Application of ICD-PM to preterm-related neonatal deaths in South Africa and United Kingdom

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Abstract

Objective

We explore preterm-related neonatal deaths using the WHO Application of the ICD-10 to perinatal deaths: ICD-Perinatal Mortality (ICD-PM) as an informative case study where ICD-PM can improve data utilisation to guide clinical practice and programmatic decision-making.

Design

Retrospective application of ICD-PM

Setting

South Africa, United Kingdom

Population

Perinatal death databases

Methods

Descriptive analysis of neonatal deaths and maternal conditions present

Main outcome measures

Causes of preterm neonatal mortality, associated maternal conditions

Results

We included 98 term and 173 preterm early neonatal deaths from South Africa and 956 term and 3,248 preterm neonatal deaths from the UK. In the South African dataset, the main causes of death were respiratory/cardiovascular disorders [34.7%], low birthweight/prematurity [29.2%] and disorders of cerebral status [25.5%]. Amongst preterm deaths, low birthweight/prematurity (43.9%) and respiratory/cardiovascular disorders (32.4%) were the leading causes. In the UK dataset, the leading causes of death were low birthweight/prematurity (31.6%), congenital abnormalities (27.4%) and deaths of

unspecified cause (26.1%). In the preterm deaths, the leading causes were low birthweight/prematurity (40.9%) and deaths of unspecified cause (29.6%). In South Africa, 61% of preterm deaths were due to the maternal condition of preterm spontaneous labour. In preterm deaths in the UK dataset, no maternal condition was present in 36%, followed by complications of placenta, cord and membranes (23%) and other complications of labour and delivery (22%).

Conclusions

ICD-PM can be used to appraise the maternal and newborn conditions contributing to preterm deaths, and inform practice.

Key words

Perinatal death, preterm deaths, classification, global, ICD

Tweetable abstract: ICD-PM can be used to appraise maternal and newborn contributors to preterm deaths to improve quality of care.

Introduction

WHO defines preterm births (PTB) as live births occurring before 37 completed weeks (259 days) of gestation(1). A 2012 systematic review estimated that 14.9 million PTBs occurred globally in 2010, equating to 11.1% of all live births worldwide(2). More than 60% of PTB were in south Asia and sub-Saharan Africa, where 52% of the global live births occur. Approximately one million liveborn babies die each year from complications of PTB(4), and it is also a major cause of multiple perinatal morbidities, including respiratory distress syndrome, necrotizing enterocolitis, intra-ventricular haemorrhage (IVH) and sepsis(5).

Given the global burden and the risk of adverse outcomes for newborns, preterm birth (and preterm-related deaths), remains a central focus in the post-2015 global agenda. Preterm birth has also been highlighted as a priority area in WHO's vision for improving the quality of care for women and newborns(6). Better utilisation of data from monitoring systems will be needed to inform the development of targeted health policies and programmes to address this burden.

There are several challenges to epidemiological research and developing estimates of the burden of preterm birth and its contribution to perinatal mortality. Of particular note, inaccurate or absent gestational age assessments for large numbers of women can lead to under-recognition that labour is preterm and a newborn is premature. Misclassification of stillbirths and early neonatal deaths can also confound assessments of liveborn preterm rates, and consequently preterm-specific neonatal mortality. Furthermore, it can be difficult to determine whether preterm delivery is a direct cause of a perinatal death (such as a death resulting from idiopathic spontaneous preterm labour), or a consequence of another

condition that causes perinatal mortality (such as an underlying infection, causing both perinatal death and preterm labour).

Building on proposals to categorise perinatal deaths by maternal as well as perinatal conditions(7), and other ongoing work related to perinatal classification systems (8-10), WHO, through a consultative process, has developed the WHO Application of ICD-10 to perinatal deaths: ICD-Perinatal Mortality (ICD-PM)(11, 12). The ICD-PM aims to be a globally applicable in its approach to capturing, reporting and understanding causes of perinatal deaths in all settings. ICD-PM systematically identifies the circumstances of a perinatal death, including: timing of the death (antepartum, intrapartum, neonatal), the underlying perinatal condition causing the death (if present) and the main maternal condition at the time of perinatal death(12). The objective of this analysis was to explore in-depth preterm-related neonatal deaths using ICD-PM in two datasets of perinatal deaths, as an informative case study of a challenging condition where ICD-PM can improve data utilisation to guide clinical practice and programmatic decision-making. This is the third in a series of papers related to the development and application of the ICD-PM (Box 1).

