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A multisite inventory study of neonatal syringe pumps in Zambia

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Abstract

Background The global neonatal mortality rate is due to miss the third Sustainable Development Goal of 12 deaths per 100 live births by 2030. However, medical devices can play a crucial role in improving the quality of care given to neonates, helping to reduce the rate further.

Methods This study focuses on quantifying the availability of syringe pumps to newborns at key hospital locations in Zambia. Inventories of syringe pumps on neonatal intensive care units (NICUs) were conducted at 7 different hospitals.

Results Syringe pumps were only available on 3 of the 8 NICUs. Only 1 of the 13 syringe pumps were found in the Copperbelt region, despite 5 of the hospitals being located there. The largest syringe pump-to-bed ratio was 0.17 at Livingstone University Teaching Hospital.

Conclusions In Zambia, there is a disproportionate availability of syringe pumps, for neonatal care, in the Lusaka and Southern regions compared to the Copperbelt region in the north.

Keywords Syringe pump, Neonate, Newborn, Zambia, NICU, Quality improvement

Introduction

Neonatal care in developing countries faces many challenges due to limited resources and inadequate healthcare infrastructure. According to UNICEF, in 2021, approximately 2.3 million [1] newborns died in the first month of life, predominantly in low- and lower-middle-income countries (LLMICs).

One obstacle to reducing neonatal mortality rates is the lack of uniform neonatal healthcare coverage [2]. The absence of quality, specialist neonatal care reduces the ability to provide the level of care needed to manage complex medical conditions and promote the development of premature and sick newborns. Neonatal intensive care units (NICUs) are not widely available in LLMICs, and those that do exist may not have the necessary equipment. By improving the quality of care provided in NICUs and other neonatal care settings, UNICEF estimates that neonatal mortalities could be reduced by 28% before 2025 [2].

Many neonatal deaths are caused by preventable causes, notably prematurity, birth complications, infections and congenital conditions [2]. Treatments such as drugs and nutrients, given to sick and premature neonates must be done in a controlled way to encourage treatment success and prevent additional comorbidities. In high-resource settings, this role is performed by a syringe pump.

Syringe pumps are electromechanical devices that slowly infuse fluids from syringes [3]. Their accuracy makes them particularly useful when treating unstable and fragile patients, such as neonates. Syringe pumps

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can contribute to 'quality health services' [4] by providing fine fluid control for a more accurate delivery rate [5]. Additionally, the autonomous device removes the need for frequent small injections, thus improving the equity of care, as doses are not missed, and coverage, as nurses can treat more patients.

Study location

The highest neonatal mortality rates globally occur in sub-Saharan Africa. According to UNICEF, a neonate in a sub-Saharan African country is 10 times more likely to die in the first month of life than one born in a high-income country [1]. The World Health Organization's Every Woman Every Child Action Plan discusses how Africa is the only global region where child and adolescent populations will increase before 2030 [6]. Hence, there is focus on improving neonatal care in sub-Saharan Africa [1].

Zambia was chosen as a research location due to socioeconomic [7, 8] and health indicators. Furthermore, the researchers had existing connections in the country. Zambia (Fig. 1) is a sub-Saharan African country with an estimated neonatal mortality rate of 25 deaths per 1000 live births [1]; more than twice the 2030 Sustainability Development Goal of 12 deaths per 1000 live births [2]. However, it already has two specialist children's hospitals, Arthur Davison Children's Hospital and Women and Newborn Hospital (University Teaching Hospitals), located in Ndola and Lusaka respectively. This suggests that Zambia should have some provisions to provide quality, specialist neonatal care, including the use of key medical equipment.

Materials and methods

Aim

This study aims to quantify the availability of syringe pumps, as a key medical device for neonatal care, on NICUs at select hospitals in Zambia.

Study design

This study was a cross-sectional descriptive study conducted on NICUs across Zambia. The study was designed to assess the availability and use of syringe pumps on the identified wards.

