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Causes and risk factors of neonatal mortality through the AMP-SR framework: a scoping review in Indonesia

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ABSTRACT

Neonatal mortality in Indonesia continues to increase, especially during the first 0–6 days of life, indicating persistent gaps in the quality of maternal and neonatal care. The maternal perinatal surveillance and response audit (AMP-SR) is implemented to identify causes of death and guide preventive and curative actions. This scoping review aims to explore the causes and risk factors of neonatal mortality using the AMP-SR framework. Article searches were conducted in Google Scholar, Garuda, and PubMed using the keywords (“Neonatal Death” OR “Cause of Death” OR “Kematian Neonatal”) AND (“AMP-SR” OR “Death Notification”). Inclusion criteria comprised primary studies published in Indonesian or English between 2021 and 2025 that examined neonatal deaths using the AMP-SR approach. Seventeen articles were selected and thematically analyzed following the PRISMA guidelines. The main causes of neonatal death were clinical conditions, including asphyxia, prematurity, sepsis, hypothermia, and congenital abnormalities. Identified risk factors encompassed maternal age, pregnancy complications, referral delays, inadequate quality of care, and limited health worker competence. Most neonatal deaths occurred within the first 72 hours of life, predominantly among male infants with low birth weight or gestational age under 37 weeks. These findings demonstrate that neonatal mortality results from interconnected medical, maternal, and health system factors that can be systematically identified through AMP-SR. From a policy and practice perspective, strengthening the routine use of AMP-SR findings to inform targeted quality improvement, referral system strengthening, and workforce capacity-building is essential to reduce preventable neonatal deaths in Indonesia.

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1. INTRODUCTION

Neonatal mortality continues to be a major public health challenge globally [1]–[3]. Worldwide, the infant mortality rate (IMR) was recorded at 2.4 million deaths, with approximately 47% or 1.1 million deaths occurring during the neonatal period (0–28 days of life) [4]. Between 2021 and 2023, the global neonatal mortality rate (NMR) ranged from 17.9% to 17.26%, with the highest rates in Sub-Saharan Africa (27.6–26.7%), followed by Southeast Asia (12.3–11.8%), including countries such as Indonesia [5]. In Indonesia, data from the maternal perinatal death notification (MPDN) system showed a 1.43% increase in infant mortality in 2023 (29,945 deaths) compared to 2022 (20,882 deaths). The majority of these deaths occurred during the neonatal period (18,281 cases), with 75.5% happening within the first 0–7 days and 24.5%

between 8–28 days [6]. In Central Java Province, the NMR rose significantly in 2023 to 7.35 per 1,000 live births, an increase of 51.23% from the previous year [7]. Demak Regency also experienced a spike in neonatal mortality, reaching 6.4 per 1,000 live births (64%) in 2024, up from 3.2 (32%) in 2023 and 2.4 (24%) in 2022. Most neonatal deaths occurred within the first 0–6 days of life (68%), highlighting the high vulnerability during the early neonatal period [8].

IMR and NMR are key indicators in achieving the Sustainable Development Goals (SDGs) [9]. The World Health Organization (WHO) has set a target for 2030: reducing the NMR to 12 per 1,000 live births and the IMR to 25 per 1,000 live births [10]. Neonatal health serves as a critical indicator of public health status and requires serious attention. The high rates of IMR and NMR remain a significant challenge; therefore, improving the equity and quality of health services, particularly for pregnant women and newborns, is a top priority in national health development [11], [12]. The rise in neonatal mortality has drawn more focus to implementing maternal perinatal surveillance and response (AMP-SR), specifically in hospitals [13], [14]. Addressing neonatal mortality issues requires an in-depth analysis through AMP-SR [15]. This program enables the identification of the causes of neonatal death as an initial step to prevent similar cases. The development of clinical audit instruments supports the analysis of the causes of neonatal death [16].

The implementation of AMP-SR represents a strategic advancement in systematically documenting, assessing, and analyzing every maternal and neonatal death—both at the health facility level and within the community [17]. AMP-SR provides unique, context-specific, and data-driven insights into the underlying medical causes, delays in care, and social determinants contributing to neonatal mortality [18]. This structured surveillance system is essential for improving health services, informing policy reforms, and ultimately reducing preventable deaths in Indonesia [19], [20]. The analysis of neonatal death causes identifies and categorizes contributing factors into socioeconomic factors (maternal employment, wealth status), maternal factors (maternal age, parity, birth spacing, complications during delivery), infant factors (low birth weight or LBW), and health service factors (antenatal care/ANC and birth attendants), with LBW being the most influential variable in neonatal mortality in Indonesia [21]–[27].

Key risk factors for perinatal and neonatal mortality include maternal age, parity, and comorbidities, all of which showed statistical significance ($p = 0.00$), whereas education level was not significantly associated ($p = 0.750$). Premature pregnancy was also found to be associated with neonatal death. A study at a hospital in Denpasar identified low birth weight ($p = 0.01$; RP 2.02; 95% CI: 1.18–3.07), asphyxia ($p = 0.00$; RP 2.56; 95% CI: 1.7–3.85), and preterm gestational age ($p = 0.00$; RP 2.52; 95% CI: 1.68–3.89) as significant contributing factors, while congenital abnormalities and infections were not statistically significant ($p = 0.1$ and $p = 0.5$). Research in Pidie Jaya District found that low birth weight was the dominant factor, followed by low education, high-risk parity, comorbidities, asphyxia, and congenital abnormalities. Other studies highlighted maternal age and nutritional status as significant factors, whereas infant gender, income, and village classification showed no significant association. Inadequate antenatal care (ANC) and passive exposure to cigarette smoke were also linked to increased risk of low birth weight and neonatal mortality [28]. Moreover, limited utilization of maternal and newborn health services, such as ANC (90.9%), INC (79.4%), and PNC (68.9%), contributes to neonatal mortality [29].