Box 1 Outline of the ICD-PM mini-series

Development of ICD-PM and our pilot testing is described in this mini-series of four articles. Paper 1(11) details the development of the ICD-PM. Paper 2 demonstrates the application of ICD-PM, using two perinatal death databases from South Africa and the UK(13). In paper 3(14), we use pre-term neonatal deaths as an informative case study of a challenging condition where ICD-PM allows better utilisation of data around the causes and contributing factors. Paper 4(15) explores the contributing maternal conditions and benefits of changes to the coding rules in the upcoming ICD-11, such that ICD-PM and ICD-MM would utilise the same maternal codes, which is currently not the case.

Methods

The development of the proposed ICD-PM system and its application to two (South African and United Kingdom) perinatal death datasets has been described(11, 13). In brief, ICD-PM currently classifies perinatal deaths according to timing (antepartum, intrapartum or neonatal) with a main cause of perinatal death and a main maternal condition at the time of perinatal death assigned, and linked to an ICD-10 code, following current coding rules.

For both the perinatal cause of death and the maternal condition at the time of perinatal death, an ICD-10 code is first applied to the recorded clinical data, based on information documented in the perinatal death certificate. That ICD-10 code is then grouped according to two pre-established ICD-PM groupings for the perinate and the mother. The ICD-PM system then organizes the ICD-10 codes for perinatal death into logical groupings (Table 1). Perinatal deaths are designated with a leading A, I, or N for the timing of perinatal death

Table 1: The ICD-PM system: perinatal causes of death, separated by timing of death, and maternal condition at the time of perinatal death

Main perinatal cause of death ICD-PM groups					
ANTEPARTUM DEATH		**INTRAPARTUM DEATH**		**NEONATAL DEATH**	
A1	**Congenital malformations, deformations and chromosomal abnormalities**	**I1**	**Congenital malformations, deformations and chromosomal abnormalities**	**N1**	**Congenital malformations, deformations and chromosomal abnormalities**
A2	**Infection**	**I2**	**Birth trauma**	**N2**	**Disorders related fetal growth**
A3	**Antepartum hypoxia**	**I3**	**Acute intrapartum event**	**N3**	**Birth trauma**
A4	**Other specified antepartum disorder**	**I4**	**Infection**	**N4**	**Complications of intrapartum events**
A5	**Disorders related fetal growth**	**I5**	**Other specified intrapartum disorder**	**N5**	**Convulsions and disorders of cerebral status**
A6	**Antepartum death of unspecified cause**	**I6**	**Disorders related to fetal growth**	**N6**	**Infection**
		I7	**Intrapartum death of unspecified cause**	**N7**	**Respiratory and cardiovascular disorders**
				N8	**Other neonatal conditions**
				N9	Low birth weight and prematurity
				N10	**Miscellaneous**
				N11	**Neonatal death of unspecified cause**

MATERNAL CONDITION	
M1	Complications of placenta, cord and membranes
M2	Maternal complications of pregnancy
M3	Other complications of labour and delivery
M4	Maternal medical and surgical conditions
M5	No maternal condition

(antepartum, intrapartum, neonatal) and organized into groups of causes: A1 – A6, I1 – I7, and N1 – N11 (Table 1).

This approach is repeated for the maternal condition at the time of perinatal death. The maternal condition is that considered by the certifying physician to be the primary condition in the pathway leading to perinatal death. In ICD-PM currently, the ICD-10 coded maternal condition is grouped in to one of five main ICD-PM groups for the maternal condition, designated with a leading M (maternal).

Setting and Participants

The proposed ICD-PM system was applied to two datasets(13)**.** In brief, the first dataset includes 658 perinatal deaths from one province in South Africa for the period October 2013 to January 2014, as part of the South African Perinatal Problems Identification Program (PPIP)(16). In PPIP, following a perinatal death, clinical review is undertaken at the relevant facility and each death assigned a primary obstetric cause of death and (in the case of liveborns who experience an early neonatal death) an early neonatal cause of death. The maternal condition at the time of perinatal death is also recorded for each death.

