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Review

The evolution of the criteria for identifying the new concept of "Neonatal Near Miss": a systematic review

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ABSTRACT

Background. The concept of Near Miss, has been used in the field of obstetrics as a tool for assessing and improving the quality of care. However, there is no standardized definition or international criteria for identifying neonatal near misses. The current review aims to investigate the development of the neonatal near miss concept based on the results of studies conducted so far on neonatal near misses and their identification criteria.

Results. Sixty-two articles were retrieved by the electronic search, and after examination of different abstracts and reading of full texts, 17 articles were considered eligible meeting our inclusion criteria. All selected articles varied in terms of concept definition and criteria used. Neonatal Near Miss was defined as any newborn with pragmatic and/or management criteria who survived the first 27 days of life. All studies reviewed showed a Neonatal Near Miss rate that was 2.6 to 10 times higher than the neonatal mortality rate.

Conclusions. Neonatal Near Miss is a new concept that is currently being debated. There is a need for universal consensus on the definition and its identification criteria. Further efforts are needed to standardize the definition of this concept, including the development of criteria that can be assessed in a neonatal care setting. This is to improve the quality of neonatal care in every setting, regardless of the local level.

Key words: Neonatal Near Miss, neonatal morbidity, neonatal mortality, emergency neonatal care - identification criteria.

Maternal near miss (MNM) is a term used by the World Health Organization to describe a woman who nearly died but survived a complication during pregnancy, delivery, or 42 days after the end of pregnancy.[1] It also helps further investigate obstetric care by looking into complications that could have been prevented. At the same time, it has helped to recognize at-risk women, diagnose them, and start early and successful therapies. Additionally, it has made it possible to evaluate the standard of maternity healthcare.[1-3] Recent studies have shown the Near Miss tool in newborn care can improve the quality of care. It can also help detect healthcare errors and system deficiencies. This concept is similar to the widely accepted World Health Organization (WHO) tool, Maternal Near Miss (MNM). Although NNM is an evolving concept, there are no concrete systems or definitions for it. Currently, there are no standard way to identify and evaluate a NNM.[4]

According to some researchers, NNM refers to a morbid event that almost caused a neonate's death during the newborn period, such as diseases, interventions, and organ dysfunction, where the neonate only lived by luck or with high-quality care.[2,3,5] Other definitions, however, have focused on a shorter time frame of seven days.[6-8] Additionally, there is a

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dispute over the best illness severity indicators for NNM. Researchers in Brazil have utilized a variety of (pragmatic) standards to identify newborns as Near Misses, including low birth weight, gestational age at birth, and an Apgar score of 5 or below.[2,7,9] To the pragmatic criteria, some authors have added additional clinical management standards.[7-10] Researchers have since used clinical criteria, the existence of organ system dysfunction, and management criteria, using data from Morocco, Burkina Faso, Ghana, and South Africa, to classify newborns as Near Misses. These standards resemble the model that the WHO has suggested.[6,10,11]

NNM has received very little research so far, and there is a dearth of information on NNM cases, notably in Morocco and low- and middle-income nations. This review was conducted to examine the evolution of the NNM concept based on the findings of studies conducted thus far and to understand the similarities, differences, and gaps in these studies, which will provide avenues for future research. It was done in consideration of its usefulness as a tool for enhancing the quality of neonatal care.

Material and Methods

Research strategy

The research was conducted to investigate the NNM concept based on the results of the studies conducted so far and their identification criteria, according to the criteria of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.[12]

A systematic search of the literature was carried out, following the analysis of different articles and publications dealing with the subject without the restriction of time (until the end of 2021) the or language of origin. The electronic databases Medline, Embase, Scielo, PubMed, and Google scholar were searched based on keywords focused on the topic such as "near miss," "neonatal near miss," "neonatal mortality," "neonatal morbidity," "emergency neonatal care," "quality of care." The WHO and UNICEF websites were also consulted.

