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ORIGINAL PAPER

Implementation of a decentralised maintenance model with a measurable impact on the functionality and availability of medical equipment in healthcare facilities in Burundi

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Abstract

Purpose This study measures the impact of implementation of the Improved Decentralized Maintenance Model on the functionality and availability of medical equipment in Burundi's resource constrained health care system with hypothesis that the model has a measurable impact.

Methods The initial model was tested in 2 provinces before being improved and extended to the provinces of Bujumbura and Rumonge. It is composed by 4 interrelated main axes (Maintenance management, Human, Financial and Material resources,). This study analyses the effects of this implementation between October 2020 and February 2022.

Results The rate of medical equipment functional in service has increased substantially, respectively +8% in the province of Bujumbura and 2% in the province of Rumonge, and the rate of medical equipment requiring maintenance has fallen by 9.7% (Bujumbura) and 2% (Rumonge). The provinces implementing the model have convincing results in terms of functionality with scores of at least 80%, while the national average is 64%.

Conclusions There is a notable positive change between 2020 and 2022 in the functionality of medical equipment and a decrease in equipment awaiting maintenance, and therefore in its availability. This study proves that a sustainable implementation of a decentralized maintenance model is feasible and highly useful in low-resource settings due to its affordability. The context of a low-resource country is a challenge in itself, but the model developed shows that by tackling the low-resource levels of preventive maintenance, we can have some impact on the functionality of the equipment and therefore on the quality of care.

Keywords Maintenance · Management information systems · Biomedical technology · HTM

1 Introduction

Biomedical equipment maintenance is one of the major concerns of the Ministry of Public Health in Burundi and a challenge to improving healthcare delivery, as it is in many low-resource countries [1]. Lora Perry et al. showed that, on average, 38.3% of equipment in developing countries was out of order and that the three main causes were lack of training, poor management of health technology and lack of appropriate infrastructure [2]. In the meantime, health workers must be able to provide quality care by having access to medical equipment that is in good condition, correctly configured and adjusted, and safe for both users and patients. The availability of functional equipment, in sufficient quality and quantity, is thus an obvious prerequisite for delivering quality care.

In Burundi, the Belgian development agency Enabel has worked since 2017 with the Ministry of Public Health and specifically with the Directorate of Health Infrastructure and Equipment on the main challenges that hinder the availability and optimal functionality of medical devices in healthcare facilities, namely:

A lack of competent and motivated human resources: in general, the professionals in charge of biomedical equipment maintenance have limited skills, are overrepresented in the capital and their work is rarely valued by hierarchy; service providers are only called upon on an ad hoc basis without

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pre-established maintenance contracts; in other cases, service providers are contracted at the national level but intervene only on a single category of equipment (vertical maintenance), for example on cold chain equipment.

A lack of maintenance planning: Maintenance activities are carried out reactively, on a case-by-case basis (corrective maintenance) and often according to the availability of funds allocated by donors and therefore in the geographical areas favoured by the latter; preventive maintenance of infrastructure and equipment of district hospitals and health centres is rarely prioritised and planned as recommended by the World Health Organisation (WHO) and other references in terms of the management of medical technologies [1, 3] and is carried out in an anecdotal manner and limited in relation to the entire country. There is no policy at the central level regulating biomedical maintenance in Burundi, which, like other low-resource countries, is becoming a dumping ground for donated equipment that is often at the end of its life cycle, useless, inappropriate and costly to maintain [4, 5].

A lack of maintenance materials and financial resources: this lack is particularly pronounced, with an almost systematic absence of maintenance workshops and a limited number of tools that do not enable technicians to work under suitable conditions. Random or non-existent budgetary resources: investment and often undifferentiated envelopes allocated without an overall vision.

A weak and fragile information system: the absence of reliable and usable databases at both local and national levels makes it difficult for the different stakeholders to justify decisions and priorities for the allocation of funds dedicated to maintenance; coordination and information sharing between the different levels of the health pyramid, partners, and equipment donors is limited; the technical documentation essential for the proper use and maintenance of medical equipment [3] is either unavailable or unsuitable (in a foreign language).

To address those problems and to improve the management of its assets, the Ministry of Public Health, with the support of Enabel, developed in 2017 a decentralised maintenance model in two pilot provinces (Kirundo and Muramvya) in an action research approach [6].

