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Electronic application to improve management of infections in low-income neonatal units: pilot implementation of the NeoTree beta app in a public sector hospital in Zimbabwe

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ABSTRACT

There are 2. 4 million annual neonatal deaths worldwide. Simple, evidence-based interventions such as temperature control could prevent approximately two-thirds of these deaths. However, key problems in implementing these interventions are a lack of newborn-trained healthcare workers and a lack of data collection systems. NeoTree is a digital platform aiming to improve newborn care in low-resource settings through real-time data capture and feedback alongside education and data linkage. This project demonstrates proof of concept of the NeoTree as a real-time data capture tool replacing handwritten clinical paper notes over a 9-month period in a tertiary neonatal unit at Harare Central Hospital, Zimbabwe. We aimed to deliver robust data for monthly mortality and morbidity meetings and to improve turnaround time for blood culture results among other quality improvement indicators. There were 3222 admissions and discharges entered using the NeoTree software with 41 junior doctors and 9 laboratory staff trained over the 9-month period. The NeoTree app was fully integrated into the department for all admission and discharge documentation and the monthly presentations became routine, informing local practice. An essential factor for this success was local buy-in and ownership at each stage of the project development, as was monthly data analysis and presentations allowing us to rapidly troubleshoot emerging issues. However, the laboratory arm of the project was negatively affected by nationwide economic upheaval. Our successes and challenges piloting this digital tool have provided key insights for effective future roll-out in Zimbabwe and other low-income healthcare settings.

PROBLEM

At Harare Central Hospital (HCH), Zimbabwe, 12 000 babies are born each year, and the 100-cot tertiary neonatal unit often runs at 140% capacity, admitting babies locally and nationwide for surgical management. Prior to this pilot quality improvement project, documentation was paper based, and accessing records for audit and research purposes was laborious and unrewarding, with excessive record loss. Quantification of basic data such as admission rates was challenging, let alone measuring quality indicators. Junior doctors spend 2 months on the unit, and senior support is overstretched. Junior doctors may have little experience of managing sick neonates, particularly identifying and managing sepsis acutely, and inappropriate antibiotics may be used (eg, using adult rather than neonatal guidelines). Nearly 60% of babies are admitted with presumed sepsis.[1] A recent *Klebsiella pneumoniae* sepsis outbreak in the unit had 33% case fatality, and control interventions were hindered by delayed and lost results from the laboratory. Prior to this study, retrieval of microbiology results involved a doctor going in person to the laboratory in a separate building on site, with a median turnaround time of 6 days.[1] Delays in feedback of negative blood culture results likely prolonged admission and antibiotic therapy while delays in positive culture results likely led to ineffective/excessively broad antimicrobial therapy, depending on sensitivities. At baseline, 98% of admitted babies received antibiotics at admission, and 99% received oral amoxicillin at discharge, which is not an evidence-based intervention.[1]

NeoTree is a digital quality improvement platform codeveloped with Malawian healthcare workers to improve newborn care in low-resource settings.[2] It offers education, decision support and suggested management

plans according to national and WHO guidelines alongside real-time data collection. The user-facing component is a tablet-based Android application (app).

Aims:

1. Demonstrate proof of concept as a real-time data capture tool, replacing handwritten paper-based admission/discharge forms over a 9-month period.
2. Deliver robust reliable data for the monthly neonatal unit morbidity and mortality meetings (within 6 months).
3. Improve the availability of data for diverse quality improvement projects.
4. Demonstrate proof of concept of NeoTree as a surveillance tool for neonatal sepsis and antimicrobial use, including reducing turnaround time for blood culture results.

BACKGROUND

Of 2.4 million annual neonatal deaths,[3] ~60% could be prevented through instigation of simple, evidence-based practices such as temperature control.[4] Efforts to improve survival are hampered by limited data collection, making it difficult to identify modifiable risk factors for mortality. This renders benchmarking and quality improvement measures challenging to implement.[5]

Sepsis is implicated in ~25% of neonatal deaths, and many surviving babies experience chronic morbidity.[6] In low-income settings, overcrowding, understaffing and restricted infrastructural and microbiological support render diagnosis and prevention of infections in neonatal units challenging. A shift to facility-based deliveries may have had the adverse consequence of rendering babies vulnerable from birth to bacteria typically associated with prolonged admissions (eg, multidrug-resistant Gram-negative organisms causing sepsis in the first 24 hours of life).[7]

Pilot work in Malawi using and codeveloping the NeoTree alpha version suggested a high degree of user satisfaction with NeoTree, with feedback used to upgrade the platform to a beta version: Minimal Viable Product (MVP-1). NeoTree has the potential to streamline record keeping, feed back results and contribute to improved sepsis surveillance, as well as providing guidance to clinicians about management of neonatal diagnoses. We piloted the beta version (MVP-1) of the NeoTree at HCH neonatal unit and additionally developed the laboratory data collection pages. We hypothesised that a novel app page for feeding back blood culture results from the laboratory to the neonatal unit could reduce test turnaround times. Establishing NeoTree as a robust data collection platform and a tool for antimicrobial surveillance could be a first step in instigating national level surveillance and antimicrobial stewardship.

