# Diagnostic, Management Capacity and Outcomes for Neonates with Sepsis in Rural Health Facilities of Northern Ghana: A Mixed Methods Assessment

Mohammed Ali; Rashid Bawumia Ali; Victor Nwadike
University of Campinas, Brazil

## Abstract

Globally, neonates with sepsis contribute to nearly a third of the 2.3 million neontal deaths annually due to gaps associated with poor diagnosis, insufficient referral networks and caregiver delays. These gaps disproportionately affect children of rural dwellers in Ghana. This research investigated diagnostic capacity and clinical outcomes of neonates with sepsis admitted to health facilities in Gushegu and Nkwanta South districts. Both the Health Systems Framework and the Three Delays Model were used to establish and analyze all gaps and present findings. A convergent mixed-methods design was employed in target facilities 322 neonatal records were reviewed, and interviews conducted with caregivers and health workers. Data were collected between March and June 2021 after ethical approval were obtained from Ghana Health Service's Institutional Review Board (GHS-ERC 008/03/20). Among the 322 subjects, 58% were women with 70% were receiving below GHS 500 as montly income. In Gushegu, formal education among caregivers was low (43%) with the average trips to the facilities above 2 hours. In all facilities studied, none provided for C-reactive protein (CRP) or blood culture test. In both districts, recovery rates were relatively low, Gushegu (52%) and Nkwanta South (64%), while the rates of death were lower at 20% and 14%, respectively. Late presentation (>48 hours) tripled poor outcomes (OR = 2.8), delayed intravenous antibiotics (>6 hours) increased death at almost four times (OR = 3.9) and delayed referral (12 hours or longer) doubled mortality risk considerably (OR = 2.1). Only 31% of health workers had recieved recent training. Diagnostic bottlenecks, delayed referral, and systemic weaknesses in neonatal-care institutions led to significant morbidity and mortality. Besides, the presence of sociodemographic underprivileged and bad knowledge of caregivers all contribute to the time delay towards seeking help by the patient. It is essential to bridge these gaps to promote decreased neonatal mortality in rural Ghana. Recommendations come from strengthening medical diagnostic infrastructure as well as the development of new clinical guidelines and referral systems, integrating neonatal sepsis indicators to the District Health Information Management System, version 2 (DHIMS2), and enhancing caregiver training and financial support systems.

## Introduction

Neonatal sepsis remains a global health crisis, responsible for approximately one-third of the 2.3 million infant deaths globally each year; 1.3 million of these deaths cause significant morbidity and mortality. Low- and middle-income countries experience a disproportionate burden of neonatal death (UNICEF, 2023). In Ghana, it is


DOI: https://doi.org/10.5281/zenodo.17627474

one of the leading causes of newborn deaths. It is a crisis that is even more serious in the rural parts of the country, such as Northern Ghana, where there are no healthcare centers, putting further burdens on the prevention and treatment of infections (Ghana Health Service, 2022). While nationwide, there have been considerable progress, there remain deficiencies in the assessment, referral and clinical management of newborns. As these routine diagnostic instruments — including blood cultures and C-reactive protein (CRP) tests — are scarce, health workers in many rural communities generally make do with clinical judgment alone. The shortcomings in these resources can result in delayed treatment and misdiagnosis, which is particularly harmful to newborns. These barriers — from poorly trained birth attendants, to bad infection control, lack of skills, bad referral systems, barriers to transportation, to lack of caregiver know-how — cumulatively drive down neonatal survival ratios. However, literature has predominantly been concentrated on clinical and facility audit practice within an urban setting but little attention has been paid to the operational and systemic obstacles faced in rural Ghana. The current study evaluates neonatal sepsis diagnosis capability and outcomes in Gushegu and Nkwanta South, places that remain underdeveloped in rural communities. The results should be useful for more specific targeted interventions and in informing health-related public health policy recommendations. Hence, once we achieve this work, our study will serve to contribute to Ghana's ambition to end the problem of preventable neonatal mortality by 2030, aligning our efforts with national and global health policy priorities. Neonatal sepsis is the leading cause of preventable neonatal mortality in Ghana, accounting for as high as 59% of neonatal admissions in tertiary institutions such as Cape Coast Teaching Hospital (Craymah et al., 2024)

