Early Detection Of Critical Congenital Heart Disease Through Pulse Oximetry Screening In Resource-Limited Settings

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Abstract.

Critical congenital heart disease (CCHD) is a major cause of neonatal mortality. Early detection using pulse oximetry (SpO_2) within 24–48 hours of life improves survival by identifying hypoxemia before clinical deterioration. A feasibility study in Yogyakarta, Indonesia, screened 1,452 newborns and detected eight CCHD cases (~6 per 1,000 live births), confirming its value in limited-resource settings. A full-term female neonate delivered by elective cesarean section had an initial SpO_2 of 96% but developed cyanosis within 24 hours, with saturation dropping to 90%. Abnormal SpO_2 results led to referral, and echocardiography confirmed critical pulmonary stenosis with PDA and PFO. Balloon valvuloplasty was performed successfully, normalizing oxygen levels. Pulse oximetry screening shows moderate sensitivity (76–83%) and high specificity (~99.9%) for detecting CCHD. Despite logistical and training challenges, it remains feasible and cost-effective in low- and middle-income settings. Integrating SpO_2 screening into routine newborn assessment, supported by national policy and staff training, can enhance early diagnosis and reduce neonatal deaths related to undetected CCHD.

Keywords: *Pulse oximetry; congenital heart disease; neonatal screening; pulmonary stenosis and early detection.*

I. INTRODUCTION

Critical congenital heart disease (CCHD) remains one of the most important causes of preventable neonatal morbidity and mortality worldwide.[1] When recognized early, these cardiac malformations can be treated effectively, leading to significant improvements in survival and quality of life. However, undiagnosed or late-diagnosed CCHD continues to contribute substantially to neonatal deaths, particularly in countries with limited diagnostic capacity.[2] CCHD includes a group of severe structural heart defects that cause life-threatening circulatory compromise within the first 28 days after birth. Globally, congenital heart disease (CHD) affects approximately 8 to 10 per 1,000 live births, and nearly one-quarter of these cases are classified as critical, requiring urgent intervention during the neonatal period.In Indonesia and other low- and middle-income countries (LMICs), the reported prevalence of CHD is consistent with global estimates, but under-detection remains a serious issue.[3] Many newborns with critical lesions are discharged home undiagnosed, only to return in critical condition once ductal closure occurs. This under-recognition is largely due to the subtle and nonspecific clinical manifestations in the first days of life and the lack of routine screening protocols in primary and secondary healthcare settings. As a result, mortality rates associated with CCHD remain disproportionately high in resource-limited regions compared to high-income countries.The early clinical signs of CCHD are often difficult to recognize.[4] Newborns with ductus-dependent lesions may appear stable immediately after birth because the ductus arteriosus temporarily maintains systemic or pulmonary circulation.

Once the ductus closes, typically within 24–48 hours, the infant may develop cyanosis, respiratory distress, metabolic acidosis, or cardiovascular collapse. In such cases, reliance on clinical observation alone is insufficient. Physical examination during the immediate postnatal period often has low sensitivity for detecting CCHD, as not all affected infants present with heart murmurs or visible cyanosis.Studies from multiple countries have confirmed that routine physical examination fails to identify up to half of newborns with CCHD before hospital discharge. This diagnostic limitation underscores the necessity of objective screening methods capable of detecting hypoxemia before clinical deterioration occurs. In many LMICs, however, access to echocardiography—the gold standard for confirming structural heart defects—is restricted to tertiary centers, making early detection at the community or primary care level even more

challenging.Pulse oximetry (SpO_2) screening has emerged as an effective, noninvasive, and low-cost method for detecting hypoxemia, a common physiological indicator of CCHD. The method measures peripheral oxygen saturation using a light sensor, allowing for the identification of abnormal oxygen levels that may otherwise go unnoticed during physical assessment.[5] Numerous large-scale studies and meta-analyses have demonstrated the utility of pulse oximetry as a screening tool for newborns. The pooled specificity is exceedingly high—approximately 99.9%—which minimizes false-positive results and prevents unnecessary referrals. The sensitivity, ranging between 76% and 83%, can increase to over 90% when combined with a detailed physical examination.

