was going to drop down dead at home . . . I didn't think I was going to live."*

*Shelley**

* Vignettes supplied by Carolyn Romer.[10] All names have been changed.

Definition of intensive care used in this report

The Intensive Care Society (ICS) defines an intensive care unit (ICU) as:[11]

> 'a specially staffed and equipped, separate and self-contained area of a hospital dedicated to the management and monitoring of patients with life-threatening conditions. It provides special expertise and the facilities for the support of vital functions and uses the skills of medical, nursing and other personnel experienced in the management of these problems. It encompasses all areas that provide Level 2 (high dependency) and/or Level 3 (intensive care) care.'

Table 1 Definitions of levels of critical care (derived from Intensive Care Society[11])

Level of care	Definition	Examples
Level 0 care	• Requires hospitalisation/normal ward care	• 4-hourly observations
Level 1 care	• Recently discharged from higher level care • In need of additional input/monitoring/critical care outreach	• Continuous insulin infusion • Requiring bolus drugs through central venous catheter
Level 2 care	• Requiring single organ support (unless advanced respiratory support)	• Use of central venous or arterial line to monitor pressures • Acute renal replacement (e.g. dialysis) • Use of single intravenous vasoactive drug to control pressures
Level 3 care	• Requiring support of two or more organs OR • Requiring advanced respiratory support (ventilation)	• Requiring both dialysis and cardiovascular support • Requiring mechanical ventilation • Requiring pressure ventilation through a laryngeal mask or tracheostomy

Such facilities may be called intensive care units (ICUs), intensive therapy units (ITUs), critical care units (CCUs) or high dependency units (HDUs). This does not normally include higher dependency areas within maternity settings ('maternal' or 'obstetric' HDUs).

Throughout this report, this definition of intensive care is used.

Organisation of critical care in pregnancy

The NMPA's organisational survey and the associated report[12] published in 2017 provide information that gives context to clinical measures. In this section, the results from the survey that pertain to organisation of critical care in pregnancy are described, in order to give context to the methods and results that follow. Differences in the configuration of care for critically unwell women in maternity settings, such as the provision or absence of high dependency areas, may impact on thresholds for admission to intensive care settings.

In January 2017, 134 trusts in England, 14 NHS boards in Scotland and seven local health boards in Wales provided on-site intrapartum care. There were a total of 185 obstetric units (OUs), of which 124 were co-located with an alongside midwifery unit (AMU), and there were 96 freestanding midwifery units (FMUs).

177 sites (96%) with an OU reported having a general HDU on site and 173 (94%) reported having an adult ICU. Those sites that did not were either very small rural OUs or very large standalone OUs.

Most OUs – 124 (67%) – reported providing dedicated obstetric high dependency care, defined as level 2 care in the questionnaire. Where sites provided obstetric high dependency care, 98 (79%) reported that they did so in dedicated obstetric high dependency beds (Table 2).

Table 2 Reported number of obstetric high dependency beds on sites with an obstetric unit (OU)

Number of births	Number of obstetric high dependency beds		
	Median	Range	Interquartile range
<2500 births per year	0	0 to 6	0 to 0
2500–3999 births per year	1	0 to 6	0 to 2
4000–5999 births per year	2	0 to 5	0 to 2
≥6000 births per year	3.5	2 to 10	3 to 4.5
All OUs	1	0 to 10	0 to 2

Maternity units may vary in the specific elements of high dependency care that they are able to provide. Few, if any, units will provide within the maternity service the full range of organ support encompassed in the critical care definition of high dependency (level 2) care (Table 1). This can impact on decisions to transfer women out of the maternity setting to intensive care. Therefore, women who might have been able to be cared for in an obstetric high dependency setting in one unit might have required intensive care admission in another.

All sites with an OU reported having consultant anaesthetist cover, and 88% reported having consultant anaesthetist provision exclusively dedicated to maternity care. Reported dedicated consultant anaesthetist presence on site tended to be higher in larger maternity units.

Further information about the provision of services is available in the NMPA's *Organisational Report 2017*[12] and on the NMPA website (www.maternityaudit.org.uk).

Methods

The analysis in this report is based on two linkages:

1 The linkage of births in NHS maternity services in England and Wales between 1 April 2015 and 31 March 2016 to the Intensive Care National Audit & Research Centre (ICNARC) Case Mix Programme (`) for admissions between 1 April 2014 and 31 March 2017*

2 The linkage of births in NHS maternity services in Scotland between 1 April 2015 and 31 March 2016 to the Scottish Intensive Care Society Audit Group (SICSAG) audit data set for admissions between 1 April 2014 and 31 March 2017*

Data from 149 of 155 trusts and boards that provide on-site intrapartum care have been included. Six trusts in England could not be included in the NMPA's clinical data collection for the period 1 April 2015 to 31 March 2016; further details are available in the NMPA's *Clinical Report 2017*.[13]

Data sources

The NMPA brings together available data sources (i.e. those that are already collected either for clinical or hospital administrative purposes) rather than collecting primary data to create a bespoke audit data set. By using existing data sets and linking these together, the aim is to minimise, if not eliminate, the burden on clinical staff of data collection for the sole purpose of the NMPA. For this project, the data sets used were the NMPA data set for births together with intensive care data sets provided by ICNARC and SICSAG.

Organisational data

In January 2017, the NMPA team conducted a survey of NHS maternity and neonatal care in England, Wales and Scotland. The methodology for this survey is described in the NMPA's *Organisational Report 2017*.[12]

Information about births

The NMPA data set contains antenatal and birth information on 683 955 births between 1 April 2015 and 31 March 2016. This represents approximately 92% of all registrable† births in England, Wales and Scotland during the time period, and is derived from data sources routinely collected in the course of antenatal, intrapartum and postnatal care. These data sources are different in each of the three home nations (Figure 1). The construction of the NMPA data set and its ascertainment is described in detail in the NMPA's *Clinical Report 2017*.[13] The scope of the NMPA is limited to registrable births.

The NMPA also holds information on all admissions to NHS hospitals for women who gave birth in the time period. These data are derived from routinely collected data sets for each home nation, used primarily for the purposes of hospital payment and monitoring (Figure 1).

* This was to allow for admissions during pregnancy and up to 1 year postnatal.

† In the UK, a 'registrable birth' is a live birth at any gestation, or a stillbirth occurring at or after 24 weeks gestation.

Maternity data source	Local maternity information systems (MIS)	Maternity Indicators data set (MIds) for Wales	Scottish Morbidity Record 02 (SMR-02), linked to Scottish Birth Record
Hospital admissions data source	Hospital Episode Statistics (HES)	Patient Episode Database for Wales (PEDW)	Scottish Morbidity Record 01 (SMR-01)
Intensive care admissions data source	Intensive Care National Audit & Research Centre (ICNARC) Case Mix Programme (CMP) data set		Scottish Intensive Care Society Audit Group (SICSAG) data set

Figure 1 Formation of linked data sets and sources of data

Information about intensive care admissions: England and Wales

ICNARC routinely collects information on all admissions to adult general ICUs and to some specialist ICUs in England and Wales.

ICNARC's Case Mix Programme (CMP) data set contains information about the type and reason for admission, about the location from which admission occurs, and about observations, diagnoses and procedures that occur within the ICU. Further information is available from the ICNARC website (www.icnarc.org).

Information about intensive care admissions: Scotland

SICSAG routinely collects information on all admissions to general and specialist ICUs and to some HDUs in Scotland. This information is used to derive quality indicators to evaluate ICUs and HDUs in Scotland.

