

Medical Equipment Utilization Efficiency and Associated Factors at Public Referral Hospitals in East Wollega Zone, Oromia Regional State, Ethiopia

Edosa Tesfaye Geta (✉ edotesfa@yahoo.com)

Wollega University

Duferu Rikitu

Wollega University

Adisu Ewunetu

Wollega University

Research Article

Keywords: Medical equipment, efficient utilization, public hospitals, Ethiopia

Posted Date: March 8th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1395733/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background

The medical equipment is any instrument, appliance, material, or other articles, whether used alone or in combination including the software necessary for the purpose of diagnosis, prevention, monitoring, treatment, or alleviation of the disease. The importance of efficient utilization of medical equipment has been brought to full public attention. The association between hospital characteristics and utilization of medical equipment has received more attention for its complicated consequences on health care costs and quality. So, the study aimed to assess factors affecting efficient utilization of medical equipment at public referral hospitals in East Wollega zone, Oromia regional state.

Methods

The study was conducted at public referral hospitals in East Wollega, Oromia Regional National State, Ethiopia from July 30-August 30, 2021. Cross-sectional study design was conducted mixed with observation and document review. About 192 equipment were included in the study. The descriptive statistics and Pearson Chi-square (χ^2) were performed to identify association between each independent and dependent variables at $p < 0.05$ to declare level of significance.

Results

Using 95% confidence interval, the level of utilization coefficient was estimated to be 0.49(0.44–0.55). Accordingly, 111(57.8%) equipment were efficiently utilized whereas 81(41.2%) of the equipment were underutilized. The form in which the hospitals received ($\chi^2 = 7.7.2$; $P = 0.005$), regularly availability ($\chi^2 = 19.30$; $P = 0.000$), the equipment breakdown ($\chi^2 = 11.57$; $P = 0.001$), availability of adequate trained staffs operating the equipment ($\chi^2 = 26.14$; $P = 0.000$), performing preventive maintenance ($\chi^2 = 91.54$; $P = 0.000$), availability of adequate spare parts ($\chi^2 = 32.36$; $P = 0.000$), and availability accessories(consumables) ($\chi^2 = 43.91$; $P = 0.000$) were the statistically significant associated factors affecting efficient utilization of the equipment.

Conclusion

On average, the utilization coefficient of medical equipment in the study hospitals was low compared to other study findings which indicated that about 42.2% of the equipment were inefficiently utilized. The significant associated factors that could affect the efficient utilization of the equipment were the form in which the hospital received, regularly availability of the equipment, the equipment breakdown, availability of trained staffs operating the equipment, performing preventive maintenance, availability of adequate

spare parts, and accessories. Every hospital should develop appropriate strategic framework to manage and utilize the available medical diagnostic equipment based on their level and demand.

Introduction

Medical equipment is an instrument, appliance, material, or other articles that can be used alone or in combination including the software necessary for the purpose of diagnosis, prevention, monitoring, treatment or alleviation of the disease [1]. In health service delivery, the medical equipment is used for different purposes like diagnosis and treatment of disease or rehabilitation following the diseases or injuries. This equipment can be used either alone or in combination with different accessories, consumables, or another piece of medical equipment [2].

The availability and efficient utilization of medical equipment in health care facilities can affect the provision of a quality diagnosis services and clinical managements of patients [3]. In current health care system, the importance of efficient utilization of medical equipment has been brought to full public attention [4]. In addition, for its complicated consequences on the care costs, the association between hospital characteristics and utilization of high-technology medical equipment has received more attention [5].

When the health care facilities use the available medical equipment to its full potential that is very important so that the realistic performance of may be set is considered as the equipment is optimal utilized. An optimal utilization of the equipment could result in optimal patient handling and rapid turnover, minimum possible cost, quality of care, and patient satisfaction [6] and in an era of cost-intensive medical care, every equipment installed in health care facilities need to be fully and properly utilized [7].

From a simple scissor to a more complex and advanced medical devices are needed by health facilities ranging from a rural clinic to large specialized hospital. Yet, most of these health care facilities lack knowledge about these medical instruments that appropriate for their need. Particularly, in developing countries where health technology assessments are rare, this is common problem [8].

Utilization of the medical equipment effectively requires as a priority, increasing the number of investigations, and cost-effective and quality treatment. The evaluation of the global health experience has revealed that the advanced medical devices are in indispensable part of the medical care in the process of prevention, proper diagnosis and treatment diseases [9].