The simplicity of the method, requiring only minimal training and equipment, makes it particularly attractive for use in low-resource environments.[6] Beyond CCHD, pulse oximetry can also detect other serious neonatal conditions such as persistent pulmonary hypertension, pneumonia, or sepsis, further increasing its value as a routine component of newborn care. As such, SpO_2 screening represents not only a diagnostic innovation but also a public health intervention that strengthens early neonatal surveillance systems.Given the robust evidence supporting its clinical effectiveness, international health organizations have endorsed the universal implementation of pulse oximetry screening for newborns. The American Academy of Pediatrics (AAP) and the American Heart Association (AHA) recommend that all newborns undergo SpO_2 screening between 24 and 48 hours of life, ideally before discharge from the hospital. [7] The World Health Organization (WHO) has also incorporated pulse oximetry into its essential newborn care guidelines, recognizing it as a feasible and impactful screening method, even in resource-limited settings.[8] The 2024 AAP Clinical Report further reinforces the importance of universal screening and encourages healthcare institutions to adopt algorithms tailored to their specific contexts.[9] These include standardized pre-ductal and post-ductal measurement protocols, structured documentation of screening outcomes in medical records, and defined referral pathways for abnormal results. The integration of pulse oximetry screening into national and hospital-level policies has already led to measurable reductions in undiagnosed CCHD cases and related mortality in several high-income countries.Despite its proven benefits, the adoption of universal pulse oximetry screening remains limited in low- and middle-income countries.

Several feasibility studies in Indonesia and similar settings have revealed both opportunities and challenges in implementing large-scale screening programs. The most common barriers include insufficient availability of pulse oximetry devices, high workload among healthcare workers (particularly midwives), and a lack of standardized national guidelines. Furthermore, inadequate training on screening techniques and interpretation of results contributes to inconsistent implementation. Financial and logistical constraints also hinder continuity. Many hospitals and primary care centers lack sustainable maintenance systems for medical devices or reliable access to consumables such as sensors and batteries.[10] In addition, limited digital health infrastructure makes it difficult to record, monitor, and evaluate screening data systematically. These challenges highlight the importance of establishing a clear policy framework and allocating dedicated funding to integrate SpO_2 screening into routine neonatal services.The clinical relevance of pulse oximetry screening can be illustrated through conditions such as critical pulmonary stenosis (PS), a ductus-dependent lesion that can cause sudden hypoxemia once the ductus arteriosus closes. Without early detection, infants may experience life-threatening decompensation. SpO_2 screening enables timely identification of these high-risk cases before severe symptoms develop, allowing for early initiation of prostaglandin therapy and referral for definitive intervention, such as balloon valvuloplasty.[11] From a public health perspective, routine screening contributes to equitable neonatal care by reducing diagnostic disparities between urban and rural facilities. Early detection prevents costly emergency admissions and long-term complications, yielding significant cost savings for families and health systems alike.

[12] Furthermore, incorporating SpO_2 screening into essential newborn care aligns with broader global health goals, including the Sustainable Development Goals (SDGs) to reduce neonatal mortality to below 12 per 1,000 live births by 2030.To ensure sustainable implementation of pulse oximetry screening in resource-limited settings, a comprehensive approach is required. Structured training programs for healthcare providers—especially midwives and nurses—are crucial to ensure consistency and accuracy in screening. National guidelines must standardize measurement techniques, define cutoff values, and outline referral

