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Barriers to the integration of medical technologies in the operating theatres of general referral hospitals in Mbandaka (DRC): a cross-sectional analytical study

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Abstract

Introduction: The integration of modern technological devices (advanced monitoring systems, digital imaging, high-frequency equipment) into the operating theatre is emerging as a key factor in ensuring the safety and optimisation of surgical procedures. In the Democratic Republic of the Congo, their use remains rudimentary. This study aimed to analyse the barriers limiting the optimal use of these tools within the general referral hospitals (GRHs) of Mbandaka, Wangata and Bolenge.

Methods: A cross-sectional analytical study was conducted between January and March 2025. Using exhaustive sampling, 120 healthcare professionals (surgeons, anaesthetists, nurses) working in the operating theatre were included. Technical, macro-financial, individual and organisational determinants were collected via a self-administered questionnaire. Univariate and bivariate analyses (Pearson's chi-square test) were performed.

Results: Only 18.3% of professionals routinely utilised the available technological resources. The predominant barriers were the instability of the electricity supply (90.8%), a lack of specialised training (87.5%), the absence of preventive biomedical maintenance (82.5%), the prohibitive cost of equipment (79.2%) and resistance to changes in practice (55.8%). Inferential analysis shows that the regular use of equipment is highly correlated with access to continuing professional development ($p < 0.001$), permanent access to a biomedical technician ($p = 0.002$) and the availability of a functional backup power source ($p = 0.004$).

Conclusion: The deployment of technology in the operating theatres of Mbandaka is hampered by a critical triad: energy shortages, lack of training and inadequate maintenance. The deployment of appropriate local solutions (reliable power systems, targeted training and shared biomedical engineering) is essential to enhance the safety of surgical care.

Keywords: medical innovations, operating theatre, systemic barriers, surgical safety, DRC.

1. Introduction

The contemporary surgical environment is characterised by a high degree of technological sophistication. The introduction of digital tools, high-precision monitoring equipment and advanced electrosurgical devices directly contributes to reducing surgical risk, standardising procedures and lowering perioperative morbidity and mortality rates [1,2]. According to the report by the *Lancet Commission on Global Surgery*, bringing surgical infrastructure up to technological standards is a fundamental prerequisite for ensuring access to safe and equitable surgical care worldwide [3].

In the healthcare systems of high-income countries, this digital and technological transition is subject to rigorous monitoring. In Germany, recent studies show that the digitisation of operating theatres improves team performance and reduces the incidence of adverse events [4]. In France, the literature emphasises that the sustainability of these innovations depends crucially on structured programmes for continuing professional development and support for healthcare professionals [5].

Conversely, in sub-Saharan Africa, and more specifically in the Democratic Republic of the Congo (DRC), the uptake of these medical devices faces chronic structural barriers. Studies conducted in Uganda and Rwanda highlight the fact that a shortage of qualified maintenance staff, the fragility of institutional budgets, the lack of spare parts and the glaring instability of the national energy supply limit the impact of these technological acquisitions, which are often relegated to the status of obsolete or non-functional equipment [6,7].

In the city of Mbandaka (Equateur Province), the three General Referral Hospitals (HGR Mbandaka, HGR Wangata and HGR Bolenge) have received theoretical allocations of medical equipment (refurbished ventilators, multi-parameter monitors, electric scalpels). However, local empirical data indicate a high failure rate and chronic underutilisation of these devices [8]. In the absence of previous quantitative data precisely mapping these factors of failure in the region, our research set out to:

1. Identify the determinants (technical, economic, human and administrative) hindering the use of technologies in the operating theatre in Mbandaka;
2. Identify the factors promoting their regular use by clinicians;
3. Develop a pragmatic action plan tailored to local budgetary constraints.

2. Methods

2.1. Study type and setting

A cross-sectional study with an analytical focus was conducted in the operating theatres of the three main healthcare facilities in the city of Mbandaka (HGR Mbandaka, HGR Wangata, HGR Bolenge) over a three-month period from January to March 2025.

2.2. Sampling and study population

Recruitment was carried out using exhaustive sampling. The study included all permanent healthcare professionals (surgeons, anaesthetists and intensive care specialists, nurse anaesthetists and operating theatre/multi-skilled nurses) who had been working in the target department for at least six months and who had freely consented to participate in the study. Staff on placement, on long-term leave or absent during the survey were excluded. In total, the final sample comprised 120 professionals.

2.3. Operational definitions

For the purposes of this study, certain terms were defined operationally to ensure a consistent understanding of the concepts used and to facilitate data analysis. **Advanced surgical technologies** refer to any electrical or digital biomedical device that has been integrated into local surgical practice for less than a decade. These may include, for example, electrosurgical generators, multi-parameter cardiorespiratory monitors or programmable operating theatre ventilators [9]. These technologies are considered advanced insofar as they improve the precision of surgical procedures, patient monitoring and the safety of operations.