Neonatal mortality in Indonesia remains persistently high, with the majority of deaths occurring within the first 72 hours of life. Despite the implementation of AMP-SR, preventable neonatal deaths continue to occur due to gaps in the identification of clinical causes, maternal risk factors, and weaknesses in health system performance. Existing evidence is scattered across different regions and study designs, resulting in a limited understanding of the dominant causes and risk patterns of neonatal mortality when viewed comprehensively through the AMP-SR framework. Therefore, a synthesized and systematic overview of neonatal mortality determinants is urgently needed to strengthen the evidence base for policy, service improvement, and targeted interventions.

Based on the aforementioned background, a systematic literature review using a scoping review approach is necessary to summarize the factors contributing to neonatal mortality based on AMP-SR data, serving as a foundation for health service policy formulation and intervention. This study aims to identify and explain the risk factors and causes of neonatal mortality based on the AMP-SR.

Despite the growing body of literature on neonatal mortality, existing studies remain fragmented, context-specific, and predominantly descriptive, often focusing on single facilities or provinces. To date, no comprehensive synthesis has systematically mapped the causes and risk factors of neonatal mortality specifically through the AMP-SR framework. This scoping review offers a novel contribution by integrating evidence from diverse settings to examine neonatal mortality not merely as a clinical outcome, but as a multidimensional phenomenon shaped by maternal, neonatal, and health system determinants within an audit-based surveillance–response approach. By positioning AMP-SR as an analytical lens rather than a reporting tool, this study advances existing knowledge and provides a more actionable understanding of preventable neonatal deaths.

2. METHOD

2.1. Study design

This study employed a scoping review design to systematically map and synthesize existing evidence on the causes and risk factors of neonatal mortality within the AMP-SR framework. A scoping review approach was selected because the available literature is heterogeneous in terms of study design, population characteristics, and outcome measurements. Moreover, this design is particularly suitable for exploring broad research questions, identifying key concepts, mapping evidence gaps, and clarifying how neonatal mortality has been analyzed through the AMP-SR lens. By adopting this approach, the study aims to provide a comprehensive overview rather than a narrow quantitative synthesis [30].

Scoping reviews are especially appropriate when examining emerging or context-specific frameworks such as AMP-SR, where methodological diversity is common, and evidence is distributed across different regions and healthcare settings. Unlike systematic reviews that typically focus on narrowly defined clinical questions, this study seeks to explore how neonatal mortality determinants are conceptualized, categorized, and interpreted within an audit-based surveillance system. Therefore, the scoping methodology enables the integration of clinical, maternal, and health system perspectives into a unified analytical framework. This approach strengthens the study's objective to reposition AMP-SR not only as a reporting mechanism but also as a strategic analytical tool.

2.2. Framework and reporting standard

The review was conducted following the methodological framework in the study by Westphaln *et al.* [30] proposed by Arksey and O'Malley and further refined by Tricco *et al.* [31] reporting adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR).

2.3. Search strategy

A systematic literature search was conducted in three electronic databases: PubMed, Google Scholar, and Garuda. The search strategy was adapted to each database using a combination of Medical Subject Headings (MeSH) and free-text terms. The core search string used in PubMed was: ("neonatal mortality" OR "neonatal death") AND ("Maternal Perinatal Audit" OR "Surveillance Response" OR "AMP-SR"). Equivalent Boolean operators and keywords were modified to suit the syntax requirements of Google Scholar and Garuda. Manual searching of reference lists was also performed to identify additional relevant studies.

2.4. Time frame justification

Studies published between 2021 and 2025 were included to capture the most recent evidence reflecting current neonatal care practices and the evolving implementation of the AMP-SR framework in Indonesia and comparable settings.

2.5. Eligibility criteria

Eligibility criteria were defined using the population–concept–context (PCC) framework:

- Population: Neonates (0–28 days of life)
- Concept: Causes and risk factors of neonatal mortality assessed through AMP-SR or comparable maternal–perinatal audit systems
- Context: Hospital-based or population-based settings in Indonesia and comparable low- and middle-income countries

Inclusion criteria comprised peer-reviewed original research articles published in English or Indonesian. Exclusion criteria included editorials, commentaries, conference abstracts, and studies lacking sufficient methodological detail.

2.6. Study selection

All identified records were screened in two stages: title–abstract screening and full-text review. Screening was conducted independently by two reviewers. Discrepancies were resolved through discussion until consensus was reached.

2.7. Data extraction

Data were extracted using a standardized extraction form capturing author, year, country, study design, sample characteristics, causes of neonatal mortality, identified risk factors, and key findings.

2.8. Quality appraisal

Although scoping reviews do not typically exclude studies based on quality, an appraisal was conducted to assess the methodological rigor of included studies. The Joanna Briggs Institute (JBI) critical appraisal checklist was used, and results were summarized narratively to inform the interpretation of findings.

2.9. Data synthesis

Extracted data were synthesized using thematic analysis. Causes and risk factors were grouped into clinical, maternal, and health system–related themes. Thematic coding was conducted iteratively, and patterns and contradictions across studies were identified and analyzed narratively.

Ethical approval was not required because this study synthesized data from previously published literature. The study selection process is summarized in Figure 1, which presents the PRISMA-ScR flow diagram outlining the identification, screening, eligibility assessment, and final inclusion of studies, including the number of records retrieved, screened, excluded, and included in the analysis.

As shown in Figure 1, 1,253 records were initially identified from Scopus, PubMed, and Web of Science. After duplicate removal, 1,013 records were screened, 177 full-text articles were assessed for eligibility, and 17 studies met the inclusion criteria for final synthesis, ensuring a transparent and rigorous selection process.