protocols. Governments and health institutions should invest in affordable, durable pulse oximetry devices suitable for low-resource environments, including those with battery-powered or portable designs. In Indonesia, integrating SpO_2 screening into the national neonatal health policy could be a transformative step toward improving early detection of CCHD. Collaboration between the Ministry of Health, professional associations, and local hospitals can foster the creation of sustainable screening systems. Incorporating digital data reporting through maternal and child health information systems will further enhance monitoring and evaluation. CCHD remains a significant cause of preventable neonatal mortality, particularly in resource-constrained environments.[13] Pulse oximetry offers a practical, evidence-based solution for early identification of hypoxemia associated with CCHD and other life-threatening neonatal conditions. Its affordability, simplicity, and adaptability make it an ideal screening tool in limited-resource settings. Strengthening policy support, capacity building, and system integration will be essential to achieve universal screening coverage and ultimately improve neonatal survival outcomes.

II. METHODS

This study was conducted as a retrospective case report and structured in accordance with the *CAse REport (CARE)* guidelines to ensure clarity, transparency, and methodological rigor throughout the reporting process. The research employed a descriptive approach, focusing on the detailed chronological clinical progression of a neonate diagnosed with *Critical Congenital Heart Disease (CCHD)*. By reconstructing the sequence of clinical events, diagnostic procedures, and therapeutic interventions, this study provides an in-depth understanding of how pulse oximetry screening can be applied effectively within limited-resource healthcare environments.

a. Study Setting and Data Sources

Data were collected retrospectively from three major healthcare institutions located in Yogyakarta, Indonesia, namely: AMC Muhammadiyah Hospital, PKU Muhammadiyah Hospital, and Dr. Sardjito General Hospital. These facilities were strategically chosen to represent a spectrum of neonatal care levels—ranging from secondary to tertiary referral hospitals—thereby allowing for a comprehensive depiction of the regional healthcare network and referral patterns for congenital cardiac anomalies.All clinical data were extracted from patient medical records, nursing notes, laboratory reports, and echocardiography findings. Ethical approval for the data retrieval and case documentation was obtained from the respective institutional review boards, and all identifying patient information was anonymized to maintain confidentiality in accordance with international ethical standards for clinical research.[14]

b. Patient Profile

The case involved a full-term female neonate delivered by elective cesarean section on May 8, 2025. The infant had a birth weight of 2,505 grams and received Apgar scores of 9 at one minute and 10 at five minutes, indicating good immediate postnatal adaptation. At birth, peripheral oxygen saturation (SpO_2) was measured using pulse oximetry at two anatomical sites: the right hand (pre-ductal) and right foot (post-ductal), both yielding an initial reading of 96%. Physical examination findings were within normal limits at admission, and capillary blood glucose measured two hours postpartum was 40 mg/dL, which remained under clinical surveillance. No signs of respiratory distress or cardiovascular compromise were initially detected.

c. Clinical Observation and Monitoring Procedures

The neonate was admitted to the newborn nursery for routine postnatal monitoring. Continuous observation of vital signs—including temperature, heart rate, respiratory rate, and oxygen saturation—was maintained throughout the first 24 hours of life. Pulse oximetry screening was performed at regular intervals as part of standard neonatal surveillance.[15] Within the first day after birth, the infant exhibited subtle clinical changes characterized by perioral cyanosis and a systemic drop in oxygen saturation to approximately 90%. Auscultation revealed a systolic murmur, raising suspicion of an underlying structural cardiac abnormality. Supplemental oxygen therapy was administered, resulting in transient improvement; however, recurrent desaturation episodes prompted further diagnostic consideration.

d. Diagnostic Assessment and Referral

The pulse oximetry results served as the primary screening indicator for possible Critical Congenital Heart Disease.[16] Given the persistence of desaturation despite adequate oxygen supplementation, the newborn was referred to a tertiary-level cardiac care unit for advanced diagnostic evaluation. Echocardiographic examination was subsequently conducted to confirm the presence and type of congenital heart defect. The diagnostic and referral process followed a stepwise approach emphasizing the role of early pulse oximetry screening as a non-invasive, cost-effective, and easily deployable diagnostic tool in limited-resource environments.