Inclusion and exclusion criteria

Sixty-two references were reviewed. Only studies with a clear definition of NNM, established criteria, and original data were considered eligible. In addition, we excluded studies and information published only as abstracts.

Data collection process

A data extraction table was used to identify data relevant to the study such as author's name, year, study title, objectives, study method, groups compared, sample, consideration of confounding and bias, the validity of tools, and conclusions supported by results.[13]

Results

To study the results of the research we reported the number of corresponding live births, the variables used as criteria for NNM, the specific neonatal data collection period, the neonatal mortality rate, and the NNM rate.

The findings of our analysis indicated that there is little literature on NNM. After looking through several abstracts and reading the entire contents of only 62 publications, 17 were deemed appropriate and matched our inclusion criteria (Fig. 1).

Between 2009 and 2021, 17 studies were released. Table I displays the evaluation of the selected studies' quality.

The concepts and selection criteria applied to each of the chosen articles vary. Table II compares the many studies that were compared in this evaluation.

Mukwevho et al.[14] from South Africa provided a useful clinical definition of severe acute newborn morbidity. This criterion was used in research by Avenant et al.[11] that used data from "Saving Babies: 2003-2005: Fifth South African Perinatal Care Survey" and included 3770 live births (LB). "The newborn's respiratory, cardiac, central nervous system, hypovolemia, hematologic, endocrine, renal, immunologic, musculoskeletal, and/or hepatic/

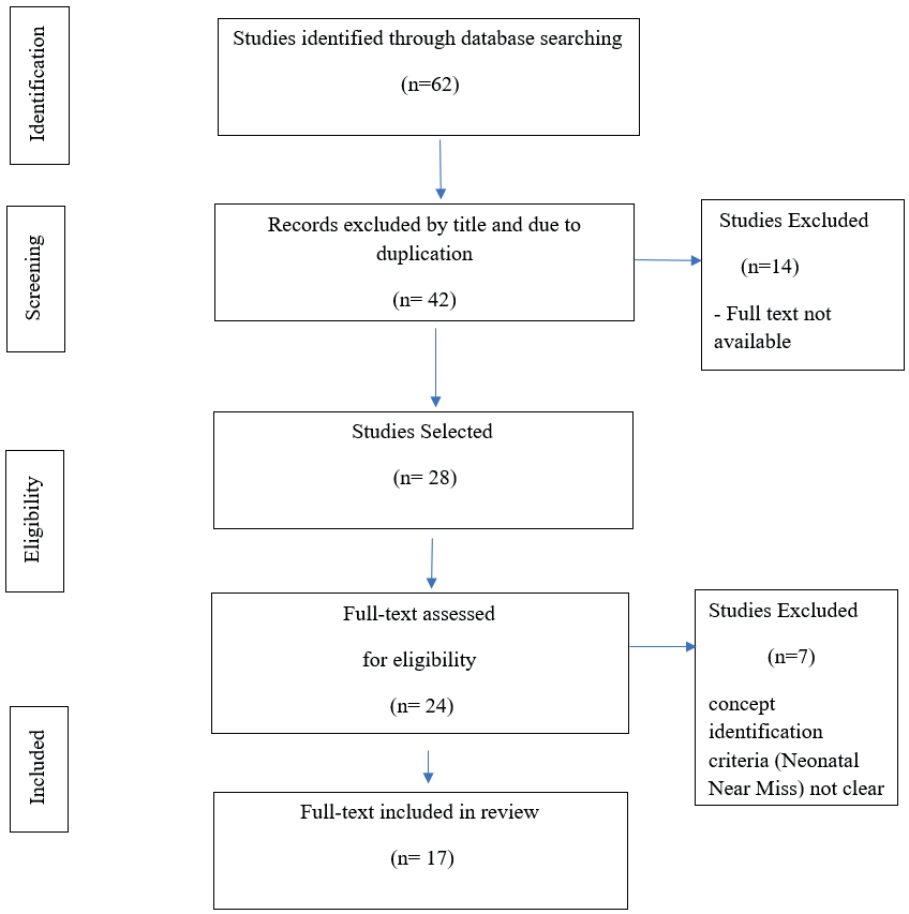

Fig. 1. Flow chart of process of systematic literature search in accordance with PRISMA.