The gestational age at time of death is documented on the PPIP form, along with the method of gestational age assessment (last menstrual period, symphysis-fundal height, ultrasound, or clinical examination) and whether this assessment was certain or uncertain. Preterm early neonatal deaths in this dataset were defined by a lower limit of a birth weight

of 500g (in the case of an uncertain gestational age) or 24 weeks gestation (where gestation was certain). The early neonatal deaths for which there was no gestational age assessment were included as preterm deaths if they had a birth weight between 500 to ≤2500g. In PIPPP, both singleton and multiple births are captured.

The UK database captured all perinatal deaths (n=9067) in the West Midlands from 1997-2010. Data is captured from death certificates completed by clinicians at time of death. An ICD code is applied to the main condition in the fetus or infant and the main maternal condition affecting the fetus or infant. One important distinction is that PPIP captured early neonatal deaths (deaths if first seven days of life), whereas the UK dataset captured neonatal deaths (deaths in the first 28 days of life). Gestational age in the UK was determined by dating scan in preference to LMP. Preterm gestation was defined by a lower gestational age of 20 weeks with an upper limit of 259 completed days. Both singleton and multiple births were included in the dataset,

The outcome of interest for this analysis is the distribution of causes of death for liveborn preterm infants. WHO defines preterm births as babies born alive before 37 weeks of gestation are completed(1). Thus, for this analysis the population of interest was neonatal deaths only - all stillbirths were excluded from both datasets.

Analysis

We conducted a descriptive analysis of the two aforementioned datasets separately. We applied the ICD-PM perinatal causes of death and the maternal condition classifications (M1-M5) to all newborn deaths overall, and stratified by term and preterm. The neonatal

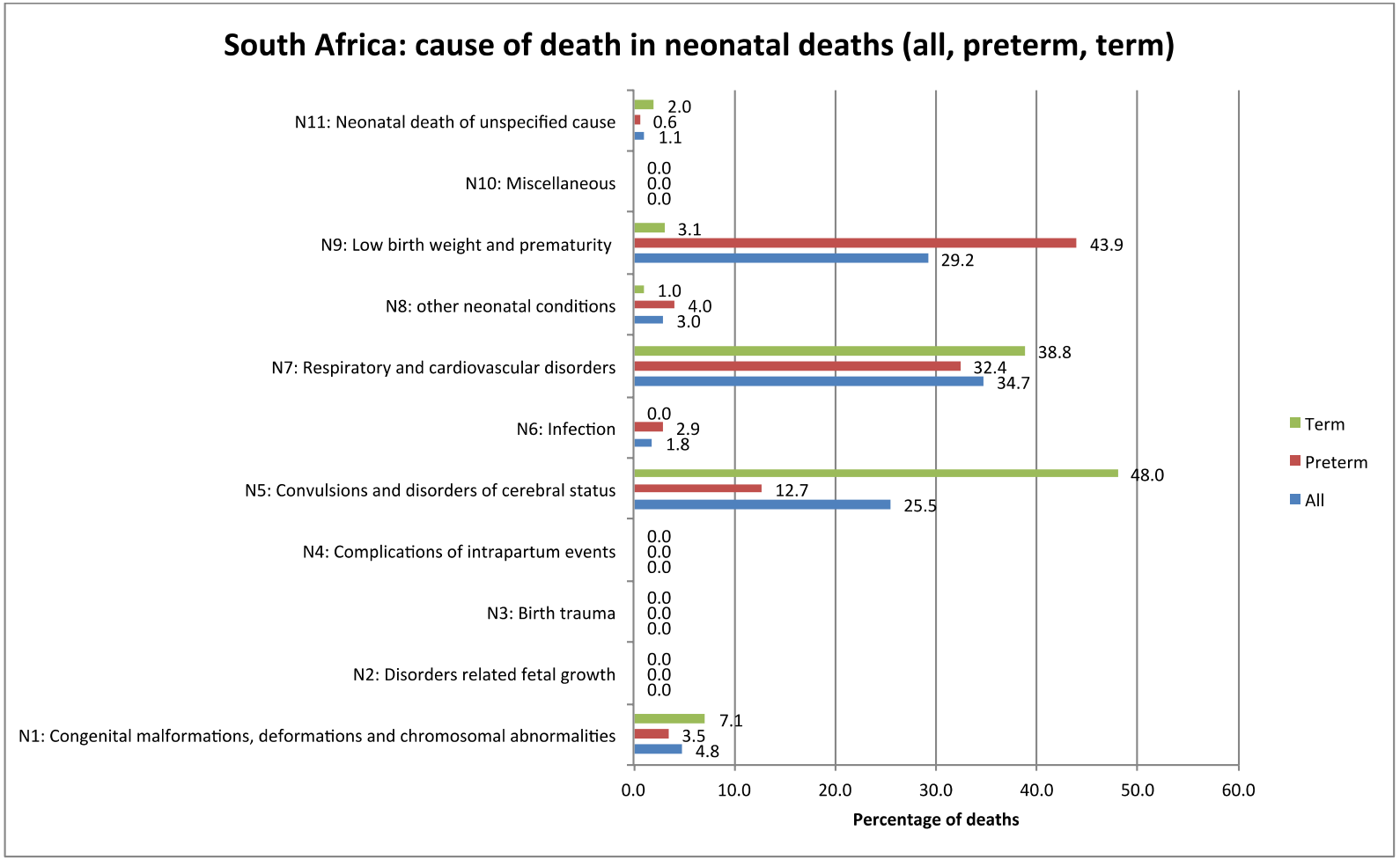
causes of death were tabulated against both sets of maternal condition classifications, reporting the proportion and percentage of neonatal deaths for each cause of death category. Analysis and reporting was focused on maternal conditions present in the leading causes of neonatal death in the two datasets.

