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Enhancing skills to promote the utilization of medical laboratory equipment in low resource settings

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ABSTRACT

Objective: This study was to demonstrate the efficacy of an intervention model involving on-going skills enhancement of users, Biomedical Engineers and Technicians (BMETs) in enhancing the utilization of medical laboratory equipment in low resource settings.

Methods: In an action research study, the condition of 202 pieces of medical equipment in seven regional blood banks in the Uganda Blood Transfusion Service (UBTS) were studied prospectively from January 2018 to December 2018. Of these, 160 pieces were included in the intervention group where users and BMETs were mentored and trained in the use and preventive maintenance for all equipment types. A second group of 42 pieces of medical equipment which were not involved in the intervention program, were assessed for comparison. Twenty-one participants were interviewed to obtain detailed information about their experiences and the impact of the training interventions.

Results: The percentage of equipment in good working condition and in use in the intervention group improved from 60% to 74%, while the improvement recorded in the second group was slower (48% to 55%) over the one-year period. Equipment in the intervention group were three times more likely to be in good working condition and in use at the end of the study period with an odds ratio of 3.2 (95% CI: 1.49 to 6.83) and P value < 0.001.

Conclusion: The model applied by Knowledge for Change (K4C) that involves co-learning and mentorship of users and BMETs was successful and should be implemented in other health facilities in Low- and Middle-Income Countries.

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Introduction

Medical technologies have significantly improved treatment outcomes and the quality of healthcare globally in the last two decades [1]. However, health facilities in Low- and Middle-Income Countries (LMICs) are still struggling to fully utilize medical technologies in service delivery. Studies show that about 40% of the medical equipment in health facilities in low resource settings are out of service [2]. The most frequently mentioned barriers to health technologies in low resource settings reported in the literature include: lack of spare parts, lack of consumables, lack of reliable power supply, lack of user training, and lack of technical personnel [3–5].

A report by the Japanese International Corporation Agency estimated that 20% of all equipment failures can be prevented by user training, 60% can be prevented by routine preventive maintenance whereas only 20% are caused by unavoidable system malfunctions [6]. User training increases the percentage of functional medical equipment in use and reduces the rate of equipment failure due to user error and negligence. Similarly, preventive maintenance averts possible causes of equipment failure before they cause any serious damage. For example, dust accumulation can cause failures in sensing systems and piping systems putting equipment out of service. Such failures can be easily avoided by regularly cleaning the equipment which can be done without any specialized knowledge. Additionally, studies conducted by Engineering World Health [7], showed that 70% of broken medical equipment in health

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facilities in LMICS can be repaired using locally available spare parts. It has also been reported that 3% - 25% of the medical equipment found out of service is functional but not in use due to lack of consumables and user training [7,8]. This implies that, with evidence-based, capacity-building, approaches, the condition of medical equipment in low and middle income countries can be effectively improved to optimisehealth service delivery.

Current evidence suggests that successful approaches to improving the utilization of medical technologies in low resource settings must include training for users and BMETs to promote proper use and preventive maintenance of medical laboratory equipment [5,7,9].In this paper, we investigate the impact of an intervention model designed to improve the utilization of medical and/or laboratory equipment in health facilities in low resource countries.

For more than five years, Knowledge for Change (K4C), a UK registered charity (charity no. 1146911) has been placing volunteers from the UK in Ugandan hospitals to share knowledge and strengthen the capacity of health and allied health professionals in Uganda through mentorship. Through its previous work, K4C recommended and lobbied for the first biomedical engineer to be placed at the Uganda Blood Transfusion Services (UBTS) in 2017 to enhance the utilization of medical laboratory equipment in the organization. In 2018, K4C implemented a project designed to support the role of this biomedical engineer through training and mentorship of medical equipment users to play their part in maintaining medical equipment. This paper presents a description of the approach used by K4C in this context and the results achieved with the aim of generating evidence to show that such approaches can enhance the utilization of medical laboratory equipment in low resource settings.

