Research Article

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Neonatal respiratory support substations within Nigerian special care baby units: a noteworthy initiative

Abstract

Many LMIC neonatal care settings such as Nigeria have been unable to develop a decisive solution against poor neonatal respiratory support that could drive down soaring neonatal mortality rate. Indigenous LMIC companies and philanthropic organisations could be strategically guided and encouraged into playing an efficient passionate role as partners in the bridging of this failure gap. Therefore, such organisations deserve a deliberate collaborative motivation by providing them with enough facts to assess the urgency to partner in saving numerous neonatal lives. A new initiative of 'neonatal respiratory support substation' as a distinct subsection of the standard special care baby unit (SCBU) in the Nigerian setting was implemented by an indigenous Nigerian company. Four tertiary hospitals across four major geo-political regions of Nigeria independently benefitted from the passionate gifts and discretely followed up to assess its early impacts. Results from the Centres were similar with each revealing 94%-100% successful sub-discharge rates within the first 18 weeks of the application. Could this be the long-awaited game changer in Nigeria and the LMICs?

Keywords: RDS, neonatal respiratory support, LMIC, neonatal hypothermia

Volume 15 Issue 1 - 2025

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Received: December 3, 2024 | **Published:** February 17, 2025

Introduction

The Grand Award Nite of the prestigious Nigeria Prize for Science (NPS, the highest prize for science on the continent of Africa), which was held on the 13th October 2023 in Lagos, Nigeria, was a huge celebration accompanied with the Nigeria Liquefied Natural Gas (NLNG) Limited, the sponsors' promise of the installation of the winning science in a few hospitals to support the survival of numerous Nigerian newborn babies who die as a result of respiratory distress syndrome (RDS) and related disorders. By the acceptance of the NPS2023 laurel, the winner signed up for a volunteer office as a Global Brand Ambassador of the Nigerian company to support their community empowerment activities globally in the related areas. Therefore, in keeping to this promises of neonatal intervention and after many deliberations, the new ambassador was taxed to lead the execution of the said project as subsequently delivered in four of Nigeria's tertiary hospitals, namely, the Special Care Baby Units (SCBU) at (1) Niger Delta University Teaching Hospital (NDUTH), Yenagoa in Southern Nigeria (2) University of Benin Teaching Hospital (UBTH), Benin-city in the mid-west (3) University of Abuja Teaching Hospital (UATH), Gwagwalada Abuja in the middle-belt, and (4) Aminu Kano Teaching Hospital (AKTH), Kano in the northern region, all for an equitable national coverage of the NLNG gift. The NPS2023 winning science was the B3-model of politeheartCPAP device.[1] The ambassador was, hence, mandated to apply the most recent model of this technology to design and implement an impactful package of neonatal respiratory support intervention across these Nigerian centres and ensuring an unambiguous outlay that could enhance easy measurable outcomes from the application.

Neonatal respiratory disorder

Neonatal respiratory distress syndrome (RDS) conditions and their associated neonatal limitations such as prematurity, perinatal asphyxia, neonatal hypoxemia, neonatal hypothermia, etc contribute significantly to neonatal deaths in Nigeria.[2] This is worse for extremely preterm neonates across LMICs as over 90% of them would die within a few hours or days after birth.[3] Nigerian hospitals are inadequately or very poorly equipped to offer necessary support for neonates experiencing these conditions and hence exacerbating the high neonatal mortality in the country.[4]

Impactful interventions may come through the installation of well-crafted and Nigerian- tailored technologies for the breathing support needed by these poorly neonates.

There have been some notable efforts of a few LMIC researchers in addressing issues of poor respiratory support previously, howbeit, with associated unresolved limitations.[5,6] However, such technologies as assessed within the Nigerian setting and climate, must be highly efficient and easy to operate and must possess sustainable qualities such as high affordability of consumables and maintenance spare parts. The lack of such devices so-described is a huge gap in the national healthcare delivery which must be efficiently and decisively closed for Nigeria's corporate neonatal mortality rate to be considerably reduced.

