The WHO application of ICD-10 to deaths during the perinatal period (ICD-PM): results from pilot database testing in South Africa and United Kingdom

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Abstract

Objective

To apply the WHO Application of ICD-10 to perinatal deaths: ICD-Perinatal Mortality (ICD-PM) to existing perinatal death databases.

Design

Retrospective application of ICD-PM

Setting

South Africa, United Kingdom

Population

Perinatal death databases

Methods

Deaths were grouped according to timing of death and then by the ICD-PM cause of death. The main maternal condition at the time of perinatal death was assigned to each case.

Main outcome measures

Causes of perinatal mortality, associated maternal conditions

Results

In South Africa 344/689 (50%) deaths occurred antepartum, 11% (n=74) intrapartum and 39% (n=271) in the early neonatal period. In the UK 4377/9067 (48.3%) deaths occurred antepartum, with 457 (5%) intrapartum and 4233 (46.7%) in the neonatal period.

Antepartum deaths were due to unspecified causes (59%), chromosomal abnormalities (21%) or problems related to fetal growth (14%). Intrapartum deaths followed acute intrapartum events (69%); neonatal deaths followed consequences of low birth weight / prematurity (31%), chromosomal abnormalities (26%), or unspecified causes in healthy mothers (25%).

Mothers were often healthy; 53%, 38%, and 45% in the antepartum, intrapartum, and neonatal deaths, respectively. Where there was a maternal condition, it was most often maternal medical conditions, and complications of placenta, cord and membranes.

Conclusions

ICD-PM can be a globally applicable perinatal death classification system that emphasises the need for a focus on the mother baby dyad as we move beyond 2015.

Key words

Stillbirth, Perinatal death, classification, global, ICD, monitoring

Tweetable abstract: ICD-PM is a global system that classifies perinatal deaths and links them to maternal conditions.

Introduction

With more than 5 million perinatal deaths occurring each year(1, 2), ending preventable stillbirths and neonatal deaths continues to form a significant part of the international public health agenda beyond 2015(3). The first step in targeting programs that aim to address perinatal mortality is the accurate capture and classification of the causes of all perinatal deaths, using a globally applicable and comparable system.

The WHO Application of ICD-10 to maternal and perinatal mortality was first conceptualised in 2008 "to facilitate the consistent collection, analysis and interpretation of information" on causes of maternal and perinatal deaths(4). The need for an international classification system that incorporates key characteristics such as recognising both the maternal condition and the perinatal condition in all perinatal deaths was called for in a 2010 review(5). Since 2009, 81 different systems have been used globally for classifying perinatal death(6, 7). A 2014 Delphi survey of experts from 21 countries identified 17 key characteristics necessary for a perinatal death classification system; foremost, participants agreed that the overall purpose of such a system is "to produce data that can be used to inform strategies to prevent perinatal deaths"(8). Through a consultative process, we developed the WHO Application of the International Classification of Diseases, version 10 (ICD-10) to perinatal deaths: ICD-Perinatal Mortality (ICD-PM)(9, 10). This is closely modelled on the WHO Application of ICD-10 to deaths during pregnancy, childbirth, and the puerperium: ICD-Maternal Mortality (ICD-MM), (4) and is based upon the 10th revision of the ICD (ICD-10), and follows all rules for mortality coding in ICD-10(11).

ICD-PM has three distinct features. It identifies the timing of perinatal death (antepartum, intrapartum, neonatal); the causes of death linked to existing ICD codes are logically

grouped; and ICD-PM links the maternal condition with the perinatal death(9, 12). Ultimately of these features facilitate straight forward and consistent capture of perinatal deaths that allows one to easily identify where interventions should be targeted to impact the health of the mother baby dyad.

We have applied ICD-PM to two perinatal death databases from South Africa (a middle income country) and the UK (a high income country) in order to 1) demonstrate the application of the ICD-PM and the information generated; 2) to inform the finalization of perinatal cause of death groups under ICD-PM; and 3) to define specific circumstances or rules needed in applying ICD-PM. In addition to this, considering the upcoming 11th revision of ICD, we used this pilot testing as an opportunity to identify potential areas within ICD for further refinement to improve the classification of perinatal deaths.