As an aspect of health technologies, medical equipment equips health care providers with tools to perform their functions effectively and efficiently. Despite the medical equipment provide an opportunity for a better health service, the lack of a national system for selection, procurement, use and management may lead to disproportionate escalation in health care delivery costs [10].

In the condition of resource constraint throughout the world in both developed and developing countries, the health systems are struggling with the challenge of how to manage health care delivery [11]. More than 50,000 different kinds of medical devices are estimated to be used in health care facilities all over the world every day. Most of the devices are quite simple, while some are complex and combine different technologies [12]. World Health Organization estimates that about 50% of medical equipment in developing countries is not functioning, not used correctly and optimally, and invariably is not maintained [13].

Medical equipment efficiency is one of the factors that are frequently overlooked by the management in health care delivery system which can lead losses by reducing yield. Inadequate preventive maintenance of equipment will result in low standards of diagnosis and treatment and increases the cost of maintenance of equipment [7].

In resource poor settings, the lack of working equipment has a devastating effect on health care delivery. In the developing world, it is often said that most the medical equipment ranging up to 95% are out of service and more than half (50%) the laboratory and medical equipment are not in service [14].

In majority of health care facilities in Africa, high quality of life saving medical devices is inaccessible and 40% of the equipment physically in possession of low resource hospitals all over the world is not usable [15].

It is estimated that more than 40% of the medical equipment available in health care facilities are not work properly at any time in Ethiopia. Lack of proper management of medical equipment has limited the capacity of health institutions to deliver adequate health care. It is estimated that only about 60% of medical equipment found in public hospitals and other health facilities are functional at any one time [16, 17].

Utilization index is one of the important parameters to monitor the functional status of the medical equipment or it is the parameter to assess the productivity of service of equipment [18].

In Ethiopia, improper utilization of healthcare technology has restricted the capacity of healthcare provider to deliver adequate healthcare services. Health technologies are essential for a functioning health system [16]. This needs the appropriate study to assess the efficient utilization of the medical equipment and associated factors in the country.

Hence, the study aimed to assess availability, utilization coefficient and factors affecting efficient utilization in public referral hospitals in East Wollega zone, Oromia Regional State, Ethiopia.

Conceptual framework

According different literature reviewed, the major factors associated with efficient utilization of medical diagnostic equipment are institutional related factors, equipment related factors, and professional

operated related factors (Fig1).

Methods And Materials

Study Area and Design

The study was conducted at public referral hospitals in in East Wollega Zone, Oromia Regional National State, It was conducted from July 01 to August 30, 2021. Cross-sectional study with mixed observational and document review was conducted.

Source and Study population

All public referral hospitals in East Wollega Zone, namely, Nekemte specialized hospital and Wollega University Referral hospital were included in the study. The selected medical equipment in study hospitals were considered as the study subjects.

Inclusion and Exclusion Criteria

All medical major equipment available in study hospitals during data collection period was included in the study and any medical equipment on shipment to the study hospitals during data collection period were excluded from the study.

Sample size and Sampling Technique

The list of all medical equipment with their serial number/unique number at the study hospitals was prepared. The total number of these medical equipment available in all hospitals was determined. From this available equipment 192 of them fulfilled the inclusion criteria and included in the study. Accordingly, from Nekemte Specialized hospital (94 equipment), from Wollega University referral hospitals (98) equipment were included in the study. Health care professional involved in the operation, handling, maintaining this medical equipment were purposely selected to interview about the selected equipment during the observation and document review.

Data Collection Tool and Technique

Structured check list was used to conduct observations of the selected equipment and interview health care professional involved in the operation, handling and maintaining the equipment. The checklist included medical equipment list which were available in the hospital.

For the purpose of this particular study four data collectors and two supervisors were assigned. Both supervisors and data collectors those had BSc degree and experience in working hospitals were assigned. These data collectors and supervisors were trained and well oriented before the pre-test and actual data collection started.

Various records of the department including purchase files, inventory registers, log books, and service records of individual medical equipment were reviewed using checklist and health care professional involved in the operation; handling and maintaining these medical equipment were interviewed for each selected equipment to collect data retrospectively for 12 months from July 01, 2020 to June 30, 2021.

