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The introduction of nursing led bubble-CPAP in a neonatal unit in Ghana: A 32-month observational report

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A R T I C L E I N F O

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A B S T R A C T

Neonatal deaths account for nearly 50 % of under-five deaths in Ghana with prematurity as the leading factor. Bubble continuous positive airway pressure (bCPAP) is important in treating respiratory distress (RD) associated with prematurity but its use in Africa is challenging. There is limited equipment to care for vulnerable newborns and insufficiently trained healthcare staff. This 32-month observational study describes the characteristics and outcomes of bCPAP treated newborns as a nursing led intervention at a regional referral hospital in Ghana. In May 2014, bCPAP was introduced to newborn intensive care unit (NICU) nursing staff. Three bCPAP machines and supplies were donated by Medical Technology Transfer and Services (MTTS). A training program provided learning opportunities for US-based and Ghanaian staff. Locally collected data included: NICU census, staffing, admitting diagnosis, birth weight, gestational age, Apgar scores, antenatal corticosteroid administration, days on bCPAP, and survival. From May 2014 to December 2016, 189 newborns received bCPAP. The mean ± SD (range) gestational age was 30.0 ± 4.2 (24–42) weeks, birth weight was 1.5 ± 0.7 (0.5–4.25) kg, and bCPAP duration was 3.2 ± 3.3 (0–14) days. In 155 (82.0 %), the admission diagnosis was prematurity with RD. Survival in this group was higher compared to other diagnostic categories and improved as birthweight increased ($p < 0.05$). Overall, 57.8 % of bCPAP treated newborns survived, but survival decreased during the last 12 months for newborns < 1.5 kg. This study supports the long-term sustainability of a nursing-led bCPAP program in Africa, but positive outcomes may be compromised by staffing, equipment, and resource limitations.

1. Introduction

Worldwide, the mortality of infants and children under the age of five has steadily decreased over the past two decades. Unfortunately, neonatal deaths have been much slower to decline and the greatest burden of the mortality remains in Africa (Hug et al., 2018). In sub-Saharan Africa (SSA), one in 36 neonates die within one month compared to one in 333 in high-income countries (HICs) (Hug, 2017). Neonatal deaths commonly occur in the first week of life from complications related to prematurity, intrapartum birth asphyxia, and sepsis (Liu et al., 2016; Wardlaw et al., 2014). To mitigate such conditions, hospital-based births with skilled birth attendants is recommended (Montagu et al., 2017; Munabi-Babigumira et al., 2017).

Ghana has similarly shown two- and three-fold reductions in infant and under-five child mortality, but newborn mortality has only decreased from 43 to 25 deaths/1000 live births and accounts for nearly 50 % of deaths in children under five (Ghana Statistical Service, 2017). Hospital births have increased from 54 % to 79 %, but the quality of care has been insufficient to prevent early neonatal deaths (Brantuo et al., 2014; Enweronu-Laryea et al., 2018; Ghana Statistical Service, 2017). Ghana, like other low- and middle-income countries (LMICs), has difficulty providing facilities, equipment, and staff necessary to care for

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small and sick newborns (Bolan et al., 2021; Thukral et al., 2016). Efforts to improve hospital care for vulnerable newborns in Africa must be accelerated if progress is to be made in reaching the sustainable development goal target of 12 neonatal deaths/1,000 livebirths (Kruk et al., 2018; Sustainable Development Goals, 2021; Standards for Improving the Quality of Care for Small and Sick Newborns in Health Facilities, 2020).

A key challenge in Africa is premature care delivery. Preterm birth, <37 weeks gestation, is the leading cause of neonatal death and contributes to prolonged hospitalization and long-term morbidity (Lawn et al., 2013; Liu et al., 2016). Simple solutions to improve preterm outcomes include higher quality antenatal care, maternal antenatal corticosteroid and antibiotic administration, and kangaroo mother care (Lawn et al., 2013; Requejo et al., 2013). Premature newborns have underdeveloped lungs, increasing susceptibility to respiratory distress syndrome and pneumonia (Jensen et al., 2016). In HIC, surfactant use and advanced ventilatory support curb mortality, but in Africa, respiratory distress (RD) treatment is often limited to low flow oxygen administered through nasal cannula (Bjorklund et al., 2019). Low flow oxygen via nasal cannula does not provide the distending pressure needed to maintain functional residual capacity or to prevent atelectasis, therefore, the World Health Organization recommends continuous positive airway pressure (CPAP) for the treatment of RD in preterm newborns in LMIC (WHO Recommendations on Interventions to Improve Preterm Birth Outcomes, 2015).