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(9) 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

Identification of cause of death on a perinatal death certificate using ICD-1

The perinatal cause of death is determined by the certifier who reports the morbid conditions and events leading to the perinatal death. Ultimately, a single underlying cause of perinatal death is assigned. In addition to this, the main maternal condition affecting the fetus or infant is also determined by the certifier and added to the appropriate section on the death certificate.

Following completion of the death certificate after clinical review of the cases, which may occur after the final investigations have occurred, trained coders assign ICD-10 codes to the underlying perinatal cause of death as well as the main maternal condition in a perinatal death. The ICD-10 codes used for coding perinatal mortality cases can be viewed in ICD-10(16).

As per current ICD-10 rules, we assigned an ICD-10 code to each case for the perinatal cause of death and the main maternal disease or condition in the perinatal death to two perinatal death datasets (described below), in order to demonstrate the ICD-PM and the tabulation the main perinatal causes of death and maternal conditions.

Application of the ICD-10 to perinatal deaths (ICD-PM)

Perinatal deaths were classified in a three-step process.

1. Deaths were firstly grouped according to timing; whether the death occurred in the antepartum period (prior to the onset of labour), intrapartum, or in the neonatal period (early up to day seven of post natal life or late day 8-28 of postnatal life).

2. The main cause of perinatal death was assigned, coded, and grouped according to the new ICD-PM groupings

ICD-PM groups the main condition in the fetus or infant into a limited number of cause of death categories under the headings of timing of death (Table 1). There are six groups of antepartum causes of death, designated by a leading “A”; seven groups of intrapartum causes of death, designated by a leading “I”; and 11 groups of neonatal causes of death, designated by a leading “N”. All of the ICD-10 codes that can be assigned to section (a) and (b) on the death certificate are represented in these new groupings. The process of re-grouping codes to construct ICD-PM has been explained in a previous paper(9).

3. The main maternal condition at the time of perinatal death was then assigned. The maternal condition was one that would be considered to be reasonably integrated in to the pathway leading to perinatal death.

The existing ICD-10 groups of maternal conditions in perinatal death have been grouped and reordered (in to groups 1-4, denoted with a leading “M”) to group the complications of placenta, cord and membranes first, followed by the maternal complications of pregnancy, other complications of labour and delivery, and maternal medical and surgical conditions. A fifth group (M5) was added to this; when there was no main maternal condition in the presence of perinatal death identified, we coded it as no condition identified. This is separate to those cases where the condition is unknown; this group of women is those where the clinician was unable to find a maternal pathology contributing to the perinatal death after review of the case (in essence a “healthy mother”). The list of the main maternal

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

Table 2: Maternal conditions in ICD-PM and the main maternal conditions (defined by ICD-10) included in each group

ICD-PM maternal condition group	Main maternal conditions included in group*
M1: Complications of placenta, cord and membranes	1. placenta praevia 2. other forms of placental separation and haemorrhage 3. placental dysfunction, infarction, insufficiency 4. fetal-placental transfusion syndromes 5. prolapsed cord / other compression of umbilical cord 6. chorioamnionitis 7. other complications of membranes
M2: Maternal complications of pregnancy	1. incompetent cervix 2. preterm rupture of membranes 3. oligo / poly hydramnios 4. ectopic pregnancy 5. multiple pregnancy 6. maternal death 7. malpresentation before labour 8. other complications of pregnancy
M3: Other complications of labour and delivery	1. breech delivery and extraction 2. other malpresentation, malposition, and disproportion during labour and delivery 3. forceps delivery /vacuum extraction 4. caesarean delivery 5. precipitate delivery 6. preterm labour and delivery 7. other complications of labour and delivery
M4: Maternal medical and surgical conditions	1. pre-eclampsia / eclampsia 2. gestational hypertension 3. other hypertensive disorders 4. renal and urinary tract diseases 5. infectious and parasitic disease 6. circulatory and respiratory disease 7. nutritional disorders 8. injury 9. surgical procedure 10. other medical procedures 11. maternal diabetes including gestational diabetes 12. maternal anaesthesia and analgesia 13. maternal medication 14. tobacco / alcohol / drugs of addiction 15. nutritional chemical substances 16. environmental chemical substances 17. unspecified maternal condition
M5: No maternal condition	1. no maternal condition identified (healthy mother)

* For a full list, definitions, and the other and unspecified conditions that are listed in each group see ICD-10 current version (http://apps.who.int/classifications/icd10/browse/2015/en) and ICD-10 volume 2 (http://www.who.int/classifications/icd/ICD10Volume2_en_2010.pdf?ua=1)

ICD-10 conditions included in each of the ICD-PM maternal condition groups can be seen in Table 2.