Fig. 1 Map of Zambia [9]

Study setting

The study was conducted in 7 public hospitals in Zambia. These hospitals were: Arthur Davison Children's Hospital (ADCH), Ndola Teaching Hospital (NTH), Kitwe Teaching Hospital (KTH), Thomson District Hospital (TDH), Roan Antelope General Hospital (RAGH), Women and Newborn Hospital (WNH), and Livingstone University Teaching Hospital (LUTH). These sites were chosen as they are in the 5 most populous towns in Zambia (Table 1), with the greatest population densities, according to the 2022 census data [10].

Additionally, ADCH, NTH, KTH and WNH are four of the country's six tertiary hospitals [11] so should be best equipped for, and serve as a fair representation of, the county's best neonatal care in public hospitals. TDH and RAGH are just 2 of the 3174 secondary-level hospitals in Zambia [12]. Although this is a small sample size, so cannot be representative of secondary hospitals overall, they service the 5th most populous town [10]. Furthermore, Luanshya (Table 1) does not have a primary hospital. Thus, they may still be equipped with priority medical devices [13], such as syringe pumps, and so give an indication of better-equipped secondary hospital NICUs in Zambia.

Data collection

The data was collected through a physical inventory of syringe pumps on each ward. The inventory was conducted by an observer who visited each ward on a specified date within July 2023. This period was determined by financial constraints. The observer used a standardised checklist to document the quantity, brand, and condition of each syringe pump on the ward.

Data analysis

The data is presented as a table and graph. The syringe pump-to-bed ratio (SPBR) was calculated as a fairer representation of how many syringe pumps should be available based on ward sizes.

Study population

The study population included all syringe pumps on the selected wards. This included syringe pumps that were currently being used and those that were not.

Inclusion criteria

All syringe pumps in use or storage on the day that the inventory was conducted were included.

Exclusion criteria

Other medical equipment, including other types of fluid control devices, such as large volumetric pumps, were excluded.

Ethical considerations

Study approval was sought from King's College London, the Tropical Disease and Research Centre in Zambia (TDREC/095/07/23), and the Zambian National Health Research Authority (NHRA-638/05/10/2023). This study did not involve any patient data or intervention, so confidentiality and patient safety were maintained throughout. The observers requested permission to perform the study from the Senior Medical Superintendent, and informed

Table 1 Hospital information [10] and inventory results

Hospital	Type	Location	Population (density person/Km2)	Date Recorded (DD/MM/YYYY)	Number of Beds on NICU	Syringe Pumps (Total (in Use))	Syringe Pump-to-Bed Ratio
Arthur Davison Children's Hospital	Tertiary, Public	Ndola, Copperbelt	624,579 (647.23)	11/7/2023	43	0 (0)	0
Ndola Teaching Hospital	Tertiary, Public	Ndola, Copperbelt	624,579 (647.23)	12/7/2023	21 (Sub-Acute) 9 (Acute)	0 (0) 0 (0)	0 0
Thomson District Hospital	Primary, public	Luanshya, Copperbelt	211,966 (225.98)	13/7/2023	7	0 (0)	0
Roan Antelope General Hospital	Secondary, Public	Luanshya, Copperbelt	211,966 (225.98)	13/7/2023	7	1 (0)	0.14
Women and Newborn Hospital	Tertiary, Public	Lusaka, Lusaka	2,204,059 (5272.87)	18/7/2023	60	6 (0)	0.1
Livingstone University Teaching Hospital	Secondary, Public	Livingstone, Southern	177,393 (241.02)	25/7/2023	36	6 (1)	0.17
Kitwe Teaching Hospital	Tertiary, Public	Kitwe, Copperbelt	661,901 (819.18)	11/8/2023	32	0 (0)	0

senior ward staff upon arrival, at each location before conducting the data collection to ensure acceptability.

Results

Syringe pumps were available on 3 of the NICUs (Table 1). Only one of the total 13 identified syringe pumps was in use on the days that the inventories were conducted. Twelve of these were found in just 2 hospitals: WNH and LUTH. None of the syringe pumps were reported as broken and none were currently being repaired or maintained elsewhere. The syringe pumps identified in the study were: Mindray Benefusion VP5, Kellymed KL-602, Karemax SP-105, B Braun Perfusor Space, ARI Medical ASP-1800, B Braun Perfusor Compact, Sinomdt SN-50C6, and MedCaptain SYS-Hawkmed HK-400 (Fig. 2). The Kellymed KL-602 was the most prevalent syringe pump.