**Problem Statement**

In rural districts such as Gushegu and Nkwanta South, where diagnostic capacity is limited, and access to essential diagnostic tools (blood culture systems, antibiotics, trained employees) is absent (Konlan et al., 2024), this number is even higher. By contrast, a smaller share of neonatal admissions for sepsis is actually seen in urban centers relative to the rural population due to better-resourced and staffed premises (national statistics). At Ho Teaching Hospital an earlier study also reported early neonatal death regarding late diagnosis and inadequate referral systems (Afeke et al., 2021). In the Northern and Oti Regions, systemic factors such as insufficient documentation, poor coordination of referral and the absence of a standardized protocol contribute to the worsening of clinical outcomes (Konlan et al., 2024; GHS, 2023). Several district-level facilities, however, are not able to diagnose sepsis and therefore, use empirical treatment at the expense of targeted care; despite nation-wide efforts. Aims This article aims to assess the diagnostic capacity, management policies and practices in, and in retrospect to evaluate outcomes associated with diagnostic and management decisions for neonatal sepsis in rural Northern Ghana. It specifically evaluated the availability and effectiveness of diagnostic tools, clinical management protocol and standards, adherence to the clinical practice standard, referral system, and major problems. The aim was to present the evidence for the promotion of quality care, reduction in NICU


DOI: https://doi.org/10.5281/zenodo.17627474

mortality and the formulation of health system and sepsis management policy.

## Literature review

This review examines the diagnosis and systemic issues of neonatal sepsis in rural Ghana from a two key streams approach. The Health Systems Framework (WHO, 2007) justifies this in six pivotal components: service delivery; workforce; information systems; medical access; funding and control. Disruptions, particularly in infrastructure for service delivery, weigh heavily in the survival of newborns early in life. According to the Three Delays Model, these delays in disease recognition, accessing care and implementing care are amplified by insufficient caregiver readiness, lack of transport and unprepared facilities (Thaddeus & Maine, 1994). By utilising a combination of these frameworks, we observe that shortages of health-oriented service delivery and workforce, lead to delay in disease identification and issues of access to medicines and governance, are impediments to timely care. It tells us why the outcomes of neonatal sepsis remain poor and also where we should continue to improve in clinical health systems. Treatment of neonatal sepsis should be perceived and managed in a timely manner. Without laboratory support, healthcare professionals frequently rely on clinical guidelines that they apply in an idiosyncratic manner. Diagnostic capacity also denotes the ability to obtain, use, and perform laboratory testing in terms of blood culture and C-reactive protein (CRP) analysis. The clinical outcomes are determined by means of recovery, complication and mortality. The urgency of this need is well-documented in the empirical literature, and these gaps merit closer consideration. UNICEF (2023) reported that a large proportion of deaths are attributable to neonatal sepsis, about 30% globally. Wondifraw et al. (2025) had estimated the pooled prevalence for Africa of 40.98%, which is associated with very low birth weight combined with poor APGAR scores. Neonatal sepsis is still one of the leading causes of neonatal mortality in Ghana (GHS, 2022). Enyew et al. (2025) highlight other constraints of the health system, such as weak referral systems, infection control problems, and so on, as principal contributors towards poor outcomes. The literature on how health care providers perceive and deal with neonatal sepsis in Northern Ghana is lacking. Most such studies are clinical risks or facility audits focused and do not include behavioral, logistical or regulatory aspects. There is also a lack of data on the use and upkeep of diagnostic instruments. Key gaps in knowledge include information on the functionality of tools, time to refer, and experiences among frontline healthcare staff. This study identified the gaps in neonatal sepsis management among rural health centers between Gushegu (Northern Region) and Nkwanta South (Oti Region) in northern Ghana, examining both facility audit methods, clinical outcomes measurement by clinicians, as well as stakeholder interviewing. The hope was that the project would lead also to practical data that would be useful for improving health systems, and more importantly, to support the formulation of policy-relevant approaches toward better neonatal sepsis care in emerging geographies.