Results

In the South African PIPP dataset of 689 perinatal deaths, we excluded stillbirths (418), leaving 98 term early neonatal deaths and 173 preterm early neonatal deaths. In the UK dataset, 4834 stillbirths, and 29 neonatal deaths with missing gestational age were excluded; the study population included 956 term neonatal deaths and 3,248 preterm neonatal deaths. All figures and tables for both datasets, including neonatal causes of death tabulated against maternal conditions separately, are available in Figures S1-S4. Figures 1 and 2 summarises the distribution of causes of death in all neonates, preterm neonates and term neonates for South African and UK data respectively.

In the South African dataset (Figure 1), the top three causes of death accounted for approximately 90% of all early neonatal deaths in both datasets (respiratory and cardiovascular disorders [34.7%], low birthweight/prematurity [29.2%] and convulsions and disorders of cerebral status [25.5%]). Comparatively, amongst the preterm deaths only, low birthweight / prematurity (43.9%) and respiratory and cardiovascular disorders (32.4%) were the leading causes of death. Among term neonatal deaths, 48.0% were due to convulsions and disorders of cerebral status, and 38.8% due to respiratory and cardiovascular disorders.

Figure 1. Cause of neonatal death in all deaths, preterm deaths and term deaths (South Africa)



In the UK dataset (Figure 2), across all neonatal deaths the leading causes of death were low birthweight / prematurity (31.6%), congenital malformations, deformations and chromosomal abnormalities (27.4%) and neonatal deaths of unspecified cause (26.1%). In the preterm newborn deaths, the leading causes of death were low birthweight / prematurity (40.9%) and neonatal death of unspecified cause (29.6%). Nearly half of term newborn deaths were due to congenital malformations, deformations and chromosomal abnormalities (49.8%), and 14.3% due to neonatal death of unspecified cause.