This model is based on recommendations from the Healthcare Technology Management (HTM) literature and takes into consideration all components of the Healthcare Technology Management cycle as shown in Fig. 1 [1]:

After 3 years of testing, this model was improved and implemented in two additional provinces (Bujumbura and Rumonge). In the improved decentralised maintenance model (IDMM) the district maintenance department is responsible for ensuring the safety and availability of medical equipment while keeping operating costs low. Selecting the best maintenance strategy is a key decision to reduce equipment downtime and maintenance costs.

Some elements of the strategy supported by Enabel have been included in the National Health Development Plan and the National Health Informatics Development Plan [7], for example the integration of maintenance technicians at the peripheral level and the use of national Computerised Maintenance Management Software (CMMS).

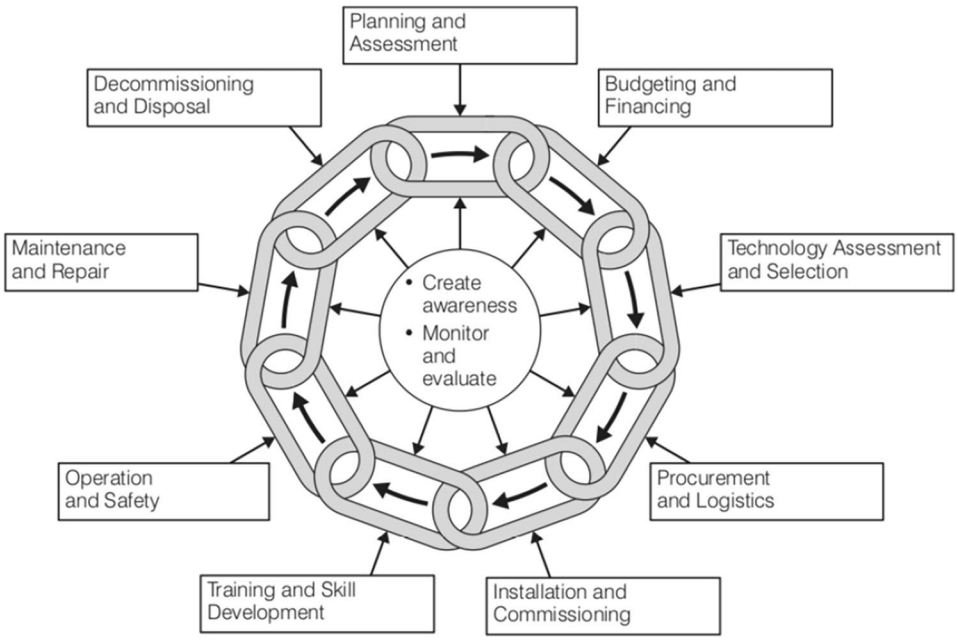

Fig. 1 HTM life cycle [1]

2 Research question

Our action research hypothesis is that the implementation of the improved decentralised maintenance model has a measurable impact on the functionality and availability of medical equipment in health centres and district hospitals.

The purpose of our study is to measure the impact of our action on the availability of functional equipment in the provinces of Rumonge and Bujumbura, where the IDMM was fully implemented.

This article will show the results of data collected between October 2020 and February 2022.

3 Materials and methods

An initial decentralised maintenance model was tested in action research in 6 districts of Kirundo and Muramvya provinces between 2017 and 2020, before being improved into an improved decentralised maintenance model and extended in August 2020 in 5 districts of Bujumbura and Rumonge provinces.

The Improved Decentralised Maintenance Model is composed of four main axes, which are interrelated and although they can be addressed individually, effectiveness depends on all 4:

- Axis 1: Human Resources
- Axis 2: Financial Resources
- Axis 3: Material Resources
- Axis 4: Maintenance Management

Each axis of the IDMM is translated into expected outputs. The activities necessary to achieve each of these outputs are formulated in an Operational Maintenance Plan (OMP). Each district develops and implements its own OMP on an annual basis.

A matrix summarises all the key information of the OMP with progress reports on achievement of the outputs measured by indicators with predefined baseline and target values. All the outputs listed are shown in the following tables.