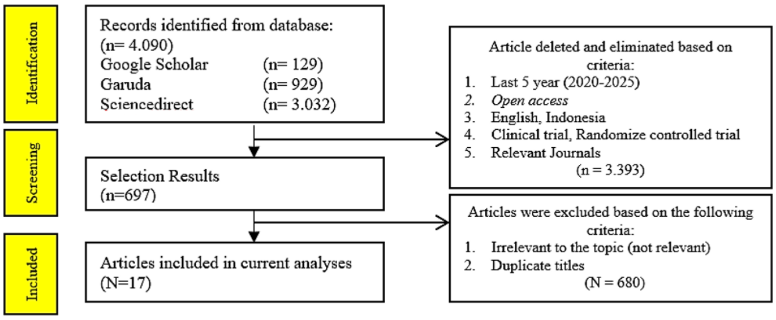

Figure 1. PRISMA flowchart

3. RESULTS AND DISCUSSION

The review identified 17 eligible studies and produced a comprehensive synthesis of neonatal mortality determinants. Findings show that the predominant causes of neonatal death are clinical conditions—particularly asphyxia, low birth weight, prematurity, and sepsis—while key risk factors include high-risk maternal age, pregnancy complications, poor recognition of neonatal danger signs, and suboptimal health service quality. This study provides new value by integrating national and international evidence into a single analytical framework grounded in AMP-SR. Unlike previous fragmented studies, this review clearly demonstrates how medical, maternal, and systemic factors interact to produce preventable neonatal deaths. The study also offers novel insight into gaps in AMP-SR implementation, such as weak referral systems, inconsistent case analysis, and limited use of audit findings in policy action. These results collectively strengthen the evidence base for improving AMP-SR and developing targeted strategies to reduce neonatal mortality in Indonesia.

The general characteristics of the included studies are summarized in Table 1 (see Appendix) [32]-[48]. This table presents key information for each study, including the authors, year of publication, country or study setting, study design, sample characteristics, and main findings related to neonatal mortality. By organizing these core attributes systematically, Table 1 provides an overview of the methodological diversity and geographical distribution of the selected studies.

The identified causes and risk factors of neonatal mortality, categorized within the AMP-SR framework, are presented in Table 2. This table synthesizes the findings of the included studies by grouping determinants into relevant domains, such as maternal factors, neonatal factors, and health system–related factors. Through this structured categorization, Table 2 clarifies how various risk factors are interconnected and how they align with the surveillance–response approach.

Findings from this study indicate that the main causes of neonatal mortality are primarily related to clinical neonatal conditions, with the most dominant being neonatal asphyxia, low birth weight (LBW), prematurity, and infection/sepsis. Risk factors for neonatal death include maternal health and pregnancy conditions, as well as healthcare service factors. Maternal factors include extreme maternal age (<25 or >35 years), high parity, low education level, pregnancy complications, and the use of contraceptive methods. In addition, premature rupture of membranes (PROM) at term gestational age also increases the risk of asphyxia and mortality. Healthcare service-related risk factors include unsafe delivery settings, delayed recognition of danger signs, suboptimal referral systems, and inadequate quality of antenatal and perinatal care.

Table 2. Matrix synthesis thematic

No.	Main causes	Risk factors	
	Clinical neonatal conditions	Maternal and pregnancy factors	Healthcare service factors
1.	Asphyxia [35], [48]	Maternal age <25 or >35 years [33], [41]	Place of delivery (home vs. health facility)
2.	Low birth weight (LBW) [42], [45]	High parity [41]	Delay in recognizing danger signs [33]
3.	Prematurity [45]	Infant caregiver (who cares for the baby)	Inadequate referral system [42]
4.	Sepsis, infection [47], [48]	Low education [41]	Quality of antenatal/perinatal care [45], [46]
5.	Antibiotic-resistant *Klebsiella pneumoniae* infection [47]	Pregnancy complications [42]	Kangaroo mother care (KMC) [46]
6.	Hypothermia	Premature rupture of membranes (PROM) at term gestation [35]	The caesarean section method was more protective against asphyxia and neonatal death
7.	Congenital anomalies [48]		

3.1. Discussion

This study adds three key contributions to the literature. First, it synthesizes neonatal mortality evidence explicitly within the AMP-SR framework, highlighting how audit-based surveillance can reveal preventable pathways of death beyond isolated clinical causes. Second, it maps the relative prominence and contextual variation of clinical, maternal, and system-related risk factors across multiple regions, identifying patterns often overlooked in single-site studies. Third, it translates audit findings into policy-relevant insights, offering a structured basis for operationalizing AMP-SR data to strengthen referral systems, antenatal care, and targeted neonatal interventions in Indonesia.

Unlike previous reviews that primarily catalog causes of neonatal mortality, this scoping review demonstrates how the AMP-SR framework enables a more integrative interpretation of neonatal deaths as outcomes of intersecting clinical and systemic failures. The findings suggest that preventable neonatal mortality is not solely driven by biological vulnerability but is strongly mediated by delays in referral, suboptimal antenatal care, and uneven health system capacity. This reinforces the strategic value of AMP-SR as a decision-support mechanism for prioritizing interventions at both facility and policy levels. The analysis of the findings from 17 reviewed articles revealed various causes of neonatal death as examined through the AMP-SR program. The analysis and discussion of these findings are presented as follows:

3.1.1. Characteristics of neonatal death

Neonatal mortality remains a significant public health issue in both Indonesia and globally, with varying characteristics influenced by biological, social, and healthcare service factors. A common characteristic of neonatal deaths is their occurrence during the early neonatal period (0–7 days). Several studies, such as those by Rukmono *et al.* [32] and Utami *et al.* [37], reported that the majority of deaths occur within the first 72 hours of life, which is the most critical period for newborn survival [49]. Demographic characteristics also show that male infants are more likely to die (60.5%), likely due to hormonal and physiological differences that increase their vulnerability [35]. Other key characteristics include low birth weight (LBW), prematurity, and neonatal asphyxia. Infants born weighing under 2,500 grams or at less than 37 weeks of gestational age are highly susceptible to complications such as asphyxia, hypothermia, hypoglycemia, and infection. A study by Ihsani and Hendrati [39] in East Java reported that preterm infants have a two to three times higher likelihood of death compared to full-term infants.

An analysis of neonatal deaths in Indonesia from 2019–2020 showed that Central Java Province had the highest neonatal mortality rate, with West Java and Central Java also recording the highest prevalence of low-birth-weight cases. Surrounding provinces with high risk also showed similar trends, suggesting the presence of spatial clusters. Spatial analysis using Moran's I and Geary’s C methods confirmed a positive spatial autocorrelation in Central Java, East Java, and West Java, indicating that neonatal deaths are not randomly distributed but rather clustered. These patterns are believed to be influenced by geographic factors, availability of healthcare services, and socioeconomic conditions [50].