gastrointestinal dysfunctions or failures were among the parameters evaluated".[11,14] The criteria were comparable to those that defined MNM. According to this study, the NNM rate was 24.7/1000 LB and the newborn death rate was 6.3/1000 LB.[11,14] A secondary analysis of the Brazilian dataset from the 2005 WHO survey on maternal and perinatal health was done as part of the Pileggi et al.[5] study. Of the 15169 LB included in this research, at least one of very low birth weight, gestational age at birth of under 30 weeks, and Apgar score < 7 at five minutes of life was present to identify NNM cases. The study's findings revealed an NNM rate of 21.4/1000 LB and an early neonatal mortality rate of 8.2/1000 LB.[5]

Pileggi-Castro et al.[7] have made other ground-breaking efforts to develop precise standards for identifying NNM instances by database analysis of two WHO investigations. The first was the Multi-country Maternal and Newborn Health Survey (WHOMCS) (2010-2011), which involved 359 health facilities in 29 countries. The second was the Global Maternal and Perinatal Health Survey (WHOGS (2004-2008)), which involved 373 health institutions in 24 countries. Two steps of analysis were carried out: Using WHOGS data first, pragmatic markers of severe newborn morbidity were created, and these markers were then verified using WHOMCS data. Too create a comprehensive set of criteria, the previously created pragmatic markers were merged with clinical management markers.[7,15]

Table I. Quality assessment of the studies included in the review.

Author/Reference	Relevance to this study	Aims clearly stated	Appropriate study method	Comparable study groups	Sample representative of target population	Confounding and bias considered	Validation of questions	Understandible tables / figures	Conclusions supported by results
Avenant. (2009)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pileggi et al. (2010)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	yes
Kale et al. (2017)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ronsmans et al. (2016)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Brasil et al. (2019)	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Wick (2017)	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Manandhar et al. (2014)	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Pileggi et al. (2014)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Silva et al. (2014)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nakimuli et al. (2015)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bushtyreyvet al. (2016)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bakari et al. (2019)	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Lima et al. (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mersha. (2019)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Ninama et al. (2019)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Suchma et al. (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table II. Comparison of the characteristics and results of the studies included in the review.

Author	Year	Site	Number of live births	Neonatal period (days)	Neonatal near miss rate	Neonatal mortality rate	Variables as criteria for neonatal near miss
Avenant (2009)	2009	South Africa	3770	Up to 28 days	24.7/1000 LB	6.3/1000 LB	Criteria of Mukwevo: Organ dysfunction/insufficiency similar to MNM
Pileggi et al (2010)	2010	Global survey (WHO)	15169	Up to 28 days	21.4/1000 LB	8.4/1000 LB	Birth weight < 1500 g Apgar < 7 at 5th min gestational age < 30 weeks
Kale et al (2017)	2011	Brazil	7315	Up to 28 days	123 (1.7%)	29 (0.4%)	Pragmatic markers: Birth weight < 1500 g Apgar < 7 at 5th min gestational age < 32 weeks
Ronsmans et al (2016)	2012	Benin, Morocco, Burkina- Faso	27857	Up to 7 days	427 cases	246 cases	Organ dysfunction/insufficiency similar to MNM
Brasil et al (2019)	2012	Brazil	24254	Up to 7 days	2098 cases	N/A	Birth weight < 1750 g Apgar < 7 at 5th min gestational age < 33 weeks
Wick (2017)	2012	Lebon	1178	Up to 7 days	17 cases	N/A	Birth weight < 1500 g Apgar < 7 at 5th min gestational age < 31 weeks
Manandhar et al (2014)	2013	Nepal Arghakhanchi	N/A	Up to 28 days	28 cases	N/A	Ventilation by mask Weight <1500g Infection Asphyxia at birth
Pileggi et al (2014)	2014	Country of WHOGS	277706	Up to 7 days	44.4/1000 LB	7.4/1000 LB	Birth weight < 1750 g Apgar < 7 at 5th min gestational age < 33 weeks
Pileggi et al (2014)	2014	Country of WHOMCS	309644	Up to 7 days	33.4/1000 LB 53.0/1000 LB 72.5/1000 LB	9.2/1000 LB 9.2/1000 LB 9.2/1000 LB	Pragmatic criteria Management criteria Combined the two criteria
Silva et al (2014)	2014	Brazilian national study	24061	Up to 28 days	39.2/1000 LB	11.1/1000 LB	Birth weight < 1500 g Apgar < 7 at 5th min gestational age <32 weeks Congenital malformation Mechanical ventilation
Nakimuli et al (2015)	2014	Uganda	2142	Up to 28 days	36.7/1000 LB	17.2/1000 LB	Modified criteria according to Pileggi and Avenant Birth weight < 1500 g Apgar < 7 at 5th min gestational age <30 weeks