Application of ICD-PM to South African data

We extracted perinatal death data from the South Africa Perinatal Problems Identification Program (PPIP)(17) from one province (>30 hospitals) for the period October 2013 to January 2014, for stillbirths weighing 1000gr or more or those born at 28 weeks or more, and for early neonatal deaths. A single province was used in this pilot testing it was the sole region with data on both maternal and perinatal condition at the time of testing. Following a perinatal death, site based clinical review is undertaken and each death is assigned in PPIP a primary obstetric cause of death and, in the case of an baby born alive, a neonatal cause of death. The deaths in the database used for this analysis represent the first four months of PPIP where all perinatal deaths also have a maternal condition associated with the death assigned in the case review, and so were appropriate for this pilot testing. ICD-PM was applied to each of these deaths. There were two types of perinatal deaths where we had extensive discussion on how to apply ICD to a clinical database.

1. In the case of early neonatal deaths, where the assignment of primary obstetric condition in PPIP was idiopathic preterm labour (and the neonatal cause of death was a consequence of this, e.g. hyaline membrane disease), if the mothers condition was assigned as “healthy”, then this was assumed to be true idiopathic preterm labour and the maternal condition was coded as such.

2. PPIP allows for a primarily maternal condition to be -coded as the obstetric cause of perinatal death (for example in the case of an intrauterine death in a woman with preeclampsia, both the primary obstetric cause of death and the maternal condition are entered as pre-eclampsia). While death in the presence of a maternal condition such as this is not an unexplained fetal death, there are limited ICD-10 codes that can be used to assign to the primary cause of death. After discussion between three authors (EA, OT, DC), the primary perinatal condition in these cases where a significant maternal condition or event was linked as the cause of perinatal death (e.g. eclampsia, abruption), then the ICD code for the primary perinatal cause of death was intrauterine hypoxia, which is ICD-PM is grouped as A3 “antepartum hypoxia”.

Application of ICD-PM to UK data

The UK database consisted of all perinatal deaths in the West Midlands from 1997-2010. Fetal death data were collected from 20 weeks, but subsequently truncated from 24 weeks according to the UK definition of stillbirths. Postnatally, it included deaths up to age 28 days. Data were captured from perinatal death notification forms which listed the primary and secondary causes, from which ICD codes were applied by a regional coding team, with codes for the main condition in the fetus or infant and the main maternal condition affecting fetus or infant. ICD-PM was applied to this database, and all codes were checked to ensure that they complied with ICD-10 coding rules.

Results

We reviewed data on a total of 9756 perinatal deaths from South Africa (n=689) and the UK (n=9067). Table 3 maps the perinatal causes of death against the maternal conditions for all perinatal deaths in the combined data sets from South Africa and UK using the ICD-PM.

Antepartum deaths were mostly classified as fetal deaths of unspecified causes (59%), deformations and chromosomal abnormalities (21%) or as a consequence of problems related to fetal growth (14%). Intrapartum deaths mostly followed an acute intrapartum event (69%), while neonatal deaths followed consequences of low birth weight and prematurity (31%), deformations and chromosomal abnormalities (26%), or were deaths of unspecified causes in mothers without an identified condition (25%).