Based on this discussion, it can be concluded that neonatal deaths typically occur within the first 72 hours of life and more frequently affect male infants, preterm infants, and those with low birth weight. The early neonatal period is thus a critical focus for neonatal death prevention efforts in Indonesia. The spatial distribution of neonatal deaths shows clustered patterns, particularly in Central Java, East Java, and West Java. This highlights the need for spatially targeted interventions and risk mapping. These findings support the necessity for neonatal healthcare policies that focus on the critical early neonatal period, improve services for high-risk infants, and implement spatial interventions in high-prevalence regions. Adaptive policy responses are essential to reduce neonatal mortality nationwide.

3.1.2. Main causes of neonatal death (neonatal clinical conditions)

The main causes of neonatal death are clinical conditions, including asphyxia, prematurity, infection/sepsis, hypothermia, and congenital anomalies. The most frequent cause of neonatal death is respiratory distress [28]. A study by Rukmono *et al.* [32] revealed that asphyxia is significantly associated with neonatal death (p 0.027 < 0.05), as affected infants experience respiratory distress that limits oxygen supply to the brain and vital organs during or immediately after birth. Another study reported that neonatal deaths and the majority of stillbirths were caused by asphyxia/hypoxia (53%), neonatal deaths by sepsis (60%), and under-five deaths by malnutrition (75%) and infections [48]. Asphyxia increases the risk of death by 15.47 times, low birth weight (LBW) infants are 8.2 times more likely to die, sepsis triples the risk of neonatal death, and preterm birth increases the risk fivefold (p 0.0001; RR 5.00; 95% CI: 2.15–11.59).30 However, another study reported that asphyxia was not significantly associated with neonatal death (p 0.309) [42].

Utami *et al.* [37] in a study at Praya General Hospital, Central Lombok, found a neonatal mortality prevalence of 21.9%, with causes including sepsis/infection (36.07%), hypothermia (28.77%), asphyxia (19.18%), and prematurity (15.98%). Verani *et al.* [47] stated that neonatal sepsis is a significant cause of death. K. pneumoniae infection was more common in health facility deaths (22%) compared to community deaths (14%). The most common clinical syndromes were sepsis (44%), sepsis with pneumonia (19%), and pneumonia alone (16%). Neonatal sepsis is linked to unsterile delivery environments, lack of maternal infection screening, delayed diagnosis, and antibiotic resistance, especially to K. Pneumoniae [47]. Early-onset neonatal sepsis (EOS) had an incidence rate of 9.6%, with 8% caused by gram-negative bacteria (90.4%). Sepsis is a direct cause of neonatal death as identified by the AMP-SR program [51].

Astria and Windasari [38] found that neonatal death was associated with asphyxia (p 0.0001; RR 15.47; 95% CI: 5.93–40.39), preterm gestational age (p 0.0001; RR 5.00; 95% CI: 2.15-11.59), LBW (p 0.0001; RR 8.20; 95% CI: 3.39–19.79), and neonatal sepsis (p 0.005; RR 3.23; 95% CI: 1.42-7.33). In Serang District, causes of neonatal death were LBW (46%), asphyxia (27.9%), congenital anomalies (11.6%), other causes (11.6%), neonatal tetanus (1.4%), and sepsis (1.4%). LBW was also significantly associated with neonatal death (p = 0.005) [42]. Fetal characteristics associated with neonatal death include male sex, short birth interval (<24 months), and small size. Prematurity contributes to underdeveloped organs, especially the lungs and immune system, increasing the risk of respiratory failure, sepsis, and temperature regulation issues [52]. Other studies found no significant association between LBW and neonatal death, but trends still pointed toward LBW as a contributing cause.

In conclusion, neonatal clinical factors such as asphyxia, prematurity, LBW, and sepsis are the leading direct causes of neonatal death. Particular attention should be paid to sepsis and antibiotic-resistant infections like K. pneumoniae. Although not all studies show statistically significant associations, the overall pattern supports the importance of addressing neonatal clinical conditions as the primary focus in efforts to reduce neonatal mortality in Indonesia. These findings underscore the need to improve early detection and management of neonatal complications, strengthen NICU capacity, and implement strict infection control protocols in all neonatal care facilities across the country.

3.1.3. Risk factors for neonatal mortality

– Maternal and pregnancy-related factors

Maternal characteristics associated with neonatal death include maternal age (p-value = 0.024) and parity (p-value 0.002). However, there were no significant associations found for maternal education level (p-value 0.226) or gestational age (p-value 0.108) [41]. Mothers at risk (<25 years or >35 years) had a 3.496 times higher likelihood of neonatal mortality compared to those in the safe age range (25-35 years) (p-value 0.006; OR 3.496; 95% CI: 1.438–8.498) [53]. Another study indicated that mothers aged <20 or >35 were 2.8 times more likely to experience neonatal death (p 0.048; OR 2.8), and low education levels also increased the risk (p 0.000; OR 0.4). High parity also increased the risk, albeit modestly (p 0.049; OR 1.2). Moreover, delivery attended by non-health workers carried a significantly higher risk-up to 8.6 times-if assistance was inadequate (p 0.000; OR 8.6). Deliveries that occurred outside health facilities also had a fourfold increased risk (p 0.025; OR 4.00) [54].

Regarding gestational age, a study found a significant association with neonatal mortality (p 0.002), while parity was not significantly related (p 0.583) [42]. This is supported by another study showing that parity did not significantly correlate with neonatal death (p 0.551; RR = 1.28; 95% CI: 0.58–2.84). Other maternal characteristics, such as post-term gestation and multiparity, were found to trend with increased neonatal mortality. Additionally, maternal age <20 or >35 years and a history of pregnancy complications were associated with higher neonatal mortality. Early neonatal death was also associated with lack of contraceptive use, even after controlling for confounding variables such as gestational age, pregnancy interval, MUAC, hemoglobin levels, and ethnicity, with p-value = 0.0001; OR = 11.4; 95% CI: 4.5–29.5. Mothers not using contraception had 11.4 times higher risk of early neonatal death. These findings emphasize the importance of community health workers in promoting family planning participation among couples of reproductive age as a strategy for preventing early neonatal mortality [55].

