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SHORT REVIEW

Neonatal near miss: A review of current definitions and the need for standardisation

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Neonatal near miss (NNM) refers to a newborn who almost died in the neonatal period and is often perceived as part of a spectrum that includes stillbirth and neonatal death. NNM audits might improve recognition of risk factors and substandard care, facilitate benchmarking and inform prevention strategies to improve perinatal outcomes. This review shows that available NNM definitions are inconsistent and vary widely. This is likely to undermine the development of effective prevention strategies and global comparisons. Expert opinion may help reaching a consensus, thus enabling targeting of the appropriate population which would lead to more meaningful data for perinatal audits.

KEYWORDS
neonatal near miss, neonatal morbidity, neonatal mortality, perinatal audits, review

BACKGROUND

Steps to reduce the devastating loss of a baby are recognised as a matter of paramount importance across all country settings.[1] According to the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), it is estimated that in 2019, 2.4 million newborns died worldwide, and 2 million more were stillborn.[2,3] While the idea that perinatal deaths are inevitable has been recognised to be a fallacy,[4] counting births and deaths, tracking program coverage and quality, advancing accountability and uncovering root causes and associated factors, are of utmost importance for achieving the best standard of practice and reducing perinatal deaths.[1]

Intrapartum stillbirth and early neonatal death are often perceived as a continuum as, in many cases, the process leading to the death may find its final pathway before or after the birth occurs. Neonatal near miss (NNM) refers to a newborn who presented with features consistent with severe complications of antenatal or intrapartum events, almost died, and survived.[5] It is hypothesised that NNM is also part of the spectrum of stillbirth-neonatal death.[6]

High-quality clinical audits of NNM would expand the opportunities for assessing maternal and perinatal care.[7] Such audits may enhance detection of risk factors for perinatal death, expand evidence for maternal and neonatal clinical care (both specific interventions and systems of care), strengthen the healthcare system and reduce childhood mortality and disability.[5] The NNM definition facilitates targeting cases for perinatal audits, which differs from the scope of severity scores and apparent life-threatening events.[6,8]

Additionally, while stillbirth or neonatal death is a tragic outcome of pregnancy leading to long-lasting impact on the family, the outcomes of NNM events can also include lifelong adverse effects on the health, wellbeing and lifespan of the child and their family. These might include a range of disabilities and neurodevelopmental delays, such as learning difficulties, cerebral palsy, or sometimes, predilection to premature organ failure, such as end-stage renal disease. The use of the NNM concept in a perinatal audit could also improve vigilance, facilitating comparisons within the same institution over time and between different institutions in various regions or countries.

Despite the increasing interest in NNM audits as a way to improve outcomes, there is no standard, internationally agreed identification criteria for NNM. A 2015 systematic review by Santos et al found four different definitions for NNM from heterogeneous studies.[7] All four use pragmatic criteria that relate to the major causes of neonatal death worldwide (prematurity and perinatal asphyxia), and three include additional management markers for severity. Three studies used databases solely from middle-income countries. The authors of this systematic review concluded that a standard validated definition was needed.[7] To our knowledge, since 2015, there is no update on NNM definitions that could be used globally for perinatal audits.

MATERIALS AND METHODS

Aiming to identify novel definitions of NNM, a systematic search of the literature was undertaken. Electronic databases MEDLINE (PubMed) and Embase (Elsevier) were searched on July 2021, with no country setting, publication date or language restrictions, using keywords developed under the guidance of a university librarian ((neonat*[tiab] OR neo-nat*[tiab]) AND 'near miss*' AND (definition* or classification* indicator* or criteria)). New definitions of NNM were included; 'modification and/or adaptation' from previous definitions strictly due to lack of local data were excluded. A hand search of the reference list from included articles was performed to ensure there were no additional articles.

RESULTS

The electronic search resulted in 76 articles in MEDLINE and 93 articles in Embase. After removal of 50 duplicates, a total of 119 titles and abstracts were screened, 35 articles underwent full-text review and seven studies were included (Fig. 1). Three studies were added to the four identified in the previous 2015 systematic review. Table 1 provides an overview of results and characteristics of the studies included.