CLAP: Latin American Center of Perinatology, GA: gestational age, LB: live births, MNM: maternal near miss, N/A: not available, NICU: neonatal intensive care unit, NNMAT: Neonatal Near Miss Assessment Tool, WHO: World Health Organization, WHOGS: WHO Global Maternal and Perinatal Health Survey, WHOMCS: WHO Multi-country Maternal and Newborn Health Survey

Table II. Continued

Author	Year	Site	Number of live births	Neonatal period (days)	Neonatal near miss rate	Neonatal mortality rate	Variables as criteria for neonatal near miss
Bushtyreyv et al (2016)	2015	Russia	16766	Up to 28 days	85.5/1000 LB	2.7/1000 LB	Pragmatic markers from Pileggi et al
Bakari et al (2019)	2015	Ghana multicenter study (NNMAT)	394	Up to 28 days	204 (74.5%) 233 (85.0%) 134 (48.9%) 16 (5.8%)	56 (82.4%) 60 (88.2%) 52 (76.5%) 7 (10.3%)	Birth weight < 1800 g Apgar < 7 at 5th min gestational age <33 weeks Management criteria, ventilation, cardiac massage, intubation Organ dysfunction Hematocrit > 30%. Hemoglobin <10dg/dl, bilirubin >10X GA Blood culture positive
Lima et al (2018)	2016	Brazil	1002	Up to 28 days	221 (22%)	44 (4.4%) early, 14 (1.4%) late neonatal deaths	Birth weight < 1750 g Apgar < 7 at 5th min gestational age <33 weeks And management criteria according to CLAP
Ninama et al (2019)	2016	India	2737 399 (NICU)	Up to 28 days	87.6/1000 LB	22/1000 LB	Pragmatic markers: Birth weight < 1500 g Apgar < 7 at 5th min gestational age <33 weeks
Suchma et al (2021)	2020	Biratnagar city of Morang, Nepal	1000	Up to 28 days	79/1000 LB	18/1000 LB	Birth weight < 1750 g Apgar < 7 at 5th min gestational age <33 weeks
Mersha (2019)	2019	Gamo and Gofa, Ethiopia	484	Up to 28 days	121 cases, 363 controls	N/A	Presence of at least one pragmatic marker or management criteria

CLAP: Latin American Center of Perinatology, GA: gestational age, LB: live births, MNM: maternal near miss, N/A: not available, NICU: neonatal intensive care unit, NNMAT: Neonatal Near Miss Assessment Tool, WHO: World Health Organization, WHOGS: WHO Global Maternal and Perinatal Health Survey, WHOMCS: WHO Multi-country Maternal and Newborn Health Survey

These analyses led to the following criteria being suggested.