Methods

Building on significant experience by Ackers and Ackers-Johnson, 2016 [10], and the promotion of the Medical Research Council's 'Complex Interventions Framework [11], the intervention took the form of an action-research study combining planned interventions with empirical research with a focus on behaviour change and service improvement. The study was conducted between January 2018 and December 2018 involved a baseline inventory of medical laboratory equipment taken at the beginning of the study, follow-up inventory assessment at 6 months and 12-months, on-going mentoring provided by K4C engineers and UK volunteers, three training courses, and key informant interviews. The study was conducted at UBTS which is the sole organisation mandated to collect, test and issue blood for transfusion to all health facilities in Uganda. UBTS has seven regional blood banks and 7 regional collection centres through which it runs its operations. In this study, data was collected from all seven regional blood banks in Gulu (Northern Region), Arua (North Western Region), Masaka (Central Region), Fort Portal (Western Region), Mbarara (South Western Region), Mbale (Eastern Region), and Nakasero blood bank headquarters (Kampala Capital City).

The baseline survey included all medical equipment used in the laboratories and excluded furniture, computers, computer accessories, medical instruments and single use medical devices. Air conditioning units were included since their working condition significantly effects equipment operation in the blood banks. By way of illustration, the packaging of blood in the laboratories significantly depends on the room temperature which is controlled by air conditioning. Additionally, some equipment such as the architect analysers were often in good working condition but out of use due to lack of functional air conditioning. A total of 214 pieces of equipment were included in the baseline inventory, out of which 169 were selected to be included in the intervention group such that users were trained specifically on equipment that belonged in this group. Selection of this equipment was done in consultation with UBTS administration to purposively identify the most vital equipment in blood storage and testing as well as the most in-need equipment based on the baseline inventory and the administrators' perspectives. During the study, 12 pieces of equipment could not be located during the subsequent assessment and were thus excluded from the data analysis.

Table 1
Equipment categories based on the condition of the equipment. This A – F scale was adopted from Ministry of Health guidelines for medical equipment inventory taking (11).

Category	Interpretation
A	Equipment in good working condition and in use
B	Equipment in good working condition but not in use
C	Equipment in use but needs repair
D	Equipment in use but needs replacement
E	Equipment out of use but repairable
F	Equipment out of use, to be replaced

Since some equipment were classified as more vital than others, selection of a control group by randomization could not be ethically achieved due to the selection bias in the intervention group. Nonetheless, 42 pieces of medical equipment were selected and included in a second group which was also studied using the same data collection tools for comparison. This paper reports the results of an action-research intervention focused on 202 pieces of equipment including 160 pieces in the intervention group and 42 pieces in the second group. Fig. 1 shows a flow diagram of the study design, participant selection and the interventions.

The data collection tool obtained the following information; equipment type, identification number, model, serial number, manufacturer, condition, physical location, date of manufacturer and date of data collection. This data was vital in order to accurately track equipment condition over a 12 month period . The tool is consistent with WHO recommendations for medical equipment inventory management [12]. The medical laboratory equipment were classified into 6 categories numbered A-F based on their condition as shown in Table 1. This classification approach was adopted from Ministry of Health recommendations for medical equipment inventory taking [13]. This data was collected by an independent biomedical engineer who determined the condition in consultation with the users and the biomedical engineer at UBTS.

We also conducted key informant interviews with 21 participants including 12 laboratory technologists, 3 laboratory managers, 4 quality officers, and 2 administrators so as to assess the impact of the interventions from the equipment users' point of view. Permission to conduct this study was obtained from the Executive Director, UBTS and all interviewees consented to participate. No personal information was collected but rather the interviews were specifically designed to obtain detailed information about the challenges of using medical equipment and the impact of the K4C capacity-building model on the utilization of medical equipment.

Interventions

In addition to on-going co-working and mentoring, 3 formal training courses were organized to train laboratory technologists, and BMETs in UBTS. At the time of the study, UBTS had only one biomedical engineer but did not have any directly employed biomedical technicians. K4C however invited biomedical technicians from the Ministry of Health to participate as they are mandated to assist in management medical laboratory equipment in UBTS. The interventions were part of the model used by K4C whereby experts in the area from the UK are placed at the study site to work alongside Ugandan health workers and mentor them over longer periods of time (10). During this project, three