Bubble CPAP (bCPAP) is a relatively simple, cost-efficient, and noninvasive form of respiratory support that requires less technical expertise than endotracheal intubation and mechanical ventilation (Kinshella et al., 2020). CPAP has been used to manage RD in HIC for decades, but its use is relatively new for hospitals in SSA (Kinshella et al., 2020; Wilson, 2019). Several studies found that bCPAP can be applied by nurses following short, on-the-job training courses; however, implementation challenges and long-term outcome studies are lacking (Kinshella et al., 2020; Koyamaibole et al., 2006; Martin, Duke, & Davis, 2014; Wilson et al., 2017; Wilson, 2019). The objective of this 32-month observational study is to describe the characteristics and outcomes of newborns treated with bCPAP following its introduction in a major referral hospital in Ghana.

2. Material and methods

2.1. Study setting

The Greater Accra Regional Hospital (GARH) is a major referral facility in the capital city and one of the largest hospitals in Ghana. The hospital conducts approximately 8,000 deliveries per year, with 70 % high-risk referrals, and 1,300 newborn intensive care unit (NICU) admissions (Srofenyoh et al., 2016). Admissions stem from births within the hospital and referrals from numerous facilities across the metropolitan area.

In 2014, the NICU at GARH had a 14-bed capacity with 14 staff nurses and four nursing supervisors providing clinical care and one senior administrative nurse. One pediatrician offered limited NICU supervision due to numerous responsibilities across the hospital campus. Medical officers provided some support to the pediatrician on a rotational basis. There was no central oxygen source; oxygen was administered via large cylinders through Y-tubing such that nasal cannula oxygen could be delivered to multiple newborns per cylinder without blending oxygen. There were occasional outages of oxygen and electricity. Handwashing was limited to one veronica bucket and one sink in an anteroom adjacent the NICU. Mechanical ventilation and surfactant were unavailable. There were limited functioning radiant warmers, incubators, cardiorespiratory monitors, and syringe pumps. Blood gas analysis and chest radiographs were limited.

In 2014, Kybele, Inc., a US based non-government organization, the Ghana Health Service (GHS), East Meets West Foundation and Access Bank partnered to improve the NICU capacity at GARH. Access Bank and GHS enlarged the physical space, East Meets West donated equipment and supplies, and Kybele, Inc. provided training and mentoring for neonatal staff, primarily in the use of bCPAP. Kybele, Inc. had previous familiarity working with front-line healthcare workers in Ghana to improve obstetric outcomes (Srofenyoh et al., 2012).

2.2. Device

Donated equipment included three bCPAP devices (MTTS, Breath of Life v3, Hanoi, Vietnam), three pulse oximeters (Lifebox, Acare Technology, New Medical Technology Transfer and Services [MTTS] Taipei, Taiwan), four oxygen control devices, 200 Ram style nasal cannulas in various size, and two wash basins, among other supplies. The MTTS CPAP system has a humidified, heated patient circuit with positive end-expiratory pressure control and oxygen blending capability. It is built to withstand variations in humidity and electrical supply. The components are durable and reusable, optimizing functionality in low resource settings.

2.3. Training

A training and mentoring program on bCPAP use was piloted at GARH from May 19 to June 3, 2014. Three US-based trainers familiar with the local conditions, included a neonatologist, a neonatal nurse practitioner, and a respiratory therapist. Didactic lectures were provided for nurses, rotational house officer physicians and the pediatrician working in the GARH NICU. Topics included: bCPAP use and cleaning, initiation and assessment of bCPAP based on Silverman-Anderson criteria (Silverman and Andersen, 1956), complications (pulmonary air leaks, gastric distention, nasal buccal erosion), monitoring and documentation, weaning and discontinuation of bCPAP, and managing bCPAP during electricity and oxygen outages. Bedside clinical mentoring was conducted using the bCPAP apparatus on newborns needing respiratory support. A bCPAP protocol and various monitoring forms were developed with input from local providers. Preterm infants 28–35 weeks gestation with RD were targeted to benefit most from bCPAP; however, the nursing staff independently allocated the bCPAP. In September 2014, two nurses and one neonatal nurse supervisor from GARH NICU were sponsored for two weeks to visit two US-based academic institutions to observe NICU practices. From April 4 to 11, 2015, the original training team returned to Ghana to assess implementation and outcomes.