Maternal healthcare service indicators include ANC (K4) coverage at 92%, skilled birth attendance at 99.4%, institutional delivery coverage at 89.3%, full neonatal visit coverage at 99.6%, and early initiation of breastfeeding (EIBF) at 77.5%.32. Mothers who did not complete ANC visits may fail to detect maternal or fetal complications early, contributing to delays in recognizing danger signs. Delays in recognizing danger signs were significantly associated with neonatal death (OR = 3.150; p-value = 0.011 < 0.05; 95% CI: 1.306–7.600), with neonates of such mothers having 3.150 times higher risk of dying. Another study found no significant association between ANC and neonatal death, but the variable still showed a relevant trend.

Obstetric complications such as premature rupture of membranes (PROM) at term increased the risk for neonatal asphyxia (OR = 1.13; 95% CI), early neonatal death (OR = 1.34; 95% CI), and clinical chorioamnionitis (OR = 4.03; 95% CI) compared to gestational ages of 34–36 weeks. However, no statistically significant difference was found between gestational age and early neonatal death (p = 0.70). Clinical chorioamnionitis incidence was higher in term pregnancies and was associated with additional risk factors such as infection and hepatitis B [35]. Infected mothers are also at risk of vertical transmission of diseases like HIV, hepatitis, and syphilis, which increase neonatal morbidity and mortality through infections and sepsis [56]. Pregnancy complications also increased the risk of preterm birth (aOR = 0.92; 95% CI: 0.53–1.60), small-for-gestational-age births (aOR = 1.19; 95% CI: 0.62–2.26), low 5-minute Apgar scores (aOR = 2.57; 95% CI: 0.93–7.15), and major congenital anomalies (aOR = 0.93; 95% CI: 0.48–1.83) [57]. However, another study found no significant association between pregnancy complications and neonatal death (p = 0.487) [42].

In conclusion, maternal factors such as extreme maternal age (<20 and >35 years), pregnancy complications (e.g., PROM, infection), inadequate infant care, and lack of contraceptive use significantly increase the risk of neonatal mortality. Although ANC coverage is high, delayed recognition of danger signs remains a critical issue. These findings support national policy recommendations to strengthen maternal support systems through community health workers, educate mothers on pregnancy and neonatal danger signs, and improve the quality of antenatal care and family planning services. Programs like *Posyandu*, *PONED*, *PONEK*, and AMP-SR should be synergized with strengthened risk communication and intensive monitoring of high-risk pregnancies to sustainably reduce neonatal mortality.

– Health service factors

Research findings indicate that the quality of prenatal, intrapartum, and delivery care plays a crucial role in preventing avoidable neonatal deaths. Medical services were significantly associated with infant death prevention only through the collaborative effort on the infant mortality (ICE) method [45]. Health system and service factors are closely linked to the birth attendant and place of delivery. Deliveries outside health facilities were found to increase the risk of neonatal death by up to four times (p = 0.025; OR = 4.0). Thus, education-based interventions, improved access to facility-based deliveries, and stronger postnatal care support are essential for reducing neonatal mortality. Moreover, the place of delivery is a strong predictor of neonatal death (p-value < 0.001). Referral systems are also a major contributor to neonatal deaths (p = 0.005), particularly due to referral delays, which often result in babies arriving in critical condition. However, the mode of delivery was not significantly associated with neonatal death (p = 0.371) [42].

That said, among early preterm groups, mode of delivery was significantly associated (p < 0.05) with outcomes such as birth weight, Apgar score, and neonatal death. In late preterm groups, significant associations were found only with Apgar scores and neonatal mortality (p < 0.05), not birth weight. Cesarean section deliveries showed a significantly lower incidence of neonatal asphyxia and death in both groups compared to other delivery methods. Certain delivery practices, such as labor induction and cesarean section, have been linked with a rising trend in neonatal deaths. Despite relatively high service coverage, persistently high neonatal mortality rates suggest ongoing issues in service quality and in addressing maternal, neonatal, and systemic risk factors. Hence, improving the quality of maternal and neonatal health services—especially in the prevention of low birth weight (LBW) and timely asphyxia management—is imperative.

Service innovation also plays a role in reducing neonatal mortality. For instance, interventions like Kangaroo Mother Care (KMC) for premature and low birth weight infants have been identified as significant predictors of decreased neonatal deaths [46]. The development of neonatal health protocols is also crucial in preventing neonatal mortality [58]. However, implementation of the AMP-SR process faces challenges such as limited human resources, inadequate budgets, irregular calibration of medical equipment, and suboptimal use of the MPDN application [14]. Other contributing factors include a lack of health worker skills, particularly in managing high-risk deliveries and performing neonatal resuscitation, as well as the limited availability of healthcare services in remote or rural areas. These include shortages of incubators, antibiotics, or even stable electricity, and the prevalence of home births—especially in regions with strong traditional beliefs or limited access—further exacerbates neonatal mortality [59].

In conclusion, the health system factors—such as place of delivery, referral systems, delivery methods, and the quality of prenatal and neonatal care—significantly contribute to neonatal mortality. Interventions such as KMC and health worker capacity-building have proven effective in reducing neonatal deaths, particularly in high-risk populations. These findings underscore the urgent need to strengthen the national neonatal care system by mandating facility-based deliveries, especially in underdeveloped regions. Policy makers play a vital role through the AMP-SR in reducing maternal and neonatal mortality. Real-time, tech-based referral systems for high-risk mothers and neonates, enhanced training in neonatal resuscitation and high-risk care, national implementation of KMC, and integrated neonatal protocols, along with sustained funding for both basic and advanced neonatal care at community health centers and hospitals, are essential steps forward.