MEASUREMENT

Our setting was HCH neonatal unit, with the population being all admitted neonates over a 9-month pilot period (November 2018–July 2019).

Four months prior to implementation of NeoTree, a prospective audit was carried out over a month to measure baseline admission/discharge rates and case fatality rates, antibiotic prescription rates, blood culture results and turnaround time.[1] The previous standard of documentation to collect total numbers of admissions/discharges and deaths was a handwritten book, completed by the sister-in-charge. There were 459 admissions over 28 days with a case fatality rate of 210 per 1000 neonates admitted. Blood culture results were fed back in a median of 6 days, with only 7/196 (4%) cultures turned around in time to impact on therapy. Oral amoxicillin at discharge was prescribed for nearly all babies despite a lack of evidence for efficacy, though this dropped to 1/161 babies at repeat audit with intensive education for junior doctors prior to NeoTree introduction.[1]

Our aim for this quality improvement project was to demonstrate proof of concept of NeoTree as a real-time data capture tool, with digital forms completed by junior doctors replacing handwritten paper admission and discharge notes over 9 months and to provide monthly results to the neonatal unit. The primary endpoint measurement was to measure the number of admissions, discharges and deaths captured on NeoTree when compared with the current standard of documentation within the unit: the admission/discharge/death handwritten book. Our target was for 100% of admissions, discharges and deaths to be recorded on the NeoTree app at 9 months. Blood culture results turnaround time was to be measured and compared with the baseline data result.

To measure the ability to provide monthly data to the neonatal unit staff by month 6, we targeted month 3 to commence formal monthly data feedback meetings (allowing time to ensure a robust data cleaning pipeline), taking a register of staff attendance and implement a culture of learning and feedback within these sessions. The sessions were to involve presentation of monthly data and feedback on the usability of NeoTree with suggestions documented and instigated promptly. Informal usability feedback was planned from day 1 to ensure a smooth roll-out and staff buy-in.

For data collection during the project, NeoTree-Beta acted as a real-time data collection tool, with pseudonymised data from each admission and discharge form being stored on the tablet after a hard, patient-identifiable copy was printed for the notes (currently only paper-based notes have legal standing in Zimbabwe). Eleven 8 GB Amazon Fire 7th generation (2017 release) tablets were supplied. Pseudonymised data were exported daily from tablets by the NeoTree Ambassador to a secure server where data were collated and analysed monthtly using R V.3.6.0 (R Core Team, Vienna, Austria) with RStudio V.1.2.1335 (RStudio Team, Boston, USA).[8] Although NeoTree has the functionality to export automatically to a cloud server on record completion, Ministry of Health conditions were that a local server must be used, rather than a commercial platform. As data were exported daily, there was protection against large-scale data loss, but on

two occasions tablets crashed causing data loss of seven patients in total. For the laboratory page (NeoLab), laboratory staff would enter blood culture results onto the laboratory tablet when available including preliminary negative results at 48 hours. These results were printed immediately on the neonatal unit via a WiFi connection where the junior doctors could collect them and file them in patient notes. Time of filing in notes was collected.

DESIGN

The team consisted of Zimbabwean and UK members. UK members were clinicians, software developers and statisticians, while Zimbabwean team members were consultant clinicians and senior laboratory scientists at HCH and the University of Zimbabwe. UK members were responsible for ongoing software development in response to clinician feedback, data management and overall project logistics. Prior to implementation, a round of informal usability testing was completed. This involved staff completing an admission and discharge form using the app and giving feedback. This feedback informed country and facility-specific adjustments to the Malawi NeoTree MVP-1 to produce 'Zimbabwe MVP-2'. The format of the NeoTree admission/discharge pages were altered using an editor platform, which requires minimal software expertise to use (ie, without having to consult the software team) to account for specific unit needs. Zimbabwean team members tailored the clinical management pages to ensure local relevance.

We hired a staff member, a research nurse with a degree in nursing (the 'NeoTree Ambassador') responsible for checking tablets in and out of the secure storage locker, charging tablets, data export, day-to-day supervision of the junior doctors to ensure the forms were correctly filled out, checking all babies admitted/discharged were being captured, training new staff members and acting as a project advocate within the unit (eg, explaining the project to families).[2]