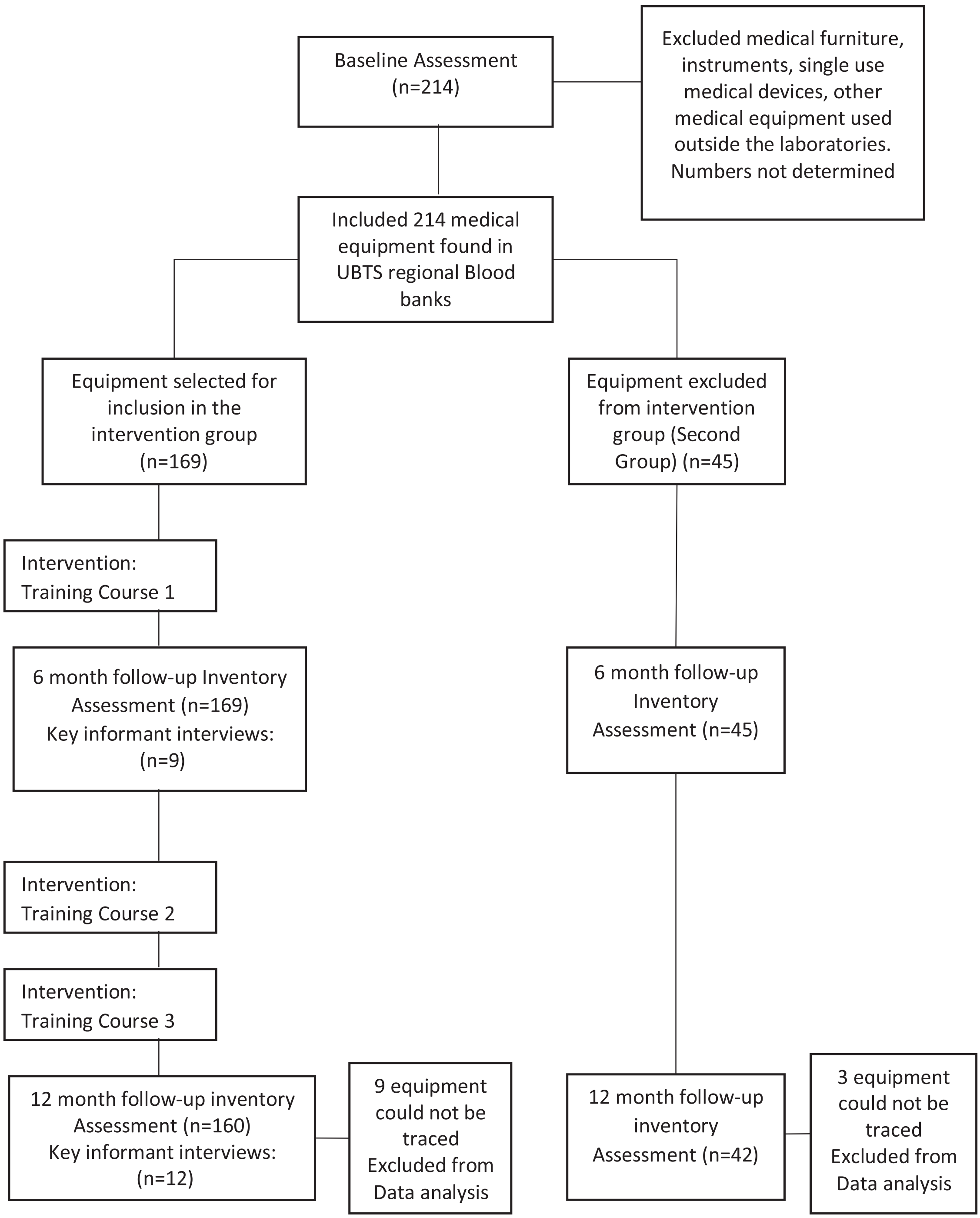

Fig. 1. Flow diagram showing the study design, selection of participants and interventions. 9 equipment in the intervention group and 3 equipment in the second group could not be located during the follow-up inventory at 12 months and were thus excluded from the data analysis.

volunteers from the UK were placed at UBTS, including a clinical engineer placed for 6 weeks, a cold chain specialist placed for 3 months and one long term (biomedical engineer) volunteer who was placed throughout the entire project duration (1 year). During this time, the K4C volunteers mentored local health professionals to support on-going knowledge sharing and translation (use) and, more specifically help to implement technical skills acquired during the formal training interventions. The team also encouraged the transfer of skills and knowledge to peer workers within their institution.