The data set contains information about the source of admission and about observations and procedures that occur within the ICU. Further information is available from the SICSAG website (www.sicsag.scot.nhs.uk).

Linkage methodology: England and Wales

The NMPA provided identifiers (NHS number, date of birth and postcode) for all women in the NMPA's data set who gave birth in England and Wales between 1 April 2014 and 31 March 2016 to ICNARC. ICNARC then looked for matches of these identifiers in their CMP data set and supplied all matching records from 1 July 2013 to 31 March 2017. This date range ensured inclusion of intensive care admissions from conception onwards up to 12 months after the birth.

Linkage methodology: Scotland

ISD Scotland linked identifiers from the Scottish Morbidity Record (SMR-01 and SMR-02) to SICSAG, using identifiers including the Community Health Index (CHI) number, date of birth, name and postcode. All identifiers were held by ISD Scotland and were not shared with the NMPA.

Analysis

Analysis was conducted using *Stata/IC 14* and *Microsoft Excel*.

Definition of cohort

Women were eligible for inclusion in the analysis if they had:

1 a record in the NMPA data set of a registrable birth in England, Scotland or Wales between 1 April 2015 and 31 March 2016

2 a record in the ICNARC or SICSAG data set of admission to an adult intensive care setting* during one or more of:

   a) pregnancy, defined as commencing from the estimated date of conception (derived from the gestation at birth and date of birth)

   b) the day of birth

   c) the postnatal period, from 7 to 42 days after birth

   d) the extended postnatal period, up to 365 days after birth.

The NMPA data set was taken as the primary record for all information about the birth (including date, gestation and mode of birth).

Reasons for admission

Reasons for admission in England and Wales were derived from the primary and secondary reason for admission recorded in ICNARC. If the primary reason for admission given was the intensive care code for 'normal pregnancy', this was considered implausible and replaced with the secondary reason for admission. Reasons for admission were not supplied for births from Scotland.

The APACHE II score was not used to evaluate severity of illness as it is poorly validated in an obstetric population.[14]

* Includes admission to general ICUs and general adult HDUs, and some specialist intensive or high dependency units, but not admission to maternity high dependency settings.

Feasibility of linkage of maternity and intensive care data

Objective	To understand the feasibility and effectiveness of linking the NMPA's maternity data to data about admissions to intensive care settings.
Findings	It is possible to link routinely collected data from NHS maternity care to that collected by ICNARC and SIGSAG and use this linked data set to gain insight into the characteristics of women admitted to intensive care and the reasons for admission. However, the linked data set does not identify women who received high dependency care within maternity settings.
Recommendations	1 National professional bodies specialising in maternity and intensive care, including the RCOG, the RCM, the Obstetric Anaesthetists' Association (OAA) and the Intensive Care Society (ICS), should jointly agree definitions of maternal 'high dependency' care to facilitate data collection. 2 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. 3 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. Maternity information system suppliers should implement this in their systems. The NMPA endorses the recommendations of the Maternity Critical Care Standards Working Group about the collection of such data.[1] 4 The NMPA, in collaboration with ICNARC and SIGSAG, NHS Digital, ISD Scotland and NHS Wales Informatics Service (NWIS), should undertake further work to understand methods and sources of information for identifying critically unwell women in routinely collected maternity data sets.

The first objective of this work was to understand the feasibility of linkage of the maternity data held by the NMPA to the intensive care admissions data held by ICNARC and SICSAG. This section describes the results of this linkage process.

England and Wales: linkage to the ICNARC CMP data set

In England and Wales, linkage was performed by ICNARC using identifier information supplied by the NMPA.

Linked records

Records were linked if the included identifiers matched either on (1) NHS number and date of birth, (2) NHS number only or (3) date of birth and postcode where NHS number was missing or invalid in either data set (linkage ranks 1, 2 and 3 respectively). The numbers of women with each linkage rank included in the study are shown in Table 3.

Table 3 Method of identifying women for linkage in England and Wales

Linkage rank	Number of women linked	NHS number	Date of birth	Postcode
1	1701	Exact	Exact	
2	36	Exact		
3	10	Incomplete[a]	Exact	Exact
	1747 women			

[a] Where the NHS number did not contradict, i.e. was missing or incomplete in one of the NMPA or ICNARC record.

Estimation of ascertainment in England and Wales

Ascertainment is the proportion of true cases that a study picks up. In order to estimate the ascertainment of women admitted to intensive care accurately, a 'gold standard' data set that correctly identifies all women as either admitted to intensive care in the time frame or not would be required. Such a data set was not available for analysis.*

The NMPA data set contains records for approximately 92% of births that occurred in England and Wales between 1 April 2015 and 31 March 2016 (NMPA *Clinical Report 2017*, page 27).[13] The ICNARC data set is estimated to contain records for 96% of all intensive care admissions to general units in the same period. ICNARC does not include all specialist ICUs (such as cardiac or neurosurgical). Reasons for possible missed matches are summarised in Figure 2.

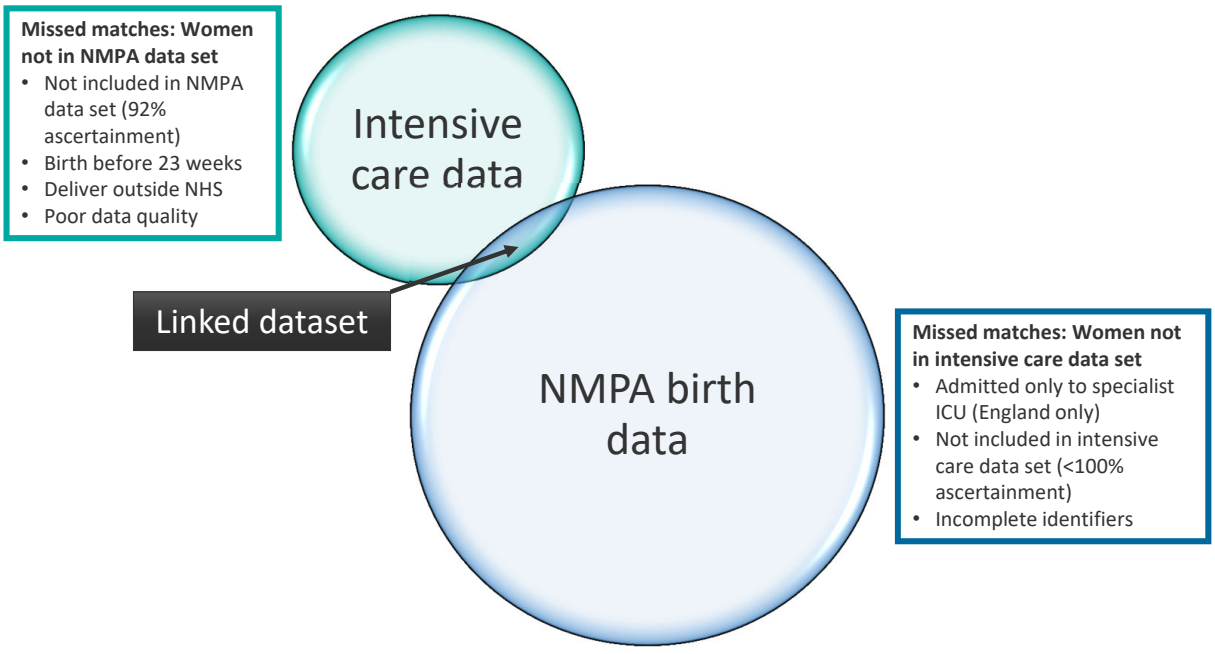

Figure 2 Ascertainment of the linked NMPA–intensive care data set

* Some maternity information systems in England record whether women were admitted to intensive care at the time of giving birth. However, these would not be expected to capture intensive care admissions that occur after the initial discharge from maternity care, and so would not represent a 'gold standard'.