Rather than doing nothing for the teeming population of needy neonates, Nigerian clinicians often resort to an 'improvised-CPAP' setup, which has been demonstrated to trigger an iatrogenic severe hypothermia complications in very preterm and extremely low birthweight neonates, leading to deaths.[7] Commercial range CPAP devices are widely unaffordable, hence unavailable in most of Nigeria's hospitals for neonatal care. A few prominent Nigeria tertiary hospitals exist where various versions of CPAP devices are donated by different global agencies, most of which are poorly understood or poorly operated for the maximum benefit of the needy neonates. The presence of the combinations of these notable devices such as—

the Pumani, Fisher-and-Paykel, Phoenics, Draeger, Diamedica, and of course the Improvised-CPAP, has yielded insignificant reduction of mortality from various classes of needy neonates, especially the extremely low birthweight category, whose survivals require an in-depth knowledge of the machine's operational effects on their special anatomical features, maturity levels, and functional physiologies. In the crowd of these various devices, it is often down to individual's perception to state the device that is doing more than the others. To be effective in the Nigerian setting, a CPAP device should be able to prevent hypothermia rather than to instigate this for lack of the capability of generating operator-selectable temperature of the respiratory gas. It should be capable of continuous real-time monitoring of the neonate's oxygen saturation (SPO_2) status, it should be capable of generating operator-selectable specific fraction-of-inspired-oxygen (FiO_2) and positive- end-expiratory-pressure (PEEP), etc. Many of these available applications are lacking in some of these essential requirements. Therefore, the much-anticipated reduction of RDS-implicated neonatal mortality continues to elude the Nigerian neonatal care system.

The politeheart continuous positive airway pressure (politeheartCPAP) device has been assessed to possess all these rare qualities and yet highly affordable. Therefore, following its emergence as the technology at the centre of winning the prestigious Nigeria Prize for Science 2023, the NLNG found it necessary in using this technology to collaborate with the few selected hospitals to initiate this humanitarian intervention for the survival of the Nigerian neonate. Hence, the aim of this mandate was to innovate a measurable high-impact implementation package of the politeheartCPAP intervention at these hospitals and to follow up on their impact for up to the first six months of usage.

Materials and methods

The presence of too many other brands of CPAP devices in the chosen hospitals would not allow easy independent assessment of the politeheartCPAP brand amidst the crowd. Therefore, the initiative of a neonatal respiratory support "substation" (RespSS) was innovated—being an isolated space within the SCBU where specially trained respiratory support nurses would apply the strict operational rules of the 'politeheartCPAP' systems to micromanage the neonates admitted into the substation of the SCBU. The B5-model is the latest version of the politeheartCPAP, designed to specifically achieve 4 goals, including (1) uninterrupted mechanical breathing for the incapacitated neonate to keep it alive whilst it continues its maturity outside of the mother's womb (2) ensure direct respiratory gas warming for thermoneutral adequacy of the internal organs via positive heat-exchange of perfused blood stream in the lungs (3) initiate breathing training for the neonate through chest muscle rhythm control when neonate is matured enough for this (4) algorithmized withdrawal of breathing support for full patient's independent breathing.

The design of the substation was crafted to ensure an uninterrupted neonatal life- support delivery in the recipient centres. Two or three units of the politeheartCPAP device were installed in each of the four chosen hospital SCBUs. A small corner or section of the existing Neonatal Intensive Care Unit (NICU) or SCBU was specifically modified to accommodate the substation's other supplementary technologies, including (i) four ports capacity polite-oxygen splitter system (PSS) which functions to multiply the utility of available medical oxygen by up to 700%[8] (ii) 10 LPM capacity oxygen concentrator (iii) one set of $6m^3$ capacity oxygen cylinder with regulator (Figures 1–5).

Figure 1 UBTH, Benin-city substation.

Figure 2 UATH, Gwagwalada.

Figure 3 AKTH, Kano substation.

Figure 4 Solar sub-power station at all centres.

Figure 5 Two NDUTH Yenagoa Substations (left – outborn, right – inborn sections).