2.4. Data collection and analysis

Retrospective, de-identified data on bCPAP use were collected by a local NICU nurse from patient folders and log books and entered into Excel (Microsoft, Redmond, WA) for analysis. Data collection included admitting diagnosis, birth weight, gestational age by last menstrual period or physical maturation assessment, one- and five-minute Apgar scores, maternal corticosteroid administration, number of bCPAP days, and survival. Additionally, from December 2014 to May 2015, a research assistant collected data on NICU census and nurse to newborn staffing ratios. Other data sources included hospital generated annual reports. Data are presented as mean ± standard deviation or number (percent) and analyzed with Chi-square or students *t*-test (Social Science Statistics, 2020), as appropriate, and $p < .05$ considered significant. Institutional review board approval for data collection and analysis was obtained from the Ghana Health Service (GHS/DGS/G-27) and the Wake Forest School of Medicine (IRB00021947). The study used retrospective, deidentified data and met criteria for waiver of informed consent. All methods were performed in accordance with the relevant guidelines and regulations.

3. Results

From May 19, 2014 to December 31, 2016, 189 newborns at GARH received nasal bCPAP following training and mentoring of frontline neonatal healthcare providers.

3.1. Characteristics of newborns provided bCPAP

For newborns treated with bCPAP, the mean ± SD (range) gestational age was 30.0 ± 4.2 (24–42) weeks, birth weight was 1.5 ± 0.7 (0.5–4.25) kg, and time on bCPAP was 3.2 ± 3.3 (0–14) days. The characteristics of newborns administered bCPAP for all causes are shown in six-month intervals in Table 1. Gestational age, weight, Apgar scores, and bCPAP duration were similar across each time segment. For bCPAP treated newborns, the primary diagnosis was prematurity with RD in 155 (82.0 %), birth asphyxia in 24 (12.7 %), and other diagnoses in 10 (5.3 %), including sepsis, twin-twin transfusion syndrome, ABO incompatibility, meconium aspiration, and term gestation with RD.

Among neonates treated with bCPAP by year, the admission diagnosis of preterm with RD was 34/37 (92 %) in 2014, 70/81 (86 %) in 2015, and 51/71 (72 %) in 2016, while the admitting diagnosis of birth asphyxia was 3/37 (8 %) in 2014, 7/81 (9 %) in 2015, and 14/71 (20 %) in 2016. Table 2 shows the Apgar scores, gestational age and weight for newborns administered bCPAP by diagnostic group. Apgar scores were lowest in the birth asphyxia group while gestational age and weight were lowest in the preterm with RD group as compared to the other diagnostic groups. The average length of time on bCPAP was similar among groups.

3.2. Survival of newborns on bCPAP

The survival of bCPAP administered newborns by diagnosis and weight categories are shown in Table 3. Survival was greatest when bCPAP was utilized for preterm newborns with RD compared to other diagnostic categories ($p < .05$). Survival for preterm infants with RD who received bCPAP improved as weight increased. Fig. 1 shows survival by weight category (<1.5 kg vs. 1.5–2.4 kg) of preterm newborns with RD that received bCPAP each year. In 2016, survival decreased in bCPAP-treated preterm newborns <1.5 kg as compared to 2014 and 2015 ($p < .05$). No difference was found in the survival of 24–36-week gestational age newborns treated with bCPAP who received or did not receive antenatal corticosteroids 51.4 % (18/35) vs. 50.0 % (38/76), respectively.

3.3. NICU census and staffing

Annual report data revealed that bCPAP use among all infants admitted with prematurity with RD gradually increased from 34 of 177 (19.2 %) in 2014, to 70 of 340 (20.6 %) in 2015, and to 51 of 203 (25.1 %) in 2016. In contrast, bCPAP use in newborns with birth asphyxia remained low; three of 146 (2.0 %) in 2014; seven of 313 (2.2 %) in 2015; and 14 of 336 (4.2 %) in 2016. From December 8, 2014 to May 31, 2015, data collected on the NICU census, cot sharing, and staffing revealed that although the number of NICU beds increased from 14 to 21, the average daily number (range) of babies in the NICU was 29 (17–50). Cot sharing among unrelated newborns was observed on 86 % of days. The average ratio of nurses to newborns on the day shift (08:00–14:00) was 1:7.4, the afternoon shift (14:00–20:00) was 1:6.4, and the night shift (20:00–08:00) was 1:7.7. The minimum nurse to newborn staffing ratio was 1:4 and the maximum was 1:11.6 during the data collection period.