All training courses were organized at the UBTS headquarters in Kampala and were delivered using lecture modes facilitated by PowerPoint presentations combined with problem-based learning. This involved participants being split into small groups of 4–6 to discuss a hypothetical or actual problem under guidance of the facilitator (14), case-based learning methodology in which participants were given a case from past experience about medical technology management, maintenance or repair (15), and practical sessions in which participants demonstrated what they had learned on equipment present at the study site. The training was

Table 2
Descriptive characteristics of the participants in the all three training courses organized during the study.

Descriptive Characteristic	Training Course 1	Training Course 2	Training Course 3
Sex			
Male	17	20	9
Female	3	1	4
Profession / position			
Regional Directors			6
Quality managers			2
Laboratory Supervisors			4
Procurement officers			1
Laboratory technologists	14	16	
Biomedical engineers	1	1	
Biomedical technicians	5	4	
Location of RBB			
North West	2	1	2
North	4	2	1
East	2	2	2
West	2	2	2
South West	3	2	1
Central	2	2	2
Kampala capital city	5	10	3

RBB = Regional Blood Bank; Training course 1 is the Health Technology Management Training; Training course 2 is the Calibration Training; and training course 3 is Role of top management in health technology management. Location refers to the region in Uganda.

delivered by K4C volunteers and local experts sourced from Ugandan biomedical engineering companies and Makerere University School of Biomedical Engineering.

Training course 1: health technology management

A formal training course designed to augment the mentoring work was conducted over a 2-week period in April 2018. It included modules on general health technology management principles, quality improvement and tailored training on specific equipment types included in the intervention group as shown in Table 3. The training modules on each specific equipment type included: the principles of operations, operational procedures, routine preventive maintenance procedures, safety precautions and basic troubleshooting. The basic troubleshooting knowledge provided was defined as knowledge required to identify the fault with a piece of equipment without taking it apart or using specialised engineering knowledge.

Training course 2: medical equipment qualification, calibration and validation

The biomedical engineer at UBTS and a quality control manager were trained and certified in the calibration of medical laboratory equipment particularly on the parameters of mass, volume, speed, temperature, and time. This Train-the-Trainers course was conducted through a private calibration company (Keane technologies), located in Kampala for a period of one week in July 2018. The trainees were then supported to conduct a one-week training programme in August 2018 on the basics of calibration, equipment qualification, development of validation protocols and documentation for users and BMETs.

Training course 3: the role of senior management in health technology management training

This was a three day training organised in December 2018 with the goal of equipping the management team at UBTS with knowledge and skills to develop and implement organisational policies and guidelines for medical equipment management and to support future training for users and BMETs on medical equipment. This training included modules on medical equipment planning and procurement, scheduling planned preventative maintenance, equipment qualification and decommissioning.

The number and descriptive characteristics of the participants in all three training courses are shown in Table 2.

Data analysis

Data collected from the equipment inventories was entered into Microsoft Excel version 2013 and then exported to STATA version 14.0 (Stata Corporation, College Station, Texas, USA) for analysis. Categorical variables were described by their proportion (number of items and percentages). Fisher's exact test was used to compare the proportion of medical laboratory equipment in the intervention group and the second group for each category during each inventory assessment. To assess the impact of the interventions on the utilization of medical equipment, we considered medical equipment in good working conditions and in use (category A) as a primary outcome and measure of utilisation. Odds ratios and 95% confidence intervals were calculated to measure the association of the intervention to the primary outcome in comparison to the second group. The level of significance was set to $P < 0.05$ for all statistical tests.

Results

A total of 202 pieces of medical laboratory equipment were studied prospectively over a period of one year. These were categorized in 17 medical equipment types and were found to be supplied from 75 different manufacturers. The number of manufacturers supplying each equipment type ranged from of 1 to 25 as shown in Table 3. The high variation in medical equipment types and manufacturers illustrates the difficulty in obtaining specific technical assistance from manufacturers on equipment breakdown and maintenance. This is a feature of equipment management in developing countries and of associated equipment donation challenges.

The baseline inventory showed that of the 160 pieces of equipment included in the Intervention group, 60% were in equipment category A, 4% were in category B, 12% in category C, 3% in category D, 18% in category E, and 3% in category F. In the second

Table 3
The table shows the number of pieces of medical equipment in each equipment type and the number of manufacturers supplying each equipment type in the intervention and the second group.