In the area of Human Resources (Table 1), the impact of skills development programmes for decentralised maintenance technicians has been demonstrated in studies in Rwanda and Nepal [8, 9]. Also A. Worm et al. have shown the importance of supporting a skilled technical workforce capable of maintaining, repairing and designing biomedical equipment using locally available materials and knowledge [10].

A series of activities were carried out to strengthen and motivate the human resources involved in the maintenance services, but also in the administrative and clinical services.

All the technicians from the two provinces concerned were involved in biomedical maintenance training

Table 1 Axis 1: Human Resources

R1: Technicians Capacity Building
R2: End-Users Capacity Building
R3: Maintenance Focal Points in Health Centre
R4: Strengthening Healthcare Technology Management
R5: Multi-annual Recruitment Plan
R6: Retention Human Resources

implemented in partnership with the NGOs MSV and Humatem over a period of almost two years. Modular training courses enabled the learners to return to their respective facilities in between modules to apply the elements acquired with a system of mentoring and a monitoring and evaluation system was used in the field to check and correct the level of knowledge. The training topics covered between August 2020 and April 2022 were the following:

- Basic module (electricity, plumbing and sanitation)
- Healthcare Technology Management
- Medical devices in the operating room and related departments (intensive care and emergency)
- Medical devices for obstetrics, gynaecology and neonatology departments
- Electrical safety, solar panels and basic electronics
- Maintenance of medical laboratory equipment
- Cold chain, sterilisation and imaging.

According to the NF-X60-010 standard [11], 5 maintenance levels from 1 to 5 are defined. Level 1 corresponds to checks carried out by internal technicians and level 5 corresponds to breakdowns requiring the intervention of the manufacturer (external). It is recognised that a significant proportion of maintenance problems arise from incorrect use of medical equipment by users and also from the absence of 1st level maintenance [1].

On the basis of user maintenance protocols defined and validated by the Ministry, the maintenance technicians planned and carried out training for all medical equipment users in the proper use of the equipment within their facilities and in the basic maintenance (1st level) of the equipment.

Each district maintenance technician is responsible for all the health centres in their district. In order to improve communication between the district and the health centre for all maintenance issues and to empower the medical and paramedical staff in the health centres, a local maintenance focal person was appointed for each health centre. The focal persons were trained by the maintenance technician on their missions and the tasks to be accomplished.

In order to feed into the Annual Action Plans and to facilitate the decision-making process, each health facility carried out a detailed financial planning including all maintenance

Table 2 Axis 2: Financial Resources

R7: Securing funds for maintenance
R8: Integration of maintenance aspects in investment budgets
R9: Detailed financial planning of maintenance activities for Annual Action Plans

activities as well as the operating costs of the biomedical workshop (Table 2).

The operation of the maintenance services has been supported by Enabel on a degressive basis.

Since February 2022, salaries and operating costs have been covered by the health centres, which pay monthly contributions to the district for the services provided. This cost varies from one district to another according to the number of health centres it comprises, between BIF 20,590 and BIF 25,403, i.e. less than EUR 15 per facility per month to ensure the sustainability of the service.

For this study, Enabel built 5 maintenance workshops (4 complete and 1 smaller unit for the district without a hospital) and provided the maintenance technicians with tools, test equipment (electrical safety analyser, digital multimeter, oxygen analyser), IT equipment (computers and tablets) and logistical means (5 motorbikes and communication costs) to enable the maintenance technicians in the hospitals and district office to carry out the maintenance operations (Table 3).

In order to organise their work and be able to respond to different requests, technicians must have an overview of their planned tasks (preventive maintenance) but also punctual tasks (corrective maintenance) and prioritise them. This process was facilitated by the creation of an annual maintenance plan for equipment. The preventive maintenance activities have been prioritised and integrated into a CMMS. Generic preventive maintenance protocols have been defined for each type of equipment and integrated into the CMMS. The implementation of the CMMS is based on the principle that preventive maintenance has a positive impact on the life expectancy of the equipment and will limit the need for corrective maintenance. L. Angelica Hernández-López et al. propose an index for prioritising preventive maintenance of medical equipment. This considers: type of equipment, function of the equipment, maintenance requirements, calibration, age of the equipment, location of the equipment and risks associated with the equipment [12]. An equivalent simplified approach has been adopted and implemented in our model based on the notion of criticality. A criticality level (1: Very Critical; 2: Critical; 3: Less Critical; 4: Non-Critical) of the equipment allowing prioritising the medical devices from a technical point of view has been defined in a consensual way for each type of equipment and for each level of care.