e. Data Interpretation and Analysis

Although this study focuses on a single patient, the findings were interpreted within the broader framework of neonatal cardiac screening protocols and global recommendations by the *World Health Organization (WHO)* and the American Academy of Pediatrics (AAP).[17] Qualitative analysis of the case emphasized temporal patterns of oxygen saturation fluctuation, diagnostic response time, and inter-facility coordination during referral. The descriptive narrative allowed identification of both clinical and systemic factors influencing timely recognition and management of CCHD in settings where access to advanced diagnostic modalities remains constrained.

f. Ethical Considerations

This case report strictly adhered to the principles of the Declaration of Helsinki.[18] Parental informed consent was obtained for the use of clinical data and anonymized imaging for research and publication purposes. All patient information was handled confidentially, and institutional permissions were secured from the ethics committees of each participating hospital.

III. RESULT AND DISCUSSION

Data Analysis

The analytical approach in this report adopted a descriptive and chronological narrative, emphasizing the clinical progression, diagnostic findings, and therapeutic management of the patient. Each clinical event was analyzed in relation to existing literature to establish the relevance of diagnostic timing and the appropriateness of the interventions provided. This method enabled an integrative understanding of how pulse oximetry screening contributed to the early identification of critical congenital heart disease (CCHD) within a limited-resource clinical context. The report thereby provides both clinical and contextual interpretation of the patient's management pathway.

a. Ethical Considerations

All ethical procedures were observed throughout the study. The patient's confidentiality was rigorously maintained, with all identifying details removed from hospital records prior to analysis and reporting. Written informed consent was obtained from the parents for the use of anonymized clinical data and for the publication of this case. The study adhered to institutional ethical regulations and complied fully with the principles outlined in the Declaration of Helsinki. The ethical oversight ensured that the reporting of this case upheld the highest professional and humanitarian standards while contributing to the advancement of neonatal cardiac care knowledge.

b. Case Presentation

A term female neonate was born via elective cesarean section on May 8, 2025, weighing 2,505 g with Apgar scores of 9 at both one and five minutes. The initial postnatal assessment showed stable vital signs, normal appearance, and oxygen saturation levels of 96% in both the right hand (pre-ductal) and right foot (post-ductal). Two hours later, capillary glucose levels were found to be 40 mg/dL, and the infant was managed conservatively for mild hypoglycemia with continuous observation and parental counseling.At approximately 24 hours of life, the nursing team detected mild central cyanosis, and pulse oximetry readings decreased to 90% in both extremities. Cardiac auscultation revealed a systolic murmur graded 2/6. These findings prompted a strong clinical suspicion of CCHD, in accordance with existing screening cutoffs that recommend further investigation for any SpO_2 reading persistently below 95%. Supplemental oxygen at 0.5 L/min was administered, leading to transient improvement. However, recurrent desaturation episodes ensued,

with SpO_2 values dropping to around 75%.The infant was referred to PKU Muhammadiyah Hospital for advanced evaluation. Echocardiography confirmed the diagnosis of critical pulmonary stenosis (PS) associated with patent ductus arteriosus (PDA) and patent foramen ovale (PFO), indicating a ductus-dependent lesion. Immediate transfer was arranged to Dr. Sardjito General Hospital, where percutaneous transluminal balloon valvuloplasty (PTBV) was successfully performed. Following the intervention, oxygen saturation returned to normal limits, and the neonate's condition improved significantly.