The largest syringe pump-to-bed ratio was 0.17 at LUTH (Table 1). Across all the hospitals, the mean SPBR was 0.04.

Discussion

There is a lack of availability of syringe pumps on NICUs in Zambia, particularly in the Copperbelt region. WNH and LUTH are the only hospitals not in the Copperbelt region, yet 12 of the 13 syringe pumps were recorded there. Although the ADCH NICU has the second-highest bed capacity, it does not have any syringe pumps available. Furthermore, although the NTH and KTH NICUs have similar bed capacities to the LUTH NICU, neither have access to syringe pumps. This disproportionate availability of syringe pumps should be addressed by relevant stakeholders. A wider inventory study of additional types of key medical equipment, for neonatal care, should be conducted to evaluate the extent of the issue.

Only one syringe pump was in use across all 7 of the NICUs. This may be due to a lack of clinical need, however it could also be due to lack of consumables or specialist staff training [14]. A more in-depth multi-day study, including staff observation and interviews, would evaluate this.

The Kellymed KL-602 is the syringe pump suggested in the UNICEF Supply Catalogue [15]. It is therefore unsurprising that this was the most common syringe pump identified in this study.

During the study, the use of large volumetric infusion pumps [3] and gravity-driven infusions were observed at every location. However, none of these are ideal for the treatment of preterm and low birth-weight neonates less than 1kg, who are recommended to only receive 110 to 130 mL of fluids per kg per day [16]. Large volumetric pumps are designed to infuse larger volumes of drugs and fluids from IV bags [3, 17]. Furthermore, commercially available infusion pumps often have lower levels of guaranteed accuracy, ≤5% according to UNICEF [17], compared to commercially available syringe pumps which have a guaranteed accuracy of ≤3% [15]. This level of accuracy is required to effectively treat neonates and prevent co-morbidities [18]. Gravity-driven infusions, controlled using a roller clamp, are also designed for infusions from IV bags. However, the gravity-driven method benefits from being low-cost and disposable [19], improving infection control [2]. Furthermore, it is non-electrical so can overcome the issue of intermittent electricity often found in LMICs [20]. However, the gravity-driven method has been recorded as having even

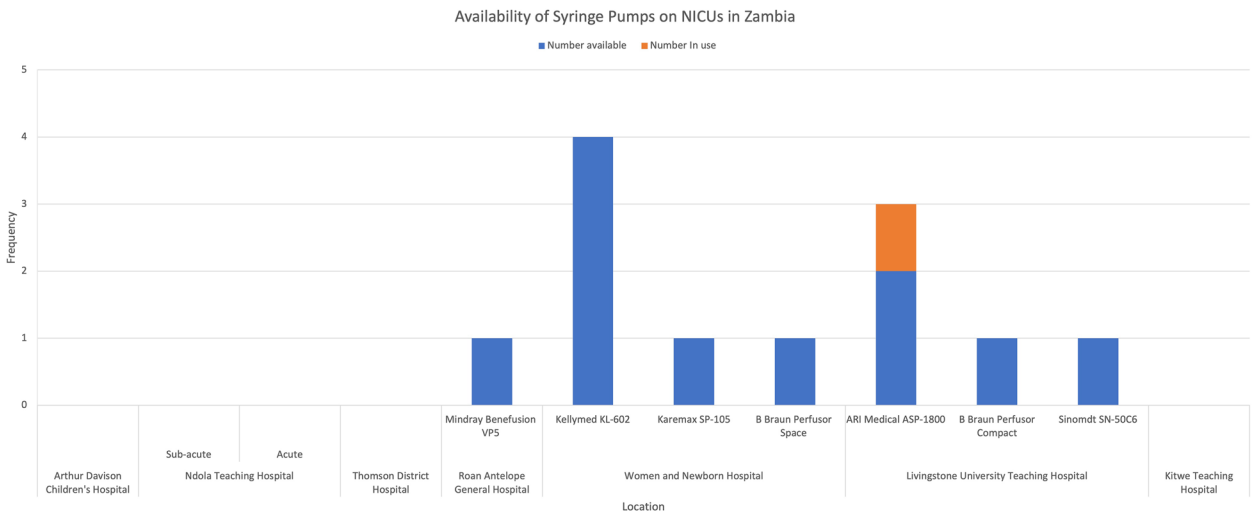

Fig. 2 Availability of syringe pumps on NICUs in Zambia

greater infusion rate inaccuracies [21] making it inappropriate for the treatment of preterm and low birth-weight neonates.

