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Challenges in Accessing Surgical Equipment in Pakistan: A Surgical Equipment Journey Perspective

Rabia Alvi[1], Kamran Akbar[2], Aliha Sami[3], Laiba Khan[4], Hira Chishti[5], Muhammad Sulaiman[6]*

[1]University of Lahore, Pakistan
[2]Khyber Medical University, Peshawar, Pakistan
[3]University of Lahore, Pakistan
[4]Superior University, Lahore, Pakistan
[5]Superior University, Lahore, Pakistan
[6]Khyber Medical University, Peshawar, Pakistan

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***Corresponding author:** Muhammad Sulaiman
Khyber Medical University, Peshawar, Pakistan

Abstract

***Background and Objective*:** In Pakistan, the demand for surgery is not being met due to a shortage of both surgical equipment and healthcare workers. This gap in the availability of surgical equipment hinders the provision of safe surgeries. To develop strategies to improve availability, it is essential to understand the use of surgical equipment in this context. This study aims to: (1) map out the different phases that surgical equipment goes through during its lifespan (i.e., the surgical equipment journey) in Pakistan, and (2) identify the barriers perceived by biomedical equipment technicians (BMETs). ***Material and Methods*:** Seven semi-structured, in-depth interviews were conducted with 17 BMETs working in Pakistan. These participants were from 6 different hospitals (4 public, one private, and one mission). The interviews took place between December 2016 and December 2018. Participants were asked to describe or illustrate the surgical equipment journey and to identify perceived barriers during this journey. ***Results*:** The surgical equipment journey comprises three phases: procurement, usage, and disposal. Key stakeholders in this journey include users, BMETs, procurement officers, local distributors, and, in the case of donations, donation agencies. Identified barriers include bureaucratic hurdles during procurement, difficulties in obtaining consumables and spare parts (especially for donated equipment), cleaning with harsh chemicals, and usage in challenging environments. ***Conclusion*:** To optimize the surgical equipment journey in Pakistani hospitals, sustainable interventions at multiple organizational levels are necessary. Participants in this study identified several strategies to increase the availability of surgical equipment in Pakistan: implementing policies on donations, procuring durable equipment, training more BMETs and university-trained biomedical engineers, and developing designs and business models suited to local conditions in Pakistan and potentially other countries in the region.

Keywords: Surgery, Surgical equipment, Pakistan, Biomedical Equipment Technicians (BMETs), Maintenance.

INTRODUCTION

Surgery necessitates human resources, equipment, medicines, and a well-organized infrastructure. Numerous authors have highlighted the gaps in the availability of surgical equipment in low- and middle-income countries (LMICs) such as Pakistan, Malawi, Sierra Leone, Nigeria, Cameroon, Somalia, and Ethiopia [1]. These gaps significantly contribute to the unmet needs for surgical care in these regions.

A comprehensive study conducted by Duke University estimated that up to 40% of the equipment available in hospitals in LMICs is not usable [2]. Additionally, a World Health Organization report titled "Managing the Mismatch" identified that consumables, spare parts, and other support systems are often limited in LMICs, rendering much of the equipment unavailable. Local conditions are frequently overlooked during the donation of equipment [3]. For instance, Howie *et al.*, described a case study in Gambia where the lifespan of donated oxygen concentrators was reduced to just 30 minutes (compared to 5–7 years in high- and middle-income countries) due to mismatched voltage and frequency, leading to overheating [4].

Limited access to maintenance, spare parts, and inappropriate donations have been previously documented as barriers to functional equipment in LMICs. However, to develop effective strategies for increasing the availability of surgical equipment, it is crucial to understand the root causes of these issues. Biomedical equipment technicians (BMETs), who are often responsible for the installation and maintenance of equipment, provide valuable insights into these challenges [5].

To explore the barriers to the availability and functionality of surgical equipment in LMICs, this study uses Pakistan as a case study. The objectives of this study are twofold: first, to map out the surgical equipment journey (the different phases that surgical equipment goes through during its lifespan), and second, to identify the barriers perceived by BMETs during these phases.

METHODS

Semi-structured, in-depth interview sessions were conducted during hospital visits in Pakistan with BMETs. These interviews took place between December 2016 and December 2018. Participants were selected using snowball sampling. They were informed that equipment such as electrosurgical units, monitors, operating theatre lights, sterilizers, and anesthesia machines were considered surgical equipment for this study. All interviews were conducted in English.

Each session consisted of two parts where participants were asked to:

1. Describe the different phases that surgical equipment goes through during its lifespan within their hospital and identify the stakeholders involved in each phase.
2. Explain how the following concepts relate to the surgical equipment journey within their hospital: supply chain, procurement, sterilization/cleaning, donation, policies, disposal, design, maintenance, costs, misuse, hidden costs, lack of infrastructure, spare parts, usage, management of equipment, training, and disposables.