ICNARC includes a variable that indicates whether women were pregnant at the time of admission or within the previous 6 weeks.* However, this does not directly link to the gestation at the time of birth. Therefore it is not possible to ascertain whether these pregnancies did result, or would have resulted, in a registrable birth, and would thus be eligible for inclusion in the NMPA.

It is therefore estimated that the linked data set study can capture approximately 88% of pregnant or postnatal women admitted to general ICUs in England and Wales.

Scotland: linkage to the SICSAG data set

In Scotland, linkage was performed by ISD Scotland using probabilistic and deterministic methods. The team at ISD Scotland has access to all identifiers, including names, for both groups of women and therefore are able to use more extensive methods to ensure linkage between records. This results in an estimated linkage rate of more than 99%.

Estimation of ascertainment in Scotland

The case ascertainment in SMR-02, the Scottish maternity data set, is 99.9%.[13] The case ascertainment for SICSAG is above 95%. Identifiers used are over 99% complete in Scottish data sets. Therefore the overall ascertainment of women admitted to intensive care in the time before, during and after childbirth for Scotland is likely to be in excess of 95%.

Conclusions

Linkage between maternity data sets and intensive care admissions is feasible. The estimated ascertainment for all three nations is high, at more than 85% of all women admitted to intensive care in the appropriate period and more than 90% of all women with records in the maternity data set. In the absence of a 'gold standard' data set, the ascertainment due to linkage cannot be accurately calculated.

Therefore the results that follow represent a large subset of all women admitted to intensive care in pregnancy, birth and the postnatal period in England, Wales and Scotland. Given the high estimated ascertainment, it is unlikely that those included differ significantly from those not included. This sample is therefore suitable for analysis to estimate the rate of admission to intensive care in the population, and to understand reasons for admission.

* Of those records for the admissions of the 1414 women who were admitted to critical care when they were either currently pregnant or up to 6 weeks postnatal, 96.4% were recorded as 'currently' or 'recently' pregnant in their ICNARC record. Of those not recorded as currently or recently pregnant, the majority were postnatal (50.9%) or admitted in early pregnancy before 20 weeks (47%).

Rate of admission to intensive care settings in pregnancy, birth or the postnatal period

Objective	To describe the overall rate of intensive care admission during pregnancy, birth and the postnatal period.
Findings	Admission to adult intensive care during and after pregnancy is uncommon. The rate of admission is: • 2.24 per 1000 women in pregnancy, birth and the postnatal period up to 6 weeks • 2.75 per 1000 women in pregnancy, birth and the extended postnatal period up to 1 year.
Recommendations	5 Maternity service providers should investigate and monitor maternal admissions to high dependency and intensive care units locally and across their regional networks. Admission counts based on routinely collected data could be supplemented with case reviews to improve insight into who gets admitted and why. 6 The NHS should monitor the overall national maternal high dependency and intensive care admission rate using routinely collected linked data sets, where possible supplemented by insight from national reviews as established through the UK Obstetric Surveillance System.

In order to understand the feasibility of using intensive care admission as a quality indicator, it was necessary to estimate the rate of admission to intensive care in pregnancy, birth and the postnatal period up 6 weeks, and in the extended postnatal period up to 1 year.

This is of interest when understanding the admissions that may be attributed to maternity care, and when comparing with rates of other severe outcomes, such as maternal death.3

Overall, 1882 women were recorded as having an admission during pregnancy, birth or the extended postnatal period up to 1 year afterwards, of the 683 955 women in the NMPA data set for Scotland, England and Wales for the period 1 April 2015 to 31 March 2016. These women between them had 2179 admissions to an adult ICU during pregnancy or the year after: 1631 (86.7%) women had one admission, and 251 (13.3%) had more than one admission.

This represents a rate of admission to adult intensive care during and after pregnancy of 2.75 per 1000 women. If this is restricted to admissions during pregnancy, birth and the postnatal period up to 6 weeks, the rate is 2.24 per 1000 women. Rates were similar in Scotland, England and Wales (Table 4).

Table 4 Rate of admission to intensive care by country

Women giving birth between 1 April 2015 and 31 March 2016 with a record in the NMPA data set	Country			
	England	Scotland	Wales	Total
Admitted to intensive care in pregnancy, birth or postnatal period up to 6 weeks (n)	1351	115	63	1529
Number of women admitted per 1000 women	2.25	2.21	2.08	2.24
Admitted to intensive care in pregnancy, birth or postnatal period up to 1 year (*n*)	1672	135	75	1882
Number of women admitted per 1000 women	2.78	2.59	2.48	2.75
Total number of women	601 610	52 104	30 241	683 955

Feasibility of the use of linkage to derive clinical indicators

Objective	To establish the feasibility of using rate of admission to intensive care settings as an indicator of care quality.
Findings	Admission to intensive care as captured in the linked data set is not suitable as an indicator of maternity care quality. Owing to heterogeneity in the organisation of care for critically ill women, equally unwell women may or may not be admitted to intensive care in different NHS organisations. Admission to intensive care is traumatic for women and their families, is usually associated with severe morbidity, and is associated with high healthcare costs. Therefore, the rate of admission to intensive care continues to warrant local and national monitoring.
Recommendations	4 The NMPA, in collaboration with ICNARC and SIGSAG, NHS Digital, ISD Scotland and NHS Wales Informatics Service (NWIS), should undertake further work to understand methods and sources of information for identifying critically unwell women in routinely collected maternity data sets. 7 NHS maternity service providers, commissioners, policymakers and regulators should not use the rate of maternal intensive care admissions identified through linkage with ICNARC or SIGSAG data as an outcome indicator of maternity care to compare hospitals, trusts or boards.

The NMPA is tasked with the development of clinically meaningful information using routinely collected data for the primary purpose of quality improvement.

In a Delphi exercise among a range of professional and lay stakeholders conducted by the National Perinatal Epidemiology Unit (NPEU) in 2013,[15] admission of women to intensive care was identified as a priority indicator for measurement by a future maternity audit. In order to capture adequate information for all admissions occurring during pregnancy, birth and the postnatal period, this required linkage to a source of intensive care admission, described above.

To ensure intensive care admission can be used as an indicator, four criteria need to be met:[16]

1 Validity – that differences in the rates of admission to intensive care are likely to reflect differences in the quality of maternity care

2 Statistical power – that intensive care admission is sufficiently common that it is possible to identify variation outside of an expected range

3 Technical specification – that available information can correctly identify those women who have an intensive care admission, and their associated features and outcomes

4 Fairness – that it is possible to accurately adjust for the case mix of cases treated by each maternity unit.

Variation in rates of admission between settings

The purpose of this section of the report is to evaluate rates of admission to intensive care as an indicator of maternity care quality.

Two proposed indicators were considered:

1. Rates of admission to intensive care during pregnancy, birth and the postnatal period up to 6 weeks, for all women with a registrable birth:*
   a) stratified by level of care required
   b) stratified by time of admission (pregnancy, birth and early postnatal period).
2. Rates of admission to intensive care in the week before, day of and week after birth for obstetric haemorrhage, among all women with a registrable birth.