Citation: Amadi HO, Abubakar AL. Neonatal respiratory support substations within Nigerian special care baby units: a noteworthy initiative. *J Pediatr Neonatal Care.* 2025;15(1):47–50. DOI: 10.15406/jpnc.2025.15.00582

The oxygen concentrator is used during sunshine, powered by solar energy, while the oxygen cylinder is applied during sunset, all discharging into the PSS for oxygen distribution across its four 'service ports' where the neonates are connected via the politeheartCPAP devices. The substation is separately equipped with an independent solar sub-power alternative delivering 4 KVA with 2400 watts gang of solar charging panels. The substation is exclusively hooked unto the automatically operated mini sub- power station (Figure 4), ensuring that the substation never shuts down even during total blackout of the main hospital mains facilities.

Hardware installation was quickly followed by operational and clinical hands-on training which ran for up to 3 days at each centre. At the end of training, the most distressed neonates at each centre were identified and given a turn-around intervention in the new substation whilst the clinical and nursing attendees learned the necessary skills for subsequent takeover of the substation's clinical operations. The NLNG ambassador remained on call duty at each hospital until all the 'training case' neonates were weaned off the system. The NDUTH Yenagoa and UATH Abuja received three units of the politeheartCPAP system and three units of the oxygen- concentrator each, while UBTH and AKTH received two units, each. At NDUTH, a second substation with a 3-service-port capacity PSS was installed to exclusively carter for neonates born within the hospital—the 'inborn' neonates (Figure 5, right).

Additional post-12-weeks maintenance and operational review was carried out across the University Hospitals, including 'advanced training' on the use of the politeheartCPAP for the management of neonatal co-morbidities such as chest- indrawing, grunting, tachypnoea, bradypnea, and hypothermia. The current training was aimed to consolidate and to build upon the basic knowledge and early practice experience that the clinicians and nurses had acquired from the initial training.

Appropriately tiny neonates, such as freshly delivered <30 weeks GA and <800 g BW, were coincidentally available during the review-mission at various hospitals, and were applied to practically demonstrate how the politeheartCPAP could aid them into independent breathing in a little over 24 hours or less. Technical maintenance and clinical support from the NLNG ambassador are continuing for a minimum of six months post-installation across the centres, and continuing follow-up of the discharged patients for up to one year post-treatment.

Results

An average of five days were spent at each hospital during initial hardware installations of the substation and the initial training of an average of 21 staff per hospital—comprising clinicians, nurses and engineers. Three 'training case' neonates were managed by the ambassador at NDUTH Yenagoa before departure or end of regular online clinical rounds – two at UATH Abuja, one at UBTH Benin-city, and two at AKTH Kano. All the neonates were successfully coached to respiratory independence using the politeheartCPAP device. The index neonate at NDUTH was weaned off politeheartCPAP after 29 hours – 24 hours at UATH, 49 hours at AKTH, and 3 days for initial wean-off at UBTH.

The politeheartCPAP device demonstrated its three different levels of neonate's support – (i) breathing for an incapacitated neonates, buying off time for it to regain strength or for the clinical team to identify and resolve the implicated primary conditions leading to the respiratory distress (ii) coaching the neonate to breathe with minimal labour, and the control of chest muscle rhythm for breathing, fixing the often associated tachypnoea, and (iii) coaching the neonate to breathe with less amount of supplemental oxygen until unpressurized atmospheric air becomes sufficient for the baby's independent breathing. None of the cases presented with hypothermia during treatment and the substations functioned with no power supply interruptions as designed. It was easy to monitor and document the 'in' and 'out' neonatal traffic and specific quality of life of neonates being sub-admitted for intervention with the politeheartCPAP and its supplementary systems, with successes and challenges easily counted at sub-discharge back into the SCBU hall. Overall, across the five substations at the four SCBUs during the initial 18 weeks leading to this publication, a total of 72 neonates (NDUTH-31, UATH-22, UBTH-14, AKTH-5) were sub-admitted, receiving an average of two days of treatment per patient, with a successful weaning-to- independent-breathing rate of 99.3%, excluding the few cases that required onward referral before the end of treatment. The two referral cases were parent-imposed to explore treatments elsewhere but who had already progressed by more than 50% of the treatment process. The treated neonates cut across all categories of prematurity and extremely-low birthweight, including many successful cases of extremely-preterm birth of 25 and 26 weeks of gestational age at NDUTH, UBTH, UATH, and AKTH substations, respectively, and 680g lowest birthweight at UBTH. Many bigger neonates of >1200 g BW or >32 weeks GA were often coached to independent breathing in less than 24 hours.