Based on previous experience in Malawi,[2] we planned to implement the Zimbabwe NeoTree MVP-2 over 4 weeks, initially with a few admissions/discharges with each junior doctor per day supported by the study coordinator/ambassador, then unsupervised day time admissions/discharges, followed by weekends and night shifts until all admissions/discharges would be captured. Each junior doctor/laboratory staff member was trained by the study coordinator/NeoTree ambassador prior to being allocated a tablet. Discharge and laboratory forms were to be matched with admission forms using a unique identifier (NeoTree number) generated by the app on admission. Prior to implementation, we carried out five 45 min sensitisation training sessions for nurses, student nurses, cleaners and administrative staff to ensure buy-in and enable all staff to answer questions that family members might have. We were inclusive across staff cadres as our experience in Malawi revealed that mothers might be more comfortable raising concerns with lower rather than higher staff cadres (eg, asking questions to cleaners rather than nurses).[2] In Malawi, some parents had thought the nurses were 'playing games' on the tablets rather than working, a misconception we were keen to avoid. Training feedback was enthusiastic, with the most common query being when would NeoTree be extended to include nursing observations. We held a monthly feedback session to present key indicator data and to encourage suggestions about potential improvements to the app and quality improvement questions that the data could be used for. Small monthly cash prizes were to be awarded to the junior doctor producing the most accurate 'NeoTrees' each month (ie, the number of admission and discharge/death forms accurately completed). Suggestions for app improvements were also encouraged on a day-to-day basis from junior doctors, and where feasible, these were rapidly incorporated within the app scripts to encourage local ownership and satisfaction, usually by the clinician project coordinator using the editor platform. It was rarely necessary to involve the software team in edits.

Ensuring the application was locally relevant was a key strategy for future-proofing the app. We were keen to make the app as useful as possible for the junior doctors and to encourage locally led ideas for quality improvement. Another part of planning for future sustainability was engaging with the Zimbabwean Ministry of Health and Child Care who had an established Electronic Medical Records Department. They had not yet developed a neonatal 'module' and so were keen to discuss how NeoTree could be embedded within local systems for future wider roll out.

STRATEGY

Leadership and co-development

Our strategy for roll out depended heavily on leadership within the unit. The medical and nursing senior team were enthusiastic about the platform's potential to improve care and data collection and provided vital support to the junior doctors using the tablets. They also provided a real-time system of quality control: if there were inaccuracies or omissions on the printed admission form within the patient notes, these were picked and fed back up by seniors during daily ward rounds. Similarly, discharge summaries were reviewed in follow-up clinics and in unit spot checks by senior clinicians. The project coordinator directly canvassed opinions from junior doctors/nurses about potential improvements and problems, initially on a daily, then weekly, then monthly basis, although the NeoTree ambassador was available every day to answer queries, troubleshoot and collect suggestions from staff. At a higher level, interactions with hospital administrative staff were led by the local Principal InvestigatorPI, with care taken to provide frequent reports and feedback on the project's progress. Administrative staff were enthusiastic about the principle of digitising patient records while maintaining the printed copies of NeoTree admissions and discharges (therefore fulfilling

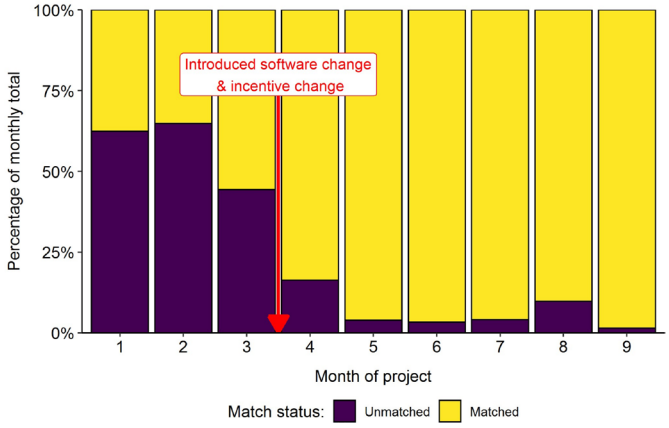

Figure 1 Trend in NeoTree ID matches per month throughout the project.

the legal obligation of having hard copy medical notes). Concerns about data ownership and storage were allayed by conservative data handling—storing data on an onsite server in the hospital rather than a commercial 'cloud'.

Implementation lessons

The monthly data feedback sessions acted as host for our progressive improvement cycles. From the laboratory side, there were considerable hurdles with availability of culture media and then with staffing issues (see 'lessons and limitations' section). Industrial action also impacted the neonatal unit. We undertook five separate plan–do–study–act (PDSA) cycles during the 9-month period.

PDSA 1: revision of death discharge forms

In month 2, we noted incomplete capture of deaths on NeoTree, when the number of deaths on NeoTree and in the handwritten death/discharge book recorded by the sister-in-charge were compared. Of 154 deaths documented from months 1–3, 143 (93%) were completed retrospectively by the NeoTree ambassador. Feedback from juniors highlighted that although the admission/discharge electronic form replaced the paper forms, the NeoTree death forms were duplicates of effort as statutory reporting of deaths mandated that deaths were documented on government forms which could not be replaced. We addressed this by intensifying scrutiny by NeoTree staff to ensure all babies who died were captured within the app, liaising directly with juniors and emphasising the importance of data entry (with support of senior clinical staff). We also altered the monthly prize to incentivise the input of deaths onto the NeoTree (splitting one $20 prize to two $10, one each for most completed admissions and discharges and one for deaths specifically). Over the next 2 months, the capture of deaths improved, although still needing ongoing input from NeoTree staff. Unfortunately, at month 7, it was found that the number of deaths documented had again decreased and particularly babies dying very shortly after admission were not being captured. We instigated a rigorous simple audit programme with support of senior clinical staff to ensure every admitted baby (either on the NeoTree, in the nurses' admission book or in the 'death' book had an outcome documented) and allowed a shortened discharge/death form to be completed without a separate admission form to be completed for these babies. Online supplemental figure 1 demonstrates the trend of death documentation throughout the project.