This study was approved by the human research ethics committee of Delft University of Technology, and informed consent was obtained from all participants.

Data Analysis

The interviews were recorded and transcribed. Data were analyzed using MASDAQ 2018. The concepts discussed during the interviews were used to code the transcripts.

RESULTS

A total of 17 BMETs from 6 different hospitals in Pakistan participated in the study (Table 1). Data saturation was achieved after 7 interview sessions. Sessions 4 and 6 were conducted in the same hospital.

Table 1: Participants' Characteristics During Each Interview Session

Session Number	BMETs During Session	Type of Hospital	Gender	Education Level
1	1	Public hospital	Female	Higher level diploma
2	1	Mission hospital	Male	Diploma
3	1	Private hospital	Male	Diploma
4	1	Public hospital	Male	Diploma
5	3	Public hospital	All male	1× Diploma, 1× Higher-level diploma, 1× Certificate
6	7	Public hospital	1× female, 6× male	3× Diploma, 3× Higher level diploma
7	3	Public hospital	All male	All diploma

Equipment Journey

Participants in this study identified three key phases in the surgical equipment journey: procurement, use and maintenance, and disposal. The stakeholders involved in this journey include the user, the BMET, the procurement officer, local distributors of medical device companies, and, in the case of donations, the donation agency.

The user refers to the healthcare worker (such as a nurse or surgeon) who operates the equipment. BMETs are responsible for the maintenance of the equipment, while the procurement officer handles the procurement process. Equipment donations to hospitals can be organized by foreign hospitals, non-governmental organizations (NGOs, such as AMREF), or foreign governments.

Procurement Phase

All participants described a similar procurement process: when a healthcare worker (a user in the equipment journey) requires new equipment, a need assessment is conducted by the user and the procurement officer. Once the need is defined, BMETs are consulted to specify the equipment requirements. A tender request is then published in local newspapers and on the hospital's website for local distributors or medical device companies to respond. Public hospitals are required to procure through tenders. The highest referral level hospitals (Level 6) can manage their own tender process, while other public hospitals do so through the county government. Private and mission hospitals also use tenders but can procure directly from local distributors or medical device companies.

The bureaucracy within the procurement phase, making it a time-consuming process, was mentioned in all 7 interview sessions. The procurement committee evaluates the bidders and often awards the contract to the lowest bidder that meets all specifications.

One participant noted, "To get a new electrosurgical unit took up to 4 months. We have to make a request, set up specifications, this is taken to the supply department who puts it in the local newspaper. The bidders get 2 weeks to respond. After 2 weeks we sit down for an evaluation, after which we write a report to the CEO advising which company to award. Then the award letter is made and then we have to wait for the supplier. Then the problems around importing it into the country start, delays often happen at customs." (Session 7)

Another participant highlighted the challenge of budgeting: "It is often a challenge to know what the market value of equipment is. Sometimes we budgeted for 1000 dollars, but the good equipment is 2000 dollars, that is also why we end up with cheaper inappropriate equipment. The procurement law states that the lowest price that suits the specifications wins. European equipment is often too expensive to win." (Session 6)

Although the procurement system is in place, much surgical equipment is often received through donations. Donations can be organized via the county government or sent directly to the receiving hospital. The private hospital visited during this study did not receive any donations, whereas one of the mission hospitals obtained most of its equipment through donations, often arranged by expat surgeons working there. Public hospitals received equipment through both donations and procurement.

Before new equipment can be used and maintained (the next phase), training is required. The difficulty in receiving appropriate usage and maintenance training from the medical device company was identified as a significant barrier and was mentioned in 4 of the 7 interview sessions. One participant stated, "We have received on-site training given by the medical device company. However, information is often quite limited. Often, we cannot open a machine to do troubleshooting because they come in with a new machine. We would recommend that we can train on models that can be opened up and where we can troubleshoot to learn what to do in case of an error." (Session 7)

Use and Maintenance Phase

Surgical equipment is used by various healthcare workers (e.g., surgeons, nurses, or medical officers) in the operating theatre (OT). Many types of surgical equipment require accessories to perform surgery; these can be either consumables (one-time use) or reusable parts. Accessories need to be cleaned and sterilized after use, which is typically done by the sterilization department. However, participants explained that some parts (e.g., accessories of the electrosurgical unit) are cleaned in the OT complex with heavy chemicals (e.g., cidex). Equipment such as electrosurgical units and anesthesia devices are often stored in the OT or in the corridors between OTs and are cleaned by the cleaning staff, often with heavy chemicals.