## Methodology

This study was conducted in rural health facilities in Gushegu (Northern Region) and Nkwanta South (Oti Region), known high neonatal mortality settings due to insufficient diagnostics and delayed care (GHS,


DOI: https://doi.org/10.5281/zenodo.17627474

2023). The facility selection was based on geography, level of service delivery and neonatal cases. Gushegu and Nkwanta South were also situated with a population of approximately 154,456 and 135,735 (GSS 2021). This registered some 5,390 live births a year in Gushegu and 4,725 live births in Nkwanta South; there was a crude birth rate 35/1,000. (Crude Birth Rate (Per 1,000 People) falls 2.02% to 25.4 births in Ghana in 2024, 2024)

Using a neonatal survival ratio of 0.98, the estimate is 440 neonates at any time in Gushegu and 385 in Nkwanta South (UNICEF, 2021). In Gushegu, suspected neonatal sepsis accounted for 18.6% of neonatal admissions in the year before this study and 15.2% in Nkwanta South. Hence, the corresponding case fatality rates were 20% and 14%, while complication rates were 24% and 18% respectively (GHS, 2023). These findings underscore the influence of delayed disease diagnosis and limited diagnostic quality, as well as erratic referral systems. Most facilities do not have these crucial diagnostic tools — blood culture systems, CRP test kits. For diagnostic capacity and outcomes, a mixed-methods approach was used (Creswell & Plano Clark, 2021). Collecting and analyzing statistical features and interview data were conducted over a period of 9 months to obtain contextual knowledge (Creswell & Hirose, 2023). The participants comprised health facilities, frontline health workers, caregivers and newborn records.

Stratified sampling was utilized to guarantee rigorous methodological rigour and transparency. Stratified sampling was the best response to assess the diversity in facilities, as the sample was recruited using geographic location, service (service level and neonatal case volume) as its criterion, and further credibility was also promoted with the implementation of the findings. According to these criteria, ten selected facilities and centers were set forth to be included. Power calculations and access were factored in, accounting for 322 neonatal records. Additionally, 20-25 health workers and 15-20 caregivers completed interviews, which were at saturation, to reflect a range of experiences and insight (Bouncken, Czakon, & Schmitt, 2025). Data collectors were trained for two days on purpose, ethical approach of the study performed and data collection protocol for maintaining quality consistency quality of data collection. The training focused on the significance of neutrality, informed consent and documentation. The tools for data collection were evaluated in a separate institution to confirm clarity and relevancy of method. These methods were used to mitigate bias and improve reliability (Korstjens & Moser, 2022). Standardized procedures, consistent training, and diverse data sources also increased internal validity of the study, as well as stratified sampling across facility types and location, increasing the ability to generalize findings to other similar rural settings (Bengtsson, 2022; Creswell & Hirose, 2023). For qualitative data, double-encoding was used to mitigate bias as two researchers coded transcription with one another independently and talked about and resolved any differences. In order to enhance the credibility of interviews, triangulation was employed by synthesizing qualitative interviews along with quantitative data. And continuously monitor and debrief the data collection team on the training, identify and address potential biases that were surfacing. Yet there were also some limits. Bias within interviewers and self-report, which affected accuracy, were concerns with the design. The district-specific