Pragmatic criteria:
- Birth weight <1750 g
- Apgar score <7 at 5 minutes
- Gestational age <33 weeks

Management criteria: Use of:
- Parenteral antibiotics (up to 7 days and before 28 days of life)
- Nasal continuous positive airway pressure (CPAP)
- Any intubation within the first 7 days
- Phototherapy in the first 24 hours of life
- Cardiopulmonary resuscitation
- Vasoactive drugs
- Anticonvulsants
- Surfactants
- Blood products

The NNM rate for management markers was 53/1000 LB and for pragmatic, markers it was 37.4/1000 LB. With sensitivity and specificity of about 93% and a very strong odds ratio of 163, the combination of pragmatic and management criteria performed better.[7]

After accounting for any pragmatic or managerial variables, the early neonatal death rate was 9.2/1000 LB and the NNM rate was 72.5/1000 LB. The findings of this study demonstrated that NNM rates and early newborn mortality differed according to the NNM detection criteria employed.

Silva et al.[16] used "Birth in Brazil" data to conduct a study with 23940 LB. In this instance, 19 variables were employed to spot instances of NNM: Apgar score of seven at five minutes of life, gestational age between 32 and 37 weeks, birth weight between 1500 and 2500 g, and multiple deliveries are all risk factors. In terms of management, the following factors were noted: the requirement for mechanical ventilation, the need for additional oxygen following delivery, admission to neonatal intensive care, nasal CPAP, tracheal intubation in the delivery room, cardiac massage, resuscitative drugs, the requirement for phototherapy in the first 72 hours of life, the administration of surfactant, and the use of antibiotics in the first 48 hours of life.

In contrast, Ronsmans et al.[6] studied NNM cases in low- and middle-income countries by analyzing at the incidence of NNM cases and deaths in 17 hospitals in Benin, Burkina Faso, and Morocco (2012-2013). These researchers used clinical characteristics, such as the existence of organ system dysfunction, and management criteria to classify newborns as NNM, which is similar to how the WHO defines MNM.[6] The study's results showed that stillbirths and NNM cases varied from 23 to 129 per 1000 LB in Moroccan and Beninese hospitals, respectively, and that perinatal mortality (from 17 to 89 per 1000 LB) were more frequent than NNM (from 6 to 43 per 1000 LB).

Between October 2010 and April 2013, Manandhar et al.[17] conducted a prospective study on NNM cases in Nepal at various healthcare facilities. The only criteria utilized in this analysis to identify NNM cases were mask ventilation, extremely low birth weight (birth weight 1.5 kg), and potentially severe bacterial infection (PSBI). There have been 28 cases of NNM reported in various hospitals. The rate of NNM in the same country, as determined by Suchma's research, was 79/1000 LB.[18] Using management and pragmatic criteria, NNM cases were identified. The pragmatic criterion with the highest frequency was birth weight <1750 g (20/65; 30.7%), followed by the Apgar score <7 at five minutes after birth (41/65; 63.1%). Only one newborn met the three pragmatic criteria.

In India, Ninama et al.[19] discovered results that were essentially identical. During the study period, there was a newborn death rate of 22 per 1000 LB while the NNM rate was 87.6 per 1000 LB. The neonatal intensive care unit (NICU) level was used for this study. In this study, NNM was defined as neonates admitted to the NICU who met any of the following criteria: birth weight less than 1500g, gestational age less than 30 weeks, and Apgar score less than 7 at 5 minutes.

A prospective cohort study was conducted by Nakimuli et al.[20] in two referral hospitals in Uganda. Clinical management criteria, the presence of organ system dysfunction, and the provision of newborn care were used to identify NNM cases. The authors used the two managerial and pragmatic criteria developed by Pileggi-Castro et al.[7] but modified the criteria for gestational age and birth weight to be less than 30 weeks and less than 1500 g, respectively.