3.1.4. Strategies for preventing neonatal and perinatal deaths

Based on the review findings, the prevention of neonatal deaths requires a multi-level approach, including individual, family, community, and healthcare system levels.

– Improving the quality of health services

One of the key strategies in preventing neonatal mortality is enhancing the quality of health services. Improving both the coverage and quality of Antenatal Care (ANC)—with at least four visits and a focus on early detection of complications—has been proven to reduce mortality rates [12]. Effective services must be supported by collaboration between health offices, healthcare facilities, and midwives in providing maternal and newborn care, with quality improvement aligned with regulations and an improved integrated referral system to reduce the trend of neonatal deaths.

Efforts must also include strengthening maternal and child health services through early detection of high-risk pregnancies via antenatal care, and establishing structured, hierarchical, regional, and integrated perinatal networks [45]. Additionally, health worker skills—particularly midwives—need further development, particularly in areas such as the mHealth in Midwifery Continuity of Care (MCOC) model, which includes early risk detection and appropriate treatment management [60].

– Strengthening health systems and referral networks

An effective and integrated healthcare system is essential in preventing neonatal deaths. Information systems for recording and notifying births and deaths are critical to these prevention efforts [61]. A digital and integrative referral system, such as the monitoring perinatal death notification (MPDN) system, enables rapid reporting and early intervention. While death notifications through the AMP-SR program have been implemented fairly well, improvements are still needed to optimize case reporting and utilization of the findings in the AMP-SR process [62]. Regular audits of perinatal and neonatal deaths at healthcare facilities are needed to evaluate causes and guide preventive actions [19]. Increasing the number of program implementers and providing comprehensive training materials can enhance the capacity and effectiveness of AMP-SR implementation [17].

AMP-SR offers hope in reducing neonatal mortality by providing early prevention and developing recommendations to avoid repeated deaths [14]. Additional public health efforts must include strengthening human resources, pharmaceutical availability, production and distribution systems, maternal and child health program implementation, and community empowerment [63]. Service system innovations include digital notification systems for birth and neonatal death. These systems have been shown to independently record over half of notifications and help prevent neonatal mortality [18], [61]. Innovative strategies for comparing prevalence and risks of stillbirth and neonatal death—particularly among small for gestational age (SGA) infants—are crucial for risk mitigation [58]. Additionally, addressing infection-related deaths requires more effective and timely detection and treatment strategies. The development and use of a K. pneumoniae vaccine could have a major global impact in reducing infant and child mortality [47].

– Empowerment through communication, information, and education (CIE)

Community empowerment through education and information is key to preventing neonatal death, especially among mothers with health problems [33], [53]. This includes raising awareness among mothers and families regarding danger signs in pregnancy and neonates, the importance of immunization, and the benefits of home visits by health workers [48]. Community-based information dissemination through revitalized *Posyandu* and health cadres is critical to supporting the family planning (FP) program and reducing early neonatal deaths. Education is also needed for birth attendants and on choosing safe places for delivery, both of which are vital in neonatal death prevention.

– Specific interventions

Specific interventions for neonatal mortality prevention include the integration of Kangaroo Mother Care (KMC) into the healthcare system. This intervention provides important insights for policymakers in developing effective implementation and scale-up strategies and serves as a foundation for future newborn care programs [46].

In conclusion, neonatal death prevention strategies focus on improving ANC and perinatal services through training health workers, strengthening information systems and referral networks, and implementing AMP-SR. Digital innovations and community empowerment through CIE also play key roles in increasing awareness of pregnancy risks, supported by active roles from health cadres, *Posyandu*, and families. KMC has proven effective for low birth weight and premature infants. Policy direction should emphasize standardized service quality, technology-based referral reform, expansion of AMP-SR, integration of CIE with FP and ANC programs, and institutionalization of KMC in healthcare service SOPs.

4. CONCLUSION

This scoping review provides a comprehensive synthesis of the causes and risk factors of neonatal mortality in Indonesia using the Maternal Perinatal Surveillance and Response (AMP-SR) framework as an analytical lens. By integrating evidence from 17 studies across diverse settings, this study demonstrates that neonatal mortality is driven by interconnected clinical, maternal, and health system factors that can be systematically identified through audit-based surveillance. The main contribution of this study lies in repositioning AMP-SR not merely as a reporting mechanism, but as a strategic tool for understanding preventable pathways of neonatal death.

Neonatal mortality in Indonesia remains a serious health system challenge, particularly during the early neonatal period (0–7 days), with the highest risk occurring within the first 72 hours of life. Deaths predominantly affect male infants, low birth weight (LBW) and preterm neonates, with leading causes including asphyxia, sepsis, hypothermia, prematurity, and congenital anomalies. Key risk factors include high-risk maternal age (<20 or >35 years), pregnancy complications, low educational attainment, suboptimal antenatal care, delayed recognition of danger signs, and weaknesses in referral and service delivery systems.

In the long term, the findings of this review contribute to strengthening the evidence base for institutionalizing AMP-SR as a core component of neonatal health governance in Indonesia. By systematically mapping preventable risk patterns, this study supports the use of AMP-SR data to guide continuous quality improvement, inform targeted policy interventions, and enhance accountability within maternal and neonatal health services. Ultimately, the integration of evidence-based AMP-SR findings into routine practice has the potential to sustainably reduce preventable neonatal deaths and accelerate progress toward national and global child survival targets.

A multisectoral and sustained approach is urgently needed—one that includes strengthening family planning programs, maternal education, improving the quality of ANC and neonatal services, and implementing systematic audits such as the Maternal and Perinatal Death Surveillance and Response (MPDSR/AMP-SR)—to significantly reduce neonatal mortality in Indonesia.

5. LIMITATION

This scoping review has several limitations. First, the analysis was restricted to peer-reviewed studies published between 2021 and 2025 and indexed in PubMed, Google Scholar, and Garuda; therefore, unpublished reports and grey literature related to routine AMP-SR implementation may not be fully captured. Second, the included studies were predominantly observational and descriptive, with substantial heterogeneity in study design, data sources, and outcome reporting, which limits causal inference and comparability across studies. Third, not all studies explicitly applied the complete AMP-SR surveillance–response cycle, resulting in limited evidence on follow-up actions and policy responses. Finally, most evidence was derived from facility-based settings, potentially underrepresenting neonatal deaths occurring in community or home-birth contexts.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
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Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
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Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [SN], upon reasonable request.