During the study, we commenced discussions with senior hospital management and the Ministry of Health to allow a NeoTree printout to be acceptable as formal death documentation. We believe while there is still duplication of effort, death documentation will be a weakness of NeoTree needing continuous monitoring and team input.

PDSA 2: revision of NeoTree ID number

By month 3, we found a high number of 'unmatched' discharge forms where the NeoTree ID entered on the discharge form had no corresponding NeoTree ID on an admission form. This was partly due to admission forms not being completed if the baby died shortly after admission (as mentioned under PDSA 1), but the percentage of unmatched discharge forms were still excessive. We found that NeoTree ID numbers were frequently entered incorrectly on the discharge form. We addressed this in month 4 partly via software changes using ongoing version control (software code available at https://github.com/neotree/analytics)—shortening the 16-digit ID number to eight digits and using 'fuzzy matching' (a code string to find very near, but imperfect matches, eg, with one digit different) to match admissions/discharges based on common mismatches in the dataset where, for example, 0 (number) and O (letter) had been confused. These were labelled as imperfect matches within the dataset. We also further amended the monthly prizes to include a 'league table' of highest percentage matches by junior doctors. This successfully reduced the number of NeoTree ID mismatches, dropping from 44% unmatched to <10% unmatched (figure 1). A small increase in unmatched records in month 8 was traced back to an individual new starter who received remedial training with good effect.

In a current parallel project, we are investigating the use of record linkage techniques, including probabilistic record linkage,[9] to improve record matching and to increase the proportion of matched admission and discharge files. The next iteration of the NeoTree app has built-in functionality to match ID numbers with currently admitted patients at discharge to minimise mismatch risk.

PDSA 3: antibiotic prescription rates at discharge

Each month, we reviewed statistics suggested by medical/nursing staff. For example, in month 5, it was requested that we review amoxicillin prescription at discharge and found the figures to have increased again to 78/354 (22%) of discharged babies since the previous audit. We undertook further training for doctors and nurses in the principles of antimicrobial stewardship in low-income and middle-income countries[10] and the lack of rationale

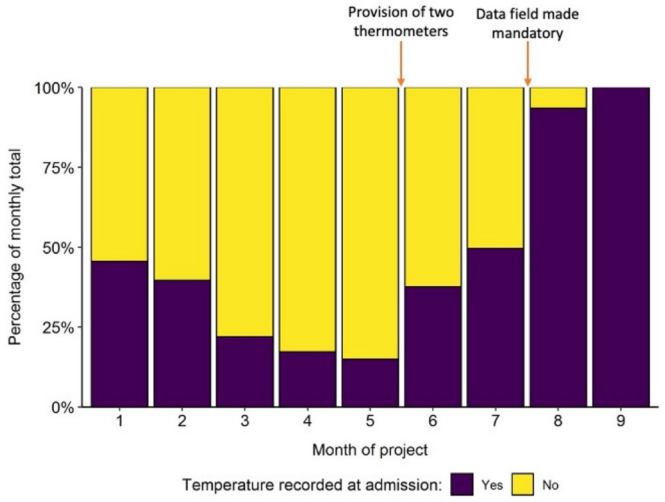

Figure 2 Percentage of babies with their temperature measured at admission throughout the project.

for amoxicillin use. This training was carried out over 1 month, informally on ward rounds and formally during weekly unit teaching sessions to doctors and nurses, and included amoxicillin statistics in the regular feedback at the monthly meeting. The rate of amoxicillin prescription reduced to 8/359 (2%) the following month and has remained low, although scrutiny is ongoing (online supplemental figure 2).

PDSA 4: thermoregulation data

Hypothermia at admission was another key indicator. Initially, this indicator was often missing. Temperatures were routinely taken by nursing staff on admission to the unit rather than junior doctors on initial examination of the newborn baby of the baby (eg, in the labour ward) so this was often left blank. Under 40% of babies in months 2–3 had temperatures recorded. We supplied thermometers for the two doctors on-call and made the data entry field mandatory (not optional), which improved the documentation. Subsequently, the percentage of babies with temperatures recorded at initial examination increased to 90% (month 8, figure 2).

From discussions with unit staff, it was felt that most babies admitted with hypothermia were outborn, not inborn. However, we showed that the majority of babies who were hypothermic were actually inborn and implemented a programme of ensuring that small, premature babies were supported with adequate temperature control (online supplemental figure 3). This is an ongoing project as we have not yet seen an improvement in temperatures at admission (online supplemental figure 4). We believe this is partly due the Zimbabwean season in which the PDSA cycle commenced (meaning ambient temperatures can be 5°C at night) and partly to do with the doctor's strike.

