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ORIGINAL ARTICLE

Electrification and specialist training associated with decreased neonatal mortality and increased admissions in Sierra Leone

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Abstract

Aim: The aim of this study was to describe the evolution of a regional neonatal service in Sierra Leone and changes in mortality and service use as it transitioned from a non-specialist service to a dedicated special care baby unit (SCBU).

Methods: This was a retrospective observational study. Anonymised data were taken from the ward admissions books at Bo Government Hospital, and trends in admissions and mortality within the neonatal service were examined for each stage of the department's evolution.

Results: Four phases of the service's development were identified between November 2015 and October 2019. Records of 2377 admissions and 333 deaths were identified. The average number of admissions per month and deaths per month varied by service development phase. There was a trend towards reduced death rates and increased numbers of admissions as the unit evolved into a dedicated neonatal unit with a reliable electricity supply.

Conclusions: The development of an adequately sized SCBU with a reliable electricity supply and specially trained staff was associated with a reduction in the death rate and an increase in admissions.

KEYWORDS
electricity, infection control, neonatal, Sierra Leone, solar power

1 | INTRODUCTION

The reduction in neonatal mortality targeted in the United Nations Sustainable Development Goals[1] will require a multifaceted strategy. Interventions such as infection control training, maternal training, and improvements in thermal regulation and homeostasis for neonates have been demonstrated to have significant impacts on survival.[2,3] The availability not just of infant warmers but also of a dependable electricity supply to power them is one example of the interdependency of factors required to make a meaningful impact on neonatal mortality in low-resource settings. Similarly, the lack of oxygen in these settings has been flagged[4] as a major impediment to achieving the neonatal and child mortality goals set out under the Sustainable Development Goals.

In 2021, the neonatal mortality rate in Sierra Leone was 31 per 1000 live births.[5] While progress has been made in reducing this

Abbreviations: BGH, Bo Government Hospital; CHO, Community Health Officer; SCBU, Special Care Baby Unit.

number, it remains one of the highest rates in the world. Newborn services in Sierra Leone are under-developed and are concentrated mostly in the capital city, Freetown. However, most of the population lives outside Freetown and has no access to specialised neonatal services.

As part of a wider plan in Sierra Leone to bring newborn care to a greater proportion of the population, work has begun to establish special care baby units (SCBUs) in district hospitals around the country. SCBUs are generally staffed by non-specialty-trained doctors, nurses, and community health officers (CHOs). District-level SCBUs have the advantage of taking unwell newborns out of crowded general paediatrics wards, where they are exposed to many infectious diseases. These units usually depend on the unreliable national grid for electricity to power incubators and other key items of equipment.[6]

Bo Government Hospital (BGH) is the main hospital serving the Bo district in Sierra Leone. It is the third most populous district in the country, with a population of approximately 600 000 people. Historically, the care of unwell newborn infants took place in the general paediatrics ward, which was situated on the opposite side of the Hospital campus to the labour ward. Between 2015 and 2019, the service evolved through several phases, with the establishment of a permanent neonatal unit happening in 2018. The staff in this permanent unit underwent basic, structured neonatal training and infection control training. A solar power system was eventually installed to augment the power supply from the national grid via the Liebreich Foundation, a philanthropic organisation based in the UK, which coordinated a global fundraising effort.

This study described the evolution in the delivery of newborn care and examines patterns of newborn admissions and deaths between 2015 and 2019 in BGH during the phased introduction of a dedicated neonatal service with specially trained staff and a reliable electricity supply.

Key Notes

- There is a developing evidence base around infrastructural changes, such as electrification, and key indicators in neonatal units in low-income settings.
- From 2015 to 2019, the neonatal service at Bo Government Hospital, Sierra Leone, evolved from delivery in a general paediatrics ward to a dedicated special care baby unit with trained staff and a reliable electricity supply.
- During this period, admissions to the service rose, and the mortality rate declined.

2 | METHODS

Data were taken from the admission records at BGH neonatal unit and anonymised prior to collation and analysis. These data were entered by nursing staff as patients were admitted to the department. The criteria for admission to the neonatal facility were determined by clinical staff on duty at any given time. These criteria remained informal throughout the study period but evolved to encourage a low threshold for admission.