Table 3 Axis 3: Material resources

R10: Construction and maintenance of maintenance workshops
R11: Supply and maintenance of tools and ECME
R12: Provision and sustainability of logistical means for technicians to carry out their missions

A series of procedures have been put in place to improve the daily work of the maintenance departments (equipment decommissioning, management, external contracting, internal operation of the workshops, etc.).

A nomenclature and grades of functionality have been defined in a clear and understandable way. The equipment nomenclature created with local terminologies familiar to technicians and engineers at the central level [6] has been improved. The classification used for the types of equipment is identical to the one used by the Ministry in the "OpenClinic" CMMS software, namely:

- THE: Technical hospital equipment
- EE: Energy Power Supply Equipment
- SE: Safety equipment
- MF: Medical furniture
- ME: Medical equipment
- WTE: Workshop tools and equipment
- ICT: Office automation, computers
- VE: Vehicle

However, for certain types of equipment in this classification, "families" have been created to facilitate the management of future maintenance plans: The "Medical Furniture" type of equipment comprises 2 families, which are

- Specific medical furniture
- Non-specific furniture

The "Medical Equipment" (ME) type includes 3 families which are

- Biomedical Equipment (BE)
- Laboratory equipment (LAB)
- Medical Refrigeration Equipment (MRE)

Another improvement to the model in the action research approach of Kirundo and Muramvya is to characterise the grade of functionality of medical devices in an objective way, in four distinct states:

- FIS: Functional and in Service: the equipment is currently in use in the department, is in good working order and does not require corrective maintenance
- MR: Maintenance Required: corrective maintenance is required to bring the equipment back into full working order

– FOS: Functional and Out of Service: equipment is functional but is not used in the facility for various reasons such as:

  - No consumables or reagents
  - Lack of sufficiently trained staff to use the equipment
  - Lack of energy to function properly
  - No need to use the equipment

– NR: Non-repairable: the equipment has been declared non-repairable and must be disposed, this may be due to:

  - Repair costs too high compared to renewal costs
  - Obsolete or outdated equipment
  - Inability to find spare parts from the manufacturer due to obsolescence

All results related with maintenance management are listed in Table 4.

This study focuses on quantitative data (inventories) collected between October 2020 and February 2022 in the 5 health districts of the health provinces of Bujumbura and Rumonge with 6 public hospitals and 97 health centres.

The inventories were initially entered, and processed in Excel and statistically verified with pvalue.io. [13]

The data were subsequently imported into the national CMMS, which includes an adapted import module. As a result, all data are in the national CMMS database of the Ministry of Public Health.

4 Results

The results on the state of the equipment stock in the health facilities concerned are describing the 2 provinces where the IDMM was implemented.

Table 5 Data from the Bujumbura Health Province Inventories 2020 and 2022: total functionality and type of equipment

		Inventory 2020 (n = 3562)	Inventory 2022 (n = 3554)
STATE, n	FIS	2909 (82%)	3098 (87%)
	MR	350 (9.8%)	151 (4.2%)
	FOS	210 (5.9%)	161 (4.5%)
	NR	93 (2.6%)	144 (4.1%)
TYPE EQUIPMENT, n	MF	1757 (49%)	1742 (49%)
	ME	1045 (29%)	1045 (29%)
	ICT	271 (7.6%)	272 (7.7%)
	EE	248 (7%)	253 (7.1%)
	THE	184 (5.2%)	185 (5.2%)
	AC	35 (0.98%)	35 (0.98%)
	SE	15 (0.42%)	15 (0.42%)
	WTE	7 (0.2%)	7 (0.2%)

For the province of Bujumbura, the total number of equipment items identified in the inventory in February 2022 was 3562, as shown in Table 5 and Fig. 2.