In this analysis, preterm newborn deaths were the population of interest. Therefore, for each dataset we analysed the maternal conditions present in all preterm neonatal deaths, as well as maternal conditions present amongst neonatal deaths due to the two most common causes (Figure 3). In South Africa, 61% of preterm neonatal deaths were due to other complications of labour and delivery, which were all cases of preterm spontaneous labour(Figure 3A). Amongst preterm neonates who died due to low birthweight / prematurity (n=76), 73% were due to other complications of labour and delivery (Figure 3C), which were all cases of preterm spontaneous labour. Of the remainder, 17% were due to maternal medical and surgical conditions, and 9% due to complications of placenta, cord and membranes. Amongst preterm neonates who died due to respiratory and cardiovascular disorders (n=56), 13% were due to preterm premature rupture of the membranes, 14% followed delivery where there was a maternal hypertensive disorder, and 57% were due to other complications of labour and delivery, which were all cases of preterm spontaneous labour (Figure 3B).

Figure 2. Cause of neonatal death in all deaths, preterm deaths and term deaths (UK)

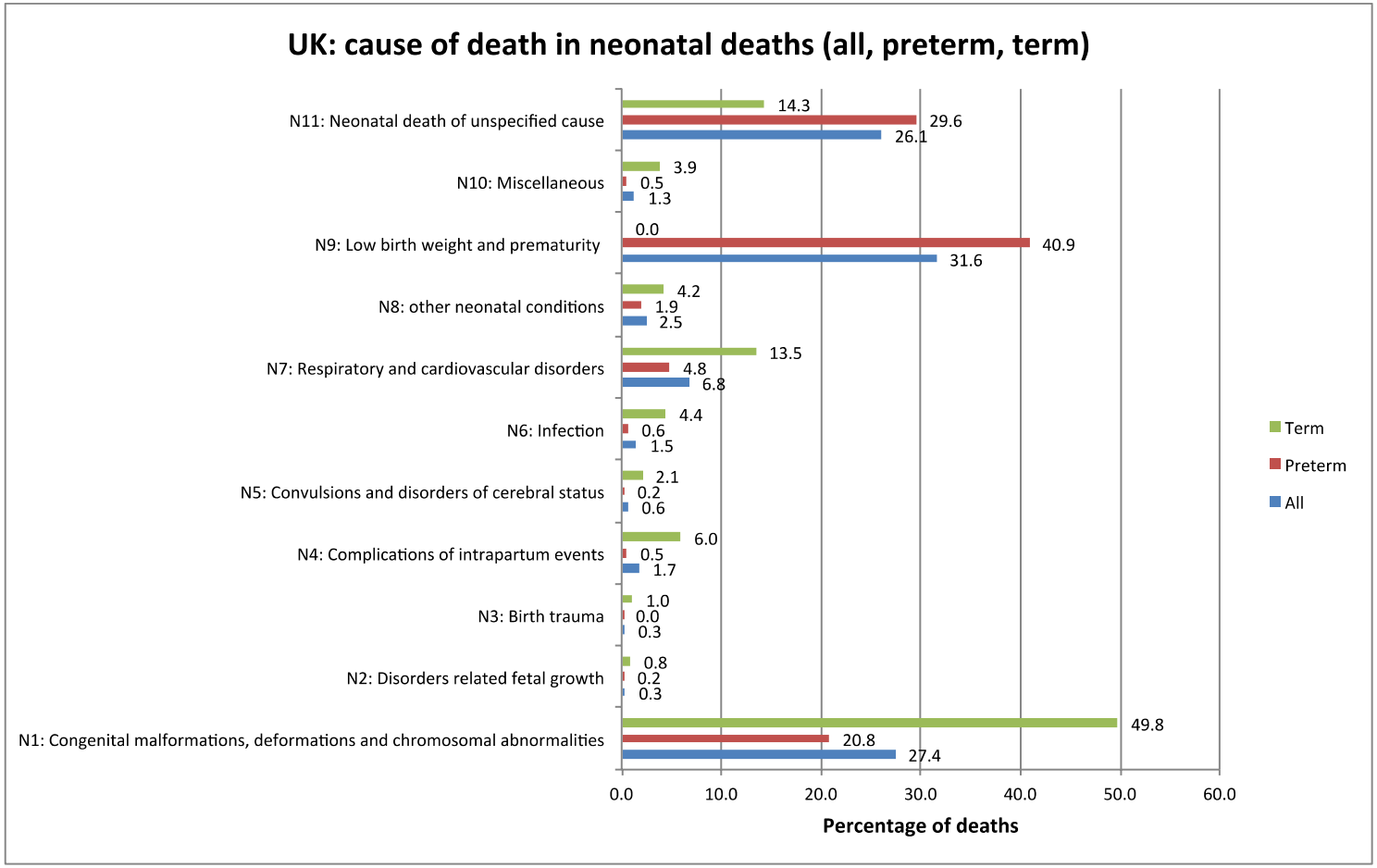


Fig 3. South African data on maternal conditions present in preterm newborn deaths