Technical specification

The technical specification of each indicator is made possible by the linkage of intensive care and maternity data, as discussed in previous sections.

Statistical power

Statistical power is the ability of a test to detect a true difference; that is, the likelihood that a clinical indicator will detect an underlying difference in rates of admission, where one exists.

We calculated the number of births needed to detect a doubling of the rate of ICU admission (Table 5). Power calculations were performed using the standard power calculation formula for detecting a difference in proportions. The difference calculated was for a doubling of the average rate; power calculations for smaller differences would result in the need for a higher number of births.

Table 5 Power calculations for women requiring admission to intensive care, with sensitivity 5% and specificity 80%

Event	Average rate	Number of births required to detect a doubling in admissions	Number of NHS trusts or boards with this number of births per year
Admission to intensive care during pregnancy, birth or up to 6 weeks postnatal	2.24 per 1000 women (0.22%)	6963	34
Admission to intensive care for women with obstetric haemorrhage	0.83 per 1000 women (0.08%)	18 619	None

For the power calculation, we set the power (the chance of finding a significant result if there indeed is a two-fold increase) at 80%, and a two-sided significance level (the chance that the observed or even more extreme results would happen based on chance alone) at 5%. Only crude rates were used, and no adjustment was made for case mix.

* The team also considered all admissions up to 1 year. However, although extended postnatal admissions are of clinical interest (and align with MBRRACE-UK definitions), this was felt to be less likely to be a measure of the quality of the hospital responsible for the *maternity* care, owing to: (1) possibility of the mother having moved to another area after giving birth; (2) possibility of admissions for non-birth conditions; (3) challenge identifying whether admission was associated with current pregnancy or a subsequent one, for those women with an inter-pregnancy interval of less than a year.

The sensitivity and specificity chosen were based on standard power thresholds. Selection of a higher specificity or lower sensitivity (reducing the chance of a false positive or negative) would increase the number of births required to detect a difference.

As it would only be possible to include a small number of trusts or boards for the first of the above measures and none for the second, the most granular level at which admission rates could be reported with enough power across England, Wales and Scotland would be by region.

Validity

Intensive care admission is variable between maternity settings based on the availability of facilities and clinicians, and on fluctuating levels of activity. For example, from a clinical perspective, the woman described in Figure 3 may be cared for in either an ICU or an obstetric high dependency setting, dependent on local circumstances. Therefore, a higher rate of admission to intensive care does not necessarily correlate with poor maternity care. Similarly, low rates may indicate poor detection of women who are very unwell and who may benefit from a higher level of care.

A 43-year-old woman in her fourth pregnancy had an emergency caesarean section for fetal distress and placenta praevia. Following birth, she had an obstetric haemorrhage and developed hypovolaemic shock requiring inotropic medication in the operating theatre. She had a one-day admission to the ICU.

Figure 3 A sample case

The large dispersion in the admission rate to intensive care displayed in the funnel plot in Figure 4 demonstrates that this proposed indicator is more likely to be a measure of variation in service configuration than of variation in women requiring a specific level of care.

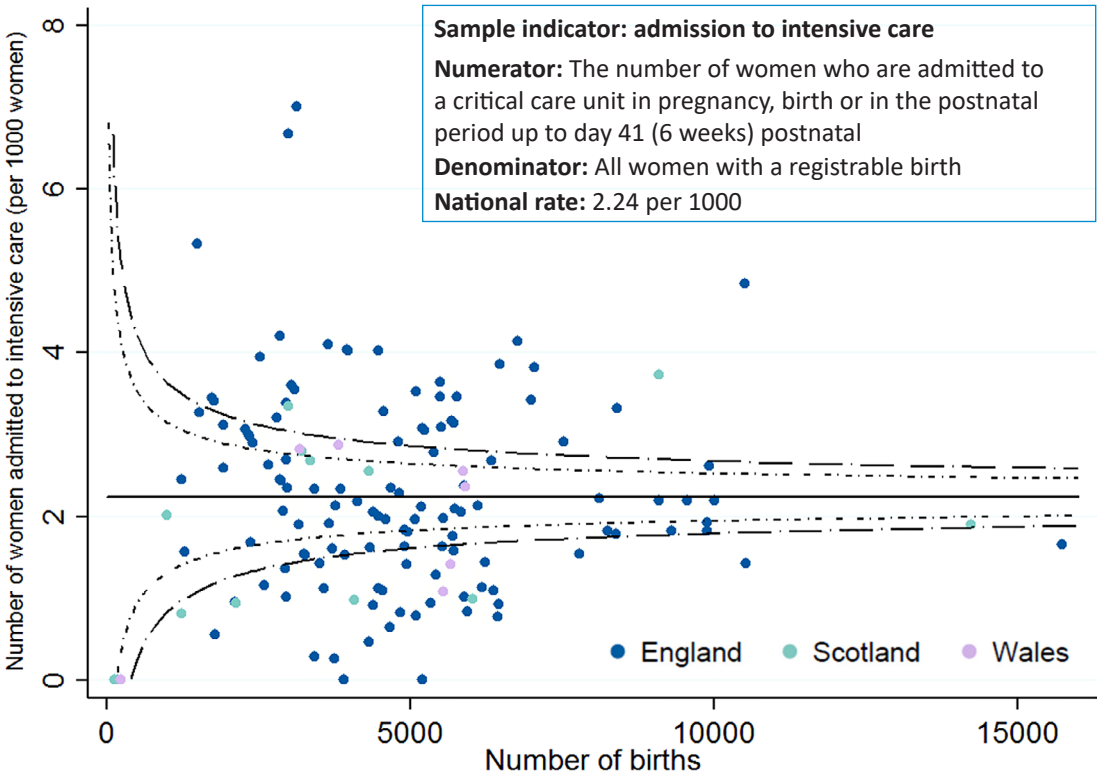

Figure 4 Maternal admission to intensive care between conception and 6 weeks after birth

Fairness

In order to ensure that an indicator is fair, adequate case mix adjustment should be possible. The NMPA uses available information to adjust for differences in maternal characteristics including age, body mass index (BMI), parity and some pre-existing conditions. However, the NMPA does not hold detailed information on complex comorbidities13 which are more common in women admitted to intensive care.

Conclusion: suitability of using routinely collected data to develop a quality indicator for maternal admissions to intensive care

Admission to intensive care as captured in the linked data set is not suitable as an outcome indicator of maternity care.

Admission is uncommon, and few maternity units care for a sufficient number of women giving birth to make a comparison of rates statistically useful. However, even if this comparison were statistically useful, this measure would not be valid. Admission to intensive care does not consistently indicate severe maternal morbidity: in different hospitals, the same clinical problem may be managed in different settings. Some high dependency areas in maternity units can provide elements of level 2 care, while in other units this is provided exclusively in a critical care unit.

This leads to high variation in the rates of admission to intensive care (Figure 4). This does not, however, mean that there is high variation in the number of women experiencing severe morbidity during pregnancy, birth and the postnatal period.

Therefore, intensive care admission is not a suitable indicator of the outcome of maternity care between units. Additional investigation of indicators of variation in severe morbidity in maternity is required, and we recommend that further work be carried out to understand methods of identifying critically unwell women using routinely collected data sets and thus identify whether it is possible to develop an indicator of severe maternal morbidity.

Admission to intensive care is deeply traumatic for women and their families, it is usually associated with severe morbidity, and it is associated with high healthcare costs. Therefore, the rate of admission continues to warrant local and national monitoring.

