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Healthcare provider perceptions of early Vayu bubble CPAP implementation in Ghana: a mixed-methods study within a national neonatal rollout

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Abstract

Background

Bubble continuous positive airway pressure (bCPAP) is an evidence-based intervention for neonatal respiratory distress and is increasingly used in low-resource settings. In Ghana, the Vayu bCPAP system was introduced into selected neonatal intensive care units (NICUs) alongside structured training and mentorship. This study explored healthcare providers' perceptions of training adequacy, device usability, clinical integration, and early implementation experiences following introduction of the Vayu bCPAP system.

Methods

A mixed-methods post-implementation study was conducted approximately six weeks after deployment of Vayu bCPAP devices and training as part of a broader rollout across 61 hospitals in Ghana. A structured self-administered electronic questionnaire was distributed to NICU staff from all hospitals. Staff from 25 hospitals responded and were used as a convenience sample. Quantitative data were analyzed descriptively, and qualitative responses were analyzed using inductive thematic analysis.

Results

Among 81 respondents, 77 (95.1%) reported using the Vayu bCPAP system following training. Providers generally described the device as functional, reliable, and easy to integrate into NICU workflows. Respondents also reported perceived benefits for neonatal respiratory care, including faster resolution of respiratory distress, improved oxygen saturation, earlier stabilization, and shorter hospital stays. Common reported implementation challenges included interface fit and prong sizing, assembly and disassembly, and cleaning requirements. Sustainability priorities identified by respondents included additional CPAP devices, maintenance systems, refresher training, reliable oxygen supply, and integration into government-supported systems.

Conclusion

Providers reported favorable early experiences with the implementation of the Vayu bCPAP system in Ghana and viewed the intervention as feasible, acceptable, and promising for improving neonatal respiratory care. Ongoing mentorship, refresher training, maintenance systems, and policy-supported scale-up will be critical to sustaining implementation and expanding access to life-saving respiratory support in low-resource neonatal settings.

Introduction

Despite substantial global progress in reducing under-five mortality, neonatal deaths now account for nearly half of all under-five deaths globally, with the greatest burden concentrated in sub-Saharan Africa and South Asia.[1] In Ghana, prematurity, low birth weight, birth asphyxia, neonatal sepsis, and respiratory distress remain major contributors to neonatal morbidity and mortality.[2] Many of these conditions are preventable or manageable with timely access to appropriate respiratory and supportive care.

Respiratory distress syndrome (RDS) is particularly common among preterm and low-birthweight infants due to immature lung development and surfactant deficiency. The World Health Organization recommends continuous positive airway pressure (CPAP) as a first-line, non-invasive respiratory support intervention for neonates with RDS because it improves oxygenation and reduces the need for invasive ventilation and mortality when appropriately implemented.[3]

However, conventional CPAP systems commonly used in high-income settings often depend on stable electricity, compressed medical air, and biomedical maintenance systems that are inconsistently available in many low- and middle-income countries (LMICs). These barriers limit access to effective respiratory support in neonatal intensive care units (NICUs), particularly in resource-constrained settings.

In Ghana, neonatal outcomes vary substantially across facilities due to differences in infrastructure, staffing, equipment availability, and clinical capacity. In some teaching hospitals in Ghana neonatal mortality among NICU admissions exceeds 20%, with mortality strongly associated with prematurity, low birth weight, birth asphyxia, and respiratory distress.[2] Similarly, a five-year retrospective review from a limited-resource neonatal unit in Ghana reported high mortality rates among preterm and very low-birthweight infants, highlighting persistent gaps in neonatal care delivery.[4] National newborn training initiatives have sought to strengthen neonatal care through programs such as Helping Babies Breathe and Essential Care for Every Baby, demonstrating the importance of standardized training and systems strengthening in improving newborn outcomes.[5]

To address gaps in neonatal respiratory support, low-cost and electricity-independent CPAP technologies have been developed for use in resource-limited settings. The Vayu bubble CPAP (bCPAP) system is designed to provide effective respiratory support without reliance on electricity, making it potentially suitable for LMIC contexts such as Ghana.[6] Emerging evidence from low-resource settings suggests that simplified bCPAP systems can improve access to respiratory support and neonatal survival. A randomized controlled trial in Malawi demonstrated improved survival among neonates treated with bubble CPAP compared with low-flow oxygen therapy.[7] Additional implementation studies have shown that simplified bCPAP systems can be feasibly integrated into neonatal units when supported by training, mentorship, and maintenance systems.[8–9]

As part of broader neonatal care strengthening efforts in Ghana, the Vayu bCPAP system was introduced into NICUs nationally alongside structured provider training and equipment distribution. A national two-day Training-of-Trainers (ToT) program trained 52 healthcare providers from 22 facilities, followed by cascade training for 1,456 healthcare providers across 61 hospitals.