Discussion

The collaborating hospitals were previously observed to experience diverse kinds of operational challenges limiting their efficiency in neonatal respiratory support, for which the newly installed neonatal substation has provided a renewed hope. Some of these were poor power supply—countered by the RespSS uninterrupted solar power installation, insufficient oxygen supply—countered by the RespSS's politeoxygen- plitter-system (the PSS), lack of any functional commercial-brand CPAP machine or lack of efficient models of the technology—countered by the usage of the politeheartCPAP device. The immediate impact of the politeheartCPAP system and the general operation of the substation were greeted with spontaneous acceptance at all the hospitals through the visible excitement of the clinicians and nurses, and the votes-of-thanks from the leadership of the hospitals.

The use of CPAP devices with selectable respiratory-gas temperature, such as the politeheartCPAP, ensures adequate pulmonary warming, preventing the reduction of organic surfactant production and minimising pulmonary vasoconstriction.[9] This saves the huge cost of pharmaceutical surfactant administration which is often unaffordable with the consequences of worsening respiratory distress and loss of life.

The trained staffs of the hospitals have so far demonstrated significant understanding of what they learnt through the subsequent successes achieved in the short period of 18 weeks to this publication, following the training and departure of the ambassador.

For example, the first recipient of the substation, the NDUTH Yenagoa, managed 31 patients on the devices and successfully weaned-off >90% of them from the machine for independent breathing—a feat they never came close to achieving in 17 years. The NDUTH office of the Chairman of Medical Advisory Committee (CMAC) reported that the overall mortality and morbidity trend from the hospital's SCBU had improved significantly with shorter length of hospital-stay and less than half of the average historic weekly mortality notifications. The SCBU of some leading Nigerian tertiary hospitals— including

UBTH Benin City—strictly advocate and insist on immediate post-natal administration of prophylactic pharmaceutical surfactant especially to very preterm neonates being managed with improvised and other available commercial grade CPAP machines as mentioned in the 'Introduction Section' of this article. However, the use of the politeheartCPAP does not require prophylactic surfactant as the device helps the neonate to preserve its organic surfactant, enabling it on the average, to achieve independent breathing for the neonate more than ten times quicker than other applications. On treatment cost, parents are required to purchase a nasal prong/cannula, which is widely available at about ₦800 (US$0.5) for the neonate's interface on the politeheartCPAP. This is the only direct cost on the parents. However, for the other applications at these leading SCBUs, parents are made to pay up to ₦500,000 (US$313) for surfactant plus up to ₦150,000 (US$94) for the one-use set of tubings required for operating some of these CPAP applications, making a total of up to ₦650,000 (US$407) for each neonate. There is a huge amount of economic savings with better clinical outcomes and positive comparative advantage of ease of device operation as qualitatively assessed from the first four months of usage by the clinicians and nurses at the centres.

The special case of a set of triplets at the RespSS of UATH Abuja created a spontaneous unintended inter-device application comparative scenario. Baby-A1, Baby-A2, and Baby-A3 were triplets, who were brought to the UATH SCBU shortly after birth. Baby-A2 was mildly distressed as compared to the other 'severely-distressed' siblings who were having laboured breathing as evidenced in them having both subcostal and intercostal chestwall recessions. Therefore, the two extremely poorly A1 and A3 were each assigned to the two available politeheartCPAP machines while the mildly distressed A2 was anchored to a Diamedica Baby CPAP machine (Diamedica UK, Kingdom Fields, Bratton Fleming, EX31 4EN, UK). The three neonates were managed by the same set of nurses on-duty throughout. Treatments began at 9.40 pm on Friday, and by 10.15 am the following Monday (2.5 days), Baby-A1 and Baby-A3 had fully recovered, independently breathing, and sub-discharged back to the SCBU hall. However, at the same time on the said Monday, Baby-A2 remained distressed with oxygen support on the Diamedica system. A decision was made by the clinicians on-duty to transfer Baby-A2 out of the Diamedica to one of the freed politeheartCPAP systems. Hence, Baby-A2 was placed on the algorithmic processes of the politeheartCPAP at 10.15 am, and by 2.10 pm (in about 4 hours only), the neonate was fully out of distress, breathing independently, and sub-discharged to join the other siblings in the open SCBU. The politeheartCPAP has quickly, in less than five months, become the preferred first choice of application at UATH SCBU for neonatal respiratory disorder due to its 100% success rate and many comparative advantages over the rest of alternative applications at the centre.