The study period ran from November 2015 to October 2019. For each month of the study period, a proforma was completed. This recorded the number of newborns admitted to the service, the number of neonatal deaths occurring during that calendar month, and the percentage of neonatal admissions that died.

Retrospective data were collected from historical admission books from November 2015 until August 2017. Data from May 2016 to February 2017 inclusive were unavailable. This is because the admission books containing these data were stored in a room that was found to contain rodents. In light of the 2013 to 2016 outbreak of Ebola, it was decided locally to destroy the contents of several storerooms that had infestations with possible Ebola Virus hosts. Data were collected prospectively between August 2017 and October 2019.

Trends in the number of admissions to the unit and the proportion of those who died per month were assessed graphically and with linear or Loess regression. Analysis was performed using Excel (Microsoft Corporation, Washington, USA) and R v4.1.2 (R foundation for statistical computing, Vienna, Austria).

The solar power system described in this paper is a photovoltaic system designed to provide power to the neonatal unit during electricity blackouts. It consisted of a 28.88 Wp solar field, three inverters of 10 KVA each (Victron, Almere-Haven, The Netherlands), and five lithium batteries of 15.5 KWH each (BYD, Guangdong Province, China). The system is monitored remotely and cost approximately $71000 USD.

3 | RESULTS

Overall, 2377 newborns were admitted to the facility, and 333 newborns died (14.0%) during the study period. Table 1 shows the number of admissions, as well as the number and proportion of deaths by phase of the neonatal service evolution. The lowest proportion of deaths and highest numbers of admissions were seen in the final phase of the SCBU's development, where babies were admitted to a large unit with a reliable electricity supply.

Historically, newborns were managed in the general paediatrics ward, for which data were available from November 2015 to April 2016. During this time, the available data showed that less than 20 newborns were admitted each month. The proportion dying during each of those months ranged from 0% to 21.0%, with a mean monthly mortality rate of 12.7%. There were no dedicated neonatal medical or nursing staff assigned to newborn care during this phase of the service's development. Care was provided by the nurses, CHOs, and doctors on the general paediatrics ward. Data from this

TABLE 1 Timeline summary for neonatal service development in BGH.

Phase/Timeframe	Development	Number of admissions	Average monthly admissions	Number of deaths	Average monthly deaths (*n*, % of admissions)
November 2015[a]–January 2017	Historical—newborns managed in the general paediatric ward—grid electricity	71	11.8	9	1.5 (12.7%)
January 2017[b]–July 2017	Neonatal annexe attached to general paediatrics ward—grid electricity	230	46	52	10.4 (22.6%)
August 2017–May 2018	Small neonatal unit built beside labour ward—grid electricity	623	62.3	115	11.5 (18.5%)
June 2018–September 2018	Large neonatal unit with diesel generator (power 18–20 h/day)	315	78.8	40	10.0 (12.7%)
October 2018–October 2019	Large neonatal unit with solar power system (power 24 h/day)	1138	87.5	117	9.0 (10.2%)
Totals		2377	62.6	333	8.7 (14%)

[a]9 months of missing data.

[b]2 months of missing data.

period in the neonatal service's history included 6 months of data and 9 months of missing data.

The next step in the evolution of the service occurred in January 2017, when a separate neonatal annexe was built onto the general paediatrics ward. This area had no dedicated nursing staff, medical staff, or any other new resources. It was also physically separated from the general paediatrics ward by a locked gate. Nurses were based in the general paediatrics ward and only attended the neonatal annexe if required for specific tasks. Data were missing for the first 2 months of this phase. However, admissions and mortality data were available for six of the 8 months that the annexe was in operation, which shows that the number of admissions was higher when the annexe was operational than before it existed. During this time, the numbers of admissions ranged from 33 to 57 per month. A higher proportion of these admissions died than during the previous phase, with a mean monthly mortality rate of 22.6%.