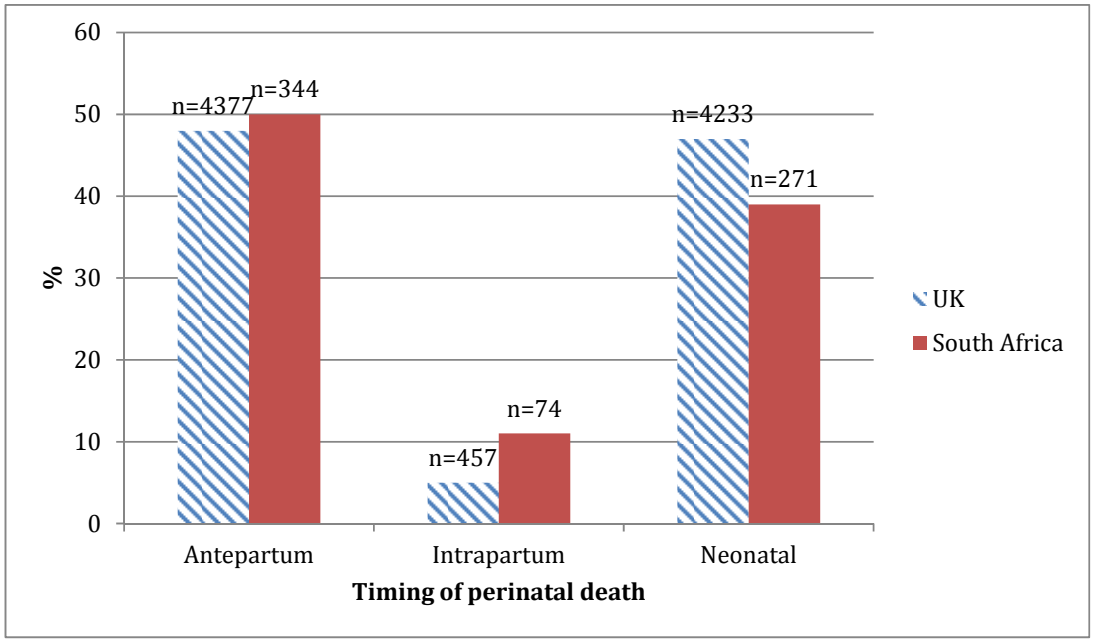
Mothers were often without an identified condition across all three time periods, 53%, 38%, and 45% in the antepartum, intrapartum, and neonatal deaths, respectively. Where there was a maternal condition associated with perinatal death, it was most often maternal conditions that may be unrelated to the present pregnancy and complications of placenta, cord and membranes.

Figure 1 shows the distribution of perinatal deaths across the antepartum, intrapartum, and neonatal periods, which is similar for both countries. The South African database consisted of 689 late fetal (birth weight >1000gr or 28 weeks gestation) and early neonatal deaths (up to 7 days). The majority (n=344, 50%) of the deaths occurred in the antepartum period, with 11% (n=74) occurring intrapartum and the remaining 39% (n=271) occurring in the early neonatal period. The UK data consisted of 9067 perinatal deaths. The majority (n=4377,

Table 3: ICD-PM tabulation using South African and UK data for perinatal cause of death and maternal condition separated by timing of death

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 identified	Other	TOTAL (%)
ANTEPARTUM DEATH							
A1: Congenital malformations, deformations and	118	391	2	38	441	0	**990 (21)**
A2: Infection	2	0	0	1	0	0	**3 (0.1)**
A3: Antepartum hypoxia	72	2	1	95	9	2	**181 (3.8)**
A4: Other specified antepartum disorder	32	5	0	10	61	0	**108 (2.3)**
A5: Disorders related to fetal growth	279	28	3	99	240		**649 (13.7)**
A6: Fetal death of unspecified cause	687	70	14	251	1766	2	**2790 (59.1)**
TOTAL (%)	**1190 (25.2)**	**496 (10.5)**	**20 (0.4)**	**494 (10.5)**	**2517 (53.3)**	**4 (0.1)**	**4721**
INTRAPARTUM DEATH							
I1: Congenital malformations, deformations and	5	1	2	1	6	0	**15 (2.8)**
I2: Birth trauma	2	0	0	0	3	0	**5 (0.9)**
I3: Acute intrapartum event	148	26	19	22	149	1	**365 (68.7)**
I4: Infection	0	0	0	2	0	0	**2 (0.4)**
I5: Other specified intrapartum disorder	1	0	0	0	0	0	**1 (0.2)**
I6: Disorders related to fetal growth	12	1	0	6	5	0	**24 (4.5)**
I7: Intrapartum death of unspecified cause	56	8	1	16	38	0	**119 (22.4)**
TOTAL (%)	**224 (42.2)**	**36 (6.8)**	**22 (4.1)**	**47 (8.8)**	**201 (37.9)**	**1 (0.2)**	**531**
NEONATAL DEATH							
N1: Congenital malformations, deformations and	78	247	3	51	792	1	**1172 (26)**
N2: Disorders related to fetal growth	3	1	2	2	6	0	**14 (0.3)**
N3: Birth trauma	0	0	1	3	7	0	**11 (0.2)**
N4: Complications of intrapartum events	31	1	3	4	35	0	**74 (1.6)**
N5: Convulsions and disorders of cerebral status	16	0	16	9	54	0	**95 (2.1)**
N6: Infection	10	1	4	4	48	0	**67 (1.5)**
N7: Respiratory and cardiovascular disorders	58	24	33	38	225	1	**379 (8.4)**
N8: Other neonatal conditions	18	6	4	11	72	0	**111 (2.5)**
N9: Low birth weight and prematurity	372	94	750	64	137	0	**1417 (31.5)**
N10: Miscellaneous	1	5	0	1	47	1	**55 (1.2)**
N11: Neonatal death of unspecified cause	293	70	16	106	624	0	**1109 (24.6)**
TOTAL (%)	**880 (19.5)**	**449 (10)**	**832 (18.5)**	**293 (6.5)**	**2047 (45.3)**	**3 (0.07)**	**4504**