Table 1
Characteristics and outcomes of newborns treated with bCPAP over time.

	5/2014–12/2014 n = 37	1/2015–6/2015 n = 43	7/2015–12/2015 n = 38	1/2016–6/2016 n = 20	7/2016—12/2016 n = 51
Gestational age, wk	32.1 ± 3.6	30.4 ± 5.6	30.5 ± 3.7	30.7 ± 3.3	31.0 ± 4.2
Weight, kg	1.6 ± 0.8	1.6 ± 0.7	1.4 ± 0.5	1.5 ± 0.4	1.5 ± 0.7
1-Min Apgar	3.8 ± 1.9	4.4 ± 1.8	4.2 ± 2.2	4.2 ± 2.0	3.3 ± 2.2
5-Min Apgar	5.2 ± 1.8	5.7 ± 1.9	5.6 ± 2.0	5.2 ± 2.1	4.6 ± 2.2
bCPAP, days	2.6 ± 1.1	2.4 ± 1.6	3.0 ± 1.6	2.1 ± 2.6	3.2 ± 3.3
Survived to discharge	27 (71.0)	29 (67.4)	24 (63.2)	11 (55.0)	20 (39.2)*

bCPAP, bubble continuous positive airway pressure.
Data expressed as mean ± SD or N (%); *$p < .05$ comparison of 7/2016–12/2016 to other periods.

Table 2
Characteristics of newborns treated with bCPAP by admission diagnosis.

	Preterm with RD n = 155	Birth asphyxia n = 24	Other n = 10
Gestational age, wk	30.3 ± 2.8	34.4 ± 5.6	35.7 ± 5.2
Weight, kg	1.4 ± 0.4	2.3 ± 1.2	2.0 ± 0.7
1-Min Apgar	4.1 ± 1.9	2.7 ± 2.1	5.0 ± 2.5
5-Min Apgar	5.4 ± 1.9	4.0 ± 2.2	6.4 ± 1.9
bCPAP, days	2.8 ± 2.2	2.4 ± 3.1	2.4 ± 1.7
Survival to discharge	100/155 (64.5)*	6/24 (25.0)	5/10 (50.0)

RD, respiratory distress; bCPAP, bubble continuous positive airway pressure.
Data expressed as mean ± SD or N (%); *$p < 0.05$ comparing Preterm with RD vs Birth asphyxia.

Table 3
Survival of newborns treated with bCPAP by weight category and admission diagnosis.

Weight	Preterm RD*	Birth asphyxia	Other	Total
<1 kg	10/26 (38.5)	0/7 (0)	0/1 (0)	10/34 (29.4)
1–1.49 kg	34/59 (57.6)	0/1 (0)	0/3 (0)	34/63 (54.0)
1.5–2.49 kg	55/69 (79.7)	2/5 (40.0)	3/3 (100.0)	60/77 (77.9)
>2.5 kg	1/1 (100.0)	4/11 (36.4)	2/3 (66.7)	7/15 (46.7)

bCPAP, bubble continuous positive airway pressure; RD, respiratory distress; other, neonatal sepsis, twin-twin transfusion, ABO incompatibility, meconium aspiration, and term newborn with RD.
*$p < 0.01$ comparing weight categories within Preterm RD.

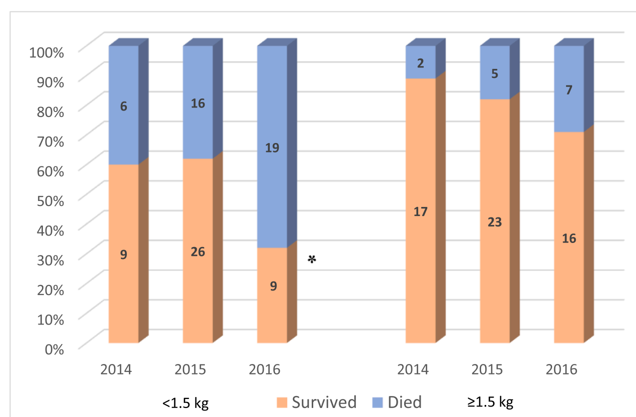

Fig. 1. Survival of preterm newborns admitted with respiratory distress and treated with bCPAP by weight category <1.5 kg and ≥1.5 kg over time. Numbers expressed within the columns are the number of newborns that either survived or died each year in the <1.5 kg and ≥1.5 kg weight categories. *$p < .05$ in 2016 as compared to 2014 and 2015 for bCPAP treated newborns < 1.5 kg.