Equipment Type	No. of pieces of equipment $n = 202$ (%)	No. of manufacturers per equipment type
Intervention group		
Refrigerators & Freezers	59 (29%)	25
Centrifuge	25 (12%)	8
Air Conditioner	21 (10%)	5
Plasma Extractor	13 (6%)	3
Tube Sealer	9 (4%)	3
Microplate Reader	8 (4%)	3
Architect analyzer	7 (3%)	1
Weighing Scale	7 (3%)	5
Platelet Agitator	5 (2%)	1
Water Distiller	4 (2%)	4
Microplate Washer	2 (1%)	2
Second group		
Auto Pipette	16 (8%)	6
Incubator	10 (5%)	7
Blood Group analyzer	6 (3%)	3
Biomixer	5 (2%)	2
Autoclave	4 (2%)	2
Pesola Scale	1 (0.5%)	1

Table 4
The status of medical laboratory equipment in both the intervention and second group (Group 2) in the baseline inventory, inventory taken at 6 months, and inventory taken at 12 months. The p-value represents measure of significant between the intervention and the second group obtained with Fisher's exact test. The key for equipment categories A – F is shown in Table 1.

	Baseline			6 months			12 months		
Equipment category	Intervention n (%)	Group 2 n (%)	P-value	Intervention n (%)	Group 2 n (%)	P-value	Intervention n (%)	Group 2 n (%)	P-value
A	96 (60%)	20 (48%)	0.103	118 (73%)	21(50%)	0.006	119 (74%)	23(55%)	0.013
B	7 (4%)	6 (14%)	0.031	8 (5%)	6 (14%)	0.046	11 (7%)	9 (21%)	0.009
C	19 (12%)	3 (7%)	0.285	5 (3%)	2 (5%)	0.447	4 (3%)	1 (2%)	0.722
D	4 (3%)	2 (5%)	0.364	7 (4%)	2 (5%)	0.592	8 (5%)	2 (5%)	0.655
E	29 (18%)	8 (19%)	0.413	19 (12%)	8 (19%)	0.167	14 (9%)	4 (10%)	0.539
F	5 (3%)	3 (7%)	0.011	5 (3%)	3 (7%)	0.218	4 (3%)	3 (7%)	0.159

group, 48% were in equipment category A, 14% were in category B, 7% in category C, 5% in category D, 19% in category E, and 7% in category F as shown in Table 4. A common example of equipment in category C was refrigerators which were able to maintain temperature within the recommended range of 2 – 6 °C (16), but had a constant high temperature alarm going off.

The percentage of equipment in good working condition and in use (category A) in the intervention group increased by 13% (from 60% to 73%) from the baseline to 6 months and then by 1% (to 74%) at the end of the 12 months period, whereas in the second group, equipment in category A increased at lower rates by 2% in the first 6 months and by 5% in the last 6 months. Medical laboratory equipment in the intervention group were three times more likely to be in good working condition and in use at the end of the study period than those in the second group with an odds ratio 3.2 (95% CI: 1.49 to 6.83) and P value $<$ 0.001.

Table 4 also shows that the significance of the difference between the intervention group and the second group differed for each category in each inventory assessment. For instance, the difference between the percentage of medical equipment in category A was not significantly different in either group in the baseline survey (P value = 0.103) but the percentage was significantly higher at 6 months (p-value = 0.006) and at 12 months (p-value = 0.013). The percentage of equipment in category B was, however, significantly higher in the second group in the baseline survey, at 6 months and at 12 months; p-values of 0.031, 0.046 and 0.009 respectively.

Of the 96 pieces of medical laboratory equipment in the intervention group that were in condition A at the start of the study, 88 pieces of equipment (92%) were maintained in this condition within the first 6 months. The inventory after 6 months showed that 121 pieces of equipment were in condition A including those that had been successfully repaired during the first 6 months. Of these, 105 (90%) were maintained in condition A over the last 6 months of this study. These results imply that about 90% of medical equipment can be maintained in good working condition and in use through routine mentoring and training for users and BMETs to promote proper use and planned preventive maintenance.

It was also observed that the percentage of equipment in good working condition but not in use (category B) in the intervention group and the second group increased from 4% to 7% and 14% to 21% respectively over the study period despite the training interventions. The medical equipment in this category required reagents or consumables that were not available in the health facilities.