Figure 1 Distribution n (%) of perinatal deaths across the antepartum, intrapartum, and neonatal time periods in South Africa (n=689, October 2013 – January 2014) and United Kingdom (n=9067, 1997-2010)



48.3%) of the deaths occurred in the antepartum period, with 457 (5%) occurring intrapartum and the remaining 4233 (46.7%) occurring in the early neonatal period.

Given that both datasets represent different settings (South Africa is a middle-income country and United Kingdom is a high-income country), we reported data for each country separately, stratified by time of perinatal death (see Table S1 and Table S2)

Antepartum deaths

South Africa

The major causes of antepartum deaths in the South Africa database were antepartum hypoxic events (n=181/344, 53%). The maternal conditions associated with antepartum hypoxia were mostly maternal medical and surgical conditions (of which n=87 (93%) were maternal hypertensive disorders) and complications of placenta cord and membranes of which 54 (75%) were other forms of placental separation and haemorrhage, a group that includes abruptio placentae. The second most common cause of antepartum death were those of unspecified cause (n=146, 42.4%). The vast majority (n=124, 84.9%) of fetal deaths of unspecified cause occurred without a concurrent maternal condition.

UK

Of the 48.3% (n=4377) deaths that occurred in the antepartum period, the majority were unexplained deaths to mothers without an identifiable condition / healthy mothers (n=1642, 37.5%). Other than this, the main perinatal causes of death were congenital malformations, deformations and chromosomal abnormalities (n=981, 22%), and disorders related to fetal

growth (n=645, 14.7%). The majority of the latter group were either in mothers with complications of placenta, cord and membranes (n=279, 43.3%) or in mothers with no identified condition (n=238, 36.9%). Across all causes of antepartum death, the main maternal conditions were complications of placenta cord and membranes (n=1116 deaths, 25.5%) and complications of pregnancy (n=494 deaths, 11.3%). There were no perinatal deaths assigned antepartum hypoxia as their cause of death.

Intrapartum deaths

South Africa

Intrapartum perinatal deaths were mostly acute intrapartum events (n=69, 93%). A third of these occurred in the context of mothers without an identified condition (n=22, 32%). The other most frequent maternal conditions were complications of pregnancy (n=17, 25%), other complications of labour and delivery (n=15, 22%), and maternal medical and surgical conditions, of which most (12 of 13 cases, 92%) were mothers with hypertensive disorders.

UK

Two hundred and ninety six (64.7%) of the 457 intrapartum deaths were as a consequence of an acute intrapartum event. A significant amount of these (n=127, 42.9%) occurred in mothers without an identified condition, and half (n=148, 49.8%) were associated with mothers with complications of placenta, cord and membranes. Intrapartum deaths of unspecified cause contributed the other largest group with 118 (25.8%) deaths. Of all of the intrapartum deaths, mothers most likely had complications of placenta, cord and membranes (n=224, 49%) or had no condition identified (n=177, 25.8%).