Recommendation

Specific attention to respiratory disorder is necessary in LMIC neonatal care to enable successful life-support—buying off enough time for the identification and treatment of the primary causes of the respiratory distress. The present initiative of neonatal respiratory support substation in SCBUs is recommended across Nigeria and LMICs to extend this same life-saving opportunity to as many other tertiary hospitals as possible to decisively lower the huge contributions of RDS to our high neonatal mortality rate.

Acknowledgements

On behalf of the Nigerian neonate, we wish to thank the MD of the Nigeria LNG Limited and his management team for this laudable gift of effective life-support for the teeming population of Nigeria's needy newborns. We hope that the hospitals who benefitted will carefully look after the devices for the longer usage of many future neonates at the various centres. Neonatal Concerns for Africa (www.neonatalconcerns.org) is a collaboration of Imperial College London United Kingdom, which anchors Professor H Amadi's research network across Nigeria. We thank Engr Onyeabo Ebenmelu, Mr Jude Nzerem, Mr Jerry Okoye and Mr Chuks Ugbome for their sacrificial services towards the successful execution of this project. We also thank the Nigeria LNG staff support team, especially Mr Ben Ochuko Apute and Mr Phatiwo Iwokiri Aprioku, for their guidance throughout the setting out and physical implementation of this project.

Funding

None.

Conflicts of interest

The authors declare that they have no conflict of interest.

References

1. Ekhaguere OA, Okonkwo IR, Batra M, et al. Respiratory distress syndrome management in resource limited settings—Current evidence and opportunities in 2022. *Front Pediatr.* 2022;10:961509.
2. Orjingene O, Teryila O, Baffoe P, et al. Factors affecting maternal and neonatal mortality in northern Nigeria: a multiple linear regression analysis. *MedRxiv*. 2022;1–23.
3. Amadi HO, Okonkwo IR, Abioye IO, et al. A new low-cost commercial bubble CPAP (bCPAP) machine compared with a traditional bCPAP device in Nigeria. *Paediatr Int Child Health*. 2019;39(3):184–192.
4. Eze JN, Edelu BO, Ndu IK, et al. Paediatric emergency medicine practice in Nigeria: a narrative review. *BMC Emerg Med*. 2023;23(1):31.
5. Rauschendorf P, Bou Saba G, Meara GK, et al. Effectiveness of a novel bubble CPAP system for neonatal respiratory support at a referral hospital in the Philippines. *Front Pediatr*. 2023;11:1323178.
6. Egesa WI, Waibi WM. Bubble nasal continuous positive airway pressure (bNCPAP): an effective low-cost intervention for resource-constrained settings. *Int J Pediatr*. 2020;2020:8871980.
7. Amadi HO, Abubakar AG, Abubakar AL, et al. Hypothesis of iatrogenic severe hypothermia of internal organs in extremely-low birthweight infants during bubble CPAP intervention at room-temperatures in Nigeria. *EC Paediatr*. 2019;8(6):517–524.
8. Amadi HO. The Politeoxygen splitter system (PSS) – a frugal LMIC oxygen delivery technology that expands the utility by up to 700%. *J Pediatr Neonatal Care*. 2023;13(2):75–80.
9. Carns J, Kawaza K, Quinn MK, et al. Impact of hypothermia on implementation of CPAP for neonatal respiratory distress syndrome in a low-resource setting. *PLoS One*. 2018;13(3):e0194144.