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A Community integrated concept that minimises death of most vulnerable neonates at poor-resource environments

Abstract

Introduction: Highest proportion of most vulnerable Nigeria neonates are concentrated in hard-to-reach local villages without proper intervention devices owing to unavailable electric power. Hence, majority of needy neonates continue to lose their lives due to their inability to journey to urban cities where few inadequately equipped neonatal intervention centres are located. The Nigerian healthcare system requires the neonates to make the often-treacherous journeys, travelling into the cities in search of possible intervention. This system has continued to fail generations of precious neonates who could have survived otherwise. It is therefore imperative to device a technique that could enable the reversal of the patient traffic – by "taking our medicine to them right where they are" instead of waiting for them to come to our medicine right where we are at urban locations.

Methods: Solar-based applicable devices and simplified neonatal intervention procedures operable by basic medical and nursing officers were developed. The technologies were fundamentally tailored for maintainability by the local people. This empowers the confidence of treating many of the regular neonatal emergencies at primary healthcare centre located within the villages. Uncomplicated treatable cases are believed to constitute over 65% of all cases and hence could be adequately supported. Appropriately remanufactured tricycle was modified to operate ambulatory services for referring the cases requiring specialist care in the city.

Conclusion: Successful implementation of this concept and its scale-up could guarantee over 75% reduction of neonatal mortality within a controlled geographical region.

Keywords: neonate, nigeria, neonatal mortality, innovative technique, neonatal rescue, neoroom

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Abbreviations: NMR, neonatal mortality rate; MDG, millennium development goal; UNIGME, united nations inter-agency group for child mortality estimation; RIT, recycled incubator technology; SCBU, special care baby units; EFS, evening fever syndrome; PHC, primary health centre; NRS, neonatal-rescue-scheme; NBC, neonatal basic care; NAC, neonatal ambulatory care; GH, general hospital; ISA, initial-setpoint-algorithm; UATH, university of abuja teaching hospital; F7D, first-seven-days of life

Introduction

Unsolved burden of high neonatal mortality in Nigeria: The burden of very high neonatal mortality rate (NMR) in Nigeria remains unsolved despite a wakeup call that could have been instigated by her failure to achieve the Millennium Development Goal (MDG) target of 2015. The United Nations Inter-Agency Group for Child Mortality Estimation (UNIGME) publication of 2021 declared Nigeria as having the highest estimated neonatal mortality in the world.[1] Previous investigation into the factor of lack of adequate functional incubators at Nigerian health facilities and the possibility of creating an affordable effective solution for neonatal thermoneutral support led to the innovation of the recycled incubator technology (RIT) in 2003.[2,3]

The RIT invention and application across many hospitals in Nigeria exposed other inadequacies of the neonatal centres; hence, it became obvious that incubator availability was only one step into the understanding of what the lack of functional incubators represented. Incubator intervention in Nigeria's climatic setting needed operational skills and practical knowledge of fundamental physics, which was lacking amongst practitioners. Incubators needed constant availability of power supply to function. This was rarely available even at tertiary centres located in big cities as unsteady electric power supply is a major challenge affecting many sectors in Nigeria.[4] Incubators needed routine maintenance to be optimally functional to save lives; however, there was a widespread lack of technical knowhow to achieve this. The Nigerian climate and various seasons of the year seemed to affect incubator functionality and hence overall neonatal thermoneutral control; however, this was not well-understood. Therefore, the neonates still died in their numbers even at neonatal centres with functioning incubators. Temperature control and thermal stability in the Nigerian neonate needed to be better studied, investigating the various militating cofactors. The successful implementation of the RIT enabled many hospitals to expand the incubator capacities of their special care baby units (SCBU) with the technical help provided by visiting 'Neonatal concerns for Africa' consultants.[5] This enabled further research investigations using the collaborating centres, inspired by the race of achieving the United Nations' Millennium Development Goal, target No. 4 agenda (MDG4) prior to 2015.

The MDG4-inspired devices and innovations: In the process of the collaborative studies with these hospitals, discoveries were made - we discovered and investigated neonatal evening fever syndrome (EFS)[6,7] and the antidote to counter the effect of this.[8] We researched and validated frugal remedies to various cofactors of neonatal morbidity in multicentre studies that were summarised in our 2014 publication.[9] These studies revealed a common deficiency at SCBUs across the entire country. This common deficiency was that neonates (especially preterm) were found to spend considerable periods of their first seven-days-of-life (F7D) at body temperatures outside the physiological safe-zone of 36.5°C to 37.4°C.[10] The situation was not very different for neonates that managed to have incubator support.