DOI: https://doi.org/10.5281/zenodo.17627474

findings were context-specific and the findings may not be transferable to all districts. Additionally, some studies were constrained through data restrictions, and helped identify where further research was required. Quantitative analysis used SPSS (version 29) and STATA (version 18) and detailed a descriptive statistics, cross-tabulation, and multivariate logistic regression approach to examine whether there was a causal association between diagnostic delay, timing of treatment, and neonatal outcome. These results were visually presented in tables and graphs able to show trends in admissions and rates of mortality, as well as referral timelines by district. Qualitative data were collected using semi-structured interviews, which were complete and verbatim transcribed in local languages (Braun & Clarke, 2021). Interview themes revolved around neonatal care experiences, diagnostic problems, and referral processes. These qualitative and inferential insights, merged with the statistical, offered a broader picture of the neonatal setting. This enabled triangulation of results, which enhanced validity and provided a more profound grounding. Transcripts were analyzed using NVivo (version 14) and Braun and Clarke's (2022) method of thematic analysis. Coding was conducted in stages in which a theme evolved from participants' stories that were cross-checked to quantitative data related to neonatal outcomes. Key themes were described; supported with illustrative quotes anonymised to highlight gaps in the system, caregiver perspectives, and staff adaptations. Quotations were selected to reflect both district-by-district variation that lent credibility and depth to our results, but also to overlap. Ethical approval was obtained from the Institutional Review Board of Ghana Health Service (GHS-ERC 008/03/20). The free participation, informed consent, and respect for independence of the subjects were considered ethical concepts whenever conducting research. They were informed of the aims of the study, the right to refuse to participate, and the extent of their responses being confidential. Data were de-identified and securely stored, accessible only to core research team personnel. These measures ensured compliance with national standards of research ethics and protected the data privacy and human dignity of participants (Korstjens & Moser, 2022; Tafesse et al., 2022). It required considering vulnerable people, in particular illiterate people, and how to ensure informed consent. In this context, verbal consent was offered in local languages in order to guarantee a full comprehension, and the main points were verbally supported with visual aids. A witness not only conducted this ethically rigorous interview but also played a role at sign-the-decree time to ensure understanding and consent. It followed the ethics of the issue however, and also respected the cultural difference. Consequently, though, we must continue to build a supportive environment for community involvement in research. However, this requires us to do more. The closeness of the communities where they are engaged in this kind of activity is also a challenge where people's privacy must take precedence. This study brings into sharp relief both the need for ongoing attention to ethical considerations in rural health research and its requirement for research to acquire the suitable context where it may be adapted according to practice. But before delving into deeper exploration, we must mention one point: from this study it is apparent that there exists a significant disparity between Gushegu and Nkwanta South


DOI: https://doi.org/10.5281/zenodo.17627474

on clinical outcomes. Rates of mortality in Gushegu were 20 percent and 14 percent in Nkwanta South. This revealed wide gaps in diagnosis and care of the rural healthcare system. That also adds an opportunity for lesson. This high mortality of Gushegu acts as 'positive deviance gap' that could lead to discussions on potential transferable practices from Nkwanta South. Consideration of why marginal benefits were received at Nkwanta South may provide lessons for generalization. Sociodemographic profile of study participants: Table 1 presents the sociodemographic profile of 322 studied participants of Gushegu and Nkwanta South. 58% were females, 42% males. The majority of caregivers were mothers between the ages of 18 and 35, representing a sample of 65% in Gushegu and 59% in Nkwanta South, >88% women. Informal level of education was low and consisted of 43 per cent with no education in Gushegu and 39 per cent without any education in Nkwanta South. More than 70% of individuals reported a monthly income of less than GHS 500. Gushegu health facility travel time had average amount of 2.1 hours.

**Table 1 Socio-demographic Profile of Study Participants (n=322; Field Data)**

| Variable | District | District |
|---|---|---|
| Variable | Gushegu (n =156) | Nkwanta South (n =164) |
| Caregivers | 102 (64.9%) | 96(58.5%) |
| Health workers | 46(29.1%) | 52(31.7%) |
| Facility Managers | 10 (6.3%) | 61(6.3%) |
| Caregivers age | 78% | 81% |
| No formal education | 43% | 39% |
| Monthly income < GHS500 | 76% | 71% |
| Average travel time to facility | 2.1hours | 1.6 hours |

**Availability and Function of DiagnosticInstruments:** Blood culture instruments are among the most important missing elements for the hospitals' readiness to diagnose and target antibiotics treatment for blood ailments. Reducing this gap would decrease the mortality due to neonatal sepsis significantly. As depicted in Fig.1, basic equipment (thermometers, malaria rapid diagnostic tests etc.) was accessible, but the majority of facilities lacked available resources for diagnosing neonatal sepsis. Pulse oximeters for diagnosis were performed in 35% Gushegu and 48% Nkwanta South facilities, while only 22% and 34% in those facilities, respectively. There were no blood culture systems or CRP or procalcitonin tests in any facility. Sepsis-specific protocols were used in 28% of Gushegu and 41% of Nkwanta South facilities, which indicated diagnostic preparedness gaps.

