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CROSS-SECTIONAL STUDY

# Clinical/Biomedical Engineering & Medical Device Trainings Capacity Assessment Survey in Somaliland

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**ABSTRACT**

The healthcare system in Somaliland was seriously affected and the healthcare facilities were totally destroyed during the Somali civil war in 1991. Somaliland now suffers from a serious shortage of health workers. The availability of biomedical and clinical engineers is critical to ensure proper use and maintenance of medical devices.

The main purpose of this study was to investigate the human resource capacity related to clinical and biomedical training access to inform future interventions for building this capacity in Somaliland. This survey design was cross-sectional and data were collected through an online questionnaire using Google Forms for a period of 1 month, 1st Oct - 1st Nov 2024, and targeted those involved in medical device use, handling, maintenance, import, sales and distribution. Data were entered and analyzed using IBM SPSS and descriptive statistics were presented using Microsoft Excel.

A total of 69 participants responded to the survey. The survey highlighted limited access to training where most hospitals don't have basic biomedical engineering departments. Major barriers to access of trainings were: lack of funds, institutions' lack of capacity to deliver the trainings and lack of awareness on the importance of the trainings. According to the responses, there is a high need for CE training particularly maternal and child health, radiology and critical care equipment.

Further comprehensive assessments and studies are needed to assess the current state of the biomedical and clinical engineering sector in Somaliland to give insights on medical device handling and maintenance procedures, human resources and infrastructure as well.

**Keywords:** Biomedical engineering, Capacity, Biomedical engineers, Somaliland, Somalia

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## INTRODUCTION

The Republic of Somaliland is situated north of the equator in the Horn of Africa. The total area of the Republic of Somaliland is 176,119.2 sq km.[1] The population of Somaliland is 4.2 million where 53% live in urban areas, according to the National Report issued by the Central Statistics Department, Ministry of Planning, Government of Somaliland.[1] Hargeisa is also the regional capital of the Maroodi Jeex region of Somaliland. Hargeisa is situated in a valley in the Galgodon (Ogo) highlands and sits at an elevation of 1,334 m (4,377 ft). Home to rock art from the Neolithic period, the city is also a commercial hub for precious stone-cutting, construction, retail services and trading, among other activities.[2]

The healthcare system was affected and the healthcare facilities were totally destroyed during the Somali civil war in 1991. The Ministry of Health of Somaliland is charged with health policy development and service delivery oversight functions. There are 21 public hospitals including six regional hospitals, 73 MCHs, 152 health posts and 7 TB centers in Somaliland. The private sector is estimated to comprise about: 80 clinics and hospitals as well as 779 pharmacies.[3] Though reliable data is lacking; it's estimated that the private sector takes approximately 70 to 75% of total medicines imports into the country.

Somaliland now suffers from a serious shortage of health workers, recently estimated at 197 doctors, 1,256 nurses and

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344 midwives, serving a population of around 3.5 million.[4] This level of coverage falls far short of the WHO-recommended minimum health worker/population ratio of 2.3/1,000. Regarding the current state of health policy implementation, there are existing gaps in the health system preparedness and capacity, regulatory status, and functioning with high burden of infectious diseases including poverty-related infectious diseases and epidemic and pandemic prone diseases.

In 13% of children aged 12 to 23 months are completely vaccinated (i.e., vaccinations for BCG, pentavalent, polio, and measles.[5] According to the Somaliland Demographic Health Survey, an overwhelming 67% of births were delivered at home, and only 33% of births in the five years preceding the survey was delivered in a health facility where 40% of deliveries were performed with the help of a trained health care provider.[6] Somaliland's Maternal Mortality Rate (MMR) has fallen to 396 maternal deaths per 100,000 live births from 418 in 2014.[6]

Regarding the burden of communicable diseases/NTDs, Tuberculosis notification rate per 100 000 population is 110 while the Incidence rate of malaria per 1 000 population is 2.4 and number of newly reported HIV cases 1118[5] (WHO EMRO, 1990).Health facilities are irregularly supplied, with an inadequate selection of drugs through a kit system (meaning that every month there is wastage and stock-outs.[6]

The COVID-19 exacerbated the need for oxygen in pandemic situations and exposed the lack of medical oxygen as a critical gap in the healthcare systems in many countries.[7] In response to this experience from the COVID-19, the seventy-sixth World Health Assembly (WHA) resolution in May 2023 called for increasing access to medical oxygen globally [7].One of the most essential requirements to have a sustainable system for oxygen production, maintenance of facilities, and supply chain is the availability of key human resources.[8] However, according to a report conducted by WHO in the EMR including Somalia, there is a limited data on the number of biomedical engineers and technicians. In some countries in the EMR, the number of biomedical engineers ranged from single digits in countries like Afghanistan and Djibouti.[7]