According to a study by Bushtyrev et al.[21] in Russia, which examined NNM cases in the city of Rostovondon between January 2011 and January 2015 using just the pragmatic markers created by Pileggi-Castro et al.[7], the incidence of NNM was 85.5% per 1000 LB out of 16588 LB.

In six public maternity hospitals in the Brazilian states of So Paulo and Rio de Janeiro, Kale et al.[22] conducted cohort research in 2011. The definitional parameters used to identify NNM occurrences were birth weight less than 1500 g, gestational age less than 32 weeks, and an Apgar score of five minutes less than seven. Out of the 7126 LB that were selected, 123 occurrences of NNM and 29 neonatal deaths were documented.

According to the following criteria (Apgar 7 at 5 minutes, weight 1750 g, or gestational age 33 weeks), NNM cases were found in a cross-sectional study carried out in Brazil by Brasil et al.[8] NNM cases survived for at least 7 days after birth. Out of 24,254 NV, 2,098 cases of NNM were found, with an incidence of (89.9%) concentrated in the public sector. However, when birth weight and gestational age were combined, both the public (43.5%) and private (46%) sectors reported nearly comparable incidences of NNM.

Lima et al.[9] used the new concept of NNM developed by the Latin American Center of Perinatology (CLAP) (pragmatic and/or managerial criteria or combination of both criteria) to conduct a prospective cohort analytical investigation in northeastern Brazil. A total of 1002 LB were present, 221 (22%) of which were NNM cases, 44 (4.4%) of which were early neonatal deaths, and 14 (1.4%) were late neonatal deaths. NNM prevalence was 220/1000 LB. A prospective, observational, multi-site investigation was carried out by Bakari et al.[10] in two tertiary referral hospitals in southern Ghana. To identify NNM cases, the study team developed the Neonatal Near Miss Assessment Tool (NNMAT), a tool with four categories: organ dysfunction, interventions made, evidence of severe consequences (matching pragmatic criteria), and investigations made (first 7 days of life). 394 newborns in all were enrolled, successfully screened with NNMAT, and followed up until age 28 at both sites. The findings of this investigation revealed various NNMAT categories, including:

-NNMAT category 1: (Apgar <7 at 5 minutes, weight <1800g, gestational age at birth <33 weeks, T°<35° or >39°, jaundice) 204 (74.5%) NNM and 56 (82.4%) neonatal death.

-NNMAT category 2: (management criteria) 233(85.0%) NNM and 60(88.2%) neonatal death.

-NNMAT category 3: (Respiratory, gastroenterological, and neurological organ dysfunction) 134 (48.9%) NNM and 52 (76.5%) neonatal death.

-NNMAT category 4: (Hematocrit >30%, hemoglobin <10g/dl, serum bilirubin >10X gestational age and positive blood culture) 16 (5.8%) NNM and 7 (10.3%) neonatal death.

Between 2019 and 2021, multiple studies in Ethiopia[23-30] were carried out at the level of the various regions of the country. using the new concept of Neonatal Near misses formulated by CLAP. NNM instances were almost ten times more frequent than neonatal mortality, accounting for 23.3 to 33.4% of the cases analyzed. In contrast, a standard structured approach was employed in the two investigations in Southern Ethiopia from Mersha et al.[30] in 2019 and Wondimu et al.[27] in 2020 to identify NNM events based on the presence of at least one pragmatic or management marker.

Wick[31] did a study on MNM and NNM cases in four public hospitals in the Middle East in Lebanon. Any newborn with extreme morbidity (weight less than 1.5 kg, gestational age at birth less than 31 weeks, and Apgar less than or equal to five minutes) who survived the condition within the first seven days of life was referred to as an NNM. Four cases of MNM and seventeen cases of NNM were found out of a total of 1178 newborns. Santos et al.[15] presented a comprehensive study in 2015 that suggested combining the three pragmatic criteria with the clinical management criteria for identifying NNM cases. Four studies, which were also covered above, served as the foundation for these recommendations.[5,7,11] It was also emphasized how important it is to standardize both the NNM concept and the standards used to evaluate its applicability at various levels.