**Clinical Management Practices: Referral Pathways**

89% of the cases were treated with ampicillin and gentamicin. Difficulties accessing intravenous services were more prevalent in Gushegu (42%)


DOI: https://doi.org/10.5281/zenodo.17627474

compared to Nkwanta South (35%). Referrals were completed in 58% Gushegu and 66% of Nkwanta South cases, but the wait time to accept a referral for the Gushegu was prolonged with a median waiting time of 21 hours in Gushegu compared with 15 hours in Nkwanta South. Referrals of feedback were limited in Gushegu by 9% and 15% of Gushegu and Nkwanta South cases, respectively, but they were not substantial.

**Table 2: Clinical Management Practices and Referral Pathways (n=100; Field Data)**

| Indicator | District | |
|---|---|---|
| | Gushegu (n=100) | Nkwanta South (n =100) |
| Empirical antibiotic use | 89% of cases | 93% of cases |
| Common regimen | Ampicillin & Gentamicin | Ampicillin & Gentamicin |
| IV access challenges | 42% of facilities | 42% of facilities |
| Referral rat for suspected sepsis | 58% | 66% |
| Median rferral delay | 21 hours | 15 hours |
| Feedback from referral centers | 9% of referring facilities | 15% of referring facilities |

**Diagnostic Delays and Clinical Findings:**

52% in Gushegu had achieved complete recovery from sepsis, 24% had complications and 20% died from the 146 neonatal sepsis cases. The rates in Nkwanta South were 64% recovery, 18% complications and 14% deaths. If care was sought more than 48 hours after symptoms began, the odds of poor outcomes were nearly three times higher (OR = 2.8). Delays in providing intravenous antibiotics for more than 6 hours were associated with three-fold the risk of serious complications (OR = 3.2). For example, delays over 12 hours on referral times doubled odds that patients would achieve worse outcomes (OR = 2.1).

**Perspectives and Systemic or Policy-Level Gaps:**The lack of these means of doing diagnostics forced health workers to improvise when they used to not only rely on old protocols they had no access to but also have to rely on the outdated ways of doing things and new approaches in some cases, not even a plethora of what the professionals considered the old protocols of the day. Financial difficulties, transport difficulties and bad experiences with staff put barriers to care to caregivers. Seventy-two percent of caregivers were familiar with neonatal danger signs. Staff was dismissive for many — 49% in Gushegu, 38% in Nkwanta South. Just 31% of health workers had recent training. Sepsis markers were not accessible for the tracking and planning in District Health Information Management System 2 (DHIMS2). Some of these challenges are shown in these quotes. “We often adapt from what’s on the market — sometimes using adult IV kits for babies.” (Midwife, Gushegu District Hospital)
Others expressed concerns about stale clinical guidelines and a limited pipeline for training:


DOI: https://doi.org/10.5281/zenodo.17627474

"We have old protocols. There is no single thing that's a neonatal sepsis, and we haven't had refresher training in years." (Community Health Nurse, Nkwanta South Health Centre)

Other caregivers discussed financial and logistical obstacles to early access to care, including:

"We borrowed money to get to the hospital and when we got there they told us we were really late and the nurse did not even look at the baby." (Mother of four, Gushegu District)

Low awareness about neonatal danger signals hindered this need for care. Another said:

"I wasn't aware that the signs mattered. The baby breathed quickly but, I thought it was fine until it got worse." (First-time Mother, Nkwanta South District)