In 2014, a second World Health Assembly resolution was approved on "regulatory system strengthening for medical products", WHA67.20; which states the importance of the regulation of medical devices for better public health outcomes and to increase access to safe, effective and quality medical products, and acknowledges the need to support the area of medical devices.[9]

The findings of a WHO implementation research study in Somalia demonstrated the lifesaving feasibility of solar powered oxygen delivery (SPO2) in volatile settings.[7] However, the absence of trained staff in conflict areas and refugee settlements, to maintain and appropriately use equipment, adds a further layer of complexity and challenge.[10] African countries are paying considerable attention to the training and production of health-care professionals. However, an important complement, namely, health-care technologies, remains in chronic under-supply and, where they are supplied, are chronically out of order.[11] Countries reporting the best health outcomes, such as a high life expectancy at birth, have invested heavily in health technologies and infrastructure, including medical devices.[11] A study conducted in the Puntland State of Somalia assessing hospital capacities showed that there was a common transversal issue of an inherent lack of devices, training and knowledge which in turn could severely affect the patients and their safety.[11]

There are currently no training programs for biomedical engineering personnel in Somaliland at any skill level, from craftsperson to technician, technologist, or engineer.[12] According to the THET assessment report, the hospitals have very few maintenance staff responsible for medical equipment.[12] Biomedical equipment management is a significant concern for safety and worth in the current hospital operations environment.[13] Medical equipment maintenance is a broad term that refers to the process of ensuring that any medical or biomedical equipment is working properly and is fully functional.[14] The maintenance of medical equipment is important for reducing dispatch costs, reducing patient dissatisfaction, timely patient treatment, and reducing mortality and risks during patient care.[15] The World Health Organization (WHO) estimates that 70% of medical equipment in sub-Saharan Africa is out of service, mainly due to the lack of trained biomedical technicians and the unavailability of spare parts.[16] WHO emphasized that equipment maintenance should be an integral part of a complete medical equipment donation. A study that assessed the availability, functionality, and barriers associated with the use of medical equipment at hospitals in an Ethiopian Region, identified key challenges such as issues with the utilization of the Medical Equipment Management Information System, a lack of spare parts and accessories, the absence of a well-equipped and standardized maintenance workshop, and insufficient operator training.[17] A study conducted in South Africa showed that medical equipment availability and functionality and inadequate maintenance facilities were the main problems in hospitals and healthcare services.[18] Another study assessing medical equipment maintenance at a teaching hospital in South Sudan reported that there was a lack of biomedical personnel, inadequate information about devices, and a lack of periodical inspection and prevention.[19]

Many countries in Africa, for example, don't have a single training program for biomedical engineering, meaning maintenance staff learn about medical equipment on the job in hospitals.[20] In Africa, the development of BME education can be traced to the late 1960s. In 1969, the Medical Physics and Bioengineering Department was formed at the University of Cape Town (UCT), South Africa.[21] However, the availability of CE training programs is scarce in the African continent. It was reported in 2008 that only twelve African universities in only six countries offered biomedical engineering compared with 229 universities in North America.[22] Due to a lack of clinical engineering professionals, and poor management

of medical devices, many African countries do not have the human resources to ensure proper healthcare technology management[23] GE Foundation and the AAMI Foundation developed recommendations for a model to train biomedical equipment technicians in low-resource settings that may be scalable, replicable and ideally sustainable for a 3-5 years period. The initiative intends to achieve: training more biomedical equipment technicians in low-resource settings overall; training them quickly and providing a system for ongoing professional support and development.

Despite the major progress made in building the capacity of the higher education sector in Somaliland, there exist numerous challenges. The Higher Education (HE) sector is relatively new in Somaliland and the first University, Amoud University, was established in 1998[24]. By 2011, the number of higher education institutions registered with the Ministry of Education reached 16, with a total student population of about 15,000.[24] The Health Professions Education (HPE) MSc by the King's Global Health Partnerships, is a one-, two- or three-year course delivered in person and online, enabling teaching staff at the University of Hargeisa, Amoud University and Edna Adan University, to obtain an accredited qualification in health professions education.[25] There is also a paramount importance to have a robust national system for quality assurance of higher education. Accreditation, a powerful tool of quality assurance, is used to assess the national system of higher education[26]. The National Commission for Higher Education (NCHE) was established in August 2011 by a presidential Degree as a body corporate to make better provisions for the advancement of Higher Education in Somaliland.[27] A Joint Review of the Education Sector (JRES) in Somaliland indicated that infrastructure in most Somaliland universities is inadequate, i.e. resources, lecture hall spaces, essential texts and other media, and science laboratories.[28]