Demographics and descriptive statistics

Objective	To describe timing and duration of admissions to intensive care settings in pregnancy, birth and the postnatal period, and the demographic features of women admitted.
Findings	Admission was most common on the day of birth. Admission to intensive care was more likely among women of advanced maternal age, of black ethnicity, of BMI over 35 and of parity over 3.
Recommendations	3 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. Maternity information system suppliers should implement this in their systems. The NMPA endorses the recommendations of the Maternity Critical Care Standards Working Group about the collection of such data.[1] 5 Maternity service providers should investigate and monitor maternal admissions to high dependency and intensive care units locally and across their regional networks. Admission counts based on routinely collected data could be supplemented with case reviews to improve insight into who gets admitted and why.

The linked data set provides a unique opportunity to understand the timing of admissions relative to the date of birth, the demographic features of the women admitted and other factors about their pregnancy, as these are not routinely captured in intensive care data sets. This enables understanding of the particular features of the population of women who are admitted to intensive care according to whether they were admitted before, during or after childbirth, which is of clinical interest and of use when planning services.

Timing of admission

The day of birth was the most common time to be admitted, with 800 admissions (36.7%) occurring at that time. A further 400 admissions (18.4%) occurred in the first week from birth. Therefore, the day of birth and the first 6 days after accounted for more than half of all admissions (Table 6).

Table 6 Timing of intensive care admission for women whose pregnancy resulted in a registrable birth

Timing of admission to intensive care	Number of admissions	Number of women who are first admitted at this time
Pregnancy (from estimated date of conception up to day before birth)	372 (17.1%)	335 (17.8%)
Day of birth	800 (36.7%)	730 (38.8%)
Immediate postnatal period (from 1 up to 6 days after birth)	400 (18.4%)	332 (17.6%)
Early postnatal period (from 1 up to 6 weeks after birth)	173 (7.9%)	132 (7.0%)
Extended postnatal period (from 6 weeks up to 1 year after birth)	434 (19.9%)	353 (18.8%)
Total	2179 admissions	1882 women

Duration of admission, discharge and outcomes among women admitted to intensive care

Intensive care admissions were usually relatively short, with 14.8% of admissions resulting in discharge on the same day, 56.6% of admissions being discharged within 2 days, and only 5.9% of admissions lasting longer than 7 days.

Thirty one women in the cohort died. Of these women, 16 were admitted in pregnancy, birth or the immediate postnatal period up to 6 weeks, and the other 15 were admitted after 6 weeks postnatal.

Demographics of women admitted to intensive care

The key demographic factors for women admitted to intensive care were identified and odds ratios calculated.

Admission to intensive care was more likely among women of advanced maternal age, of black ethnicity, of BMI over 35 and of parity of 3 or more (Table 7). This is consistent with findings by MBRRACE-UK.[3]

Table 7 Demographics of women admitted to intensive care

Characteristic	All women	Admitted to ICU	Rate of admission in group	Crude odds ratio	95% confidence interval
Number of women	685 295	1882			
Maternal age (years)					
<16	484	0			
16–19	20 290	71	0.35%	1.23	(1.19, 1.27)
20–24	94 905	270	0.28%	Reference category[a]	
25–29	174 445	382	0.22%	0.77	(0.76, 0.78)
30–34	190 089	497	0.26%	0.92	(0.91, 0.93)
35–39	105 842	360	0.34%	1.20	(1.18, 1.21)
40–44	23 335	109	0.47%	1.64	(1.60, 1.69)
≥45	1 667	16	0.96%	3.40	(2.98, 3.87)
Missing	20 793	42	0.20%		
Maternal BMI (kg/m²)					
<18	8 787	29	0.33%	1.40	(1.30, 1.50)
18–24.9	267 590	631	0.24%	Reference category[a]	
25–29.9	156 290	420	0.27%	1.14	(1.13, 1.15)
30–34.9	72 795	212	0.29%	1.24	(1.22, 1.25)
35–39.9	30 163	127	0.42%	1.79	(1.76, 1.82)
40–44.9	11 003	51	0.46%	1.97	(1.89, 2.05)
45–49.9	3 362	26	0.77%	3.30	(3.05, 3.57)
≥50	1 422	12	0.84%	3.60	(3.04, 4.26)
Missing	135 083	374	0.28%		
Ethnicity					
White	472 359	1273	0.27%	Reference category[a]	
Black	36 393	169	0.46%	1.73	(1.70, 1.75)
Asian	67 473	184	0.27%	1.01	(1.00, 1.02)
Other	24 189	61	0.25%	0.94	(0.90, 0.97)
Unknown	80 916	190	0.23%	0.87	(0.86, 0.88)
IMD[b]					
Least deprived = 1	99 437	263	0.26%	Reference category[a]	
2	84 110	210	0.25%	0.94	(0.93, 0.96)
3	112 190	283	0.25%	0.95	(0.94, 0.97)
4	134 746	363	0.27%	1.02	(1.01, 1.03)
Most deprived = 5	161 838	502	0.31%	1.17	(1.16, 1.19)
Missing	39 529	126	0.32%		
Smoking status at time of birth					
Non-smoker	462 386	1217	0.26%	Reference category[a]	
Smoker	78 283	279	0.36%	1.36	(1.34, 1.37)
Unknown	144 227	386	0.27%		
Parity					
0	236 682	638	0.27%	Reference category[a]	
1	212 611	503	0.24%	0.88	(0.87, 0.88)
2	87 867	242	0.28%	1.02	(1.01, 1.03)
≥3	54 327	230	0.42%	1.57	(1.55, 1.59)
Missing	95 008	269	0.28%		

[a] All odds ratios are quoted in reference to this category. For example, women aged 45 or older at the time of birth are 3.4 times more likely to be admitted to intensive care than women aged 20–24 at the time of birth.

[b] Index of Multiple Deprivation, a within-country measure of socio-economic status.

Associated medical conditions among women admitted to intensive care

The details of selected common associated medical conditions were derived from diagnosis codes available in the hospital record. Further information is provided in the NMPA technical specification.[17] Women with pre-eclampsia, diabetes and placental disorders such as placenta praevia were more likely to be admitted than women without these conditions (Table 8).

Table 8 Recorded comorbidities in women admitted to intensive care

Comorbidity	All women	Admitted to ICU	Rate of admission in group	Crude odds ratio	95% confidence interval
Number of women	685 295	1882			
Pre-eclampsia/eclampsia	11 500	201	1.75%	7.11	(7.03, 7.19)
Hypertension (without proteinuria)	3 347	36	1.08%	4.01	(3.79, 4.24)
Diabetes (gestational or pre-existing)	34 598	188	0.54%	2.09	(2.07, 2.12)
Placental disorder (e.g praevia, accreta)	5 918	149	2.52%	10.10	(9.95, 10.25)
Previous caesarean section	94 575	481	0.51%	2.15	(2.14, 2.16)

Reasons for women to be admitted to intensive care in England and Wales

Objective	To describe the reasons for intensive care admission in England and Wales.
Findings	The most common reasons for admission were obstetric haemorrhage and infection. On the day of birth, obstetric haemorrhage was the most frequent indication. Among infections, the most common reason was pneumonia. Most admissions during the postnatal period are for reasons unrelated to pregnancy.
Recommendations	3 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. Maternity information system suppliers should implement this in their systems. The NMPA endorses the recommendations of the Maternity Critical Care Standards Working Group about the collection of such data.[1] 5 Maternity service providers should investigate and monitor maternal admissions to high dependency and intensive care units locally and across their regional networks. Admission counts based on routinely collected data could be supplemented with case reviews to improve insight into who gets admitted and why. 6 The NHS should monitor the overall national maternal high dependency and intensive care admission rate using routinely collected linked data sets, where possible supplemented by insight from national reviews as established through the UK Obstetric Surveillance System.