Regular use refers to the actual and documented use of these technologies in at least 75% of eligible procedures. This use is assessed based on the practitioner's self-reported evaluation, taking into account the actual frequency of use of the equipment available in the operating theatre. Thus, a technology is considered to be used regularly when it forms an integral part of standard surgical practice and is not merely deployed on an occasional basis.

Technical barriers refer to difficulties related to the physical operation of the equipment. These include, in particular, recurring breakdowns, the local unavailability of spare parts, repair difficulties, and fluctuations in electrical voltage, which can compromise the continuous and safe use of biomedical devices. These technical constraints can reduce the effectiveness of advanced surgical technologies and limit their sustainable integration into surgical practice.

The financial barrier refers to all institutional budgetary constraints that prevent the acquisition, use or proper maintenance of equipment. It may relate to the purchase cost of devices, the supply of consumables, maintenance costs or the replacement of faulty parts. In a hospital setting with limited resources, this barrier often constitutes a significant obstacle to the modernisation of the surgical suite.

The human barrier refers to factors related to the skills, attitudes and perceptions of healthcare professionals. It includes a lack of the technical skills required to use the equipment, psychological resistance to innovation, or the fear of damaging biomedical tools. These factors can negatively influence the adoption of advanced technologies, even when they are available within the healthcare facility.

Finally, **the organisational barrier** concerns shortcomings related to the internal management of equipment and the organisation of work. It includes the lack of standardised procedure sheets, the absence of a preventive maintenance schedule, and the lack of clear governance over the equipment [10]. These organisational weaknesses can lead to the misuse of equipment, irregular maintenance and a reduction in its lifespan. Thus, clarifying these definitions allows for a better analysis of the conditions under which advanced surgical technologies are used and the factors that limit their integration into surgical practice.

2.4. Data collection

All variables were collected using an anonymous, self-administered questionnaire comprising 25 items, which had been validated beforehand by an internal consistency test. The questionnaires were distributed in French directly at the workplaces. After coding, the data were entered into Microsoft Excel and then transferred to the statistical software R (version 4.3).

2.5. Statistical analyses

The univariate analysis involved calculating frequency distributions and proportions to describe the characteristics of the population and the prevalence of barriers. Bivariate analysis used Pearson's chi-square test (χ^2) to identify factors statistically associated with regular use of the equipment, with a significance threshold set at $p < 0.05$ [11].

2.6. Ethical considerations

The study received formal approval from the institutional ethics committee of ISTM-Mbandaka (Authorisation No. 112/2025). Data collection was conditional upon the systematic obtaining of a written informed consent form,

guaranteeing the confidentiality of responses through strict coding.

3. Results

3.1. Professional profile of participants

The study included 120 healthcare professionals. The median age of the population was 38 years (interquartile range, IQR: 31–46), with a clear predominance of men (70.8%). The breakdown by professional profile showed that 55.0% were general nurses, 25.0% were anaesthesia nurses, 12.0% were surgeons and 8.0% were anaesthetists. The average cumulative experience in the operating theatre was 9.4 years (± 6.2). Furthermore, only 25.8% of respondents reported having attended at least one continuing professional development session focused on the management of medical technologies.

3.2. Overview of technology use

The rate of routine use of operating theatre technologies was found to be particularly low, at 18.3% ($n=22$). Regarding the functionality of operating theatre-specific equipment at the time of the survey, the rate of unavailability due to technical failure was 52.0% for electronic ventilators, 45.0% for electrosurgical units (electric scalpels) and 38.0% for multi-parameter monitors.

3.3. Descriptive analysis of barriers to adoption

The various factors limiting the use of technologies, ranked in descending order of frequency, are detailed in the table below:

Table 1 – Breakdown of barriers to the use of medical technologies in operating theatres (N=120)

Type of barrier	Description of the operational constraint	Frequency (n)	Proportion (%)
Technical	Chronic instability of the power supply (load shedding, micro-cuts)	109	90.8%
Human	Lack of initial and ongoing training on equipment	105	87.5%
Organisational	Lack or absence of an in-house biomedical maintenance service	99	82.5%
Financial	Excessive purchase costs for equipment and associated consumables	95	79.2%
Technical	Prolonged downtime of equipment due to minor faults caused by a shortage of parts	88	73.3%
Human	Resistance to change and a preference for conventional methods	67	55.8%
Organisational	Lack of user guides and protocol sheets at the patient's bedside	61	50.8%
Human	Lack of available time due to staff being overworked	54	45.0%

3.4. Inferential analysis of associated factors

Statistical cross-tabulation of the variables reveals highly significant correlations between the hospital's structural organisation and the optimisation of technological practices.