Providers of health technology management training

Training programs on health technology management at UBTS were previously provided through four sources:

(a) medical equipment manufacturers, that organise training programs for the health workers in facilities purchasing their equipment;
(b) medical equipment distributors (vendors). These often organise training sessions for users following installation of new medical laboratory equipment;
(c) externally funded implementing partners such as K4C that obtain funding from donors and NGOs to improve quality health service delivery often include training and skills development among local health workers, and;
(d) UBTS which organizes internally funded training sessions for its health workers on various topics which could include medical equipment management.

The study found that, prior to the K4C intervention, only one manufacturer had organised training on their equipment. UBTS had never funded a training session on medical equipment management, and neither had any implementing partner organised training on medical equipment management. Vendors organised training sessions when installing new equipment, however, the health workers reported these sessions were ineffective because; (1) they are scheduled for a very short time, sometimes as low as 5–10 min for a piece of equipment, (2) they usually include only the basics of how to switch the equipment on and perform a routine procedure, (3) they usually train one or two health workers available at the time of installation who might forget or leave the facility. This highlights an existing gap in training of users and BMETs in low resource settings on the medical equipment they operate or manage.

Discussion

Health facilities in low income countries have limited access to technical support from equipment manufacturers which is a unique problem when compared to the high income countries [3,17]. Further, this study found that one health facility can procure equipment of the same type from up to 25 different manufacturers. This provides evidence to support observations previously made in previous literature that policies in medical equipment procurement in LMICs are either weak or lacking [9]. The high variance in manufacturers supplying the same equipment types further aggravates the challenge of lack of technical support for medical equipment in health facilities in low income countries. Observations made in this paper therefore suggest that procurement policies for medical equipment in low resource settings be carefully revised to consider the lack of local technical expertise and lack of access to technical support from foreign manufacturers during use.

Additionally, previous studies suggest that about 3% to 25% of medical equipment in low resourced health facilities are functional but not in service especially due to lack of user training or installation [5,8]. Our results show that the percentage of medical equipment in good working condition but not in use increased from 4% to 7% in the intervention group. This was small deviation compared to the increase from 7% to 21% observed in equipment in the second group thus demonstrating that user training enhances the utilization of medical equipment in these settings. The observed increase in equipment in this category was attributed to lack of reagents and consumables. There is a tendency for manufacturers in Ugandan (and other LMICs) to supply medical equipment to health facilities at little or no initial cost, and in exchange the health facilities sign a contract to procure expensive reagents from their suppliers. These health organisations enter these contracts but later cannot use the equipment because they cannot afford the reagents. We observed that in UBTS, blood analysis in some blood banks is put to halt, sometimes for several months, due to lack of reagents. One of the equipment users noted that, "*You can take a whole week when you are not having reagents. Then they bring those which can only last 4 days, after 4 days, you wait for another week when you are not having; that is the main challenge we are having*." This also points towards major challenges in procurement and planning, attributes to lack of policy and tools for appraisal of contracts [9]. We recommend stringent policies on appraisal of procurement and donation contracts that consider the lifetime costs of the medical equipment rather than focusing on the initial cost alone.

As indicated, UBTS had only one qualified biomedical engineer and no biomedical technicians to support her in managing and maintaining medical equipment in all seven regional blood banks. There is clearly a shortfall in the recruitment and human resource policies in government health facilities. The distance covered and the workload present is simply too much for one technical person. As of July 2019, there were 119 biomedical engineers trained locally in Uganda, out of whom 114 were trained in Makerere University. However, the rate at which these biomedical engineers are being absorbed by the Ministry of Health has been very slow. Indeed, biomedical engineers were not on the scheme of service for human resource until 2016 [18]. Implementing partners working with the Ministry of Health and other public health institutions should therefore lobby to have positions created and filled by BMETs so as to improve the status of medical equipment. K4C accomplished this at UBTS to place at least one biomedical engineer in 2017 by persistently advocating for this position to the top management but this clearly not sufficient. The lack of BMETs also justifies the need for training of users to use equipment appropriately and to maintain equipment in good working condition.

The lack of BMETs in health facilities in low resource countries implies that the health professionals using the equipment are in most cases solely responsible for maintaining it in good working condition. However, to our knowledge, there is no curriculum for medical, nursing and laboratory students in Uganda that teaches medical equipment management. Further, specialised laboratory equipment such as that used in blood banks or other state of the art laboratories especially demand training beyond that offered by existing curricular for laboratory professionals. Yet these users have limited opportunities for medical equipment training from the manufacturers, suppliers or the host health institutions. There is a need for policies on the inclusion of training on medical technologies in the curricula of health professionals in low resource countries and in associated professional development programs.