In the same sense, a narrative study conducted in India by Surve et al.[32] showed the rate of NNM varies from 21 to 72% in the different studies analyzed, due to the divergence of criteria used. This study recommended the inclusion of additional management criteria, and congenital malformations.

Santos et al.[15] presented a comprehensive study in 2015 that suggested combining the three pragmatic criteria with the clinical management criteria for identifying NNM cases. Four studies, which were also covered above, served as the foundation for these recommendations.[5,7,11] It was also emphasized how important it is to standardize both the NNM concept and the standards used to evaluate its applicability at various levels.

A table with information from the 17 studies that were examined was put up to compare the evaluated factors with the related indicators of newborn mortality rate, NNM rate, and (Table II). Studies that employed longer neonatal periods (up to 28 days) and research that mixed pragmatic and management criteria generally had greater rates of newborn near misses, whereas studies that used more thorough criteria for detecting neonatal near misses had lower neonatal mortality indices.

Discussion

The definition of the NNM concept still poses a problem regarding the elements to be taken into consideration, there are no common recognition criteria at the international level. Indeed, most of the studies carried out so far have been based on the fundamental work of Pileggi et al.[5,7] NNM has been defined as newborns who suffer a life-threatening complication after birth and survive the first 28 days of life.[2,5,9,11,16,18-21,27,30] However, other definitions have used a shorter period of 7 days.[6-8,31] There is also disagreement on the most appropriate markers of complication severity that identify and evaluate NNM cases.

To determine if a newborn was a case of NNM, the researchers evaluated a number of characteristics. These requirements include "pragmatic markers" with discrepancies, like low birth weight (1500 g or 1750 g), low gestational age at birth (30, 31, 32, or 33 weeks), and an Apgar score of less than 5 or 7.[2,5,7,8,19-21,31] They are viewed as pragmatic since crucial information is widely accessible in medical literature and healthcare databases, and because the classification is simple to utilize for clinical and epidemiological purposes.[15] In addition to data accessibility, some studies have employed the criteria of preterm and perinatal asphyxia, the two main causes of neonatal death, to aid in the development of a practical definition of NNM. a pragmatic set of criteria that can be used in various socioeconomic circumstances and in the absence of applied care technologies to more accurately identify newborns with severe neonatal morbidity.

In a similar vein, CLAP recommends classifying newborns as NNM if they meet pragmatic and/or management criteria and have made it through the first 27 days of life. Even while each study's selection of criteria, like preterm and hypoxia, was identical, how these indicators were applied varied from study to study.

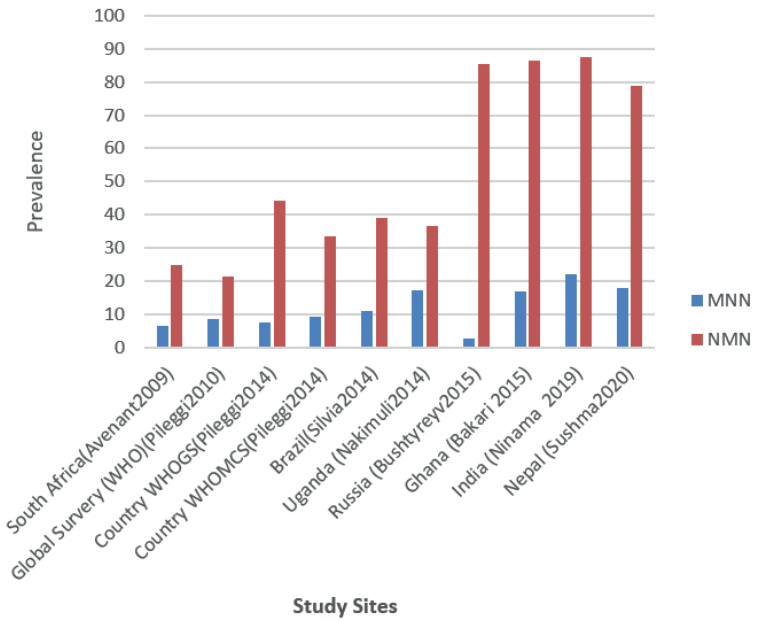

Fig. 2. Multi-country maternal and newborn health survey.