PDSA 5: sepsis surveillance

We set up the NeoLab forms to overcome the issues described in the 'Problem' section of logistical hurdles leading to lengthy turnaround times for blood cultures, the test used to confirm neonatal sepsis. Initially, there was enthusiasm from laboratory staff meaning in the first 6 weeks, we cut median turnaround time to 3 days, but this was followed by 5 months of unavailability of culture media. Once culture media was available, laboratory staff had adopted 'flexible working' owing to disputes over wages, which led in turn to laboratory staff feeling too overstretched to fill in the NeoLab page (despite the page taking only a few seconds longer to complete than the paper form) and morale being low. We attempted reinvigorating staff with daily visits and encouragement from the NeoTree ambassador and engagement of the head of laboratories who was supportive although few inroads were made. The most recent iteration of this PDSA cycle is the naming of NeoTree Champion within the laboratory who will have personal responsibility for completing the forms in return for a small monthly stipend. This cycle remains ongoing.

As this was a quality improvement project aimed at strengthening routine clinical care and data were pseudonymised, requirement for individual consent was waived.

RESULTS

We trained 41 junior doctors, 9 laboratory staff and sensitised 94 nursing/midwifery staff. We presented preliminary audit data at a national level and to the hospital executive. There were 3222 admissions and discharges/deaths of babies entered using NeoTree software, despite a 6-week doctor strike and a national shutdown including cessation of the internet nationwide. Monthly admission, discharge and mortality data are shown in figure 3. We fulfilled aims 1 and 2 by providing admission, discharge and death data on a monthly basis for the unit including statistics required by hospital management, such as mortality by term/preterm and birth weight, causes of death, receipt of prevention of mother-to-child transmission therapy for HIV and admission/discharge diagnoses (online supplemental table 1). Meetings were attended by between 15–30 medical, nursing and administrative staff from junior and senior cadres.

We fulfilled aim 3, providing data for locally led Quality Improvement (QI) projects such as antimicrobial stewardship, which has resulted in a sustained decrease of unnecessary prescriptions of oral amoxicillin at discharge (online supplemental figure 2). Adherence to appropriate first line antimicrobial therapy has improved: at baseline, 9% of babies received ceftriaxone as opposed to crystalline penicillin and gentamicin. At last review, 1.5% of babies received ceftriaxone as first-line therapy. The hypothermia QI project is ongoing.

However, aim 4, the laboratory arm of the project continues to be more challenging and has not yet been fulfilled. Initially, we reduced laboratory turnaround time for blood culture results from 6 days to 3 days within the first 6 weeks of introduction. However, this was not sustained (see Lessons and limitations), and the

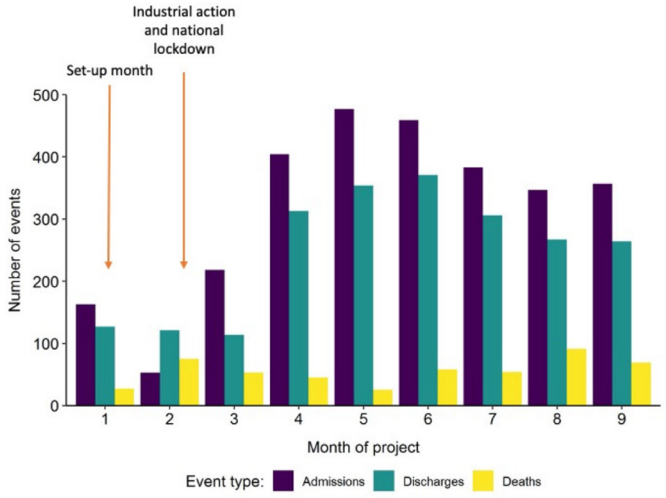

Figure 3 Frequencies of admissions, discharges and deaths per month throughout the project.

current turnaround time for results to be fed back using the NeoTree is between 6 and 10 days, with laboratory staff feeding back that they have no earlier opportunity to fill in the NeoTree form. We have unfortunately also had such incomplete laboratory data that we have not yet been able to develop the surveillance platform.

The NeoTree data are currently being used for two locally led quality improvement projects: management of congenital syphilis and management of late preterm infants. In addition, NeoTree data will be used in Zimbabwean-led research projects in neonatal sepsis, antenatal steroid use and hypothermic ischaemic encephalopathy (this last project in conjunction with developing a platform for labouring mothers with Zimbabwean obstetricians—the 'MummyTree'). We are in advanced discussions with the Ministry of Health about how to incorporate the NeoTree into their plans for nationwide electronic medical record roll out.