Study Variables

Utilization of medical equipment was considered as dependent variables, and institutional related factors (power interruption, inappropriate place, no service maintenance performed, no repair, limited working hours, poor procurement and management, lack of inventory, no calibration, no bioengineers), equipment related factors (not installed, lack of safety (potential hazard), no spare part, no accessories (consumables), equipment lifetimes, needs special condition, no operating procedures/user manual, lack of software) and professional operated related factors (lack of training, no demand to use, lack of information about the equipment, no preventive maintenance) were considered as independent variables (Fig 1).

Operational Definitions

- **Availability of the medical equipment:** The medical equipment were counted and checked by observation of different units using the checklist. The functional status of the equipment was determined as functional if it was on use during data collection, not functional if it stopped functioning and not in use if it was not ever used since the equipment were procured or donated.
- **Use coefficient (UC):** UC was applied to assess the utilization of equipment, i.e., whether the equipment was optimally utilized or underutilized. UC was measured by the following formula;
- $UC = (A \times B/C \times D) \times 100$, where, A is the number of days, the medical diagnostic equipment was actually used during for 12 months from July 01, 2020 to June 30, 2021. B is the number of hours the equipment was actually used for a working day in for 12 months from July 01, 2020 to June 30, 2021 (average time taken by a procedure by that equipment \times average number of procedures performed on a working day). "C" is the number of days the medical diagnostic equipment could have been available (if the equipment was put in working order). For this, the total number of working days in 12 months from July 01, 2020 to June 30, 2021 was found out as mentioned above. "D" is the number of hours the medical equipment could have been available on a working day (if the equipment was put in working order [19]. To assess the UC of the equipment, working hours of the

study hospitals was recorded. If the UC is <50%, it was considered to be underutilized and hence a bad investment which inefficient utilization [3].

- **Efficient Utilization:** if the % of average number of hours the medical equipment was used per day divided by maximum number of hours the equipment could be used per day in study hospitals was >50% for past 12 months from July 01, 2020 to June 30, 2021.
- **Equipment Related Factors:** Any factors that are expected be inherited from the selected medical equipment in study hospitals and could affect the efficient utilization of the equipment for past 12 months from July 01, 2020 to June 30, 2021
- **Institutional Related Factors:** any factors related to the study referral hospitals that could affect the efficient utilization of the selected equipment in study hospitals for past 12 months from July 01, 2020 to June 30, 2021
- **Professional Operated Related Factors:** any factors related to the professional personnel who were responsible to operate the medical equipment that could affect the efficient utilization of the selected equipment in study hospitals for past 12 months from July 01, 2020 to June 30, 2021.

Data Quality Assurance

The check-lists were pre-tested using some medical equipment and operating professional personnel, and then correction was done accordingly. Data collectors were instructed to check the completeness of each checklist at the end of each interview and observation. The completeness of the checklists at the end of the day was rechecked by supervisors. This was also double checked by the principal investigators.

Data Management and Analysis

The completed check lists were checked for completeness and consistency by supervisors. After completeness of each check list checked, data entry and analysis were made using SPSS windows version 25 software.

The descriptive statics was performed for all study variables. The UC of diagnostic equipment was calculated for all selected equipment to determine whether the equipment is utilized efficiently or not. The Pearson Chi-square (χ^2) was performed to identify association between each independent and dependent variables at $p < 0.05$, the level of significance was declared.

Results

Medical Equipment Utilization Efficiency

From the study hospitals, 192 equipment were selected and assessed for their level of utilization and associated factors. Using 95% CI interval, the level of utilization coefficient (UC) was estimated to be

0.49(0.44-0.55). Based on the UC score the equipment with less than ≤ 0.5 was considered as the equipment was under-utilized (inefficient utilization) whereas the equipment with UC score equals or greater than 0.5 (≥ 0.5) was considered as optimum utilization (efficient utilization). Accordingly, 111(57.8%) equipment were efficiently utilized whereas 81(41.2%) of the equipment were underutilized (**Figure 2**).

About 110(57.3%) equipment were purchased and 42(42.7%) were obtained by donation from different organizations and agencies. During the study period almost all equipment were installed, only 11(5.7%) were uninstalled and 144(75%) the equipment were functional and 48(25%) were not functional.

About 163(84.9%) equipment were used regularly which means on daily basis whereas 29(15.1%) were not used on daily basis that were available based on the request or permission. In past twelve months, 75 (39.1%) of the equipment were exposed to breakdown.