This study examined NICU staff perceptions of the training and early implementation of the Vayu bCPAP system in Ghana. Specifically, the study aimed to: (1) describe provider perceptions of the adequacy and usefulness of Vayu bCPAP training; (2) explore early experiences with device usability and clinical integration; and (3) identify perceived clinical benefits, implementation challenges, and sustainability needs to inform future scale-up.

Methods

Study design

This study employed a descriptive mixed methods design in accordance with the Declaration of Helsinki to assess NICU healthcare providers' perceptions of training adequacy, device usability, implementation experiences, and sustainability considerations following the introduction of the Vayu bCPAP system in Ghana.

A mixed-methods approach was selected to provide a comprehensive understanding of the implementation experience. Quantitative data were used to assess training adequacy, device utilization, and perceived clinical impact, while qualitative data captured contextual factors, implementation barriers, and provider experiences.

Study setting

The study was conducted across 25 hospitals conveniently sampled across 61 facilities that had or were to receive Vayu bCPAP devices and training as part of a national neonatal care strengthening initiative. Participating facilities included regional referral hospitals and district-level hospitals with functional NICUs located across multiple regions of Ghana.

Hospitals were selected to capture diverse implementation experiences across urban and rural settings and varying levels of neonatal care capacity. All participating hospitals had completed standardized provider training prior to data collection.

Training intervention

The implementation initiative included a national two-day Training-of-Trainers (ToT) program for 52 healthcare providers from 22 facilities, followed by one-day cascade trainings for 1,456 healthcare providers from 61 hospitals.

Training content included:

- Device assembly and operation
- Patient selection
- Monitoring and troubleshooting
- Infection prevention and control

- Oxygen monitoring and respiratory management

The training used practical demonstrations and hands-on simulation to support competency development.

Data collection

Data were collected approximately six weeks after completion of training and deployment of the Vayu bCPAP devices. This time frame was considered sufficient to allow initial clinical use and early implementation experiences to emerge.

A structured self-administered questionnaire was distributed electronically using Google Forms. Survey links were disseminated through email and WhatsApp communication channels established during the training program and managed by facility and regional coordinators.

The questionnaire included both closed-ended and open-ended questions. Closed-ended questions captured demographic information, prior CPAP experience, training perceptions, and early device use. Open-ended questions explored implementation experiences, perceived clinical benefits, barriers, and sustainability recommendations.

Data analysis

Quantitative data were exported from Google Forms into Microsoft Excel for cleaning and descriptive analysis. Frequencies and proportions were calculated to summarize participant responses related to training perceptions, device utilization, and implementation experiences.

Qualitative responses were analyzed using inductive thematic analysis. Three researchers independently reviewed responses to identify recurring themes and implementation patterns. Initial codes were developed and refined iteratively through team discussion. Themes were grouped into six overarching implementation domains:

- Training experience
- Device usability
- Perceived clinical impact
- Enabling factors
- Implementation challenges
- Sustainability considerations

Results

Participant characteristics and device utilization

A total of 81 healthcare providers participated in the survey. Of these, 77 (95.1%) reported using the Vayu bCPAP system at least once following training. Some providers reported using the system in up to 100 neonates during the initial implementation period.

Training perceptions

Overall, the training was well received, with most respondents describing improved knowledge and clinical confidence related to neonatal respiratory care. Twenty-five respondents specifically described gaining new clinical skills, while 20 highlighted learning how to correctly use the Vayu bCPAP system. The most commonly identified limitation of the training was insufficient hands-on practice, reported by six participants.

Device usability and integration

Providers generally described the Vayu bCPAP system as functional, reliable, and easy to integrate into routine NICU workflows. Respondents reported that device setup, operation, and initiation of respiratory support were straightforward and facilitated timely neonatal care.

Ten participants reported no significant implementation challenges. Among those who identified challenges, the most frequently reported concerns included:

- Interface fit and prong sizing difficulties (n = 14)
- Assembly and disassembly challenges (n = 10)
- Cleaning difficulties (n = 4)
- Workload and device performance concerns (n = 2)

Perceived clinical impact

Most respondents perceived improvements in neonatal respiratory outcomes following introduction of the Vayu bCPAP system. The most commonly reported benefit was rapid resolution of respiratory distress (n = 46).

Additional perceived benefits included:

- Improved oxygen saturation and stabilization of vital signs (n = 9)
- Faster recovery
- Shorter hospital stays
- Improved overall clinical outcomes
- Perceived reductions in severe respiratory complications and mortality (n = 5)

Providers also reported that earlier stabilization and discharge of neonates helped reduce pressure on overcrowded NICUs.