Lessons and limitations

The most challenging aspect of the project was the laboratory side. After an initial 6 weeks where we improved turnaround time, there were then 5 months of issues with media availability, meaning no cultures were performed. When the media finally became available again, economic upheaval and industrial action led to a policy of 'flexible working' in the laboratory, meaning skeleton staffing became the norm. Despite financial incentives from the NeoTree, project morale was very low, and it was increasingly challenging to motivate staff to complete the laboratory form. Further interventions are ongoing, but this aspect of the project has suffered from force majeure. By contrast, despite industrial action by junior doctors in months 2–3, the remaining skeleton junior staff (two out of a rostered eleven) were strong advocates for NeoTree and continued to use it although more for discharges than admissions. This meant when the full staffing complement returned in January 2019, using NeoTree was the departmental norm, and there was considerable peer-to-peer training in addition to that provided by NeoTree staff. In general, the junior doctors were familiar with touchscreen technology and quick to learn the process of using the app and printing the forms. Availability of reliable WiFi provision (needed for connecting tablets to a printer and exporting data) and power was key. These facilitating factors may not be reproducible in other settings, particularly power and the staff cadres using NeoTree. The app is designed to work offline with data exported intermittently, maintaining the education functionality, although alternative printing arrangements such as Bluetooth options would need to be in place. A variety of staff cadres found NeoTree to be highly 'usable' in Malawi, although with more training.[2]

CONCLUSION

We have shown the NeoTree app to be an effective tool for data capture, replacing handwritten paper-based admission and death/discharge forms within HCH neonatal unit. The data captured were routinely fed back to the unit during monthly presentations, when regular feedback was taken about the app, with subsequent iterative improvements made and further locally driven quality improvement projects commenced. These data were presented at hospital executive and national levels. Antimicrobial stewardship was supported by effective surveillance of amoxicillin at discharge. However, despite the successful integration of the NeoTree into the neonatal unit, the laboratory arm suffered from challenges often encountered in low-income settings, namely economic upheaval, industrial action and shortages of supplies. We are continuing to work towards our aim of implementing a sepsis surveillance platform.

The NeoTree app has been embedded into usual clinical practice for admission and death/discharge documentation, with the monthly presentations now normal practice within the unit, guiding and changing local practice with minimal external input from the NeoTree team. An essential factor for this success was strong local leadership, which will also be key in long-term sustainability. Regular feedback and the ability to adapt to local needs is a vital attribute of the NeoTree project. The next steps are planned piloting in a provincial hospital to test usability in a nurse-led unit using the iterative PDSA processes as described previously. Economic analysis (currently ongoing) will be crucial to ensure feasible and sustainable further roll-out as well as ensuring the platform is robust in a wider variety of settings. Close cooperation and coordination with Ministries of Health will also be key to ensuring sustainability in Zimbabwe and elsewhere.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval The project was approved by Harare Central Hospital Ethics Committee (HCHEC 250418/48) and by University College London Ethics Committee (5019/004).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data collected for the study cannot yet be made publicly available yet because analysis for the implementation evaluation of the NeoTree, as well as secondary analysis are ongoing. A goal of our implementation is the establishment of an open-source anonymised research database of data collected using the NeoTree in order to maximise the reach and utility for researchers aiming to improve outcomes for neonates in low income settings. This database is under development and subject to negotiation with relevant Ministries of Health.