Indeed, some have used only pragmatic markers, others have combined them with management markers and few studies have proposed their own criteria for the classification of NNM cases.[10,17] Notwithstanding, we find that the combination of both pragmatic and managerial markers has generated a higher number of NNM cases.

While other researchers have used management criteria to develop the NNM concept, some investigators have expanded the pragmatic criterion to include mechanical ventilation and congenital malformations.[16,17] The latter criteria, which indicate the presence of the finest healthcare circumstances, maybe more significant for nations with low death rates and perform better than the pragmatic markers.[7,9,27,31] In contrast, research using information from Morocco, Burkina Faso, and Uganda classified a newborn as a case of NNM using clinical characteristics, organ system dysfunction, and management criteria is similar to how the WHO defines a case of NNM.[6,10,11]

The rate of NNM was found to be 2.6 to 10 times greater than the newborn death rate in all the studies that were examined (Fig. 2). Unfortunately, due to the significant differences in how the notion of NNM is operationalized, direct comparisons of NNM rates across studies were not feasible. This result supports the findings of Wondimu et al.[27] who argue that the various research adoption of different criteria caused the NNM magnitude to vary significantly. The majority of research is also retrospective, and some studies have only analyzed NNM instances in certain contexts, such as referral health facilities or tertiary levels, and under certain circumstances, such as obstetric complications, as predictors of NNM.[26-30]

In addition to pragmatic and/or management criteria for defining NNM, seven studies have described the association between maternal complications and the occurrence of NNM cases.[9,18-21,27,30]

After reviewing the literature, it seems useful to choose criteria for defining the NNM concept that is simple, practical, and easy to use in all healthcare institutions. Clinicians, managers, and other healthcare specialists should all be able to use these factors to make decisions. Regardless of the level of local infrastructure,

they must be stable in terms of severity and suitable to a range of contexts. It is recommended that, among the results now available, the pragmatic NNM criteria be applied whenever practical.

It is recommended to employ the three criteria (Apgar 7, birth weight 1750 g, and gestational age 33 weeks) that were found and covered by the largest WHO study for this purpose. All three criteria are among the crucial health indicators that are regularly gathered and can be calculated after the fact. In nations with higher resources, the combination of the three criteria plus the management criteria appears to be the optimum method for identifying NNM cases for a more thorough prospective examination.[11]

Investigating NNM, which shares many characteristics with neonatal mortality in developed nations like Australia where neonatal mortality is very low, will not only increase the number of cases that can be evaluated but is also of interest to providers because it may be less dangerous to them as it deals with survivors.[33] Given the similarities between NNM and neonatal deaths, applying the NNM concept appears to be a potential strategy for raising the standard of healthcare by exposing service gaps and offering a crucial chance to improve care delivery.

Our study contributes a pertinent contribution by focusing on the definition of NNM in light of various criteria and markers employed by various studies completed thus far, given that the concept is still new and up for debate.

The definition and standards for defining NNM appear to require universal agreement. No matter the local level, having straightforward, relevant criteria can raise the standard of newborn care everywhere.

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Ethical approval

The study protocol was approved by the Ethics Board of the Faculty of Medicine and Pharmacy, Mohammed University in Rabat, Morocco (Ethical Approval No: C64/20) delivered on February 24th, 2021.

Author contribution

The authors confirm contribution to the paper as follows: study conception and design: CK, BA, BF; data collection: CK, AF; analysis and interpretation of results: CK, LFZ, BF; draft manuscript preparation: CK, BA, AF, BF, LFZ.

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Conflict of interest

The authors declare that there is no conflict of interest.

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