Case files showed that many of the deceased neonates remained in this poor thermal condition until death. The published demography of highest risk foetal and new born babies in Nigeria implies that this situation is fewer than 35% of the national population of the perinatal cases – essentially those who have access to the urban city located facilities.[11] The remaining 65% or more of cases are found within the local, rural, and suburban communities with no good access roads or grid electric power to run any effective neonatal units within their nearby primary health centres (PHC). It is expected that the neonates who are being born at these rural communities are, by far, in worse outcome situations than the urban-accessible infants. Hence, for the rural neonate, the fight for survival requires traveling to the urban cities in search of intervention – a journey they rarely complete before death. Therefore, a successful battle to drastically lower neonatal mortality in Nigeria must be fought and won at the rural community Healthcare centres, targeting the >65% of the cases – rather than concentrating all efforts at the urban city tertiary hospitals.

Hypothesis of present concept

We hypothesise that a successful reversal of patient traffic by 'taking our medicine to their remote locations' instead of waiting for them to come to our urban locations will reduce neonatal mortality by more than two-thirds.

Aim

This was to apply all our trialled frugal technologies and scientific lessons gleaned during the MDG4 race to develop a range of essential neonatal devices which are maintainable by the local people and designed with the capability of direct or indirect access to solar energy, thus harnessing the sun for uninterrupted power to support neonates in remote Nigerian villages.

Materials and methods

Concept description

The broad concept of Nigerian neonatal-rescue-scheme (NRS) is divided into three intervention levels – (1) Neonatal Basic Care (NBC) at the community/rural healthcare centres, (2) Neonatal Ambulatory Care (NAC) which is a basic educated technique of neonatal transport for referral cases, and (3) Specialist Neonatal Care for referred cases at tertiary hospitals (NRS hubcentre). The NRS at NBC level identifies fundamental neonatal morbidities which could easily be treated with access to essential technologies by knowledgeable attendants who have basic nursing and midwifery training. The basic nursing and medical officers are trained on how to carry out early assessments to isolate difficult cases. Hence, conditions requiring specialist care such as certain congenital conditions and complications are recognised. Therefore, NRS applies two cadres of facilities in each regional (controlled) cluster of service delivery, fundamentally designed for 10 healthcare facilities per cluster – constituting of one 'Hub-centre' for specialist cases surrounded within 30 km radius by up to nine 'Neorooms' for neonatal basic care at PHC level.

The neoroom

This is a miniaturized special neonatal Unit (room) created near the maternity section of the PHC facility. This involves a new or renovated 1-2 room spaces in an existing and strategically located PHC or General Hospital (GH). The Neoroom-unit is architecturally rebuilt to fit the purpose of NBC, operated by existing PHC maternity staff who would have undergone a special NBC training. The neoroom is set at 7-10 patient capacity with its predominantly solar-power dependent devices. The NBC training involves essential neonatal management courses specifically designed to equip practicing medical officers, nurses and technical/nursing assistants within the local community on (1) how to apply provided solar-powered devices to deliver thermoneutral support, respiratory support, treat severe/mild jaundice and resuscitate a distressed neonate (2) how to recognise and isolate severe and complicated neonatal conditions for referral, and adequately prepare patients for effective neonatal transport to the appropriate NRS Hubcentre. The specifically remanufactured solar-adapted devices for the Neorooms include: solar-neonatal incubators, radiant warmers, suction machine, patient vital-signs monitor, intensive and normal phototherapy machines, oxygen concentrator, special oxygen distribution system – the polite O2 splitter system[12] overhead water tank distribution system, direct solar lighting installation system – the polite-light-bank (PLB) system, which provides intensive lighting within and outside the facility building, automatically switching to cover all night hours – from dusk to dawn. The Neoroom is designed to generate and bank over 200% of its daily required power utilisation from the sun, on site, for equipment operation and facility lighting. A power banking factor-of-safety of 1.2 is applied to prevent the failure of neoroom operations or facility lighting during rainy periods when daily sunshine is reduced. Wind-power generators are anticipated supplements at neoroom facilities especially during the intensive rainy days; however, this has not yet been installed for trialling.

The hubcentre

The hubcentre is created from existing neonatal referral centre of a tertiary hospital located within the NRS regional or geographical cluster. The NRS hubcentre is an upgraded version of a typical Special Care Baby Unit usually found at a Nigerian tertiary hospital, which has practicing neonatologists or paediatricians. The hubcentre admits and treats local cases as well as prioritizes referrals from all nine neorooms within its catchment cluster. An NRS ambulatory service stationed at the hubcentre uses a specifically remodelled vehicle equipped with low voltage powered transport incubator and tailored respiratory support gadgets to appropriately retrieve referred neonates from the Neorooms within its cluster for specialist care at the hubcentre. The low-cost locally maintainable ambulance is constructed using a widely used tricycle vehicle which Nigerians popularly call 'keke'. The ambulance operates with two specifically trained nurse-driver combos per duty run. The hubcentre is fully equipped with similarly tailored resilient devices and techniques for economically constrained settings as earlier described in the literature.[13]