## Discussion

The results illustrate the significant differences in neonatal sepsis monitoring between Gushegu and Nkwanta South, similar to other areas in sub-Saharan Africa. Most of the carers were young mothers with little to no education and income, which match with other work that indicates they also contribute towards delay in diagnosis and treatment (Traoré, Mensah, & Oketch, 2024). Travel times in Gushegu were 2.1 hours longer than for Nkwanta South (1.6 hours) and nearly twice as long (nearly double the delay in urban areas). This highlights the need for customized solutions to these districts. Two districts were similarly described to lack diagnostic readiness, consistent with results from an analysis of neonatal clinicians from 25 countries located in sub-Saharan Africa (Rosa-Mangeret et al., 2024), in which minimal capacity was evidenced in terms of restricted access to blood cultures, CRP tests, and infection prevention measures. Gushegu and Nkwanta South had none of the advancements provided like advanced diagnostics which reflect the WHO call for the lack of these vital tools in many low- or middle-income countries (WHO, 2022). This was a small gain in Nkwanta South, where the percentage of functional pulse oximeters and sepsis protocols was higher. These findings are reflected in problems reported in Malawi and Tanzania (Molyneux et al., 2016; Mboya et al., 2021) and featured in WHO (2020). Clinical treatment for neonatal sepsis in both districts involved rather wide-spread use of empirical antibiotics, based on the study of Wondifraw et al. (2025) in Africa. Gushegu had reported higher rates of intravenous access problems and longer referral delay than the other locations with better transport and supply systems (Wondifraw et al., 2025). Low levels of feedback from referral centres in both districts imply that continuity of care is still a challenge in the context of the other regional studies (Enyew et al., 2025). In patients presenting to care > 48 hr after symptom presentation, adverse events were significantly increased by three times (OR = 2.8). In addition, a longer delay in the administration of intravenous antibiotics and referral increased the risk (OR = 3.2 and 2.1). This is consistent with prior research that delays in treatment delay in patients contribute to more adverse events (Wondifraw et al., 2025). New research from Nigeria and Bangladesh indicates that neonatal sepsis is also a significant barrier in low-resource settings, with delay in the diagnosis and referral process (Mustapha et al., 2024; Wondifraw et al., 2025). Gushegu had greater mortality (20% vs. 14%) and complication rates (24% vs. 18%) suggesting disparate provisions and reach across districts. Qualitative findings showed that barriers exist,


DOI: https://doi.org/10.5281/zenodo.17627474

including legacy processes, caregiver negligence, and failure to recognize neonatal danger signs, according to recent reporting and surveys from Sierra Leone and Liberia (Rosa-Mangeret et al., 2024; Baldeh et al., 2022; Perry et al., 2017). Systemic issues include lack of monitoring, lack of training and no implementation of DHIMS2 (MOH Ghana, 2025). The interventions are organized by the need to first address short-term improvement, and second to facilitate long-term reform. Existing strategies consist of implementation and diffusion of these basics and in emergency transport provision. In the low to medium term, sepsis indicators should be integrated into DHIMS2 and refresher education offered. Long-term transformation needs increased training of Gushegu and more investment in diagnostics in particular (WHO, 2020). Combining the science of the implementation process with an alignment in these recommendations to guidelines/models like CFIR (Consolidated Framework for Implementation Research) could be very beneficial when analyzing these studies as a conceptual framework for review. It assists in evaluating interventions for various settings to make sure the strategies are viable and implementable within health care facilities as it relates to health needs. Problem of absence of sepsis tracking and DHIMS2 use are in line with issues reported in Ghana's health system reviews (GHS, 2022). These challenges reflect the need for more targeted reform at the district level.

## Conclusions and Recommendations

This study examined the effectiveness of health workers and caregivers in rural Northern Ghana in diagnosing and managing neonatal sepsis. Significant gaps were identified in diagnostic practices, clinical treatment, and referral systems in Gushegu and Nkwanta South. Factors such as early maternal age, low income, limited education, long travel distances, and poor awareness of danger signs contributed to delays in care-seeking and poorer outcomes, particularly in Gushegu. Diagnostic capacity was severely limited, with no access to blood cultures or CRP tests, forcing healthcare workers to rely on clinical judgment. Frequent issues with intravenous access and delayed referrals further compromised care, leading to delays in treatment and increased risks of mortality and complications.