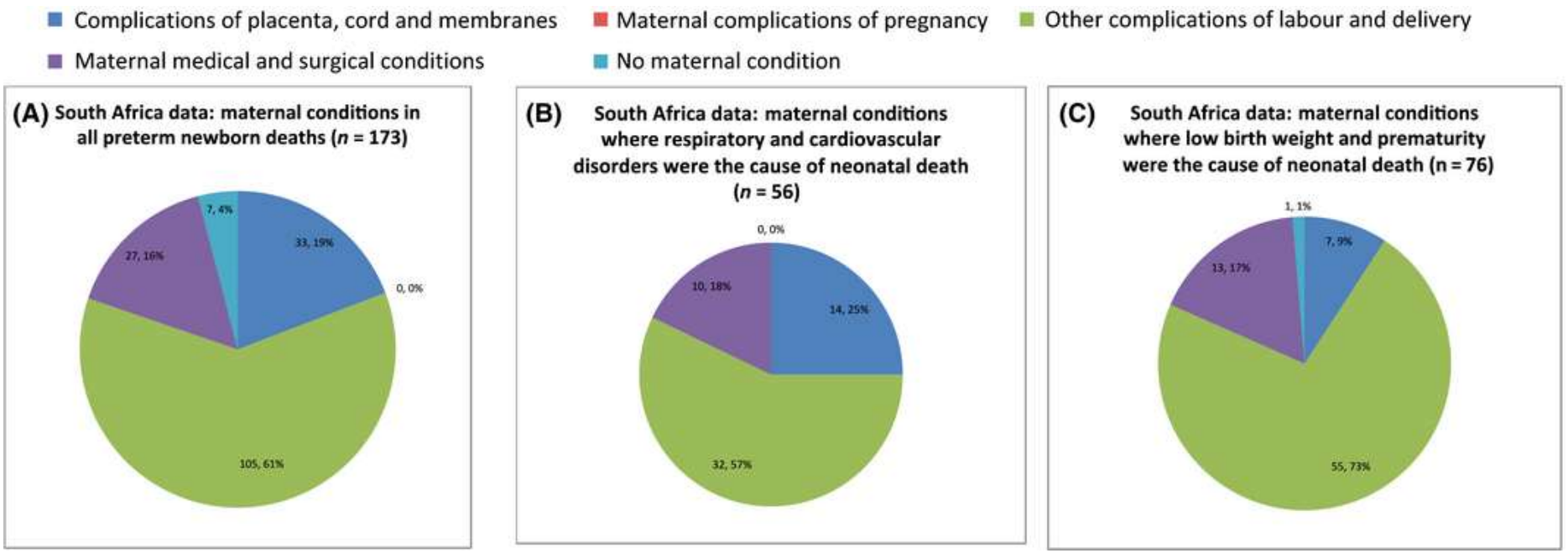
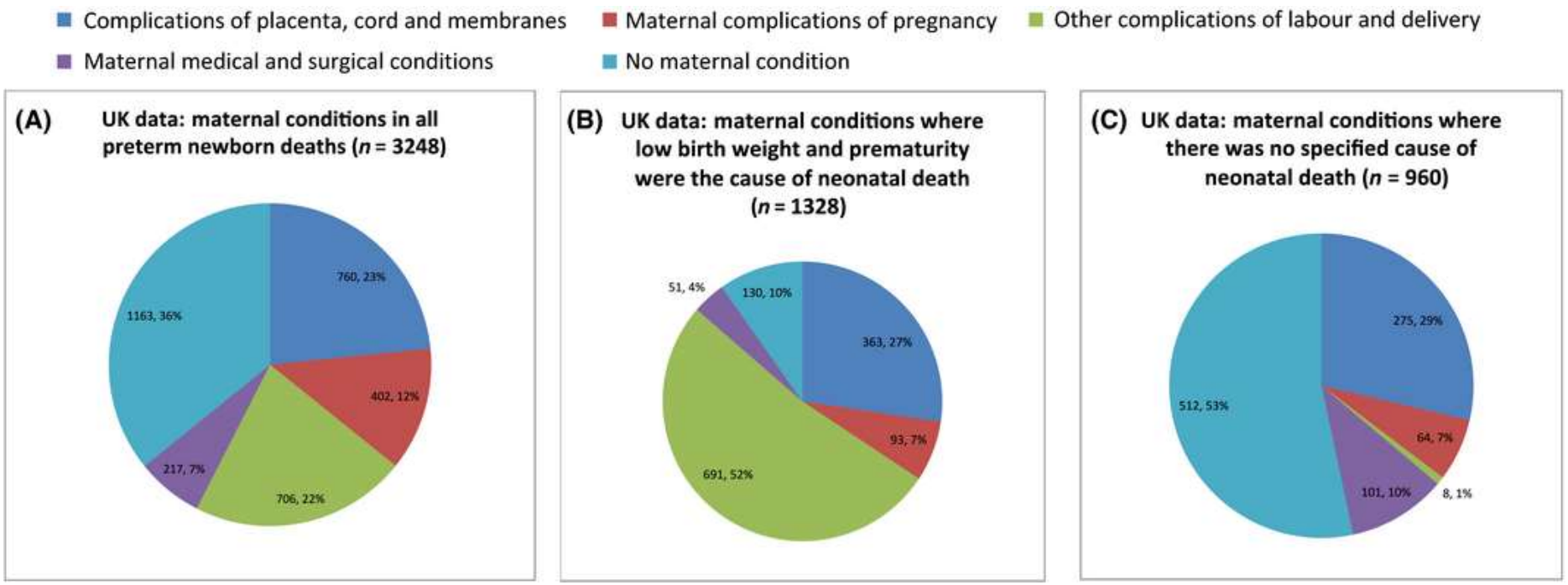