Discussion

Early recognition of *critical congenital heart disease* (CCHD) plays a pivotal role in improving neonatal outcomes, as delayed diagnosis is consistently linked with elevated morbidity and mortality. Numerous studies have emphasized that the timing and method of screening determine the clinical trajectory of affected infants. Among the available modalities, pulse oximetry screening (POS) has emerged as a practical, accurate, and cost-efficient tool for early detection of hypoxemia—one of the earliest physiological indicators of CCHD. By identifying low oxygen saturation before the onset of clinical cyanosis or hemodynamic collapse, POS serves as a bridge between routine postnatal assessment and life-saving interventions.Current clinical guidelines, including those issued by the American Academy of Pediatrics (AAP) and the World Health Organization (WHO), advocate that screening be conducted between 24 and 48 hours of life. This time window aligns with the period when neonatal oxygenation stabilizes after birth, thereby enhancing the reliability of saturation readings and minimizing false-positive outcomes. Screening too early, particularly within the first 12 hours, may result in overdiagnosis due to transitional circulation changes, while screening beyond 48 hours risks missing early deterioration among ductus-dependent lesions. If early discharge is anticipated—often within 24 hours in many healthcare facilities, particularly in low- and middle-income countries (LMICs)—screening prior to discharge remains strongly advised. Empirical findings demonstrate that performing POS after 24 hours of age reduces false-positive rates and increases diagnostic yield.

Meta-analyses consistently report pooled sensitivity between 76–83% and a specificity nearing 99.9%, yielding an exceptionally low false-positive rate. Sensitivity increases further when POS results are interpreted alongside a comprehensive physical examination, reflecting the complementary nature of both approaches.Pulse oximetry functions as an indirect measure of oxygenation and perfusion. In neonates with CCHD, systemic desaturation may occur because of mixing of oxygenated and deoxygenated blood or due to obstruction to pulmonary or systemic outflow. Early identification of these abnormalities enables clinicians to initiate prostaglandin therapy, maintain ductal patency, and arrange prompt referral for definitive management.A broad spectrum of CCHDs—such as transposition of the great arteries (TGA), truncus arteriosus, coarctation of the aorta, hypoplastic left heart syndrome (HLHS), pulmonary atresia, and critical pulmonary stenosis (PS)—can be detected by POS. Many of these lesions rely on a patent ductus arteriosus (PDA) to preserve either pulmonary or systemic circulation. Once the ductus closes, infants may rapidly decompensate, leading to hypoxemia, shock, or cardiac arrest. Therefore, early screening within the optimal window is crucial to capture this critical transition period.The presented case provides practical evidence of how timely recognition and appropriate interpretation of POS results can significantly alter clinical outcomes. The infant initially appeared clinically stable with normal oxygen saturation but exhibited a marked decline within the first 24 hours of life. This temporal pattern aligns with the physiological closure of the ductus arteriosus, unmasking an underlying ductus-dependent lesion.

Notably, the patient's oxygen saturation did not improve despite supplemental oxygen administration, signaling a pathological rather than transitional hypoxemia.Prompt referral for echocardiography confirmed the diagnosis of critical pulmonary stenosis, a condition in which pulmonary blood flow is obstructed due to severe narrowing at the pulmonary valve. The infant underwent percutaneous transcatheter balloon valvuloplasty (PTBV) with favorable outcome. The success of this case underscores the value of vigilant monitoring, the clinical significance of even minor desaturation trends, and the necessity for rapid escalation of care once ductus-dependent physiology is suspected.In ductus-dependent lesions such as critical PS, oxygen therapy requires careful administration. While supplemental oxygen may transiently improve saturation, excessive oxygen concentration can accelerate ductal closure through oxygen-mediated

vasoconstriction of the ductus arteriosus. Hence, oxygen should be administered judiciously, ideally with an inspired oxygen fraction (FiO_2) below 30%, while maintaining prostaglandin E1 (PGE_1) infusion to preserve ductal patency. Failure to recognize this delicate balance can precipitate abrupt hemodynamic deterioration.This clinical principle further reinforces the importance of early and accurate screening. When CCHD is identified promptly, clinicians can adopt targeted management strategies that prevent iatrogenic harm and optimize pre-intervention stabilization.The diagnostic accuracy of POS has been extensively validated across multiple large-scale studies.