In August 2017, the neonatal service moved across the hospital campus to a small unit with eight cots beside the labour ward. This was a 24-h service with approximately three nurses assigned to the department at any given time, with one doctor working from 0900 to 1700 hours each day. Out-of-hours medical cover was provided by the on-call CHO for paediatrics. Formal infection control training was also commenced using a cascade training model. Experienced neonatal nurses from Freetown came to BGH to teach infection control practices to neonatal nurses. This training focused mostly on handwashing and the avoidance of cross-infection contamination. Two nurses were sponsored by the Ministry of Health to spend a number of weeks at the neonatal unit in Freetown. There, they received intensive training in newborn care, with a particular focus on infection control and prevention. These nurses then returned and provided on-the-job mentoring and delivered formal in-house training to their colleagues and to new nurses between 2017 and 2019. This resulted in a good institutional culture of infection prevention and control. This training also equipped the nurses with the skills to provide bubble CPAP and to use overhead warmers when electricity was available. This development came with additional dedicated nursing staff, and electricity was supplied from the national grid, which provided power on an erratic basis. While the proportion of newborns dying remained high during this period, there was a steady decline in mortality over this 10-month period, as infection control procedures were rolled out. The proportion dying in the first month was 21.9% and had dropped to 13.0% by May 2018, the final month before the unit moved to a larger room. The overall mean mortality rate in this phase was 18.5%.

Following the movement of the neonatal unit to a larger room with 23 cots in the same part of the hospital in June 2018, infection control practices were maintained, and a reliable electricity supply became available. Nursing staffing increased to four nurses during daytime hours and three nurses in the evening and overnight. There remained one doctor on duty from 0900 to 1700 hours each day, and out-of-hours medical support was provided by the CHO on-call for paediatrics. This SCBU had no solar power system during its first 4 months in existence. During this time, a temporary diesel generator was installed, providing electricity for approximately 18–20 h/day, while the department transitioned to a 24-h solar power system. In the 17 months that followed, high numbers of admissions were seen, with October 2019 seeing 119 newborns admitted to the unit. There were 100 or more babies admitted to the service in four

of the 13 months after installation of the solar power system. During the period for which data were available, the unit had only ever admitted 100 babies in a month on one occasion previously. Moving the SCBU into a large space with a reliable electricity supply was associated with a dramatic reduction in the proportion of newborns dying, as well as the numbers admitted. The proportion of children dying after the establishment of a reliable electricity supply and a larger treatment space was 10.8%. There was a small difference in the proportion dying while electricity was supplied from a generator (12.7%) compared to when the solar power system was installed (10.2%).

Figure 1 shows the increase in demand for the neonatal service from 2015 to 2019. The stepwise evolution of the SCBU saw a progression from admitting approximately 20 babies per month in 2015 to frequently seeing 100 babies per month in 2019. Figure 2 illustrates the reduction in mortality over time and how this aligned with the different phases in the evolution of the neonatal service. There was a continuous reduction in the proportion of newborns dying from late 2017 until 2019. The death rate stayed consistently low in 2018 and 2019 when the unit was large enough to facilitate basic infection control practices and when there was a reliable electricity supply.

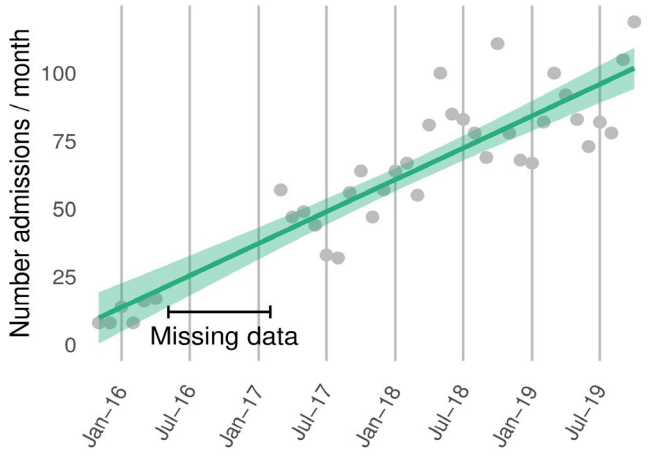

FIGURE 1 Neonatal admissions to BGH by month, November 2015–October 2019.