For only 44(22.9%) equipment, power was adequate without interruption for past 12 months on the equipment. These equipment were installed with uninterrupted power supply (UPS) devices. For more than 3/4 of the equipment 148(77.1%) there was power interruption frequently when the equipment was working.

Almost all equipment, 181(94.3%) were placed on appropriate place in the hospital according to the manufacture instructions, only 11(5.7%) were misplaced. For more than half of the equipment, 107(55.7%) service maintenances were performed according the schedule.

Out of 75 damaged equipment, more than half them, 47(62.7%) were not repaired timely to make the functional and more than half the equipment, 133(69.3%) were not calibrated according the manufacturer instructions and schedule.

Regarding the training on the operating the equipment, on 80(41.7%) equipment staffs who were operating the equipment had no adequate training. For 15(7.8%) equipment available in the hospital, the hospital had no demand to utilize.

For more than of the equipment 124(64.6%), the preventive maintenance was performed according the schedule. Only 15(7.8%) of the equipment lacked safety that were potential hazard to the operators.

For more than half of the equipment, 127(66.1%) adequate spare parts for the equipment were available and 124(64.6%) adequate accessories (consumables) for the equipment were not available in the market when need. Only 31(16.1%) equipment needed special condition to be operated. For about 78(40.6%) equipment, there were no operating procedures and user manuals.

Factors Affecting Medical Equipment Utilization Efficiency

The study has identified significant factors that could affect the efficient utilization of medical equipment in the study hospitals. Accordingly, the form in which the hospital received the equipment (purchased or donated) ($\chi^2=7.7.2$; $P=0.005$), regularly availability of the equipment ($\chi^2=19.30$; $P=0.000$), the equipment breakdown in last 12 months ($\chi^2=11.57$; $P=0.001$), availability of adequate staffs operating the equipment had adequate training ($\chi^2=26.14$; $P=0.000$), performing preventive maintenance according to the manufacturer instruction and the schedule ($\chi^2=91.54$; $P=0.000$), availability of adequate spare parts when needed ($\chi^2=32.36$; $P=0.000$), and availability accessories(consumables) when needed ($\chi^2=43.91$; $P=0.000$) were the statistically significant associated factors of efficient utilization of the equipment (**Table 1**).

Table 1: Factors influencing efficient utilization of medical equipment at public referral hospitals, in East Wollega, Oromia regional state, Ethiopia, 2021.

Variables N=192	Possible answers	Total N (%)	Utilization Status		χ^2	P
			Inefficient N (%)	Efficient N (%)		
Form of equipment received	Purchased	110(57.3)	37(19.3%)	73 (38	7.72	0.005
	Donated	82(42.7)	44(22.9)	38(19.8%)		
The equipment regularly used	Yes	163(84.9)	58(30.2%)	105(54.7)	19.30	.000
	No	29(15.1))	23(12)	6(3.1)		
Breakdown in last 12 months	Yes	75(39.1)	43(22.4)	32(16.7)	11.57	0.001
	No	117(60.9)	38(19.8)	79(41.1)		
Power interruption in last 12 months	Yes	44(22.9)	20(10.4)	24(12.5)	0.25	.617
	No	148(77.1)	61(31.8)	87(45.3)		
Service maintenance performed	Yes	85(44.3)	30(15.6)	55(28.6)	2.97	0.85
	No	107(55.7)	51(26.6)	56(29.2)		
Calibration performed In last 12 months	Yes	59(30.7)	27(14.1)	32(16.7)	0.45	0.5
	No	133(69.3)	54(28.1)	79(41.)		
Adequate trained Operators available	Yes	112(58.3)	30(15.6)	82(42.7)	26.14	0.00
	No	80(41.7)	51(26.6)	29(15.1)		
Preventive maintenance performed	Yes	124(64.6)	21(10.9)	103(53.6)	91.54	0.00
	No	68(35.4)	60(31.3)	80(4.2)		
Availability of spare parts when needed	Yes	65(33.9)	9(4.7)	56(29.2)	32.36	0.00
	No	127(66.1)	72(37.5)	55(28.6)		
Availability of accessories	Yes	68(35.4)	7(3.6)	61(31.8)	43.91	0.00
	No	124(64.6))	74(38.5)	50(26.0)		
Does equipment need special condition	yes	31(16.1)	10(5.2)	21(10.9)	1.49	0.222
	No	161(83.9)	81(37)	111(46.9)		
Availability of operating manuals	yes	114(59.4)	48(25.0)	66(34.4)	0.001	0.98
	No	78(40.6))	33(17.2)	45(23.4)		

Note: χ^2 =Pearson Chi-square P=Significance level

Discussion

Utilization index is one of the important parameters to monitor the functional status of the equipment or it is the parameter to assess the productivity of service of equipment. An optimum utilization of the equipment will result in optimal patient handling and rapid turnover, minimum possible cost, quality patient care, and patient satisfaction [18]. Accordingly, the study determined utilization coefficient and factors affecting efficient utilization in public referral hospitals.