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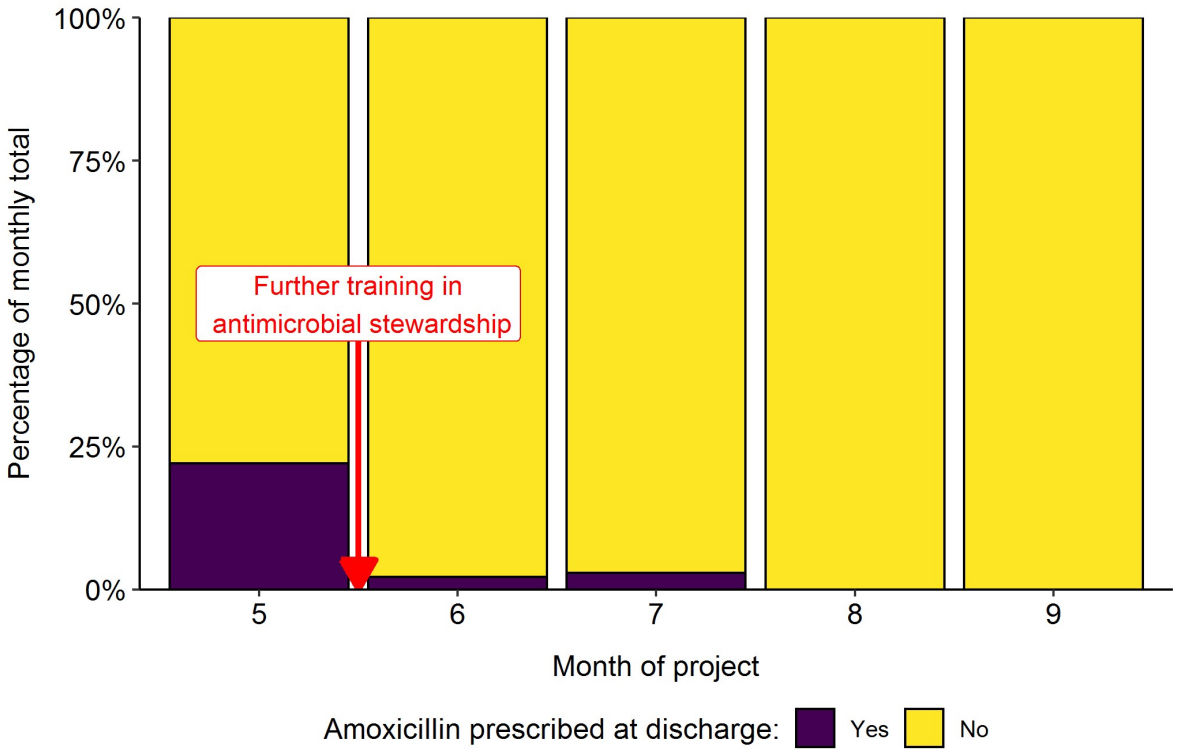
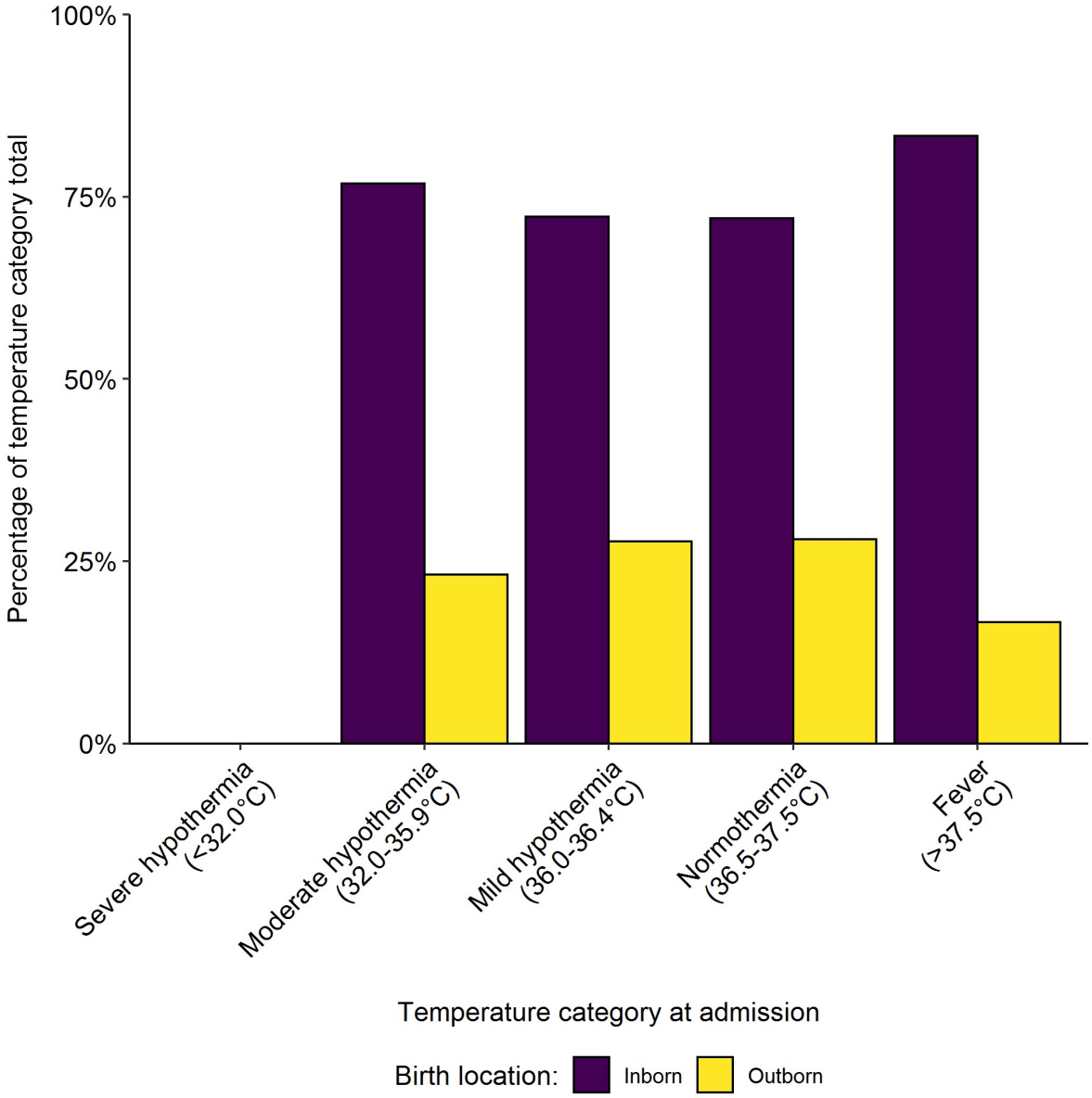
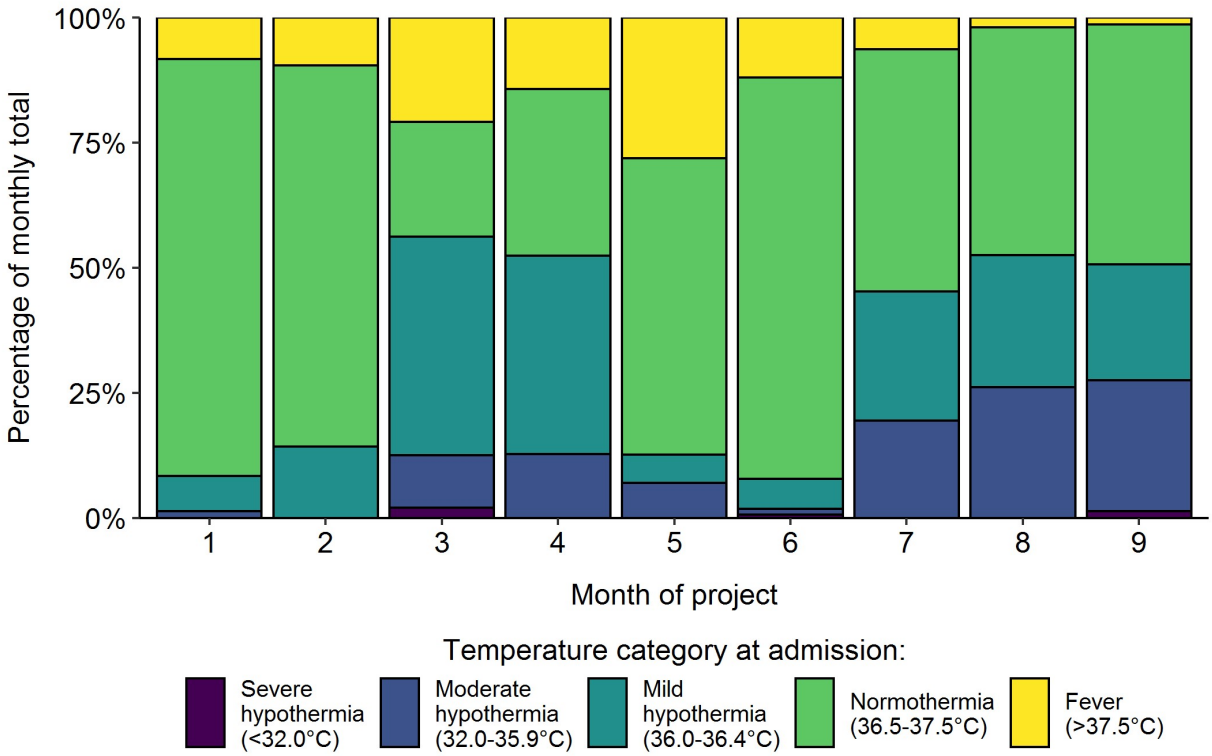
Supplementary Figure 1