Although syringe pumps have the potential to help improve the quality of care given to sick and premature neonates [5, 18], there are potential barriers to their deployment in LLMICs. Syringe pumps are often battery-powered [3, 5, 18] to allow for patient transport. However, this limits their use during extended periods of no electricity [20]. Another limitation can be that some designs require specific consumables [3, 18]. This can be an issue in LLMICs where supplies can be inconsistent [20]. Inadequate design has also been noted as a key issue [22]. Complex user interfaces have reportedly caused inaccurate data entry and difficult setup procedures [22]. This can be a particular issue in LLMICs where there are fewer adequately trained, clinical staff [23]. In addition to this, although syringe pumps reduce the need for frequent smaller injections, the World Health Organization recommends that the peripheral IV site is checked at least twice a day; adding to nurses' checklists. More complex devices are also more difficult to service, leading to disuse, storage issues and disposal costs [6, 24, 25]. Designing and deploying syringe pumps, appropriate to the unique challenges of LLMICs - with ease of serviceability and a focus on simplicity to avoid extensive training would be crucial in overcoming some of these issues [18].

Limitations

This inventory was conducted exclusively within government hospitals due to time and ease of access constraints. Although this provides insights into the availability of syringe pumps to larger healthcare providers, it does not extensively record the number of syringe pumps available to neonates throughout Zambia.

Additionally, there is potentially a sampling error. Clinicians at ADCH reported that there was a single syringe pump, belonging to the paediatric intensive care unit (PICU), that was borrowed when available. On the day of recording, it was being used by the PICU so did not meet the inclusion criteria of the study but is used to treat neonates. Clinical staff at other locations confirmed no other syringe pumps were missing; however, this could not be evidenced. Repeating this study across multiple days would reduce this potential error.

Future work

For a more comprehensive understanding and a well-rounded comparison of neonatal syringe pump usage in Zambia, future endeavours should incorporate a broader spectrum of healthcare facilities. This would include private hospitals, humanitarian medical centres, and other relevant healthcare institutions.

To obtain a global overview of the availability of syringe pumps to neonates, the study could be repeated across multiple LLMICs in different global regions. From this, researchers can gather data from a wide range of healthcare settings, considering varying economic conditions, cultural practices, healthcare infrastructures, and resource constraints. A multi-country, multi-region inventory would contribute to a more robust evidence base for best-practice healthcare policymaking and resource allocation.

Conclusion

This study demonstrated a limited availability of syringe pumps on NICUs in Zambia. NICUs in the Copperbelt region had a lower SPBR. Stakeholders should investigate the causes of this and re-evaluate the allocation of resources.

Abbreviations

LLMICs	Low- and lower-middle income countries
NICU	Neonatal intensive care unit
ADCH	Arthur Davison children's hospital
NTH	Ndola teaching Hospital
KTH	Kitwe teaching hospital
TDH	Thomson district hospital
RAGH	Roan antelope general hospital
WNH	Women and newborn hospital
LUTH	Livingstone university teaching hospital
SPBR	Syringe pump-to-bed ratio
PICU	Paediatric intensive care unit

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Authors' contributions

The study was conceived by ON and PJ. The data was collected by ON, SN, ML and EM. The first draft of the paper was written by ON and further drafts were edited by ON and PJ.

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Availability of data and materials

All data generated or analysed during this study are included in this published article.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Ethical approval was sought from King's College London, the Tropical Disease and Research Centre in Zambia (TDREC/095/07/23) and the Zambian National Health Research Authority (NHRA-638/05/10/2023).

Consent for publication

Not applicable.

Competing interests
The authors declare no competing interests.

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