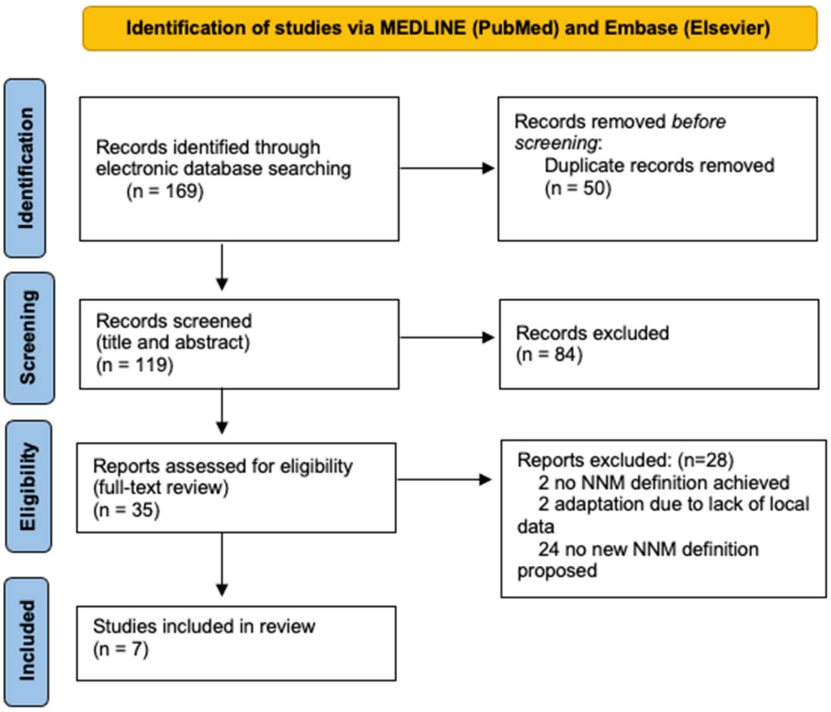

FIGURE 1 Flow chart of study search and inclusion in this review. NNM, neonatal near miss.

TABLE 1 Characteristics of included studies

Author	Year	Variables as criteria for neonatal near miss	Neonatal period (days)	Study type	Country	NNM rate (/1000 LB)	Neonatal mortality rate (/1000 LB)
Avenant†[8]	2009	Criteria of Mukwevo: Respiratory failure/dysfunction; cardiac failure/dysfunction; central nervous system failure/dysfunction; hypovolaemia; haematological failure/dysfunction; endocrine failure/dysfunction; renal failure/dysfunction; immune system: response to infection/dysfunction (eg neutropenia); musculoskeletal morbidity; gastrointestinal/hepatic failure/dysfunction	Up to 3 days	Retrospective cohort 'Saving Babies 2003–2005' (multi-site)	South Africa	24.7	6.3‡
Pileggi†[5]	2010	Pragmatic criteria only: Birth weight <1500 g; gestational age <30 weeks Apgar 5 min <7	Up to 7 days	Retrospective cohort '2005 WHO Global Survey Brazil' (multi-site)	Brazil	21.4	8.2
Bonnaerens[9]	2011	Established metabolic acidosis at birth: Arterial pH <7.05 or venous pH <7.17, in association with base excess ≤−10 mmol/L In cases of sampling or analysis error, neonates with persistently low Apgar score of ≤6 after 5 min were considered clinically at risk for metabolic acidosis	At birth	Prospective audit (single-site)	Belgium	11.4	7.1§
Manandhar[20]	2014	Mother and Infant Research Activities (MIRA) and HealthRight tool: Any neonate who received bag and mask ventilation during neonatal resuscitation, birth weight <1500 g, any neonate treated and/or referred for any one of the following 10 conditions of possible severe bacterial infection: 1. unable to breast feed; 2. lethargic or unconscious; 3. fast breathing; 4. severe chest indrawing; 5. Grunting; 6. Fever; 7. hypothermia; 8. umbilical discharge with redness extending up to surrounding skin; 9. ten or more than 10 pustules over skin of baby or one big abscess; 10. weak or absent cry	Unclear	Prospective operational research MIRA and HealthRight International (HRI)' (multi-site)	Nepal	Not described	Not described