Figure 4A, 4B and 4C. UK data on maternal conditions present in preterm newborn deaths



In the UK dataset, the contributing maternal conditions were more heterogeneous (Figure 4). In all preterm neonatal deaths, no maternal condition was present in 36% of deaths, followed by complications of placenta, cord and membranes (23%) and other complications of labour and delivery (22%). Figure 4B shows the maternal conditions present in preterm neonatal deaths due to low birthweight and prematurity – 52% were due to other complications of labour and delivery (of which 685/691 cases were spontaneous preterm labour), and 27% due to complications of placenta, cord and membranes, which were largely premature rupture of the membranes, and antepartum haemorrhages. The second leading cause of death in all preterm newborns was neonatal death of unspecified cause (Figure 4C). In this group, 53% had no maternal condition, and 29% were due to complications of placenta, cord and membranes, which were premature rupture of the membranes, abruption placentae, and antepartum haemorrhages.

Discussion

Main findings:

In this analysis we used the ICD-PM system for demonstrating the feasibility and utility of understanding contributing maternal factors to neonatal deaths, to guide clinical practice and programme decision-making. We focused on preterm neonatal deaths to show the added value for specific important sub-groups. There were substantive differences in the pattern of causes of death between the two datasets, likely reflective of the underlying differences in the populations and settings.

Strengths and limitations:

Strengths of this analysis include a relatively large sample of preterm neonatal deaths, with representation from both a middle-income and high-income country to provide contrast. Both PPIP and West Midlands datasets are prospectively collected datasets; the West Midlands dataset has been running for several years. However, there are some limitations. Identification of preterm status relies directly on correct identification of gestational age, which may be limited by the issues around access to health care services and available resources, particularly in the South African setting. The quality of any analysis of perinatal death data rests on the quality of data collection and documentation at the time of death, by the attending clinician. Local differences in assigning causes of death and coding, as well as inaccurate data collection may have biased these results, however both systems used trained coders and quality control checks to decrease errors. The relatively large number of women in the UK preterm neonatal deaths without a maternal condition (36%) may reflect lack of identification or documentation of a maternal condition, rather than actual absence of condition. This is also true for the South African data, although the relative number classified as no maternal complication was less. All data collectors in the South African cases used in this analysis have been trained by a single person. Users are also very familiar with the system and the assigning of causes of death and maternal conditions using PPIP, as this is the system now mandated for use by the South African government in every facility where births occur. However, in this retrospective analysis it is not possible to comment on the alignment between the two settings in applying the cause of death and associated ICD code, given differences in setting, resources and disease patterns. The use of a birth weight of 500 g in the case of uncertain gestational age in the South African data potentially excludes preterm neonates with a lower birth weight who may have the potential for survival.