It is also important to note that organisations, such as the Ugandan Blood Transfusion Service (an organisation heavily dependent upon equipment to function) do not provide on-going Continuing Professional Development in the area of equipment management for their technicians or users.

Our results show that medical laboratory equipment on which users were trained, was three times more likely to be in good working condition and in use. Further, 90% of the medical equipment in the intervention group were maintained in good working condition and in use over the 12-month study period. This impact is also illustrated by the following typical quotes by equipment users:

> "*The training was relevant because after that training we came back and did some (preventive) maintenance and we have not had a major break down of the equipment since*." Laboratory technologist

> "*The impact (of the training) I have seen is the awareness being created. People are more alert on the equipment. The biomedical engineer is doing more and better. People who have been trained have picked up interests especially in (medical laboratory) equipment; I have also seen a record of documentations, standard operating procedures, manuals. This paper work is now available*." Laboratory supervisor.

It should be noted that the same users trained in this study operate both equipment in the intervention and the second group used for comparison. As such the benefits of the training including knowledge learned, enhanced motivation and confidence in management of medical equipment is transferable to all medical equipment beyond the intervention group.

There are several groups and organisations that are contributing to improving the status and utilisation of medical equipment by conducting occasional outreach programs to repair broken equipment in health facilities in low resource countries. In Uganda, these include programs by biomedical engineering student volunteers [19], externally funded projects such as Engineering World Health [20] and the Ministry of Health's technical teams. These programmes can increase their impact by including extensive user training sessions in their activities since one time repair of medical equipment has a short lived impact due to the high frequency of breakdown of medical equipment in low resourced health facilities [21,22]. There is also evidence to show that improvements in the condition of medical equipment continue for up to two years after the end of the interventions that involve skills development [23–25]. We therefore expect the impact recorded in this study to be sustained by the trained staff beyond the project timeline especially if further support is rendered from the decision makers within UBTS and policy makers in Uganda.

Limitations

While these interventions were focused on medical equipment that belonged to the intervention group, the knowledge learned from the training such as safety precautions, documentation and proper management can be applied to all equipment types including those in the second group especially since the same users trained operate equipment in both groups. It is therefore likely that the training courses conducted had a positive impact on the condition of medical laboratory equipment in the second group as well. This implies that the reported impact of the training on improving the utilisation of medical equipment is likely underestimated when comparing the intervention group and the second group. As such the second group cannot be accurately termed as a "control" group. Future research studies should include an analysis of the cost of training and preventive maintenance versus the cost of equipment breakdown.

Conclusion

In conclusion, the results of this study show that the model applied by K4C that involves co-learning and mentorship of users and BMETs was effective in enhancing the utilisation of medical equipment in UBTS. This calls for development of standardised programs or curricula to train medical professionals in low resource countries on medical equipment management based on this approach. There is also a need for policies on routine user training for health professionals and inclusion of medical equipment management in the curricula for medical, health and allied health professionals including laboratory staff.

The curricula used in the training courses in this study were designed to answer the questions: (1) how does this equipment work? (2) How is it used in normal operation? (3) What are the recommended preventive maintenance procedures? (4) What are the common errors, their causes and solutions? And, (5) what are the safety precautions to consider when using this machine? Answers to these questions are widely available for most equipment therefore similar courses can be easily developed for various medical equipment types available in any health facility. The proposed training curriculum should be accredited and approved by recognised educational institutions such that the participants are awarded certificates of completion that contribute towards career and academic upgrading. This is a major factor that motivated health workers to attend training programs and also contributes significantly to motivating them to apply the knowledge and skills learned in practices to improve the conditions of medical equipment and towards quality service delivery [26,27].

The impact of the proposed training approach is effected by decisions made during planning and procurement of medical equipment. This calls for development of strict policies and guidelines for medical equipment donations, procurement and planning at both national and organizational level. These guidelines should consider minimizing the variance in manufacturers and suppliers, and also carefully consider indirect costs of a particular equipment especially cost of reagents, consumables, user training, technical expertise and spare parts. This can be specified in a guideline for appraisal of procurement bids and contracts on the organizational level. This paper provides evidence to support the development of policies at organisational and national level to train health professionals and BMETs and improve the utilisation of medical equipment in health facilities in low resource countries.

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Ethical approval

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