TABLE 1 (Continued)

Author	Year	Variables as criteria for neonatal near miss	Neonatal period (days)	Study type	Country	NNM rate (/1000 LB)	Neonatal mortality rate (/1000 LB)
Pileggi-Castro†[6]	2014	Global Survey on Maternal and Perinatal Health (WHOGS) database:[11] Pragmatic criteria only: Birth weight <1750 g; gestational age <33 weeks Apgar 5 min <7 Multicountry Survey on Maternal and Newborn Health (WHOMCS) database:[12] Pragmatic criteria (above) AND Management criteria: parenteral antibiotics for up to 7 days before 28 days of age; use of a continuous positive airway pressure (CPAP) device; any intubation lasting for up to 7 days before 28 days of age; phototherapy within the first 24 h of life; cardiopulmonary resuscitation; use of vasoactive drugs, anticonvulsants, surfactant, or blood-derived products or use of steroids to treat refractory hypoglycaemia; and any surgical procedure	Up to 7 days	Retrospective cohort 'WHOGS and the WHOMCS' (multi-site)	International database: WHOGS (24 countries) WHOMCS (29 countries)	WHOGS 44.4 WHOMCS 72.5	WHOGS 7.4§ WHOMCS 9.2§
Silva†[13]	2014	Pragmatic criteria: Birth weight <1500 g; gestational age ≤32 weeks; Apgar 5 min <7 Management criteria: use of mechanical ventilation Other: congenital malformations	Up to 28 days	Retrospective cohort 'Birth in Brazil Survey 2011-2012' (multi-site)	Brazil	39.3	11.1¶
Bakari[10]	2019	NNMAT: 4 categories: Category 1: Evidence of severe/life-threatening complications: Apgar <7 at 5 min; gestational age <33 weeks; birthweight <1800 g; suspected subgaleal bleed; major congenital abnormality; axillary temperature <35 or >39°C; severe jaundice requiring blood exchange; surgery in first week; Category 2: Clinical interventions suggestive of a near miss: including resuscitation (bag and mask) at birth; resuscitation in the neonatal intensive care unit; nasal CPAP; cardiac massage/chest compressions; intra-venous fluid bolus, any intubation during admission; double blood exchange transfusion; oxygen therapy; caffeine citrate/aminophylline therapy; thermal protection >4 h Category 3: Any organ dysfunction Category 4: Laboratory abnormalities in the first 7 days: including haematocrit <30%, haemoglobin <10 g/dL; white blood cells <4000 cells/mm^3; blood culture done; blood culture positive Exclusion criteria: birth weight <500 g or gestational age <28 weeks	Up to 28 days	Prospective cohort (multi-site)	Ghana	57.7	105.6‡

LB, live births.
†Study was included in Santos et al 2015 systematic review.
‡Mortality rate first 3 days of age.
§Mortality rate first 7 days.
¶Mortality rate first 28 days.

The study design, population and the NNM definition were heterogeneous. The NNM incidence varied from 11/1000[9] to 72.5/1000[6] live births while the NNM to neonatal mortality ratio ranged from 0.54[10] to 7.9.[6] One study was performed in a high-income country (HIC),[9] whereas five used databases solely from low (LIC) and middle-income countries (MIC). The largest study[6] used two World Health Organization (WHO) databases, the 'Global Survey on Maternal and Perinatal Health' (WHOGS)[11] and the 'Multicountry Survey on Maternal and Newborn Health' (WHOMCS),[12] to validate pragmatic and management criteria, but only 10% of the included newborns were from countries with a very high human development index. The timing for inclusion of NNM was variable, with some definitions including only those where problems presented 'at birth'[5,9] and others including neonates whose presentation was up to 28 days of life.[10,13] Five of seven studies included criteria measured at birth such as Apgar, birth weight and gestational age but the cut-off values were variable (Table 1). Four definitions included at least one blood test result (eg blood gas or glucose),[6,8–10] while others included clinical signs or exposure to treatment (such as respiratory support, antibiotics or phototherapy). The majority of the current definitions used neonatal deaths as a 'gold standard' to test validity. Some authors used 'congenital abnormalities' as inclusion criteria.[10,13]