Surgical equipment can be out of service due to breakdowns or planned preventative maintenance (PPM). Repairs and PPMs are carried out by the BMET department in all hospitals in this study. Spare parts, tools, and manuals are required to keep equipment functioning. Spare parts can include power boards or displays that need replacement when broken, as well as filters that need periodic replacement.

All hospitals reported their repair orders in hardcopy books, except for 2 hospitals (1 mission and 1 private) that also stored digital copies in a software program. The difficulty in obtaining spare parts in Pakistan was mentioned in all 7 interview sessions. The 5 hospitals that received donations all faced challenges in obtaining both consumables and spare parts required for the equipment.

One participant noted, "The challenge with donated equipment comes when it breaks, the spare parts are often not available. For example, for the electrosurgical unit, a different patient plate is available within the country than the ones that came with the device, so we have to find a way to work around this." (Session 2)

For procured equipment, the supply chain of consumables and spare parts remains a challenge due to the long bureaucratic procurement process, high costs, or delays because parts have to come from outside Pakistan or the region. Only a small portion of the equipment available in hospitals is supported by a maintenance service contract, which means that maintenance, spare parts, and consumables are provided by the medical device company.

One participant mentioned, "If we have imported a machine from overseas, we also have to import the spare parts. Getting the spare parts becomes tricky and takes a lot of time." (Session 3)

Another participant highlighted the issue of obtaining permission for PPM: "Sometimes BMETs only get permission to fix when the equipment is broken. When it is still functioning but needs to be serviced to keep functioning, this is not understood. At the moment it is obsolete, everyone starts looking for a spare part." (Session 1)

Participants in 2 hospitals also mentioned equipment breakdowns due to the challenging environment in which it is used. Modern sensitive equipment is often not designed to withstand power interruptions, unstable electricity networks, dust, and high temperatures. Additionally, the use of heavy chemicals for cleaning was noted to shorten the lifespan of the equipment.

One participant stated, "Power in Pakistan is different, also temperatures, altitudes, pressure, and the users are trained differently than in Europe and Asia where equipment comes from." (Session 4)

Disposal Phase

When equipment becomes obsolete, it needs to be disposed of either by the hospital or through government channels. All participants were involved in the disposal process, but approval often had to be obtained from the disposal committee or the procurement department. This procedure is time-consuming and often results in piles of unused equipment accumulating on hospital grounds. As one participant from session 5 described: "You find we even get used machines and they are most of the time obsolete. Then we only have to worry about the disposal, and that means extra work for us." (Session 5)

DISCUSSION

Surgical equipment is not always readily available in LMICs, leading to delays in surgeries that are urgently needed by the population. Other studies have identified common barriers to medical equipment availability across different LMICs. This study provides insights from frontline BMETs who perform maintenance daily, explaining why these barriers exist by mapping the journey of surgical equipment throughout its lifespan. Participants worked in 6 different hospitals in Pakistan, and to ensure theoretical saturation, 5 additional hospitals (1 private hospital, 3 public hospitals, and 1 mission hospital) were visited.

The identified surgical equipment journey in this study revealed that equipment undergoes three phases during its lifespan: procurement, use and maintenance, and disposal. Within the procurement phase, a difference between public and private hospitals was found, resulting in different procurement routes: public hospitals are required to procure via tenders, whereas mission and private hospitals can also buy directly from medical device companies. Procurement of equipment was identified as a lengthy process by all participants. Besides the tender process being time-consuming, it does not always result in the most appropriate type of equipment when the lowest bidder wins. Diaconu et al. identified that equipment costs often dominate procurement planning in many LMICs, underestimating the true costs of maintenance, servicing, and user training [6].

Public hospitals can only buy equipment from respondents to the tender, and those respondents need to provide equipment that fits the tender specifications. According to participants in public hospitals, this means they often cannot buy from large international brands because they do not respond to tenders or are out of scope due to budget constraints set in the tender specifications. However, training opportunities and companies' track records on spare part delivery and support are becoming increasingly important during the tender awarding process, according to some participants in this study. Diaconu et al. also identified that careful consideration of the context of use results in the most successful uptake of medical technology in LMICs [7, 8].

Procurement of appropriate equipment is the first step in a well-functioning surgical equipment journey. The use phase should be properly organized, starting with providing training for both the user and the BMETs. Participants in this study have experience with on-site training and overseas factory training at medical device companies. Participants indicated that some on-site training is very short and superficial, especially when the training is done with functioning equipment without the possibility to open up or troubleshoot. By the time maintenance is required, the company has to be consulted for advice again because it was not covered during the training. Maintenance is now often recorded offline in repair books, which is difficult to consult during the procurement of new devices. Computer software for inventory, repair, and maintenance records could increase the amount of information about previously procured or donated equipment and their lifespan within the hospital, which can be helpful during the procurement process.