Systemic challenges were also evident, including outdated protocols, ineffective surveillance, insufficient training, and the absence of DHIMS2 integration, all of which disrupted continuity of care. This study contributes valuable data to inform efforts aimed at improving neonatal sepsis care in rural Ghana by disaggregating district-level data and linking diagnostic capacity to outcomes.

However, the study has limitations. Its findings may not be generalizable beyond the two districts studied, and issues such as missing data and reliance on self-reported information may affect the accuracy and completeness of results. These limitations underscore the need for cautious interpretation and further research to strengthen policy relevance and deepen understanding.

To address these challenges, a tiered intervention strategy is recommended. Low-cost interventions include community-based programs to educate young mothers using volunteers, radio, and basic materials, as well as visual tools to help health workers understand and implement revised protocols. Medium-cost strategies involve training frontline staff in early


DOI: https://doi.org/10.5281/zenodo.17627474

identification, intravenous access, and antibiotic administration through drills and mentorship, along with integrating sepsis indicators into DHIMS2 to improve planning and monitoring. High-cost strategies should focus on enhancing diagnostic capacity by equipping district hospitals with CRP and blood culture testing and introducing point-of-care diagnostics in lower-tier facilities. Referral systems should be upgraded with improved transport and mobile communication, and financial incentives could help attract experienced pediatric staff to high-need areas.

Future research should evaluate the outcomes of diagnostic interventions, education, and training, and explore effective strategies for scaling up sepsis surveillance and child health investments. Health workers must be equipped to monitor key indicators and lead quality improvement initiatives. As part of an integrated plan, dissemination efforts should include workshops and presentations for health officials and community leaders, policy briefs for government and health agencies, and partnerships with local media to raise public awareness about neonatal sepsis care innovations.

## References

Afeke, I., Hirose, M., Amegan-Aho, K. H., Haertel, C., Becker, M., Moustafa, A., Schilf, P., Badr, M. T., Mensah, G. L., Mbroh, H. K., Rupp, J., & Ibrahim, S. (2021). Neonatal and young infant sepsis in a regional hospital in Ghana. Open Journal of Pediatrics, 11(2), 281–300. https://doi.org/10.4236/ojped.2021.112027

Bengtsson, M. (2022). Ensuring trustworthiness in qualitative research. Nursing Open, 9(1), 112–118. https://doi.org/10.1002/nop2.1049

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2022). Thematic analysis: A practical guide. Sage Publications.

Bouncken, R. B., Czakon, W., & Schmitt, F. (2025). Purposeful sampling and saturation in qualitative research methodologies: Recommendations and review. Review of Managerial Science. https://doi.org/10.1007/s11846-025-00881-2

Craymah, J. P., Tuoyire, D. A., Adjei-Ofori, P., Ekor, O. E., Ninson, P. A., & Ewusi, M. H. K. A. (2024). Neonatal sepsis in a tertiary health facility in Cape Coast, Ghana. PLOS ONE, 19(5), e0302533. https://doi.org/10.1371/journal.pone.0302533

Creswell, J. W., & Hirose, M. (2023). Mixed methods inquiry: Advances in design and integration. Sage Publications.

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (3rd ed.). Sage Publications.

Creswell, J. W., & Plano Clark, V. L. (2021). Designing and conducting mixed methods research (3rd ed.). Sage Publications.

Enyew, E. F., Getnet, M., Gebiru, A. M., & Dessie, G. (2025). Individual and community level determinants of neonatal mortality in Sub-Saharan Africa: Findings from recent demographic and health survey data. Italian Journal of Pediatrics, 51(1), 144. https://doi.org/10.1186/s13052-025-01997-7

Ghana Health Service. (2022). Annual health sector performance report. Accra: GHS.