DISCUSSION

Similar to the systematic review by Santos et al,[7] this updated search has shown wide variation in NNM definitions. The seven NNM definitions in the included studies use different variables, from simple pragmatic cut-offs on gestational age, Apgar and birth weight, to consideration of clinical observations, interventions, judgements about organ system dysfunction and laboratory tests. The marked variation in NNM rates and in NNM / neonatal mortality ratio is likely explained not only by the country setting but also by the differences in the NNM definition. Consequently, comparing those cohorts might be inappropriate and it is likely that the true NNM group remains ill-defined.

The use of congenital abnormalities as a criterion is arguable for NNM audits because some congenital anomalies that have long term consequences cause little risk of death at birth, and conversely some but not all potentially perilous consequences in the neonatal period are preventable. For example, a baby with severe polycystic renal disease may present with neonatal respiratory and renal failure regardless of antenatal and intrapartum care. Congenital anomalies are a very important contributor to neonatal morbidity and mortality and averting poor neonatal outcomes is an important goal, but inclusion of surviving infants as NNM cases may require careful consideration, or secondary screening criteria, such as the presence of organ failure or the need for urgent treatment.

Since most studies were conducted in LIC and MIC, there are concerns about external validity. For instance, a baby born at 32 weeks may not survive in many LIC whereas in HIC survival after birth at this gestation resembles that of full-term babies. Therefore, different gestation criteria for NNM may be appropriate in LIC and HIC, while still recognising the importance of strategies to reduce preterm birth as critical for reducing both perinatal mortality and NNM. When accounting for perinatal deaths, a lower weight and gestation limit for stillbirths and a longer post-birth interval for neonatal deaths has been adopted by many HIC when compared to the WHO definitions for global trends. Likewise, different NNM criteria might be needed for international and local benchmarking depending on the country setting and/or level of care.

The use of different intervals after birth for detection of neonatal morbidity has been assessed in a MIC[14,15] with no significant difference found. One study showed an increase in the sensitivity of the definition when morbidity in the first 27 days was included compared to the first six days.[15] However, the criteria used in most definitions (such as exposure to various treatments or measurements of abnormal physiology) were not compared for sensitivity, specificity, or any other aspects of reliability. Contributing to the international heterogeneity, other studies have revised criteria for NNM cases, such as by producing hybrid versions of previous definitions to accommodate the data available and local clinical judgement.[16,17] There is often no standard or testing for reliability of the 'newly described cohort'.

This review update discloses prevailing uncertainty about how to define the NNM group. We advocate the need for a definition that is sufficiently broad to capture a range of serious events, to enable scrutiny in order to recognise opportunities for prevention. At the same time, the definition needs to be broadly applicable, feasible to apply, and narrow enough to be pragmatic, or it is unlikely hospital or health services committees will have sufficient resources to ever use it. A possible approach to this conundrum is to gain consensus expert opinion for a definition, identification criteria and classification of NNM using Delphi methodology.[18] The Delphi design allows a panel of experts to confirm, provide feedback, and revise the proposed definitions over a series of 'rounds', until consensus is achieved. This approach was used to delineate maternal near miss criteria in LIC[19] and could be used to define and stratify NNM criteria according to the country setting. Additionally, involvement of key regional professional groups and societies should be sought to strengthen the definition and broaden its impact. Such definition has the potential to support future perinatal audits through a meaningful delineation of NNM cases.

CONCLUSION

The aim of identifying NNM cases is to target a group of newborns for clinical audit to assess the quality of care, enable benchmarking, and inform policy and practice, to ultimately reduce perinatal adverse outcomes. The lack of a consensus definition of the NNM cohort and the use of varying criteria undermines the quality of data available for regional and international benchmarking and

is likely to lead to missed opportunities for prevention. Standard and meaningful NNM identification criteria are needed.

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ETHICAL APPROVAL

Ethics approval was not needed for this literature review.

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