The study determined the level of medical equipment utilization based on utilization coefficient which was 58.8% that indicated about 42.2% the equipment were inefficiently utilized the hospitals. Using 95% CI interval the level of UC was estimated to be 0.49(0.44-0.56). In addition, the study showed that at least 2 out of 5 medical equipment were underutilize.

This finding is almost similar with WHO estimates that around 50% of medical equipment in developing countries is not functioning and not used correctly and optimally [13] and high-quality life-saving medical devices are inaccessible to the vast majority of health facilities in Africa. 40% of equipment physically in possession of low-resource hospitals all over the world is not usable [15] and 41% of equipment of first level hospitals studied in Nigeria did not have a functioning radiograph[20].

This very high inefficient utilization of medical equipment when compared the study findings in China which indicated 77% of medical equipment under study showed an adequate UC that showed only 33% of the medical diagnostic equipment were underutilized [3]. This difference could be due to the level of study hospitals and the training of the operating staff in the study hospitals.

In contrast, the finding showed the level of under-utilization of the medical equipment in the study hospitals was lower than the study finding conducted in India which showed that around 50% of this medical equipment were underutilized [7]. This difference could be due to the study institution differences, which our study hospitals were the hospitals which were providing all health care using all type of medical equipment whereas the study conducted in India focused on dental institution.

The study showed that about 48 out of 192(25%) were not functional during the study period. Similarly, the study conducted in different hospitals in Ethiopia showed that 32% available devices at Jimma University Specialized hospital and 35.2% at Shenen Gibe general hospital were not functional [21].

Again study showed the for about 68(35.4%) medical equipment the preventive maintenance was not performed according the schedule and performing preventive maintenance according the schedule was stastical significantly associated with the utilization of medical equipment ($\chi^2=91.54$; $P=0.000$). similarly, the study conducted in India showed that only 33% of medical equipment had regular preventive maintenance [7].

The study also identified the factors causing under-utilization of medical diagnostic equipment in the study hospitals. Accordingly, the form in which the hospital received (purchased or donated) ($\chi^2=7.7.2$; $P=0.005$), regularly availability of the equipment ($\chi^2=19.30$; $P=0.000$), the equipment breakdown in last

12 months ($\chi^2=11.57$; $P=0.001$), availability of adequate staffs operating the equipment had adequate training (the equipment breakdown in last 12 months ($\chi^2=26.14$; $P=0.000$), performing preventive maintenance according the schedule ($\chi^2=91.54$; $P=0.000$), availability of adequate spare parts when needed ($\chi^2=32.36$; $P=0.000$), and availability accessories(consumables) when needed ($\chi^2=43.91$; $P=0.000$) were the statistically significant associated factors of associated with utilization of the equipment.

Similarly the study conducted in Ethiopia identified being dependent on donation; lack/absence of spare-parts for donated medical devices, lack of training while medical devices installed, taking responsibility to operate machines without appropriate training; being not available in the market; power interruption and lack of maintenance staff as factors affecting functionality of the available medical devices [21, 22].

Similarly, the study conducted in China also identified similar factors causing underutilization of medical equipment that were break-down, affordability, availability of trained manpower, non-availability of consumables and spares, maintenance delays, limited working hours, and restricted availability were taken into account [3].

The study also identified that availability of adequate spare parts when needed ($\chi^2=32.36$; $P=0.000$) and availability accessories (consumables) when needed ($\chi^2=43.91$; $P=0.000$) were the statistically significant associated factors of associated with utilization of the equipment. Similarly, the study conducted in Benin showed that lack of spare parts of medical devices is the main factors that can affect medical device access and utilization in health facilities [23, 16].

The study revealed that availability of adequate staffs operating the equipment had adequate training was one significant associated factors affecting efficient utilization of medical equipment ($\chi^2=26.14$; $P=0.000$). Similarly, the World Health Organization concluded that critical care equipment can be utilized more fully, cost-effectively and safely if a formal and regular training programme is implemented [22, 16].