Previous studies mentioned the lack of consumables and spare parts as barriers to the availability of surgical equipment in LMICs [9-11]. Our study confirmed these barriers within the surgical equipment journey. However, this study also researched the underlying processes contributing to these barriers. We identified that the procurement of consumables and spare parts can be a timely and costly process. Firstly, spare parts can become very expensive when they have to be imported from overseas. Secondly, parts for donated equipment are often no longer manufactured, leading to the disposal of equipment. Lastly, participants indicated that they do not always get permission to order a spare part for PPMs because the equipment is still functioning. When the delivery of consumables is delayed, this results in equipment being out of use. This is one reason why consumables are often reused. The costs of consumables are often paid by the patient, so reusing these parts reduces the cost of surgery for patients.

Participants in this study indicated that despite the challenges associated with donated equipment, such as maintenance and the need for consumables, they still

welcome donations. This is because newer technology would otherwise remain inaccessible due to its high costs. Some medical device companies are beginning to lease high-end equipment to hospitals in Pakistan. These hospitals enter into contracts with the medical device companies for the provision of consumables and servicing of the equipment.

Additionally, the Pakistani government has recently equipped numerous public national and county hospitals with brand new equipment for intensive care units, diagnostic imaging, and surgical procedures. This program includes training and servicing for at least 7 years [12].

Pakistan aims to enhance the quality of its healthcare system, aligning with the WHO and the global health community's goal to increase access to safe surgery worldwide [13]. The availability of medical equipment is crucial for achieving these objectives. The leasing of high-end equipment and the government's implementation of new equipment are efforts to increase the availability of surgical equipment in Pakistan. However, sustainable interventions at multiple organizational levels are necessary to optimize the surgical equipment journey in the future.

A list of potential interventions to increase availability, as identified by participants, is provided in Table 2.

Table 2: potential interventions to increase the availability of surgical equipment as stated by the participants in this study

Theme	Potential Intervention
Donations	- Policies on donations
Procurement	- Procurement of durable equipment, including training, access to spare parts, and consumables
Training	- More university-trained biomedical engineers, more on-site training for users and BMETs
	- Training by the medical device company on models that can be opened to troubleshoot
Equipment	- Demonstrations before equipment is procured
	- Robust designs suitable for the context (able to withstand: erratic power supply, dust, high temperatures, cleaning detergents, etc.)
Medical Device Companies and Manufacturing	- Medical device companies within the country or continent
	- Users and BMETs in contact with R&D departments to give feedback
	- Adapted strategies for LMIC-based hospitals (placement of equipment or leasing equipment)

This study only included BMETs working in Pakistan, and the quality of the healthcare system in Pakistan (ranked 73rd on the GDP list by the World Bank) is expected to be higher than in other countries, such as Uganda or Mozambique (ranked 106th and 132nd, respectively). Pakistan has several colleges for BMET training and university programs for biomedical engineers, which equip BMET departments with well-trained professionals. In contrast, other countries may lack BMET departments within their hospitals or BMET training programs. They often hire employees with a technical background but without specific training in medical equipment. The barriers identified in this study could be even more significant in these countries.

Commonalities and best practices of both medical providers and BMETs in other countries may provide additional insights into the root causes of limited availability of surgical equipment in LMICs. Despite these limitations, we believe that this study can serve as a starting point for designing strategies to increase the availability of surgical equipment in the future, whether by academia, medical device companies, or policymakers. It also underscores the importance of including local stakeholders' input in the design and development of plans for the provision of surgical care.

CONCLUSION

This study highlights the significant challenges in accessing surgical equipment in Pakistan, emphasizing the need for sustainable interventions at multiple organizational levels. By mapping out the surgical equipment journey procurement, use and maintenance, and disposal and identifying barriers perceived by BMETs, we have provided valuable insights into the complexities of ensuring the availability and functionality of surgical equipment.

The findings underscore the importance of addressing bureaucratic hurdles in procurement, improving access to consumables and spare parts, and ensuring proper training for both users and BMETs. Additionally, the study suggests that policies on donations, procurement of durable equipment, and robust designs suitable for local conditions are crucial for optimizing the surgical equipment journey.

While the study focused on Pakistan, the identified barriers and potential interventions may be applicable to other LMICs facing similar challenges. By incorporating local stakeholders' input and leveraging best practices, policymakers, academia, and medical device companies can develop effective strategies to

enhance the availability of surgical equipment, ultimately improving surgical care and patient outcomes in LMICs.

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