The percentage of medical equipment (ME) that is functional and in service (FIS) in Bujumbura province has increased significantly from 73% to 81%. The percentage of equipment in a state of required maintenance (MR) has decreased significantly by 9.7%. The percentage of functional but out of service equipment (FOS) remained stable and the percentage of non-repairable equipment increased slightly as shown in Table 6.

The percentage of energy equipment (EE) such as generators and solar power equipment, functional and in service (FIS) in Bujumbura province increased significantly by 11% to 75%. The percentage of equipment in MR condition decreased significantly by 9%. The percentage of FOS equipment decreased by 3.3% and the percentage of NR equipment increased slightly as shown in Table 7.

Table 4 Axis 4: Maintenance management

R13: Inventories of equipment stock
R14: Deployment and operation of CMMS
R15: Carry out corrective and preventive maintenance for each facility
R16: Adoption of a preventive and continuous equipment replacement policy
R17: Promote the homogeneity of the equipment stock
R18: Establish and operate an equipment decommissioning committee and procedure for the effective disposal of decommissioned equipment
R19: Strengthen the maintenance contracting process
R20: Implementation of internal maintenance management procedures
R21: Implement workshop and tooling management procedures
R22: Establish procedures for interfacing with the various hospital departments
R23: Integration of technicians in the decision-making processes of the facilities
R24: Setting up technical libraries

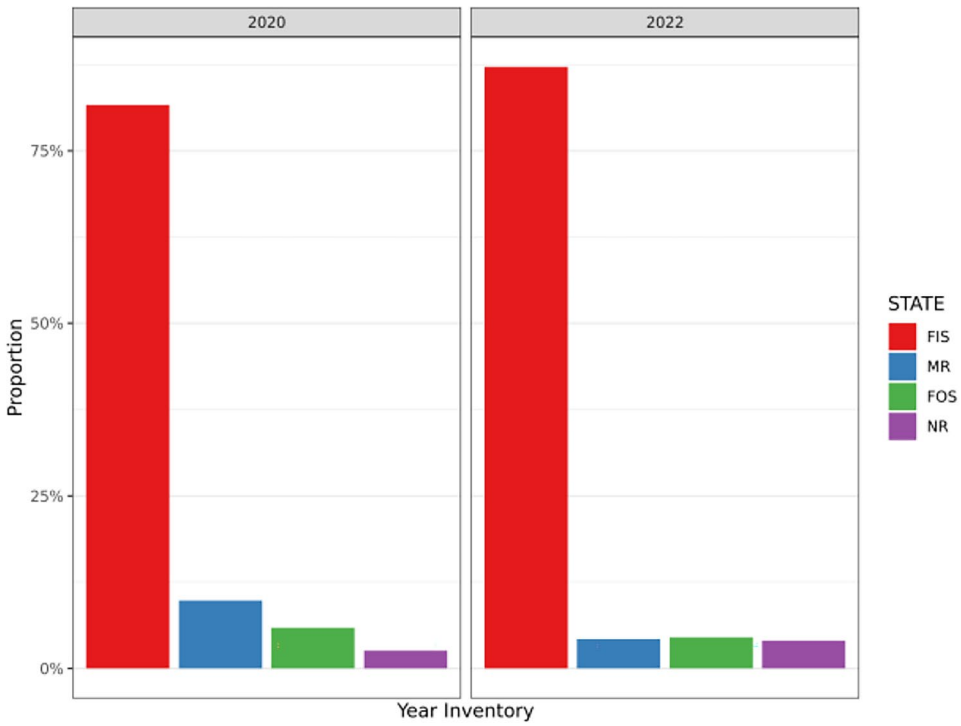

Fig. 2 Evolution of state of functionality of equipment in Bujumbura Health Province

The percentage of medical furniture in functional condition and in service (FIS) in Bujumbura province increased by 4% to over 90%. The percentage of equipment in a state of required maintenance (MR) has decreased by 2.4% and is extremely low. The percentage of functional equipment out of service (FOS) decreased by 2% and the percentage of NR equipment increased slightly as shown in Table 8.

For the province of Rumonge, the total number of equipment items identified in the inventory increased from 2490 items in October 2020 to 2522 items in February 2022, as shown in Table 9 and Fig. 3.