4. Discussion

This study describes the introduction of nursing led bCPAP for neonates in an African referral hospital where nasal cannula oxygen was previously the only respiratory support available. Bubble CPAP use was sustained over the 32-month period, the longest consecutive period described in SSA. The most common diagnosis among bCPAP treated newborns was prematurity with RD. Survival was highest in this diagnostic category and improved as birth weight increased. Overall, survival was 58.7 % for bCPAP-treated infants during the 32-month period; however, survival decreased in 2016 in newborns <1.5 kg.

Two studies report higher survival rates in bCPAP-treated neonates than in this study. A small six-month randomized trial in a Tanzanian referral hospital compared bCPAP ($n = 25$) to nasal cannula oxygen ($n = 23$) in preterm infants <37 wks and ≥ 1 kg and reported 77.3 % survival in the bCPAP group compared to 47.8 % in the nasal cannula group (Mwatha et al., 2020). Similarly, Kawaza et al. (2014) performed a non-randomized study based on bCPAP and staff availability over 10-months for neonates ≥ 1 kg with severe RD in a regional hospital in Malawi. Seventy one percent of the bCPAP treated newborns survived compared to 44 % in the nasal cannula group. Our nursing-led, observational study did not have strict criteria for initiating bCPAP; thus, it included some infants *in extremis*, term infants with birth asphyxia and infants <1 kg. However, the survival of infants with birth weight 1–1.49 kg treated with bCPAP in our cohort in 2014 and 2015 was 57.1 % and 67.7 %, respectively, which is comparable to 65.5 % survival reported in the same weight category by Kawaza et al. (2014). Similar to our findings, McAdams et al. (2015) in Uganda found that bCPAP treated preterm infants with a diagnosis of RD had higher survival rates than did those diagnosed with birth asphyxia, 62.5 % versus 40 %, respectively.

Two studies initiated bCPAP as part of a quality improvement program. Carnes et al. (2019) reported outcomes of nursing-led CPAP use in 26 rural hospitals in Malawi consisting of a 5.5-month pre-CPAP period, a 15-month post-bCPAP implementation period ($n = 366$ CPAP treated), and an additional 11-month follow-up period ($n = 257$ CPAP treated) during 2013–2015 as part of a 3-phase quality improvement program. They reported significant improvements in survival among 1–2.49 kg neonates with RD who received CPAP (54.5 %) and results were sustained. The survival in our cohort in the corresponding weight category was (89/128) 69.5 %. The authors found that hypothermia, power outages, and staff turnover limited CPAP use and sustainability (Carns et al., 2019). Switchenko et al. (2020) evaluated the use of CPAP in >1 kg infants with RD in a referral hospital in Kenya. They compared a 22-month, pre-bCPAP period to a 12-month post-bCPAP period and found that mortality in the bCPAP group ($n = 100$) decreased from 56 % to 22 % over the course of their Plan-Do-Study-Act cycles in the post-bCPAP period. Improvements included enhancing existing infrastructure, staff training, standardizing care, and employment of a nurse educator. The authors noted that bCPAP use was adversely impacted by labor interruptions due to strikes.

4.1. Barriers and facilitators to bCPAP implementation

Understaffing was likely a barrier for bCPAP utilization in the present study. Staffing guidelines developed by the American Academy of Pediatrics and affirmed by the Association of Women's Health, Obstetric and Neonatal Nurses, recommend a nurse-to-patient ratio of one to three to four low-risk newborns and one to one for severely ill newborns (Guidelines for Professional Registered Nurse Staffing for Perinatal Units Executive Summary, 2011). Our census and staffing observations revealed an average nurse to newborn ratio of 1:7, which exceeds the recommendations. Other studies have similarly found inadequate staffing as a limitation to the provision of higher-quality neonatal care (Bolan et al., 2021; Kinshella et al., 2020; McAdams et al., 2015; Nyondo-Mipando et al., 2020). In Uganda, NICU staffing was consistent with the current study in that one pediatrician reviewed NICU patients daily and two to four nurses were assigned per shift (McAdams et al., 2015). They reported an average daily NICU census of 22, a nurse-to-patient ratio of 1:5 and 52 % survival in bCPAP treated infants >1 kg, similar to our findings; however, the study only included 21 newborns (McAdams et al., 2015).