The study is expected to provide insight and useful information for the efficient utilization of medical equipment in referral hospitals. However, it might prone to lack of adequate information on some medical equipment that were available in the study hospitals.

Conclusion

On average, the utilization coefficient of medical equipment in the study hospitals was low compared to other study findings which indicated that about 42.2% the equipment were inefficiently utilized by the hospitals. In addition the study concluded that 2 out of 5 medical equipment were under-utilized.

The significant associated factors that could affect the efficient utilization of the equipment were the form in which the hospital received (purchased or donated), regularly availability of the equipment, the equipment breakdown, availability of adequate staffs operating the equipment had adequate training,

performing preventive maintenance according the schedule, availability of adequate spare parts, and availability accessories (consumables) when needed.

So, every hospital should develop appropriate strategic framework to manage and utilize the available medical equipment based on their level and demand. This strategic framework should include the procurement process considering the availability of spare parts and accessories in the market, the form in which the equipment can be obtained (purchasing or donation) based on the hospitals' demand, regularly availability of the equipment to utilize on daily basis, repairing the equipment, training adequate staffs operating the equipment and performing maintenances.

Declarations

Ethics approval and consent to participate

Since the study population was medical equipment or materials, the ethical concern did not matter the study. However, official letter for clearance was obtained from the Institutional Review Board of Wollega University, Institute of Health.

Consent for publication

Not applicable

Availability of data and materials

The data sets generated and/or analyzed during the present study are available from the corresponding author on reasonable request.

Competing interests

We would like to declare that we have no conflicts of interest related to this work.

Funding

Wollega University covered the data collection fees.

Authors' contributions

All authors participated in developing the study concept and design of the study. Geta ET contributed to data analysis, interpretation, report writing, manuscript preparation and acted as the corresponding author, Rikitu D, Ewunetu A. contributed to developing the data collection tools, data collection, and data entry to statistical software.

Acknowledgements

We would like to acknowledge Wollega University for funding for data collection, Nekemte Specialized Hospital and Wollega University referral hospital staffs for their due cooperation.

Authors Contributions

All authors made substantial contributions to conception and design, acquisition of data, analysis and interpretation of data as well as took part in drafting the manuscript.

References

1. Medicines and Health Care Products Regulatory Agency. Medical Devices and Medicinal Products. London: Medicines and Health Care Products Regulatory Agency; 2011. p. 15.
2. World Health Organization. Medical device technical series: introduction to medical equipment inventory management. Geneva, Switzerland: WHO Press; 2011.
3. Chaudhary P, Kaul P. Factors affecting utilization of medical diagnostic equipment: A study at a tertiary healthcare setup of Chandigarh. *CHRISMED J Health Res* 2015; 2:316-23.
4. Mengqi H. A Study on Medical Imaging Equipment Productivity and Utilization. 2015.
5. Yan W, Hao Y, Jingsong G, et al. Hospital efficiency and utilization of high-technology medical equipment: A panel data analysis. *Health Policy and Technology*; 2018:7,65-72.
6. Gupta S, Kant S. Hospital Stores Management an Integrated Approach. 1st ed. New Delhi: Jaypee Brothers; 2000. p.134-5.
7. Gupta V, Gupta N, Sarode GS, Sarode SC, Patil S. Assessment of Equipment Utilization and Maintenance Schedule at a Dental Institution in Bengaluru, India. *World J Dent* 2017;8(2):104-108.
8. Ethiopian Food, Medicine and Health Care Administration and Control Authority (EFMHACA). Ethiopian List of Medical Instrument with Minimum Specification. Addis Ababa; 2013. Available at: http://www.fmhaca.gov.et/wp-content/uploads/2019/03/ethopian_list_of_medical_instrument_with_minimum_specification.pdf
9. V. Sontea, S. Morgoci, Gh. Turcanu, C. Pislaru. Medical Devices Management Strategy in the Republic of Moldova. 3rd International Conference on Nanotechnologies and Biomedical Engineering, 2016, Volume 55. Available at: https://link.springer.com/chapter/10.1007/978-981-287-736-9_113
10. Technical discussions Medical devices in contemporary health care systems and services, WHO Regional Committee for the Eastern Mediterranean EM/RC53/Tech.Disc.2.
11. WHO. Medical device technical series, Health technology assessment of medical devices. 2011.
12. Epsicom Business Intelligence. Medistat: medical devices market analysis and country profiles. UK, Print Binders, 2003.
13. Health Technologies: The backbone of health services. Geneva, World Health Organization, 2003.
14. Bryce C, Cline K. The supply and use of selected medical technologies. *Health Aff.* 1998; 17:213–24.