The percentage of medical equipment (ME) that is functional and in service (FIS status) in Rumonge district increased by 2% to 76%. The percentage of equipment in MR condition decreased by 2%. The percentages of FOS and NR equipment remained stable as shown in Table 10.

The percentage of energy equipment (EE) in functional and operational condition (FIS) in Rumonge district increased by 2% to 88%. The percentage of equipment in required maintenance (MR) decreased by 3.7% to 9.3%. The percentage of functional out-of-service (FOS) and non-repairable (NR) equipment remained unchanged as shown in Table 11.

The percentage of medical furniture (MF) that is functional and in service (FIS) in Rumonge district has increased by 1% and is 96%. The percentage of equipment in need of maintenance (MR status) decreased by 1.2% to 3%. The percentages of FOS and NR equipment remained unchanged and extremely low as shown in Table 12.

If we compare the data extracted from the national CMMS, we realise that the 4 provinces supported by Enabel have convincing results in terms of equipment

Table 6 Evolution of the state of functionality of ME between 2020 and 2022 / Bujumbura Province

		Inventory 2020 (n = 1045)	Inventory 2022 (n = 1045)
STATE, n	FIS	763 (73%)	847 (81%)
	MR	171 (16%)	66 (6.3%)
	FOS	58 (5.6%)	57 (5.5%)
	NR	53 (5.1%)	75 (7.2%)
FAMILY EQUIPMENT, n	BE	680 (65%)	681 (65%)
	LAB	245 (23%)	244 (23%)
	RME	120 (11%)	120 (11%)

Table 7 Evolution of the state of functionality of EE between 2020 and 2022 / Bujumbura Province

		Inventory 2020 (n = 248)	Inventory 2022 (n = 253)
STATE, n	FIS	158 (64%)	191 (75%)
	MR	55 (22%)	33 (13%)
	FOS	30 (12%)	22 (8.7%)
	NR	5 (2%)	7 (2.8%)

Table 8 Evolution of the state of functionality of MF between 2020 and 2022 / Bujumbura Province

		Inventory 2020 (n = 1757)	Inventory 2022 (n = 1742)
STATE, n	FIS	1587 (90%)	1635 (94%)
	FOS	86 (4.9%)	48 (2.8%)
	MR	65 (3.7%)	23 (1.3%)
	NR	19 (1.1%)	36 (2.1%)

functionality with scores of at least 80%, while the national average for the other provinces is 64%, as documented in Table 13.

Specifically, for the 3 types of equipment that we analysed in our study, the results for the provinces outside Enabel zone are as follows:

For the ME type: 69% were FIS, 5% were FOS, 10% were NR, 16% required maintenance.

For the EE type: 64% were FIS, 3% FOS, 22% required maintenance and 11% were non-repairable.

Finally, the MF type seem to be in relatively good condition throughout the country with a rate of 95% FIS. Only 3% of the MF were classified as NR.

These data remain relative and depend on the quality of the data entered by the technicians in the software, but they show a clear trend of the benefit of the IDMM model.

Table 9 Data for the Rumonge Health Province 2020 and 2022: total functionality and type of equipment

		Inventory 2020 (n = 2490)	Inventory 2022 (n = 2522)
STATE, n	FIS	2084 (84%)	2142 (85%)
	MR	294 (12%)	264 (10%)
	FOS	69 (2.8%)	69 (2.7%)
	NR	43 (1.7%)	47 (1.9%)
TYPE EQUIPEMENT, n	MF	1155 (46%)	1169 (46%)
	ME	878 (35%)	896 (36%)
	ICT	185 (7.4%)	185 (7.3%)
	EE	153 (6.1%)	153 (6.1%)
	THE	96 (3.9%)	96 (3.8%)
	AC	20 (0.8%)	20 (0.79%)
	SE	3 (0.12%)	3 (0.12%)

5 Discussion

The results obtained and discussed in this chapter are the result of the implementation of the 4 axes of the model as described in chapter 2. They are inseparable and all contribute to the achievement of the results as described below.