Several have reported the lack of bCPAP use following training due to poor staff motivation related to understaffing and frequent turnover (Fulton, 2014; Nahimana et al., 2015; Ntigurirwa et al., 2017). Poor motivation was unlikely a factor in the present study because bCPAP use was consistent over time even with staffing limitations. More likely, limited availability of bCPAP devices impacted its use. Although bCPAP use for preterm infants with RD increased over time from 19 % in 2014 to 25 % in 2016, the fact that only 25 % of preterm infants received bCPAP suggests equipment limitations. In a similarly sized NICU in Malawi, 20 % of all newborns were estimated to require bCPAP. Given that bCPAP use continued for 3–4 days per eligible infant and admissions were unevenly distributed, at least five bCPAP machines would be required (Crehan et al. 2018). In the present study, there was an average (range) of 29 (17–50) babies in the NICU each day. Since prematurity with RD was a leading cause for admission, it is likely that more babies were eligible for bCPAP than received it due to the availability of only three bCPAP machines. The selection process for which newborns received bCPAP given the likely equipment limitation is unclear. Furthermore, equipment limitations could have also delayed bCPAP initiation, which may have also impacted survival. Limited availability of bCPAP devices and intermittent oxygen supply have been similarly reported (Kinshella et al., 2020).

Several factors may have facilitated bCPAP use in our study. The MTTS bCPAP device was embraced by the nursing staff due to its relative simplicity. The device was low maintenance without consumable parts, making it ideal for use within a resource-limited setting. Others have reported sustainability challenges with donated commercial CPAP systems, due to lack of maintenance capability (Kinshella et al., 2020; Ntigurirwa et al., 2017). In our study, the suppliers had an in-country office and were able to provide maintenance support. The machines themselves, designed to withstand environmental fluctuations in electrical supply and humidity, remained functional well beyond the project period. At the time of this writing, one of the initial bCPAP machines is still functioning, and additional machines have been obtained locally. Another factor which may have favorably impacted bCPAP implementation was the training methodology. We utilized intermittent, interactive onsite training and coaching by experienced clinicians and selected local nurses for observational experiences in the US. Indeed, regular, interactive training by a combination of external consultants and local leaders in dedicated NICU positions has been shown in several studies to facilitate bCPAP implementation (Nahimana et al., 2015; Ntigurirwa et al., 2017; Olayo et al., 2019). The regular, short visits by external consultants provided context specific training while ensuring long-term ownership of clinical care by the local nursing staff (Ntigurirwa et al., 2017). Experience sharing trips, even when conducted in-country to higher level neonatal units, have been shown to enhance motivation and knowledge gain (Fulton, 2014; Kinshella et al., 2020).

5. Limitations

This descriptive study has several limitations. Data was unavailable for the number of newborns who met criteria for bCPAP treatment but were unable to receive it, although this was likely to have occurred. In a chart review from Rwanda, only 52 % of infants who met the criteria for bCPAP received it, suggesting gaps in identification and initiation of bCPAP among eligible infants (Nahimana et al., 2015). In our study, it was unclear how closely the guidelines for bCPAP initiation and use were followed, or how nurses determined which newborn should receive bCPAP in the event of equipment limitation. We did not assess complications related to bCPAP use, although data from a recent systematic review of bCPAP in SSA found no major complications among 17 studies

(Kinshella et al., 2020). We relied on routinely collected clinical data and could not verify the accuracy of the admitting diagnosis; however, others have reported that information provided by clinicians in similar settings is reasonably consistent (Nahimana et al., 2015). Additionally, we were unable to determine why survival decreased in 2016 for bCPAP treated neonates <1.5 kg. There is evidence that deaths due to sepsis doubled in 2016 compared to 2013–15 (2017 NICU annual report) for reasons that are unclear. We cannot exclude the possibility of infection related to use of the bCPAP apparatus; however, infection may have also occurred because admissions frequently exceeded bed capacity with cot sharing among unrelated newborns. Finally, we acknowledge there was significant delay in the preparation of this manuscript due to travel and other restrictions posed by the Covid pandemic. This, however, does not change the validity of the findings.

6. Conclusion

This study on bCPAP use in a busy referral hospital in Ghana extends other reports from SSA. Because the study spans 32 months of bCPAP use, it supports the ongoing feasibility of a bCPAP program led by nurses but also highlights the potential limitations of sustaining positive outcomes over time. Restricted staffing, electricity, oxygen supply, equipment maintenance, ancillary supplies, and the lack of comprehensive care elements (hand hygiene, thermoregulation, pulse oximetry, cardiorespiratory monitoring) may potentially compromise the benefit of bCPAP.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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