15. Perry, L., Malkin, R. Effectiveness of medical equipment donations to improve health systems: how much medical equipment is broken in the developing world?. *Med Biol Eng Comput* 49, 719–722 (2011). <https://doi.org/10.1007/s11517-011-0786-3>
16. Ethiopian FMOH, “Ethiopian Hospital Reform Implementation Guidelines, Vol.2”, Ethiopian Hospital Management Initiative, 2010.
17. Ethiopian Standard Agency. Ethiopian standard; Comprehensive Specialized Hospital; Requirements.2012.
18. Hospital Equipment Utilization: Increasing Operational Efficiency; 2008. Available from: <http://www.medicalbuyer>
19. Kumar PN. Utilization study of CT scan in a multi-specialty hospital. *Int J Sci Res* 2014 Jul; 3(7):1-2.
20. Oluwasoga O. reating Affordable Access to Medical Equipment in Africa Using System Design; 2017. Available at: <https://sdm.mit.edu/wp-content/uploads/2017/02/MDAAS-Presentation-3-13-17.pdf>
21. Ademe BW, Tebeje B, Molla A. Availability and utilization of medical devices in Jimma zone hospitals, Southwest Ethiopia: a case study *BMC Health Services Research* (2016) 16:287. DOI 10.1186/s12913-016-1523-2
22. WHO. Increasing complexity of medical technology and consequences for training and outcome of care. 2010.
23. Hougbo PT, G. J. v. d W, Medenou D, Dakpanon LY, Bunders J, Ruitenber J. Policy and Management of Medical Devices for the Public Health Care Sector in Benin. 2012. p. 320.