Results

Proof of concept

Trialling of Hub-centres (Neonatal hospital Minna in northern Nigeria and Federal Medical Centre Owerri in southern Nigeria): A typical hubcentre facility with its sub-units, sections and specialist gadgets for neonatal interventions was set up at the Jummai Babangida Aliyu Maternal and Neonatal Hospital Minna Nigeria in 2017. These gadgets and hubcentre systems have been trialled for five years leading up to this article and have been assessed as highly successful by the Ministry of Health of Niger State Government of Nigeria.[14] All the necessary mains-voltage or solar-power hybrid neonatal devices for the hubcentre strategies were installed and implemented for over five years at the Minna hubcentre. In a '5-years of operation report' released by the office of the Niger State Governor – the owners of the centre – the new concept has enabled a drastic reduction of neonatal mortality within Minna city and the entire State capital territory. The report revealed that facility-based mortality which was previously quantified at 900 per 1000 neonates who presented prior to 2017 had

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reduced to 100/1000 presenting neonates by 2022.[14] This success was attributed to the efficiency of the hubcentre technologies and strategies. A second hubcentre was constructed and opened for service at the Federal Medical Centre Owerri Nigeria in 2022. The Owerri hubcentre serves a dual purpose, including full hubcentre strategies as well as the trialling of the developed prototypes of gadgets, devices and procedures used in the implementation of the Neoroom strategies of rural village settings.

Each of the Neoroom devices is designed with 'semi-autonomous' power supply function. This enables each device to operate additional private power storage 'buffer unit', which is a system that enables it to independently continue its operation after sunset via its privately banked energy in battery packs. Many of the devices are modified or remanufactured from existing standard machines which have been adapted to operate using the harvested solar low-voltage power. The devices cover the wide range of essential systems for neonatology intervention adapted to operate primarily on power harnessed from solar or wind energy. Therefore, 100% of daily power requirement are generated from the sun, on site. These neonatal devices have been demonstrated, trialled, and continuing in use at the Special Care Baby Unit of the Federal Medical Centre Owerri Nigeria as at the time of writing this article.[15] The showcased technologies and devices attracted the attention of the Cable News Network (CNN) and were featured in their independent documentary of "Inside Africa" programme of July 2022.[16]

Discussion

Scale-up

More than 65% of unborn Nigerian neonates who would need emergency neonatal special intervention would be born at remote locations, far from functional facilities which are in big cities.[11] Lack of neonatal care facilities within the rural communities and poor road infrastructure for long distance neonatal transport make it almost impossible to save the huge number of needy neonates with emergency conditions as many of them would die before they could reach an appropriate intervention facility. Those who may arrive alive would present with very poor vital signs that might become irredeemable. This age-long scenario of neonatal care system in Nigeria has continued to limit the ability of Nigeria to lower her high neonatal mortality rate till date. The NRS concept provides the empowerment for effective immediate neonatal intervention by rural community healthcare workers, with the potential of saving many lives, and reversing the trend of neonatal mortality in Nigeria. The individual successes of all the developed hubcentre and neoroom devices confirm the potential success of a rollout of any full-scale Neonatal Rescue Scheme as conceptualised.

Basic procedures

Over the last 12 years, we have researched and developed basic attendant's procedures that could enable us achieve zero-tolerance to neonatal temperatures outside the neonatal thermal safe-zone.[17] Hence, the Handy-approach procedure was published in 2012, and the impact assessment of this application was carried out in another study in 2015.[7,10] The Initial-set point-algorithm (ISA) procedure was developed and introduced in several collaborating Nigerian centres in 2014 to specifically address initial thermal instability of neonates within the first hour of neonatal care. In a proof-of-concept study of the combined effect of ISA and Handy-approach procedures at the SCBU of University of Abuja Teaching Hospital (UATH), the neonatal mortality rate (NMR) of extremely preterm neonates was shown to have been reduced from 484/1000 (as it stood previously) to <5/1000 – without any mortality recorded during the first-seven-days of life (F7D) period.[17] The Book of Abstracts of the 2016 conference of Paediatrics Association of Nigeria reported mortality related outcomes from independent studies at six different referral centres. Four of these centres which operated conventional techniques reported mortality figures such as 464/1000, 168/1000, 133/1000 and 128/1000, respectively. However, the two remaining studies came from centres that were managed based on our ISA and Handy-approach concepts – these reported outcomes such as 58/1000 (FMC Owerri) and <5/1000 (UATH Abuja), clearly revealing the distinction between the new innovations and the conventional methods.[18–24] These unconventional techniques demonstrate how we may achieve a drastic reduction of early neonatal deaths (during F7D period), thereby buying enough time for any effective intervention before it is too late for the neonate.

These concepts of ISA and Handy-approach, in conjunction with the introduced supporting hardware devices, have been shown to provide rapid and consistent physiological stability – which the neonate essentially requires for readjusting in its strangely new environment outside the womb. It is currently known that 4-in-5 of the neonates that would not survive in Nigeria would die within the F7D period and that neonates contribute nearly 50% of under-5 mortality.[25–27] Therefore, the reduction of F7D mortality – as has been demonstrated in this article – is a crucial requirement to solving the problem of high overall NMR in Nigeria. This can be achieved by the scale-up of these concepts in a rollout that would target an entire State or in bits of smaller geographical areas in Nigeria.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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