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APPENDIX

Table 1. Data extraction

No	Author & title	Research design	Cause	Factor risk
1.	Rukmono *et al.* [32], Hubungan Asfiksia dan Kematian Neonatal di RSUD Dr. H. Abdoel Moeloek Bandar Lampung.	Type study quantitative with a cross-sectional method using a total sampling of 549 neonates at Abdul Moeloek Regional Hospital in 2020. Secondary data in the form of medical records. *Chi-Square* data analysis.	Neonatal asphyxia (p 0.027)	· Preeclampsia · Weight (LBW, LBW) · Age gestation (<36 weeks />36 weeks) · Age neonates (<1 day / <7 days)
2.	Paunno & Siahaya [33], The effect of pregnancy and childbirth care on the incidence of neonatal death	Study an observational with approach quantitative use design *case-control*. Calculation size sample *case-control* done without *matching*, with a proportion case: control (1:1). Total sample of 86 people. Sampling with *non-probability sampling*, *quota sampling*. Analysis *Chi-Square*.	Asphyxia (respiratory failure)	Factor age mothers <25 or >35 years (p 0.018; OR 3.496). Maintenance pregnancy (p 0.009; OR 0.374) Late recognition of neonatal danger signs (p 0.011; OR 0.315)
3.	Nugraha and Anggraini [34], Metode persalinan dan luaran neonatus pada kehamilan premature	A retrospective cohort study was conducted at Dr. Moewardi Surakarta Regional Hospital, with a total sample size of 484 cases, divided into *early preterm* and *late preterm* from 2019 to 2021. Analysis of bivariate Chi-square and Kruskal-Wallis.	Asphyxia (APGAR) Birth weight	Method of childbirth; non- sectional delivery, cesarean section during pregnancy, premature increase risk of asphyxia and neonatal death. SC prevents asphyxia and neonatal death.
4.	Yordian *et al.* [35], Analisis luaran PROM antara 34-36 minggu dan usia kehamilan cukup bulan	Study studies *cross-sectional* use simple *random sampling* technique. Subject study of 450 women diagnosed pregnant with PROM at 34-36 weeks and pregnancy term long during period January 2019 - December 2021. P<0.05 is considered significant in a statistical way.	· Asphyxia · Age gestation (preterm 34-36 weeks; term; >36 weeks).	Premature rupture of membrane (PROM) on aterm; high risk to asphyxia (OR = 1.13), neonatal death (OR = 1.34), and chorioamnionitis (OR = 4.03), but difference in premature neonatal death. No significant.
5.	Fajar *et al.* [36], Gambaran spasial kasus kematian neonatal di Sumatera Selatan	Study descriptive with secondary data from the South Sumatra Provincial Health Service report for 2019, consisting of variables case neonatal mortality and factors causes, and birth weight low birth weight (LBW) and *antenatal care*, aggregate data originate from 17 districts and cities. Spatial analysis using QGIS (*Geographic Information Systems*) with visualization maps and analysis correlation.	LBW as a reason for direct respiratory failure.	Low ANC coverage (K1-K4) <4x (no significant difference in statistics, but there is a trend as a risk of neonatal mortality)
6.	Utami *et al.* [37], Prevalensi kematian neonatal dengan BBLR di RSUD Praya Lombok Tengah	Study a quantitative analytic observational with design study cross sectional. Purposive sampling technique with a sample of 219 respondents. Data analyzed using the SPSS program.	LBW (causes sepsis)	· A baby with low birth weight died from sepsis. · More cases of LBW lots found in baby women The LBW category is classification most compared to very low birth weight (BBLSR) and extreme birth weight/low (BBLER).
7.	Astria and Windasari [38], Faktor yang berhubungan dengan kematian neonatus di RSUD Sanjiwani Gianyar	Study analysis with a cross-sectional design. Research data obtained from secondary data. Consecutive sampling technique with a sample of 104 neonates who met the inclusion and exclusion criteria. Data was analyzed using the chi-square test with p-value <0.05 with 95% confidence interval (CI)	· Asphyxia · Low birth weight · Preterm Sepsis	Factors associated with the risk of death in neonates include: · Asphyxia (p=0.0001; RP=15.47; 95% CI: 5.93–40.39) Age pregnancy *preterm* (p=0.0001; RP=5.00; 95% CI: 2.15–11.59) LBW (p=0.0001; RP=8.20; 95% CI: 3.39–19.79), Neonatal sepsis (p=0.005; RP=3.23; 95% CI: 1.42–7.33). Parity No show connection significant with death of neonates (p=0.551; RP=1.28; 95% CI: 0.58–2.84).
8.	Ihsani and Hendrati [39], Peta Distribusi kematian neonatal terhadap berat badan lahir rendah berdasarkan provinsi di Indonesia	Study descriptive analysis with design studies correlation. Data taken from 2019 and 2020 Indonesian Health Profiles used 34 provinces in Indonesia. Data processing used the Health Mapper application version 4.3.0.0 with product version 4.03 to analyze data descriptive research. This uses statistical tests, Spearman correlation, with the use of the IBM SPSS 21 application.	· Low birth weight	Factor risk from LBW as a reason for neonatal mortality: · Parity · Complication's pregnancy · Maternal health · Central Java has the highest number. Adjacent areas with provinces with high cases of LBW and neonatal mortality tend to have high cases of LBW and neonatal mortality.