4 | DISCUSSION

Neonatal mortality is a major contributor to the overall child mortality picture in Sierra Leone[3] and globally.[7] This study shows that the number of newborns accessing care and surviving hospital admission increased in association with the development of an SCBU with adequate space for infection control practices, appropriate training of staff, and a reliable electricity supply. The major differences in the service between 2015 and 2019 were proximity to the labour ward, reliable availability of electricity and space, as well as training that allowed for the implementation of some rudimentary infection control practices. Although data exist to show that broad quality improvement programmes can significantly reduce neonatal mortality in low-resource settings,[8,9] there are no data examining the effect of a phased improvement in services at the more extreme end of the low-resource spectrum, such as that seen in Sierra Leone. This is no surprise, given the difficulty in collecting data and the challenging baseline situation, which includes a lack of running water and power cuts that can last for weeks at a time. This is the first study that we are aware of to examine the introduction of such changes to a neonatal unit in West Africa. There are difficulties in trying to look at the various interventions in isolation to ascertain which were most effective, and this study is unable to establish a causal relationship between those changes and improved mortality; it is possible that other factors influenced the changes observed. Hospital-acquired infections are an established problem in neonatal units within low-resource settings,[10] and implementation of infection control programmes have been shown to reduce the number of bloodstream infections and deaths from hospital-acquired infections[11,12] It is worth noting that one of the drivers to seek funding for a solar power system at BGH was the

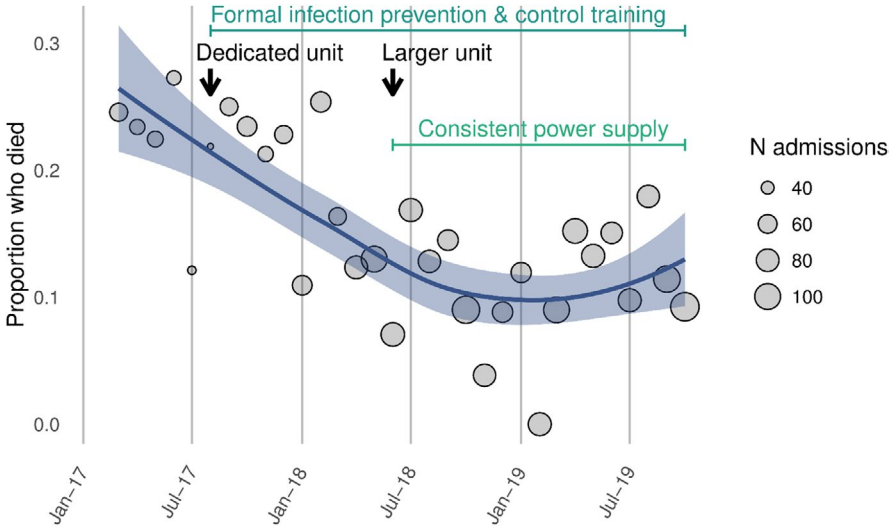

FIGURE 2 Proportion of newborns who died in BGH from November 2015 to October 2019.

experience of staff within the SCBU that many babies died rapidly as soon as the national grid electricity would cease to function, as happened regularly prior to the installation of a dependable system.

Of note, the various phases of quality improvement were associated with very significant increases in the number of babies admitted to the neonatal unit for treatment. The majority of newborns admitted to the SCBU at BGH are seriously unwell, which begs the question as to what happened to these children before the dedicated neonatal unit was established. It is likely that most would have died in the community. This suggests that quality improvement processes also give parents and other healthcare workers the confidence to bring newborns for care in what they see as a functional, safe unit. This is the first study to examine the link between improvements in service and the numbers of admissions to a neonatal service in West Africa. While a broader piece of work prospectively examining the effects of solar power and infection control practices would be useful, this study suggests that bigger units with reliable electricity have an important role in reducing neonatal mortality in the hospital setting in low-resource countries.

4.1 | Limitations

This study had important limitations. There were significant amounts of missing data. As all data in the hospital are kept in a handwritten logbook, there is no computerised backup. For some of the very early phases, the period without data is a significant portion of the total time period that was examined. However, the reasons for the missing data starkly illustrate the challenges of care in this setting. Hospital records also don't allow for a reliable comparison of baseline characteristics, such as gestational age and weight, between babies in different phases of the unit's evolution.