Linked intensive and maternity care data provide a unique opportunity to understand the reasons for admission to intensive care in relation to the day of birth, as this information is only recorded in the maternity record.

In this section, we describe the reasons for admission to intensive care in England and Wales. The ICNARC data set contains a primary and secondary reason for admission. This information was not available to the NMPA for admissions in Scotland. We also describe the length of stay by reason for admission, and investigate in more depth the two most common reasons for admission: obstetric haemorrhage and infection. Breakdowns for other categories of admission are available in Appendix 1.

Reasons for admission

The most common primary reason for admission to intensive care was the medical or surgical management of obstetric haemorrhage (Table 9).

For full details of how admissions were categorised, see Appendix 1. Admissions for obstetric haemorrhage were more common on the day of birth (Figure 5). Non-pregnancy causes were more common during the antenatal and extended postnatal periods.

Table 9 Primary diagnosis at admission, by timing of intensive care admission

Timing of admission to intensive care	Number of women and percentage overall, by primary diagnosis at admission					
	Obstetric haemorrhage	Infection	Other direct pregnancy related	Cardiac	Other	Total
Pregnancy (from estimated date of conception up to day before birth)	6 (1.7%)	132 (37.4%)	21 (5.9%)	15 (4.2%)	179 (50.7%)	353
Day of birth	403 (54.8%)	69 (9.4%)	119 (16.2%)	30 (4.1%)	112 (15.2%)	736
Immediate postnatal period (from 1 up to 6 days after birth)	123 (33.0%)	76 (20.4%)	58 (15.5%)	24 (6.4%)	92 (24.7%)	373
Early postnatal period (from 1 up to 6 weeks after birth)	18 (11.0%)	56 (34.4%)	9 (5.5%)	12 (7.4%)	68 (41.7%)	163
Extended postnatal period (from 6 weeks up to 1 year after birth)	15 (3.7%)	48 (11.7%)	9 (2.2%)	36 (8.8%)	302 (73.7%)	410
Total	565 (27.8%)	381 (18.8%)	216 (10.6%)	117 (5.8%)	753 (37.1%)	2032

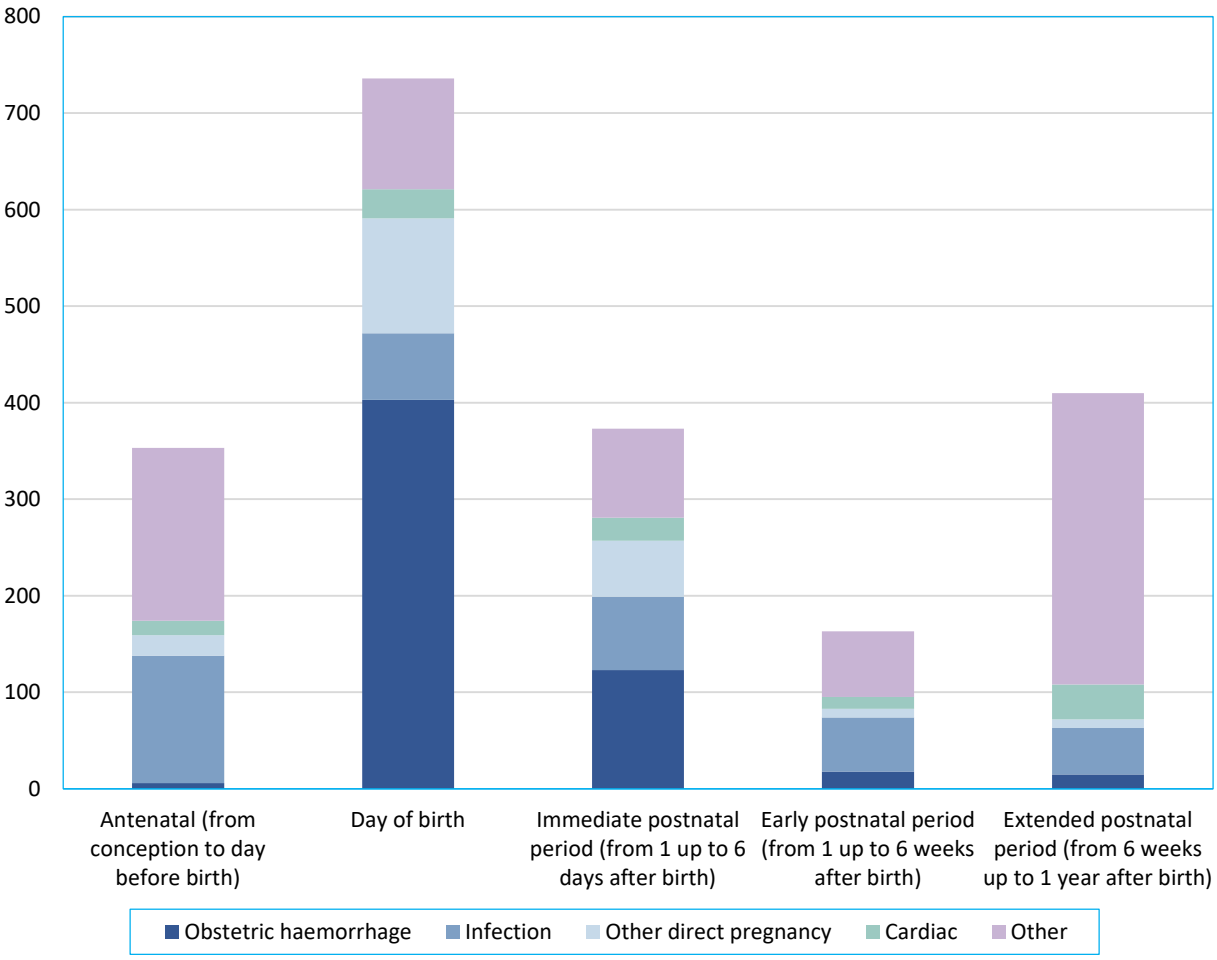

Figure 5 Admissions to intensive care, by cause and timing of admission

Duration of admission and levels of care by indication for admission

Admissions with infection or cardiac cause lasted longer than those with a haemorrhage or other direct pregnancy-related cause (Table 10).

Table 10 Duration of admission by primary recorded reason for admission

Reason for admission	Duration of admission (among women who survived), in days	
	Median	Interquartile range
Obstetric haemorrhage	1	(1, 2)
Infection	2	(1, 3)
Other direct pregnancy related	1	(1, 2)
Cardiac	2	(1, 5)
Other	2	(1, 3)
Overall	1	(1, 3)

The majority of ICU admission days were for care at level 2 (requiring single organ support) or level 3 (requiring multiple organ support or ventilation). The proportion of level 3 care days was higher for admissions for a cardiac cause (45.0%) than for haemorrhage (40.0%) or infection (35.1%). Further details on number of care days are given in Appendix 1.

Admissions for obstetric haemorrhage

The most common indication for admission on the day of and days surrounding birth was obstetric haemorrhage, with 527 admissions occurring in the week before, the day of and the week after birth. The majority of these occurred on the day of birth. 407 of the admissions for obstetric haemorrhage occurred in trusts with reliable data on blood loss,* and had blood loss at time of birth documented (Table 11).