Neonatal deaths

South Africa

Neonatal deaths in the South African dataset were composed largely of respiratory and cardiovascular disorders (n=94, 34.7%), complications of low birth weight and prematurity (n=79, 29.2%) and convulsions and disorders of cerebral status (n=69, 25.5%). Respiratory distress of the newborn and neonatal aspiration syndromes contributed the bulk of the respiratory and cardiovascular disorders groups, 46 and 43 cases respectively. Of the perinatal deaths with convulsions and disorders of cerebral status (n=69), all except one were hypoxic ischaemic encephalopathy.

UK

Neonatal deaths were most likely to result from low birth weight and prematurity (n=1338, 31.6%). The maternal condition in most of these cases (n=691, 51.6%) was other complications of labour and delivery, which encompasses idiopathic preterm labour. Three hundred and sixty five of the low birth weight and prematurity deaths (27.3%) were associated with maternal complications of placenta, cord and membranes. The second most common cause of death was congenital malformations, deformations and chromosomal abnormalities (n=1159, 27%). Neonatal deaths of unspecified cause contributed the other main group to deaths in this time period (n=1141, 27%), with most of these having mothers with no identified condition (n=653, 57.2%). Respiratory and cardiovascular disorders contributed 6.7% (n=285) of all neonatal deaths, with most of these (n=148, 51.9%) being respiratory distress of newborn and other respiratory conditions in mothers with no condition identified.

Discussion

Main findings:

We have demonstrated the WHO application of ICD to perinatal deaths (ICD-PM) such that the timing of a perinatal death, the cause of perinatal death, and the maternal condition can be analysed in two datasets from different resource settings. In the datasets from the UK and South Africa, antepartum deaths are mostly unexplained, a consequence of congenital malformations, deformations and chromosomal abnormalities, or as a consequence of problems related to fetal growth. Intrapartum deaths are mostly hypoxia related, and neonatal deaths follow consequences of low birth weight and prematurity. While mothers were often healthy across all three time periods, where there is a maternal condition associated with perinatal death, it is most often maternal medical and surgical conditions and complications of placenta, cord and membranes. The medical and surgical conditions were mostly pregnancy related hypertensive disorders (gestational hypertension, pre-eclampsia, and eclampsia).

Strengths and Limitations:

This is the first application of ICD-PM in two databases from different resourced settings to inform the further development, dissemination, and implementation of ICD-PM globally. The deaths in the South African database included stillbirths from 28 weeks gestation onwards or 1000gr (the WHO definition of stillbirth for global comparison), whereas the UK stillbirths were captured from 24 weeks gestation. While this wouldn't change the application of the system, it may change the overall ratios of causes of death and maternal conditions. In addition, the two datasets, being retrospective when pilot tested, were not compiled using the same standardised instructions, which may have affected the coding. Both of these limitations underline the importance of using standardised definitions across

settings, and the need for training to increase local capacity to capture perinatal death. We are not able to comment on the extent of investigation in to each perinatal death.

Interpretation:

Thorough data capture around perinatal deaths is often poor; indeed it is reported that only 2% of late stillbirths globally are counted(18). It is envisaged that in structuring a separate ICD module for perinatal deaths (which are unique in that they occur in the context of two individuals, and are therefore potentially more challenging for clinicians to classify), in a way that more clearly sets out the groups for perinatal cause of death at different time periods, and for maternal conditions, ICD-PM can facilitate more consistent collection of data on perinatal deaths.

ICD-10 has been criticised for not recognising the fetus as its own entity(19), and not reflecting changes in the understanding of causes of perinatal death(18). As ICD-PM evolves, and the ICD 11 is developed, it is timely now to consider updates to the perinatal cause of death codes specifically on how the system can be clearer and more user-friendly, and how it can better serve the needs of mothers and babies globally. Considerations should be given to changes in perinatal death codes in the ICD revision process. Low birth weight and prematurity is a good example; these cases are coded together in ICD-10 (with the qualifying note that when both birth weight and gestational age are available, priority of assignment should be given to birth weight) yet while prematurity may be a cause of low birth weight, the inverse is not necessarily true. More importantly, the outcomes for babies born preterm and appropriately small are different from babies of the same weight yet small for gestational age(20). A huge step forward would mean a separate registration of the gestational age at delivery and birthweight based on the available data at the time.