Table 1. Data extraction (continued)

No	Author & title	Research design	Cause	Factor risk
9.	Kurniatillah *et al.* [40], Gambaran faktor risiko kematian neonatal di Kabupaten Serang	Study descriptive statistics with a quantitative method. Data collection was conducted in the month of February-April 2021. Data collection techniques: total sampling. The population in the study is all about neonatal mortality in the Regency area Attack. Samples taken are the total population, as many as 215 neonatal deaths. Analysis done through processed summary and review of available data based on findings/reports, Family Health Section of the District Health Office Attack 2020.	· Low birth weight (46%) · Asphyxia · (27.9%) · Abnormalities congenital (11.6%) · Neonatal tetanus, sepsis)	· Type sex that is man 60.5% and women 39.5% (organ maturity). · Health services; c health service coverage (K4) 92%, coverage helps delivery (99.4%), coverage delivery in health services (89.3%), coverage complete neonatal visits (99.6%), coverage initiation early breastfeeding (77.5%). · Maternal health factors
10.	Ekawati *et al.* [41], Analisis faktor risiko kematian neonatal berdasarkan data laporan kematian neonatal	Study quantitatively with design studies case control. Population of all neonatal deaths occurring in 2023. Instrument study using report data on neonatal mortality in Bogor City in 2023.	· Asphyxia · Infection	· Age mother (<20/>35 years) and parity mother (1/>4) in contact with significant neonatal mortality. · Education and age pregnancy No relate.
11.	Siswari *et al.* [42], Faktor-faktor yang berhubungan dengan kejadian kematian neonatal di ruang NICU RSUDP NTB	Type study: This is an observational analytic with a case-control design. Sample chosen with systematic random sampling technique with a comparison big sample control and case samples 1:1 totaling 49 cases. Chi-Square analysis.	· Low birth weight · Asphyxia	Age pregnancy (preterm), system referral, and LBW are significantly related. Parity, delivery, complications, pregnancy, and asphyxia. No relation.
12.	Rohaeti *et al.* [43], Analisis penyebab kematian neonatal di Kabupaten Lebak tahun 2019	Studies epidemiology analytically. Design case control study. Secondary data for the month of August-December 2020. A population study on neonatal death due to asphyxia and low birth weight in the Regency Lebak period, January – December 2019, with a sample of 255. Chi-square statistical test.	· Low birth weight · Asphyxia	Age mother (<20/>35 years), low education, parity (>3G), non- health worker assistant, and place of childbirth (non- health facility) related to neonatal deaths due to low birth weight and asphyxia.
13.	Yuliasih *et al.* [44], Trend determinan penyebab kematian bayi di Kabupaten Magetan tahun 2020–2022	Study descriptive with a retrospective approach. Population all over death baby 2020-2022 in the Regency Magetan. The sample consisted of 193. Data collection was carried out through secondary data that is the maternal neonatal death notification application. Analysis using statistics, simple distribution frequency.	· LBW · Asphyxia	Factor mother: · Age mother risky · Age preterm/ postterm pregnancy · Multiparous mother · Factor neonates; · Neonate early, neonate advanced · Birth weight low · Baby type sex Woman · Service · Labor induction Labor section secaria
14.	Dias *et al.* [45], Risk factors related to preventable infant mortality in Espirito Santo, Brazil	Data from infant mortality records recorded in the mortality information system. A total of 5,089 cases. A baby's death is classified as a death that can be prevented and one that cannot be prevented based on the method international collaborative effort on Infant Mortality (ICE) and *the* state system of Data Analysis Foundation (SEADE). Analysis of regression logistics.	· Asphyxia, severe, born prematurely.	· Factor risk related to quality care, before childbirth, and when labor's own role is important to the death of a baby who can be prevented (73% of deaths) according to ICE and 76% according to SEADE (state system of data analysis foundation) is categorized can prevented. · Medical services significant only on the ICE method. Factor risk: premature birth, heavy born 3,000–4,000 grams.
15.	Muhammad *et al.* [46], Scaling up kangaroo mother care through a facility delivery model in rural districts of Pakistan	Use a mixed-method design based on implementation science. This involves developing adaptive strategies for manager facilities and manpower health. Activities cover initial data collection, training on power health, intervention in the form of contact skin mother-baby, initiation of breastfeeding, as well as actions carried out post-discharge.	· Hypothermia	· Integration of KMC in service assists in the implementation and development strategies of newborn baby programs. · coverage target ≥80% · Indicator: number baby registered KMC, duration of KMC, breastfeeding exclusive, upgrade weight, and neonatal mortality; evaluation by the team data management for 18 months.

Table 1. Data extraction (continued)

No	Author & title	Research design	Cause	Factor risk
16.	Verani *et al.* [47], Child deaths caused by Klebsiella pneumoniae in sub-Saharan Africa and South Asia [34].	Study from CHAMPS data from seven countries in sub-Saharan Africa and South Asia (2016–2021) to identify reason death children under 5 years and stillbirths. Data collected through surveillance activities, including minimally invasive tissue samples, as well as microbiological, molecular, and pathological tests. The expert panel set the reason for death. The analysis also includes resistance to antibiotics, which only includes antibiotics tested on ≥30 isolates and excludes antibiotics that are not effective against Klebsiella spp.	Sepsis and pneumonia	- Resistance to ceftriaxone (84%) and gentamicin (75%). - Infection with *K. pneumoniae* contribute big on death of children <2 years.
17.	Madrid *et al.* [48], Causes of stillbirth and death among children <5 years in eastern Hararghe, Ethiopia	Post-mortem research based on the population. This was conducted in three regions in eastern Ethiopia (Kersa, Haramaya, and Harar) as part from CHAMPS network. System reporting death has improved in facilities, health, and the community. Ante-mortem data was collected, followed by verbal autopsy and taking post-mortem samples through minimally invasive tissue sampling in stillbirths (≥ 1000 grams or age pregnancy ≥28 weeks) and children aged <5 years who have been living in the study area for ≥6 months. Molecular, microbiology, and histopathology were conducted on samples, and expert panels set the reason classified deaths become primary, comorbid, and direct, separated for stillbirth, neonatal death (0–27 days), and death of children (28 days –<5 years).	Asphyxia, infection, abnormalities, default	- Asphyxia (53%) - Abnormalities neonatal congenital 21%; - Sepsis 60% - Children <5 years: 75% malnutrition - Infection dominant; 95% pathogenic *K. pneumoniae* and *S. pneumoniae*.

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