Sustainability and scale-up considerations

Eleven themes emerged related to sustainability and future scale-up. The most commonly identified priorities included:

- Need for additional CPAP equipment (n = 24)
- Routine maintenance systems and spare parts availability (n = 20)
- Ongoing refresher training and mentorship (n = 20)
- Reliable oxygen supply
- Adequate staffing
- Integration of bCPAP into government-supported systems

Respondents emphasized that sustained implementation would require continued health system support, including equipment maintenance, supply chain strengthening, and policy-level integration.

Discussion

This study found that healthcare providers perceived the Vayu bCPAP system, supported by structured training and cascade mentorship, as feasible, acceptable, and beneficial for improving neonatal respiratory care in Ghanaian NICUs. Six weeks after implementation, most respondents reported increased confidence in respiratory management and perceived improvements in neonatal stabilization and recovery.

The perceived improvements in respiratory outcomes reported by participants are consistent with previous studies demonstrating the effectiveness of bubble CPAP in low-resource settings. A randomized controlled trial conducted in Malawi demonstrated improved survival among neonates receiving bubble CPAP compared with low-flow oxygen therapy.[7] Additional implementation research from sub-Saharan Africa has highlighted the role of CPAP in improving neonatal respiratory support where access to mechanical ventilation and surfactant therapy remains limited.[8]

High rates of device utilization and positive perceptions regarding ease of use suggest strong early adoption and integration into routine neonatal care workflows. Similar findings have been reported in other implementation studies of simplified bCPAP systems in LMIC settings.[9–11] Providers reported that straightforward device setup and compatibility with existing NICU workflows facilitated rapid initiation of respiratory support.

Despite these positive perceptions, several implementation challenges were identified. Difficulties related to nasal interface fit, prong sizing, assembly and disassembly, and cleaning requirements were commonly reported. Similar barriers have been identified in prior CPAP implementation studies and underscore the importance of ongoing mentorship, availability of multiple interface sizes, and regular competency-based training. [8]

Sustainability emerged as a critical implementation concern. Providers emphasized the importance of reliable maintenance systems, spare parts availability, refresher training, and consistent oxygen supply. These findings align with broader health systems literature suggesting that equipment-based interventions are most successful when embedded within supportive systems that include maintenance capacity, supply chains, workforce development, and government ownership.[12,13]

The findings of this study have important implications for national neonatal scale-up initiatives in Ghana and similar LMIC settings. While low-cost respiratory technologies such as Vayu bCPAP may improve access to life-saving respiratory support, sustained implementation requires investment not only in equipment, but also in workforce capacity, mentorship systems, biomedical support, and health systems integration.

Limitations

This study has several limitations. First, findings were based on self-reported provider perceptions rather than objective clinical outcomes, introducing the possibility of reporting bias. Second, data collection occurred relatively soon after implementation, limiting assessment of long-term sustainability and clinical impact. Third, participating hospitals were purposively selected and may not fully represent all NICU settings in Ghana.

Despite these limitations, provider perceptions remain important indicators of feasibility, acceptability, and early adoption, which are critical determinants of successful implementation in real-world healthcare settings.

Conclusion

The introduction of the Vayu bCPAP system in Ghana was perceived by healthcare providers as feasible, acceptable, and beneficial for improving neonatal respiratory care in NICUs. Providers reported improved confidence in neonatal respiratory management and perceived improvements in neonatal stabilization and recovery.

However, successful long-term implementation and national scale-up will require continued investment in competency-based training, mentorship, maintenance systems, oxygen infrastructure, and integration into government-supported health systems. These findings contribute to the growing body of evidence supporting implementation of low-cost respiratory support technologies in low-resource neonatal care settings.

Declarations

Ethics approval and consent to participate

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Institute for Medical Research rules, which are based on the U.S. Common Rule, exempted the study from ethical review as it comprised secondary review of routine program monitoring data[14,15]. Following standard ethical research practice, data collection methods were designed and carried out in accordance with the Declaration of Helsinki. Electronic informed consent was obtained from all participants prior to survey completion. The dataset was anonymized prior to analysis and contained no personally identifiable information.

Consent for publication

Not applicable

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Author Contribution

JA led conceptualization, analysis, methodology, supervision, writing. AA, EA, JO, and UO contributed to review and editing. SA contributed to data analysis. RA carried out analysis, review, and editing.

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Data Availability

All data are available on reasonable request. Contact the corresponding authors to access the data analysed in this study.

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Supplementary Files

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- SupplementaryfileVayuPostTrainingFollowupSurveyTool.docx