A secondary analysis of the deaths in the West Midlands database based on weight and gestation at birth increased the number of antepartum deaths with growth disorders (A5 in ICD-PM) to n=1694 or 38.7%. This is consistent with previous findings using a stillbirth classification which included a category for fetal growth restriction based on birthweight and gestational age(21). For intrapartum deaths, assigning growth restriction codes (category I6) to all small for gestational age babies resulted in I6 becoming the second largest intrapartum cause of death category, with 127 (27.8%) of cases.

The inherent challenges in assigning a perinatal cause of death can partly be overcome by improving capture of the maternal condition. Where it is not possible to see a clear entry point for intervention by looking at the perinatal causes of death, it may be the maternal condition that adds the information needed. Currently, a clinician documenting the cause of death for an intrauterine fetal demise in a woman with eclampsia is limited in what they can assign as the cause of death to that fetus. Even with the addition of autopsy and placental histology (which are rare in the setting of most perinatal deaths), it can be challenging to assign a cause of death any more specific than “hypoxia”. While ICD-10 specifically discourages this (in favour of greater specificity), this is not always possible under the current system. Having the maternal condition captured and analysed together with the perinatal cause of death offers valuable information on plausible pathways leading to the perinatal death, and further guidance as to where interventions might be beneficial.

Another demonstration of the added value of capturing the maternal condition is in the case of unexplained fetal death. In the South African data, antepartum stillbirths with a maternal condition (e.g. pre-eclampsia) were coded with intrauterine hypoxia as their cause of death. The UK data has no antepartum cases with this code, but a significant number of

unexplained fetal deaths with associated maternal conditions. These fetal deaths due to pre-eclampsia do ultimately follow intrauterine hypoxia, akin to all adult deaths following cardiac arrest. However the different codes (but from the point of ICD coding rules, equally valid) do not offer the necessary detail on the cause of perinatal death, nor do they indicate where intervention should be directed. It is the linked maternal condition that does this, which highlights the value of ICD-PM. Perinatal death classification systems frequently have high rates of unexplained fetal deaths(22). Given the difficulty of diagnosing perinatal causes of death, even in settings with intensive investigative power, having the maternal condition always recorded may overcome this challenge in previous systems. Improving the quantity and quality of data on the maternal condition present at perinatal death may provide the necessary critical information to target interventions to prevent these deaths.

One of the main advantages of ICD-PM is that it is a programmatically-oriented classification system, such that the mother-baby dyad (acknowledging the role that maternal conditions play in perinatal deaths(23, 24)) can both be beneficiaries of intervention, a notion that aligns with the recommendation in the Every Newborn Action Plan that encourages the capturing of maternal complications as part of perinatal death registration(3). Moreover, a system that captures perinatal deaths at all three time periods allows the antenatal death to be identified and investigated across the continuum of care throughout the perinatal period. While this may be challenging in some settings, moving forward it is important to keep the emphasis on each death regardless of the time period. Based on this pilot testing, it could be suggested that programs addressing management of hypertension, the outcomes of intrapartum care, and the prevention of preterm birth are needed in a setting like South

Africa, and those addressing prematurity and the maternal and obstetric complications of placenta, cord and membranes, are highlighted as needed from the UK data.

A classification system is only as good as the data entered in to it. It is true that in perinatal mortality, there is scope for conflicting data or variable interpretations of causes of death. WHO, with guidance from experts, has worked to address these concerns of classification systems in two ways. The upcoming ICD-PM document has detailed guidance for how and when a cause of death can be assigned. Further use of the ICD-PM will further refine this guidance and improve data collection. Moreover, the ICD-PM is also incorporated and supported by the upcoming WHO guide on audit and review of stillbirths and neonatal deaths. The audit guide aims to generate information about modifiable factors contributing to stillbirths and neonatal deaths and to use the information to guide action.

Conclusion

While a global classification system will never be perfect for every setting and eventuality, the three step approach of ICD-PM, based on a system already utilized in 117 countries for mortality reporting (16), offers broad applicability and thus facilitates standardized comparisons of data internationally. The WHO Application of ICD to Perinatal deaths (ICD-PM) can be a globally applicable perinatal death classification system that emphasises the need for a focus on the mother baby dyad as we move beyond 2015.

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Ethics

The PPIP program has ethical approval from the University of Pretoria. The data is 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:

EA and OT drafted the manuscript. JG and RCP provided access to the databases and guidance for the pilot testing. EA and AQ 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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