There is a notable and significant positive change between 2020 and 2022 in the functionality of medical equipment and

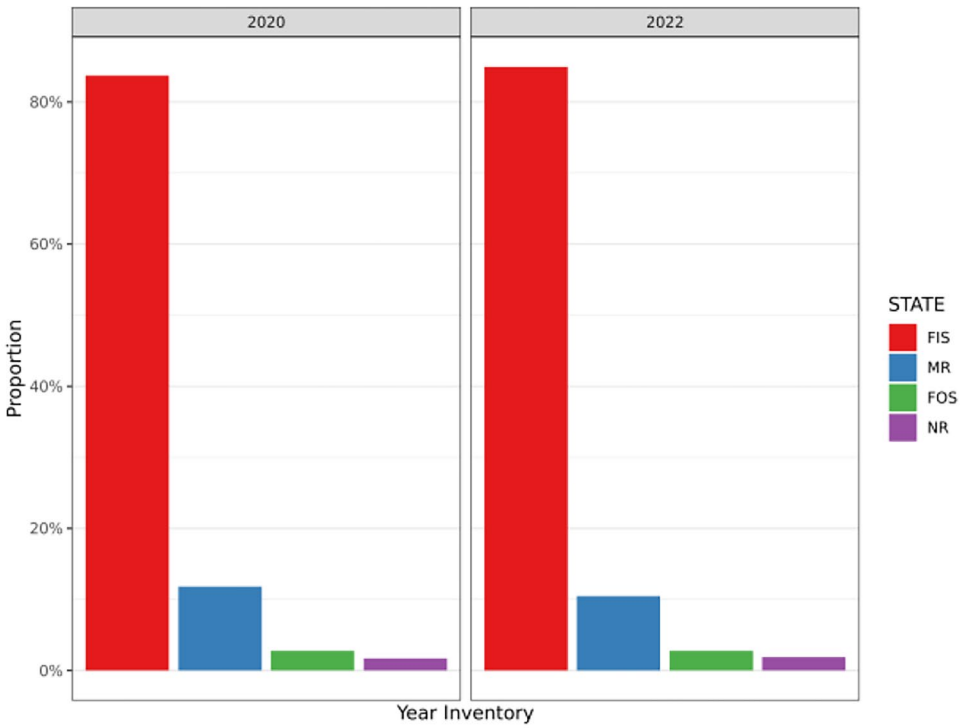

Fig. 3 Evolution of state of functionality of equipment in Rumonge Health Province

Table 10 Evolution of the state of functionality of ME between 2020 and 2022 / Rumonge District

		Inventory 2020 (n = 877)	Inventory 2022 (n = 896)
STATE, n	FIS	653 (74%)	682 (76%)
	MR	146 (17%)	134 (15%)
	FOS	42 (4.8%)	43 (4.8%)
	NR	36 (4.1%)	37 (4.1%)
FAMILY EQUIPMENT, n	BE	520 (59%)	533 (59%)
	LAB	255 (29%)	259 (29%)
	RME	102 (12%)	104 (12%)

a significant decrease in equipment awaiting maintenance, and therefore in its availability. The trends differ according to the type of equipment and the provinces concerned, with a significant improvement in the case of electrical equipment compared to medical furniture.

The results obtained in our study show the positive impact of the improved decentralised maintenance model, developed by the Ministry of Public Health in Burundi. Biomedical maintenance, being an inseparable component of health systems, cannot remain concentrated at the central level and must be close to the assets to be maintained.

There has been a significant increase (+11%) in the rate of functional electrical equipment (EE) in Bujumbura province, which can be explained by the technicians' mastery of maintenance technologies and processes, the relatively easy local availability of spare parts, the low cost of preventive maintenance operations, and the prioritisation of maintenance of this equipment due to its critical nature (access to energy). By mirror effect, the rate of equipment requiring maintenance (MR) has logically decreased (-9%).

The relatively high residual rate of Functional and Out of Service equipment can be explained by the ongoing programmes to implement solar power equipment installations.