Table 2 – Bivariate analysis of factors influencing the regular use of innovations in the operating theatre

Environmental and individual factors	Regular use (n=22)	Irregular use (n=98)	χ^2 value	p-value
Specific continuing professional development	18 (81.8%)	13 (13.3%)	41.52	<0.001
• Yes	4 (18.2%)	85 (86.7%)		
• No				
Biomedical technician available	16 (72.7%)	28 (28.6%)	9.86	0.002
• Yes	6 (27.3%)	70 (71.4%)		
• No				
Functional alternative backup power	19 (86.4%)	45 (45.9%)	8.47	0.004*
• Yes	3 (13.6%)	53 (54.1%)		
• No				
Years of experience in interventional practice	10 (45.5%)	48 (49.0%)	0.01	0.920
• ≥ 10 years	12 (54.5%)	50 (51.0%)		
• < 10 years				

Statistically significant association at the 5% alpha level

Analysis note: The results demonstrate that the technical upskilling of healthcare staff ($p < 0.001$), technical support from a biomedical engineer or technician ($p = 0.002$) and the availability of a stable power supply ($p = 0.004$) are major factors influencing usage. In contrast, staff seniority has no significant influence ($p = 0.920$), confirming that years of experience do not compensate for logistical and cognitive barriers.

4. Discussion

The results of this descriptive study highlight the existence of major systemic barriers, with only 18.3% regular use of biomedical innovations in Mbandaka. This situation, which is detrimental to the safety of surgical procedures, is consistent with observations reported in Nigeria (15%) and Rwanda (22%), confirming the cross-cutting nature of medical-technical challenges in Central and West Africa [12,7].

4.1. The systemic impact of the energy crisis and maintenance

The instability of the electricity grid (90.8%) is the major obstacle identified in our study. In Mbandaka, sudden voltage fluctuations and unannounced power cuts cause irreversible damage to the electronic circuits of sensitive devices, such as multi-parameter monitors [13]. This situation is exacerbated by the complete absence of dedicated maintenance technicians within the three hospitals (82.5%).

Biomedical equipment is thus managed on the basis of short-term reactive repairs, with no preventive measures in place. To break this vicious circle, initiatives for the inter-hospital pooling of biomedical engineering resources, coupled with partnerships with local technical education institutes, have proven effective in similar resource-constrained settings [14].

4.2. The training deficit as a barrier to adoption

Nearly nine out of ten professionals (87.5%) cite a lack of training in the use of available equipment. This reality creates a sense of technical insecurity among healthcare teams, who prefer to avoid using monitors or ventilators for fear of making programming errors or damaging the devices. The findings of Mbonye et al. in Uganda confirm this observation, showing that the absence of short training courses (48-hour coaching) hinders the adoption of technological innovations, even when these are provided free of charge by international aid programmes [6].

4.3. The human factor and change management

The resistance to change expressed by 55.8% of respondents can largely be explained by this lack of educational support. Indeed, when faced with new and complex digital interfaces, experienced practitioners naturally fall back on the old manual approaches they have mastered perfectly. However, inferential analysis clearly demonstrates that this reluctance disappears once structured training is implemented. This corroborates Rogers' models of innovation diffusion, according to which technical adoption depends far more on

the clarity of practical demonstrations than on criteria such as age or length of service [15].

4.4. Economic perspectives and technological choices

The high cost of technology (79.2%) remains an unavoidable reality for Congolese public institutions. Faced with insufficient state subsidies, hospitals must direct their choices towards so-called frugal or 'low-tech, high-impact' technologies. The World Health Organisation recommends the acquisition of equipment specifically designed for low-resource countries, such as solar-powered rechargeable pulse oximeters or cautery units equipped with long-life internal batteries [16].

4.5. Methodological limitations of the study

The standardised cross-sectional approach used does not allow for tracking changes in practices over time or for formally establishing cause-and-effect relationships. Furthermore, the data are partly based on subjective statements, which are subject to recall bias or social desirability bias. Nevertheless, the comprehensive inclusion of active staff within the three-block ' ' in the city of Mbandaka gives these results significant guidance value for local health governance.

5. Conclusion and recommendations

Analysis of operating theatre activity in Mbandaka's hospitals shows that access to modern technologies remains severely limited by energy, logistical and educational constraints. Fewer than one in five healthcare workers is able to regularly utilise the available biomedical innovations, which limits the expected impact of these tools on the quality and safety of surgical procedures.

In order to remedy this situation effectively, the following recommendations are made:

1. **To Hospital Management Teams (HGR Mbandaka, Wangata, Bolenge):** Urgently ensure a stable power supply to operating theatres by purchasing industrial voltage stabilisers and installing an alternative power source (UPS units or emergency generators) dedicated exclusively to the surgical area.
2. **To Continuing Professional Development Managers:** Introduce quarterly, four-hour practical training sessions focused on the handling, basic adjustment and first-level maintenance of specific equipment.

3. **To the Central Health Zone Office (BCZS):** Recruit a mobile biomedical technician whose working hours and costs will be shared between the three hospitals, in order to ensure the long-term preventive maintenance of the equipment fleet.
4. **To the Heads of the Surgery and Anaesthesia Departments:** Produce simplified procedure sheets in the form of laminated posters (including start-up steps, common settings and the procedure to follow in the event of an alarm) and display them in the immediate vicinity of each piece of equipment.

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