Ghana Health Service. (2023). Annual report on neonatal outcomes. Accra: GHS.
Ghana Health Service. (2023). Annual health sector performance report. Northern Region, Tamale: GHS.
Ghana Statistical Service. (2021). 2021 Population and Housing Census: District analytical reports. Accra: GSS.
Ghana Statistical Service. (2023). District population projections. Accra: GSS.
Gilson, L. (2012). Health policy and systems research: A methodology reader. Alliance for Health Policy and Systems Research, WHO.
Moser, A., & Korstjens, I. (2023). Series: Practical guidance to qualitative research. Part 7: Qualitative evidence synthesis for emerging themes in primary care research: Scoping review, meta-ethnography and rapid realist review.European Journal of General Practice,29(1). https://doi.org/10.1080/13814788.2023.2274467
Korstjens, I., & Moser, A. (2022). Series: Practical guidance to qualitative research. Part 6: Longitudinal qualitative and mixed-methods approaches for longitudinal and complex health themes in primary care research. European Journal of General Practice, 28(1), 118–124. https://doi.org/10.1080/13814788.2022.2053106
Konlan, K. D., Nukpezah, R. N., & Doat, A. R. (2024). Nurses' experiences in neonatal sepsis prevention and management: A qualitative cross-sectional study at selected hospitals in a metropolitan area. BMC Health Services Research, 24(1), 1298. https://doi.org/10.1186/s12913-024-11811-5
Mustapha, S. S., Zaidu, A. M., Azaria, N. T., Aliyu, S., & Abdulkadir, I. (2024). Neonatal sepsis—a peek into our findings in Northwest Nigeria: A prospective study. Egyptian Pediatric Association Gazette, 72, Article 53. https://doi.org/10.1186/s43054-024-00294-y
Ministry of Health, Ghana. (2025). National Health Quality Strategy 2024–2030. https://www.moh.gov.gh/wp-content/uploads/2025/05/National-Health-Quality-Strategy-2024-2030.pdf
Tafesse, N., Samuel, A., Geta, A., & others. (2022). Clinical ethical practice and associated factors in healthcare facilities in Ethiopia: A cross-sectional study. BMC Medical Ethics, 23(61). https://doi.org/10.1186/s12910-022-00800-0
Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed-method implementation research. Administration and Policy in Mental Health and Mental Health Services Research, 42(5), 533–544. https://doi.org/10.1007/s10488-013-0528-y
Rosa-Mangeret, F., Dupuis, M., Dewez, J. E., Muhe, L. M., Wagner, N., & Pfister, R. E. (2024). Challenges and opportunities in neonatal sepsis management: Insights from a survey among clinicians in 25 Sub-Saharan African countries. BMJ Paediatrics Open, 8(1), e002398. https://doi.org/10.1136/bmjpo-2023-002398
Traoré, F. B., et al. (2024). Prevalence and factors associated with maternal and neonatal sepsis in sub-Saharan Africa: A systematic review and meta-analysis. Frontiers in Public Health, 12, 1272193. https://doi.org/10.3389/fpubh.2024.1272193
UNICEF. (2023). Levels and trends in child mortality: Report 2023. United

Nations Inter-agency Group for Child Mortality Estimation.
UNICEF. (2024). Neonatal survival estimates and projections. New York: UNICEF.
WHO. (2022). Improving neonatal outcomes in low-resource settings: A roadmap for action. Geneva: World Health Organization.
World Health Organization. (2022). Newborn health: Sepsis and infections. https://www.who.int/news-room/fact-sheets/detail/newborn-health
Wondifraw, E. B., Wudu, M. A., Tefera, B. D., & Wondie, K. Y. (2025). The burden of neonatal sepsis and its risk factors in Africa: A systematic review and meta-analysis. BMC Public Health, 25, Article 847. https://doi.org/10.1186/s12889-025-22076-w
Ghana Statistical Service. (2021). 2021 Population and Housing Census: Population of regions and districts (Vol. 3A).
UNICEF. (2021). Levels and trends in child mortality: Report 2021. https://data.unicef.org/resources/levels-and-trends-in-child-mortality/


DOI: https://doi.org/10.5281/zenodo.17627474