Thangaratinam et al. reported a pooled sensitivity of 76.5% and specificity of 99.9% in detecting CCHD, with significant reductions in delayed diagnosis and neonatal mortality. Similarly, van Vliet and colleagues analyzed data from over 870,000 neonates and demonstrated that combining POS with routine clinical examination improved sensitivity to 93%, outperforming either approach alone.These findings reinforce the notion that the integration of POS into standard newborn examination substantially enhances detection rates. Beyond mere identification, early diagnosis allows timely referral for definitive interventions, including surgical or catheter-based procedures, thereby improving both short- and long-term outcomes.Despite the robust evidence and endorsement by international bodies, implementation of universal POS screening remains inconsistent, particularly across LMICs such as Indonesia. Barriers include limited access to pulse oximetry devices, inadequate training of healthcare personnel, and the absence of national standardized screening protocols. In many primary and secondary care facilities, midwives and nurses bear substantial clinical workloads, leaving insufficient time for structured screening and documentation. A feasibility study in Yogyakarta, Indonesia, revealed that while SpO_2 screening is practicable within local hospital settings, challenges persist in terms of workflow integration, documentation systems, and referral linkages. These findings underscore that successful implementation requires a multi-dimensional strategy involving:

1. Policy and governance support — issuance of clear national or regional guidelines to standardize procedures and thresholds;
2. Resource investment — procurement of cost-effective and durable pulse oximetry devices suitable for neonatal use;
3. Capacity building — regular training programs for healthcare providers to ensure accurate measurement, interpretation, and follow-up;
4. System integration — embedding POS within routine postnatal care and digital health records to ensure continuity and traceability.

In Indonesia, as in other LMICs, establishing a structured CCHD screening pathway represents a crucial step toward equitable neonatal care. Integrating POS into the national neonatal screening program—alongside existing screenings for metabolic and endocrine disorders—would ensure comprehensive early-life health evaluation. The incorporation of this practice into standard operating procedures within maternity wards, both public and private, could significantly increase coverage and early detection rates.The Indonesian Ministry of Health, supported by pediatric cardiology associations, has begun to issue guidance and pilot projects advocating for this integration. Nonetheless, variability in local implementation persists, particularly in rural and under-resourced regions. Expanding such initiatives through public–private partnerships and donor-supported programs may accelerate adoption, ensuring that the benefits of POS reach even the most marginalized populations.From a public health standpoint, the widespread use of POS aligns with the broader agenda of reducing preventable neonatal deaths—a key target under Sustainable Development Goal (SDG) 3.2. CCHD accounts for a significant proportion of congenital-related neonatal mortality, and early screening offers a cost-effective intervention capable of averting these deaths. Economic analyses have shown that the incremental cost per life-year saved through universal POS screening is relatively low, particularly when compared with the cost of late-stage cardiac interventions or prolonged intensive care.Furthermore, early detection mitigates parental anxiety and fosters informed clinical decision-making, enabling families to access timely specialized care. These cascading benefits underscore the role of POS as a simple yet transformative technology within the continuum of newborn health services. The reported case reinforces key lessons relevant to clinical and public health practice.

First, even in resource-limited environments, early recognition through POS and vigilant clinical monitoring can avert fatal outcomes. Second, normal oxygen saturation at birth does not rule out CCHD, particularly ductus-dependent lesions that may manifest only after physiological closure of the ductus arteriosus. Third, the management of such conditions demands judicious use of oxygen and prompt initiation of prostaglandin infusion, followed by transfer to a facility equipped for definitive intervention.The success achieved in this case—culminating in timely PTBV and full recovery—illustrates the practical feasibility and life-saving potential of early detection. Importantly, this case also highlights the interdependence between frontline healthcare workers and tertiary referral centers in establishing a functional neonatal cardiac care pathway.In summary, this discussion emphasizes that pulse oximetry screening represents a simple yet powerful innovation capable of transforming neonatal cardiac care. Its ability to detect critical congenital heart disease before clinical deterioration enables timely intervention and significantly reduces mortality. The presented case exemplifies how early recognition, guided by both clinical observation and SpO_2 monitoring, can result in favorable outcomes even within limited-resource settings.Wider adoption of this screening practice—supported by national policy, training, and infrastructural investment—will be instrumental in achieving equitable neonatal survival rates across different regions. As demonstrated by both global evidence and local experience, early screening is not merely a diagnostic step but a cornerstone of preventive neonatal medicine, bridging the gap between detection and survival.