100%
75%
50%
25%
0%
Percentage of monthly total
Further training in antimicrobial stewardship
5
6
7
8
9
Month of project
Amoxicillin prescribed at discharge:
Yes
No


100%
75%
50%
25%
0%
Percentage of temperature category total
Severe hypothermia (<32.0°C)
Moderate hypothermia (32.0-35.9°C)
Mild hypothermia (36.0-36.4°C)
Normothermia (36.5-37.5°C)
Fever (>37.5°C)
Temperature category at admission
Birth location:
Inborn
Outborn


100%
75%
50%
25%
0%
Percentage of monthly total
1
2
3
4
5
6
7
8
9
Month of project
Temperature category at admission:
Severe hypothermia (<32.0°C)
Moderate hypothermia (32.0-35.9°C)
Mild hypothermia (36.0-36.4°C)
Normothermia (36.5-37.5°C)
Fever (>37.5°C)

Supplementary Table 1: Example of the statistics given to the Sister in Charge (July 2019)

Main Ward

Admissions			357
Discharges			264
Deaths	Preterm	Early NND	29
		Late NND	6
		Early NND	32
		Late NND	2
			69
	Antiretrovirals for PMTCT given at admission		22

Top 5 Conditions at Discharge

Jaundice	35
Safekeeping	32
Hypoxic Ischaemic Encephalopathy	26
Transient Tachypnoea of the Newborn	25
Prematurity with Respiratory Distress	20

Causes of Death

Prematurity with Respiratory Distress	26
Hypoxic Ischaemic Encephalopathy	13
Gastroschisis	8
Prematurity	6
Neonatal sepsis	5
Aspiration	2
Pneumonia	2
Necrotising Enterocolitis	1
Imperforate anus	1
Jejunal atresia	1
Meconium aspiration	1
Prune belly syndrome	1
Neural tube defect	1
Congenital abnormality	1