Table 11 Recorded blood loss at birth for women with a peripartum admission to ICU for haemorrhage

Blood loss at birth	Number of women with ICU admission for haemorrhage[a]	Percentage of all haemorrhage admissions[a]
<1000 ml	65	16.0%
1000–1999 ml	48	11.8%
2000–2999 ml	54	13.3%
3000–4999 ml	155	38.1%
≥5000 ml	85	20.9%
Total	407	100%

[a] For admissions in trusts with reliable data on blood loss.

* Further detail on required quality checks is available in the technical specification[17] for the NMPA's *Clinical Report 2017*.[13]

Admissions among women with blood loss less than 2000 ml

We examined individual records for the 113 women admitted to an intensive care setting with a primary diagnosis of haemorrhage but a recorded blood loss at birth of less than 2000 ml, where the birth occurred in trusts with reliable data on blood loss. Of these women, 71 (62.8%) were admitted on the day of birth and 38 (33.6%) in the week following birth. Table 12 explores additional indications for admission in those women admitted on the day of birth.

Table 12 Recorded secondary reasons for admission in women with a recorded blood loss of less than 2000 ml at birth, who were admitted to intensive care on the day of birth with a primary diagnosis of haemorrhage

Reason for admission in addition to blood loss	Number of women (%)
Cardiovascular shock	10 (14%)
Hysterectomy[a]	13 (18%)
Pre-eclampsia/HELLP	6 (8%)
Cardiac	5 (7%)
Other recorded[b]	7 (10%)
None recorded	30 (42%)
Total	71

[a] Hysterectomy recorded in any of intensive care (ICNARC), maternity or admissions (HES in England, PEDW in Wales) data sets.

[b] Includes infection and sepsis: frequency count for these was less than 5 and would be suppressed.

Insufficient information was available to establish why more than two-fifths (42%) of those women with a recorded indication of haemorrhage and a blood loss of less than 2000 ml were admitted to intensive care, illustrating the limitations of routinely collected data sets.

Admissions for infection

The second most common reason for admission was infection, with 381 admissions to intensive care with a primary diagnosis of infection in England and Wales. The most common infection overall was pneumonia (Figure 6). Pneumonia was the most common reason for admission in the antenatal, immediate postnatal and extended postnatal periods (Table 13).

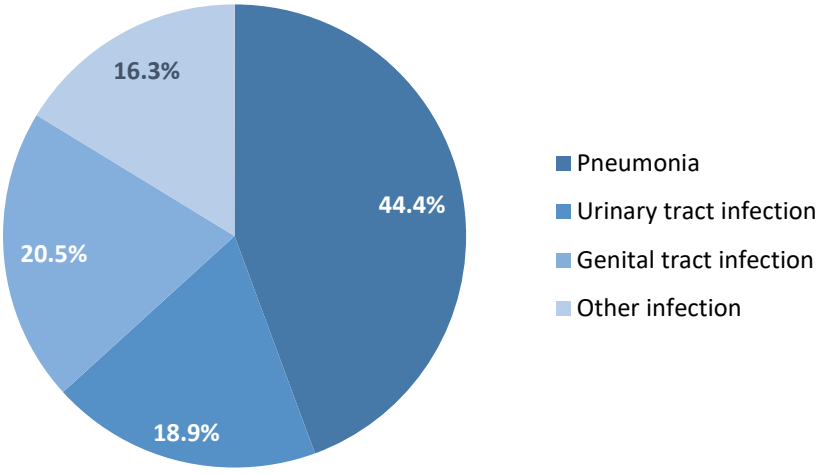

Figure 6 Infection admissions by type of infection, pregnancy to 1 year postnatal

Table 13 Admissions with a primary diagnosis of infection by timing of intensive care admission and by type of infection

Timing of admission	Type of infection				Total by timing of admission
	Pneumonia	Urinary tract infection	Genital tract infection	Other infection	
Pregnancy (from estimated date of conception up to day before birth)	72 (54.5%)	48 (36.4%)	2 (1.5%)	10 (7.6%)	132
Day of birth	26 (37.7%)	8 (11.6%)	26 (37.7%)	9 (13.0%)	69
Immediate postnatal period (from 1 up to 6 days after birth)	37 (48.7%)	5 (6.6%)	20 (26.3%)	14 (18.4%)	76
Early postnatal period (from 1 up to 6 weeks after birth)	12 (21.4%)	4 (7.1%)	27 (48.2%)	13 (23.2%)	56
Extended postnatal period (from 6 weeks up to 1 year after birth)	22 (45.8%)	7 (14.6%)	3 (6.3%)	16 (33.3%)	48
Total by type of infection	169 (44.4%)	72 (18.9%)	78 (20.5%)	62 (16.3%)	381

Women admitted due to pneumonia stayed longer and required a higher level of care than those admitted for other types of infection (Table 14). Admissions for pneumonia accounted for more ICU care days than all other infections combined (Rigure 7).

Table 14 Length of stay and level of care required for women with a primary diagnosis of infection, by type of infection

Type of infection	Length of stay (days)		Levels of care (days)			Total number of care days[a]	Proportion of days with level 3 care
	Median	Interquartile range	Level 0/1	Level 2	Level 3		
Pneumonia	2	(1, 5)	58	471	375	902	41.6%
Genital tract infection	1	(1, 2)	9	62	74	184	40.2%
Urinary tract infection	1	(1, 2)	16	93	98	259	37.8%
Other infection	2	(1, 3)	3	65	15	121	12.4%

[a] This is slightly lower than the sum of the three levels, as for some days two levels of care were recorded.

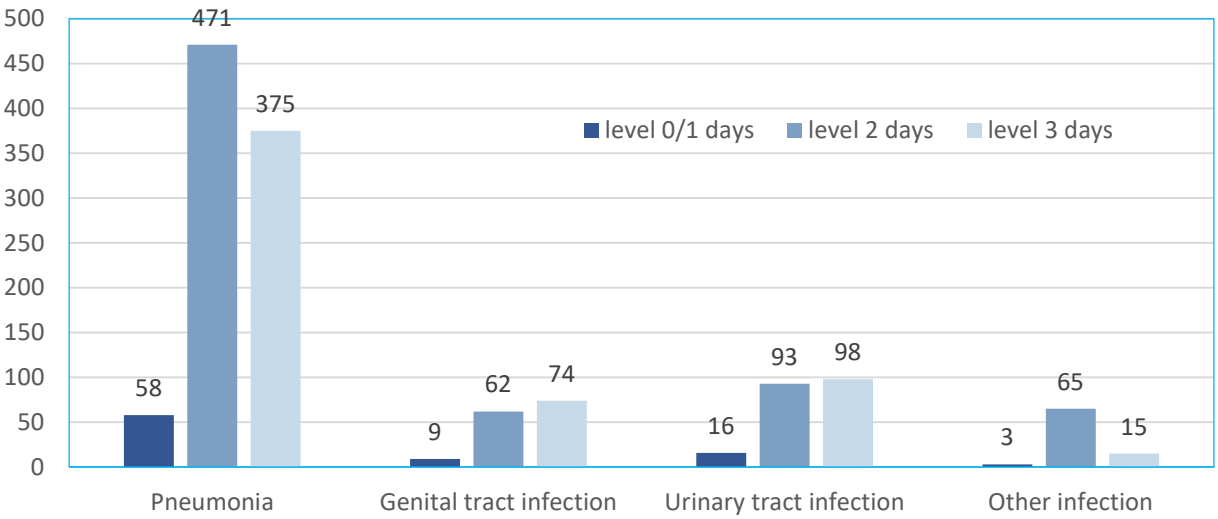

Figure 7 Number of days in intensive care by level of care and type of infection

Discussion

This is the first time that maternity care data have been directly linked with intensive care admission data. This linked data set provides information about the rates of intensive care admission during pregnancy, birth and the postnatal period of women with different characteristics and offers the opportunity to evaluate the development of an outcome indicator of maternity care.