IV. CONCLUSION

The findings discussed in this study reaffirm that pulse oximetry screening (POS) represents a highly valuable, noninvasive, and cost-effective approach for the early detection of *critical congenital heart disease* (CCHD) in newborns. Early recognition of CCHD before the onset of circulatory collapse substantially improves neonatal survival and reduces the risk of irreversible hypoxemia. Evidence from global and regional studies consistently demonstrates that POS possesses excellent diagnostic accuracy, with sensitivity ranging between 76–83% and specificity approaching 99.9%. When combined with clinical examination, sensitivity increases further, highlighting the complementary role of physical assessment and SpO_2 monitoring in neonatal screening.The reported case illustrates the clinical importance of timely detection. The infant, who initially appeared well, developed progressive desaturation within the first 24 hours of life—a period coinciding with the physiological closure of the ductus arteriosus. The inability to normalize oxygen saturation despite oxygen supplementation prompted immediate referral and echocardiographic confirmation of critical pulmonary stenosis.

This timely diagnosis enabled early percutaneous transcatheter balloon valvuloplasty, resulting in a favorable outcome. Such clinical success underscores the significance of structured screening and vigilant postnatal monitoring, particularly within the first 48 hours of life.Despite well-documented benefits and clear recommendations from the American Academy of Pediatrics (AAP) and the World Health Organization (WHO), implementation of POS in low- and middle-income countries (LMICs) remains inconsistent. Barriers include limited device availability, lack of healthcare worker training, absence of standardized guidelines, and insufficient integration into routine neonatal care. Overcoming these systemic challenges is crucial for ensuring equitable access to life-saving screening across diverse healthcare settings.Overall, this study highlights that POS is not merely a diagnostic tool but an essential component of preventive neonatal medicine. Its widespread adoption can significantly reduce undiagnosed CCHD cases, prevent delayed treatment, and contribute to achieving global goals for neonatal mortality reduction under the Sustainable Development Goals (SDG 3.2).

To enhance early detection and improve neonatal outcomes, several key recommendations are proposed:

1. Institutionalization of Universal Screening: Governments and health authorities should mandate the inclusion of pulse oximetry screening in national newborn screening programs. Implementation should be supported by clear clinical protocols and standardized thresholds for referral and follow-up.
2. Capacity Building and Training: Continuous training programs for nurses, midwives, and pediatricians are essential to ensure accurate measurement, interpretation, and timely response to abnormal results.

Simulation-based learning and periodic competency assessments should be integrated into continuing medical education.

3. Resource Allocation and Technology Adaptation: Health institutions should invest in affordable, durable, and validated pulse oximeters designed for neonatal use. Local innovation and public–private partnerships can help reduce procurement costs and enhance sustainability.

4. Integration into Routine Care Pathways: POS should be incorporated into the standard discharge checklist for all neonates, particularly those discharged within 24 hours after birth. Integration into electronic medical records and national registries will enable systematic monitoring and data-driven policy adjustments.

5. Community Engagement and Awareness: Public health campaigns should raise awareness among parents and caregivers about the importance of early screening and follow-up care. Educated families are more likely to consent to screening and adhere to referral recommendations.

6. Research and Policy Evaluation: Implementation research is needed to evaluate the real-world effectiveness, cost-benefit ratios, and context-specific barriers of POS programs. Evidence from such studies will guide future policy improvements and regional adaptations.

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