5 | CONCLUSION

In conclusion, this was a pragmatic, observational study performed in a challenging environment where little high-quality data exists. The data collected shows an improvement in the proportion of neonatal deaths and a significant increase in the number of admissions when neonatal care was delivered in an adequately sized facility with a reliable electricity supply. This suggests that the provision of dedicated neonatal units, with the opportunity for adequate infection control practices, along with access to a dependable solar-powered electricity supply, could have a significant role in saving newborn lives in low-income settings such as Sierra Leone.

AUTHOR CONTRIBUTIONS

Niall Conroy: Conceptualization; investigation; writing – original draft; methodology; writing – review and editing; formal analysis; project administration; data curation. **David Adam Barr:** Writing – original draft; methodology; validation; writing – review and editing; software; formal analysis; data curation. **Joy Nalley:** Writing – original draft; methodology; writing – review and editing; formal analysis; investigation. **Juliana Emilia Mamie Conteh:** Investigation; writing – original draft; methodology; writing – review and editing; data curation. **Louise Mitchell:** Writing – original draft; methodology; validation; writing – review and editing; software; formal analysis; data curation. **Gerard Bury:** Conceptualization; investigation; writing – original draft; methodology; writing – review and editing; supervision.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

ETHICS STATEMENT

Ethics approval was granted by the Sierra Leone Research Ethics Committee and by the University College Dublin School of Medicine Research Ethics Committee (Approval number LS-C-22-116-Conroy).

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REFERENCES

1. United Nations Sustainable Development Goals – Goal 3. Accessed March 25, 2022. https://sdgs.un.org/goals/goal3
2. Harris C, Patel H, Corn O, Harris U, Munyagwa M, Greenough A. Infection control and treatment guidelines and neonatal mortality in a rural hospital in Uganda. Paediatr Int Child Health. 2019;39(2):124-7. doi:10.1080/20469047.2018.1528757
3. Wastnedge E, Waters D, Murray SR, et al. Interventions to reduce preterm birth and stillbirth, and improve outcomes for babies born preterm in low- and middle-income countries: a systematic review. J Glob Health. 2021;11:04050. doi:10.7189/jogh.11.04050
4. Sa'avu M, Duke T, Matai S. Improving paediatric and neonatal care in rural district hospitals in the highlands of Papua New Guinea: a quality improvement approach. Paediatr Int Child Health. 2014;34(2):75-83. doi:10.1179/2046905513Y.0000000081
5. UNICEF Country profiles-Sierra Leone. Accessed March 24, 2022. https://data.unicef.org/country/sle/
6. The World Bank-Access to electricity, rural (% of rural population) - Sierra Leone. Accessed March 24, 2022. https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=SL
7. Li Z, Karlsson O, Kim R, Subramanian SV. Distribution of under-5 deaths in the neonatal, postneonatal, and childhood periods: a multicountry analysis in 64 low- and middle-income countries. Int J Equity Health. 2021;20(1):109. doi:10.1186/s12939-021-01449-8
8. Burgoine K, Ikiror J, Akol S, et al. Staged implementation of a two-tiered hospital-based neonatal care package in a resource-limited setting in eastern Uganda. BMJ Glob Health. 2018;3(1):e000586. doi:10.1136/bmjgh-2017-000586
9. Cavicchiolo ME, Lanzoni P, Wingi MO, et al. Reduced neonatal mortality in a regional hospital in Mozambique linked to a quality improvement intervention. BMC Pregnancy Childbirth. 2016;16(1):366. doi:10.1186/s12884-016-1170-y
10. Zaidi AK, Huskins WC, Thaver D, Bhutta ZA, Abbas Z, Goldmann DA. Hospital-acquired neonatal

infections in developing countries. Lancet. 2005;365(9465):1175-88. doi:10.1016/S0140-6736(05)71881-X

11. Landre-Peigne C, Ka AS, Peigne V, Bougere J, Seye MN, Imbert P. Efficacy of an infection control programme in reducing nosocomial bloodstream infections in a Senegalese neonatal unit. J Hosp Infect. 2011;79(2):161-5. doi:10.1016/j.jhin.2011.04.007
12. Darmstadt GL, Nawshad Uddin Ahmed AS, Saha SK, et al. Infection control practices reduce nosocomial infections and mortality in preterm infants in Bangladesh. J Perinatol. 2005;25(5):331-5. doi:10.1038/sj.jp.7211283

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