Concerning the Medical Equipment (ME) family, the rate of equipment that is functional and in service has also increased substantially, respectively by 8% in the province of Bujumbura and 2% in the province of Rumonge, and the rate of equipment requiring maintenance (MR) has fallen by 9.7% (Bujumbura) and 2% (Rumonge). The results are

Table 11 Evolution of the state of functionality of EE between 2020 and 2022 / Rumonge District

		Inventory 2020 (n = 86)	Inventory 2022 (n = 86)
STATE, n	FIS	74 (86%)	76 (88%)
	MR	11 (13%)	8 (9.3%)
	FOS	1 (1.2%)	1 (1.2%)
	NR	0 (0%)	1 (1.2%)

Table 12 Evolution of the state of functionality of MF between 2020 and 2022 / Rumonge District

		Inventory 2020 (n = 764)	Inventory 2022 (n = 777)
STATE, n	FIS	727 (95%)	749 (96%)
	MR	32 (4.2%)	23 (3%)
	FOS	3 (0.39%)	2 (0.26%)
	NR	2 (0.26%)	3 (0.39%)

mitigated by the following difficulties: access to spare parts and their cost and to consumables; the heterogeneity of the stock, access to technical documentation, the absence of a maintenance contract.

Concerning the type of medical furniture, the variations, although positive, are of a smaller magnitude, rate FIS + 4%; MR -2.4% for Bujumbura and FIS +1%; MR -1.2% for Rumonge. This is due to the fact that this type of equipment does not require specific training for its maintenance or significant technical and financial resources, and therefore the initial rate (2020) of FIS equipment was already high at 86% and 95% respectively, and so the margin for progress is more limited and more difficult to achieve.

Among the challenges and prospects, we identify (i) the need for close monitoring of technicians and material resources to implement maintenance operations; (ii) the change in practices requires time, but after one year of implementation, palpable results can be observed; (iii) the need to raise awareness of the importance of maintenance among decision-makers, with effective involvement of health facility managers and maintenance technicians in the decision-making process; (iv) the context of a low-resource country is a challenge in itself, but the model developed shows that by tackling the low-resource levels of preventive maintenance, we can already have some impact on the functionality of the equipment and therefore on the quality of care; (v) the development of local skills remains a constraint, as there is no dedicated biomedical engineering programme in Burundi to meet existing needs, in line with the WHO global strategy on human resources for health [14, 15].

Table 13 proportion of functional equipment in IDDM provinces compared to other provinces

	Equipment FIS	Total Equipment	Percentage FIS (%)
Provinces outside Enabel area	10442	16291	64%
Bujumbura	3098	3554	87%
Rumonge	2142	2522	85%
Muramvya	575	693	83%
Kirundo	1140	1428	80%

Cobos Muñoz et al. have shown that overall, lessons from low-income countries suggest that factors such as an adequate mix of technical skills at the local level to carry out decentralised tasks, effective decentralisation of decision making to the periphery, and political leadership are key factors for successful decentralisation [16]. Our study confirms these conclusions.

5 Conclusion

The implementation of all the components of the model in a coherent, sustainable and inseparable manner is essential for the proper functioning of the maintenance system.

The impact of the implementation of this model was visible after 15 months, which is encouraging compared to other studies that show the effects of the introduction of ICT in health care after 3 years [17, 18].

The study shows clear correlation between the implementation of the activities of the different axes of the maintenance strategy and the effective availability and functionality of medical devices in the departments. It also shows the affordability of the model that is financially sustainable.

On the strength of this experience and the convincing results obtained, the Ministry of Public Health is seeking to invest in the duplication of the decentralised maintenance strategy in all the country's health districts with the support of its partners. The National Health Development Plan includes the main lines of the strategy and encourages the peripheral level to comply with it.

Authors' contributions All authors whose names appear on the submission. 1) made substantial contributions to the conception of the work 2) drafted the work or revised it critically for important intellectual content; 3) approved the version to be published; and 4) agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Availability of data and material All data used in the study are available

Code availability NA.

Declarations

Ethics approval NA.

Consent to participate This article does not contain any studies with human or animal subjects performed by the any of the authors.

Consent for publication I, Farah Beniacoub, give my consent for manuscript (Implementation of a decentralised maintenance model with a measurable impact on the functionality and availability of medical equipment in health care facilities in Burundi, Farah Beniacoub) to be published in Biomedical Engineering Education. I understand that the text and any pictures published in the article will be freely available on the Internet and may be seen by the general public. The pictures and text may also appear on other websites or in print, may be translated into other languages or used for commercial purposes. I have been offered the opportunity to read the manuscript.

Conflicts of interest Disclosure of potential conflict interest: Farah Beniacoub declares that she has no conflict of interest.

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