This feasibility study shows that linkage between maternity and intensive care data sets can provide insight into the demographics of women admitted to intensive care settings, the reasons for admission and the duration of admission. This adds to previous reports that have focused on admissions in more detail, although those studies have not had the benefit of linked data to compare with the population from which those admissions are drawn.[6] The rate of admission in England, Scotland and Wales in this report is similar to that reported previously in England[6] and in the Netherlands. [18]

However, admission to intensive care does not meet the criteria for use as an outcome indicator of maternity care. It is not a common enough event to be statistically relevant. Moreover, owing to variation in provision of higher dependency care between settings, it is not a valid comparator of severe maternal morbidity.

Limitations

Women given high dependency care in maternity settings

The number of women who receive high dependency care on maternity units is increasing. Such episodes of high dependency care are not currently routinely captured in maternity data sets, ICNARC or Hospital Episode Statistics (HES). This suggests that there are a large number of women experiencing significant morbidity in pregnancy, birth or the postnatal period who will not be captured by the linkage of maternity data to intensive care data. Therefore, we strongly endorse the recommendations of the Royal College of Anaesthetists to improve data capture of women who receive high dependency care on maternity units.[1]

In contrast to England, SICSAG collects information from some maternity HDUs in Scotland.[19] This suggests that the expansion of intensive care data sets in England and Wales to this population is possible.

Women admitted to intensive care in pregnancies that do not result in a registrable birth

Only approximately two-thirds of all recognised pregnancies result in a registrable birth. The proportion of pregnancies resulting in a registrable birth in women admitted to intensive care is unknown. The complications of ectopic pregnancy and miscarriage have been shown in other studies to be important contributors to intensive care admissions in pregnancy.

Availability of information in routinely collected data sets

Routinely collected information does not offer sufficient detail to fully establish whether an admission to intensive care is appropriate. For example, for women admitted with haemorrhage on the day of

birth where the recorded blood loss at birth was less than 2000 ml, only half had a secondary reason for admission recorded. This limits the use of routinely collected data in this setting to derive clinically meaningful findings.

Recommendations

1 National professional bodies specialising in maternity and intensive care, including the RCOG, the RCM, the Obstetric Anaesthetists' Association (OAA) and the Intensive Care Society (ICS), should jointly agree definitions of maternal 'high dependency' care to facilitate data collection.

2 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.

3 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. Maternity information system suppliers should implement this in their systems. The NMPA endorses the recommendations of the Maternity Critical Care Standards Working Group about the collection of such data.[1]

4 The NMPA, in collaboration with ICNARC and SIGSAG, NHS Digital, ISD Scotland and NHS Wales Informatics Service (NWIS), should undertake further work to understand methods and sources of information for identifying critically unwell women in routinely collected maternity data sets.

5 Maternity service providers should investigate and monitor maternal admissions to high dependency and intensive care units locally and across their regional networks. Admission counts based on routinely collected data could be supplemented with case reviews to improve insight into who gets admitted and why.

6 The NHS should monitor the overall national maternal high dependency and intensive care admission rate using routinely collected linked data sets, where possible supplemented by insight from national reviews as established through the UK Obstetric Surveillance System.

7 NHS maternity service providers, commissioners, policymakers and regulators should not use the rate of maternal intensive care admissions identified through linkage with ICNARC or SIGSAG data as an outcome indicator of maternity care to compare hospitals, trusts or boards.

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Appendix 1

Primary reasons for intensive care admissions during pregnancy, birth and the postnatal period up to 1 year and levels of care in England and Wales, for women giving birth between 1 April 2015 and 31 March 2016

Reason for admission	Antenatal admissions (from conception to day before birth)	Admissions on day of birth and in 6 days following birth	Postnatal admissions (1 week to 6 weeks after birth)	Extended postnatal admissions (6 weeks to 1 year after birth)	Total number of admissions	Number of care days	Number of level 3 care days
Obstetric haemorrhage	6	526	18	15	**565**	1308	530
Pneumonia	72	63	12	22	**169**	902	375
Pre-eclampsia, eclampsia or HELLP	7	123	#[a]	#	**135**	350	15
Other[b]	23	56	11	28	**118**	430	118
Cardiac	15	42	11	32	**100**	496	78
Malignancy	9	8	#	69	**89**	375	89
Genital tract infection	#	46	27	#	**78**	235	74
Non-infectious pulmonary disease (including asthma)	30	20	6	22	**78**	282	209
Urinary tract infection	48	13	#	7	**72**	227	98
Other infection	10	23	13	16	**62**	236	15
Diabetes	31	13	0	15	**59**	163	156
Bowel complications (e.g. adhesions, perforation)	12	13	13	18	**56**	222	10
Seizure disorder (non-eclamptic)	11	13	#	13	**39**	145	67
Self harm	#	0	6	30	**38**	101	50
Gastroenterology	6	7	#	19	**36**	162	67
Venous thromboembolism	8	12	8	7	**35**	154	14
Non-seizure neurology	8	7	#	14	**32**	231	26
Anaphylaxis or drug reaction	7	11	#	10	**29**	66	13
Operative injury	#	20	#	#	**29**	73	146
Renal failure	7	8	#	6	**24**	83	10
Non-obstetric haemorrhage	5	7	#	9	**23**	113	2
Endocrine	8	10	0	#	**22**	99	59

Reason for admission	Antenatal admissions (from conception to day before birth)	Admissions on day of birth and in 6 days following birth	Postnatal admissions (1 week to 6 weeks after birth)	Extended postnatal admissions (6 weeks to 1 year after birth)	Total number of admissions	Number of care days	Number of level 3 care days
Acute pancreatitis	#	#	0	15	**20**	207	44
Pulmonary oedema	0	12	#	#	**17**	102	16
Other trauma	#	5	0	11	**17**	95	37
Complications of early pregnancy (including ovarian hyperstimulation syndrome (OHSS) and ectopic pregnancy)	11	0	0	#	**14**	48	0
Coma or encephalopathy	#	5	#	#	**12**	114	13
Stroke	#	#	#	5	**12**	41	3
Acute fatty liver of pregnancy	#	9	0	0	**11**	52	16
Uterine rupture	0	10	#	0	**11**	25	13
Sickle cell crisis	#	#	0	0	**8**	30	28
Hypertensive disease	#	#	0	0	**6**	17	50
Vascular (including dissection)	#	#	#	#	**6**	27	8
Water intoxication	0	#	#	#	**5**	14	52
Amniotic fluid embolism	0	#	#	#	**5**	11	154
Total	353	1109	163	410	**2032**	7236	2655

Key[c]
Obstetric haemorrhage
Direct pregnancy related
Infection
Cardiac
Other

[a] The # symbol represents numbers smaller than 5, which have been suppressed to maintain patient confidentiality.

[b] This category contains all indications with frequency of less than 5 that cannot be grouped, for example liver transplant donor/recipient, as well as all admissions without a valid code for admission type.

[c] These categories are not exhaustive and many of the 'other' conditions may be made more likely or exacerbated by pregnancy.

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