Figures

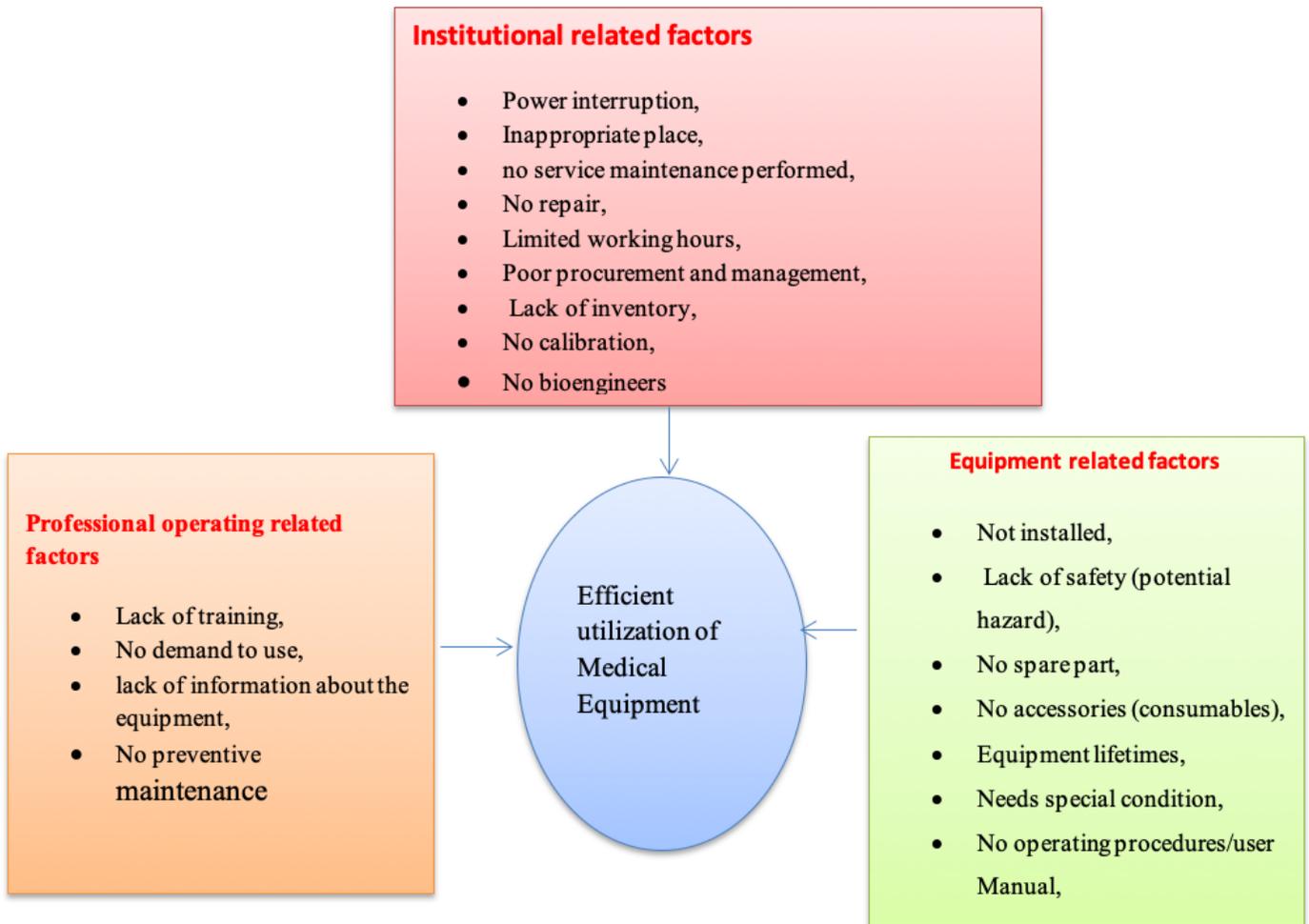


Figure 1

Conceptual framework of medical equipment utilization at public referral hospitals

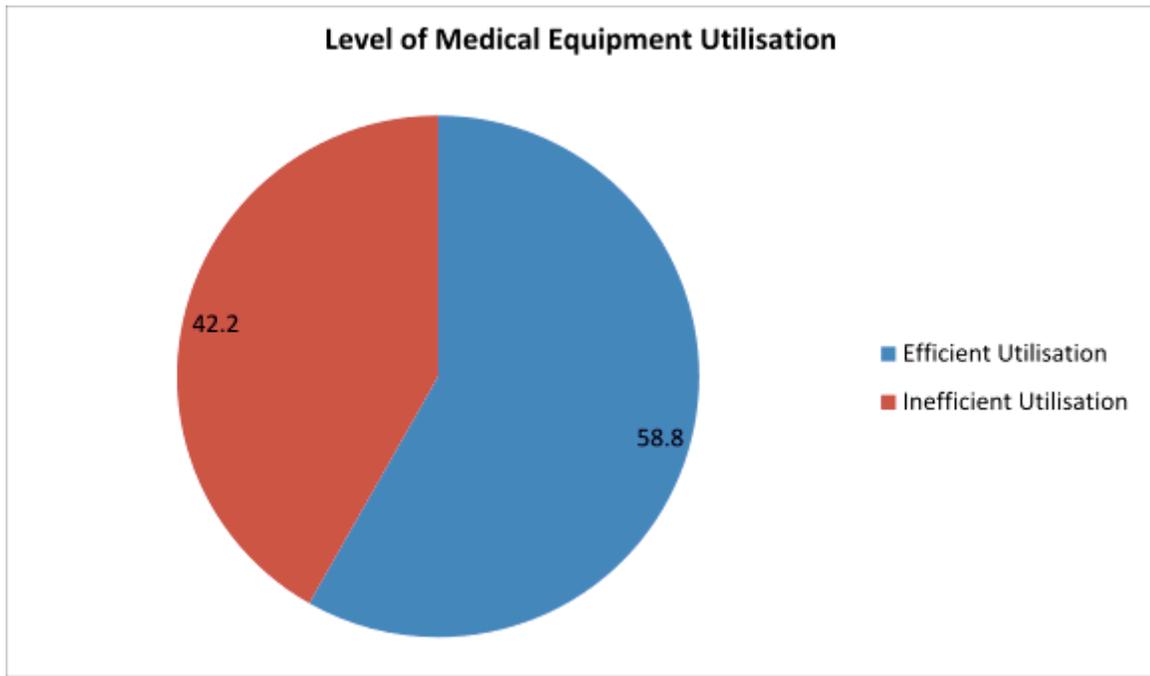


Figure 2

Level of Medical equipment utilization at Public referral hospitals in East Wollega Ethiopia, Oromia Regional State, Ethiopia, 2021.