Interpretation:

In the SA dataset, two-thirds of neonatal deaths were preterm, and the two leading causes of death accounted for three-quarters of these deaths. The contribution of maternal conditions overall and within the cause-of-death groups was quite consistent; other complications of labour and delivery (57% - 73%), which were spontaneous preterm labour. In terms of reducing deaths of premature newborns, clinicians in these settings should therefore focus quality improvement efforts on those interventions known to be effective in this clinical situation. That is, improving the diagnosis and management of preterm labour (particularly use of antenatal corticosteroids), and early, effective care of liveborn preterm infants, such as kangaroo mother care(17-19).

In the UK dataset, a third of preterm newborn deaths had no maternal condition identified, and nearly a quarter of the deaths were due to preterm labour and delivery. However, over 50% of deaths due to low birth weight / prematurity occurred following maternal preterm labour, also highlighting the need for improved management of preterm labour and the premature newborns. Where there was no specified newborn cause of death, nearly 30% were due to complications of placenta, cord and membranes, namely prelabour preterm rupture of the membranes, abruptio placentae, and antepartum haemorrhages. It may be that the cause of death was not specified as the clinician was unable to assign a more specific cause than perinatal hypoxia following the maternal event. Knowing the maternal conditions contributing to these deaths however may highlight the need to consider antibiotics in preterm rupture of membranes(20), or early recognition and provision of emergency obstetric care in abruption placentae.

As this is a retrospective analysis of both datasets, further testing including prospective collection of perinatal death data using ICD-PM is warranted to confirm these findings and inform the implementation process. The differences in the cause of death analysis between the two settings may reflect different local approaches to assessing a death, different demographics of included patients, and variable resources used to manage the same condition. The strength of ICD-PM in this analysis is its utilisation in different settings, which potentially allows targeted programmatic intervention**.** ICD-PM derived data could also be used to inform clinical teams in making real-time improvements in clinical care as part of quality improvement processes. As WHO and national health systems move towards ICD-11, there is also the opportunity to align the codes used in ICD-PM to reflect those used in ICD-MM for maternal mortality and morbidity, as explored in this mini-series(15)**.**

Conclusions

Given the global burden and the risk of adverse outcomes for newborns, preterm birth (and preterm-related deaths), remains a central focus in the post-2015 global agenda. ICD-PM can be used to appraise the maternal and newborn conditions contributing to preterm deaths, and inform clinical care. Further evaluation of using ICD-PM to guide quality improvement initiatives is warranted.

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Ethics

The PPIP program has ethical approval from the University of Pretoria. The data was collected with permission from the South African Department of Health. This secondary analysis was approved by the PPIP technical task team. The UK data was collected by the West Midlands Perinatal Institute. Maternal consent was obtained by provision of information about the use of the data and opportunity for opt-out The Institute's confidentiality and consent protocol was approved by the UK Information Commissioner and NHS Connecting for Health.

Disclosure of interests:

JJHM, VJF, JFF, JG, and RCP have all been involved in the development of a perinatal death classification system. There are no other disclosures of interests to declare. The ICMJE disclosure forms are available as online supporting information.

Contribution to authorship:

JPV and EA drafted the manuscript. JG and RCP provided access to the databases and guidance for the pilot testing. JPV and EA undertook the analyses. EA, OT, JG, AF, RCP, JPV, JJHM, VJF, JFF, JN, AQ, DC, MM, LS, AMG reviewed the drafts and approved the final version of the manuscript.

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