The local universities in Somaliland contribute a large share to training students in various fields and disciplines while also many young Somalilanders seek higher education in foreign universities. Some of the largest universities in Somaliland such as Amoud University, University of Hargeisa, Gollis University and Edna University have health training colleges. Amoud College of Health Science, Somaliland's first Health training institution, was set up in 2000.[29] The College partnered with King's College London and THET in 2002 and the first intake of students graduated in 2007[25]. Edna Adan University Hospital has been involved in health professional training for many years and is Somaliland's longest-established nursing and midwifery school. King's Global Health Partnerships has worked with Edna's since 2002 as the hospital formalized and expanded its training programs, which now include 4-year programs in Nursing, Midwifery, Nutrition, Medical Laboratory, Public Health, and 5-year programs in Pharmacy and Dentistry[25]. Also, The University of Hargeisa College of Medicine and Health Sciences was opened in 2003 and graduated its first cohort of doctors in 2009[30].

Regulation of medical devices and health technologies is also critical for providing quality and safe health services. Most of the challenges in Africa-related medical devices are linked to inadequate governance of medical devices, including regulation, oversight and management. Moreover, in many low and low-middle-income countries, including countries in Africa, the regulation of medical devices remains generally less well established and defined than those for other health technologies such as medicines and vaccines.[31] In the African context, a scoping review examining medical devices regulation and oversight reported that available literature on this topic is limited and the current frameworks and guidelines are focused mainly on national-level guidelines and processes, which are generally described as inadequate.[32] The regulatory capacity for medical devices and health technologies assessment is poor in Somaliland. According to the WHO MDs Atlas, the National Medicines Regulatory Authority (NMRA) under the Department of Medical Services of the Ministry of Health Development of Somaliland has an HTA role, but not well established.[33] A rapid benchmarking of the capacity of the National Regulatory Agency (NRA) by the WHO-IGAD-MoH Joint Initiative was done in 2017 which found that only 16% of the total indicators for the regulatory system has been implemented.

Africa has one of the fastest-growing and an increasingly youthful population in the world but also one of the highest morbidity and mortality rates globally, notwithstanding recent progress. For example, the world saw the average life expectancy rise from approximately 52 years in 1960 to approximately 71 in 2014, while that of sub-Saharan Africa was 58.6 in 2014. This is far from the target contained in the African Union's Agenda 2063: The Africa We Want, a regional framework that is intended to see Africa "enjoying a life expectancy of above 75 years."[34] Improvement in health technology accounted, however, for a drop in the death rates attributable to both, communicable and non-communicable diseases. For example, according to the Economic Commission for Africa (ECA), deaths caused by communicable diseases declined by 42.4% between 2000 and 2012, while deaths due to non-communicable diseases fell by a mere 5.9% during the same period.[34]

Globally, the medical devices market was estimated to be worth between $320 billion in 2016.[35] Medical device market is growing at an annual average rate of approximately 6% globally.[36] Africa's share of the world market for medical devices was estimated at $3.2 billion in 2010, and ECA estimated that it should have reached at least $3.8 billion by 2014.[37]

Africa is dependent on imported medical equipment and devices much of which is neither adequately managed nor designed with the levels of redundancy needed for these settings.[38] Consequently, these devices and equipment are not well adapted to the environment in which they are deployed.[36] An audit study of skills, capacity and translational capability in East Africa was conducted gathering data across many countries in the region including Burundi, Kenya, Rwanda, Tanzania, and Uganda, found that common existing challenges are gaps related to skills, resources, translational competence, regulations, procurement and role/status of biomedical

engineers) and addressing these gaps is critical for the aspiration of biomedical engineering as a driver for improvements in healthcare in East Africa.[39] Several studies report on the tendency of hospitals in LMI settings to become "graveyards of medical equipment and technologies."[40] Digital health and its use in improving healthcare is also a key area we can emphasize that can enhance delivering quality health service in Somalia. The implementation of digital health solutions in Somalia has the potential to improve accessibility to healthcare, streamline data administration, and improve the quality of patient care.[40] The use of telemedicine and its potential has also been investigated in Somalia. Telemedicine is *the use of electronic information and communications technologies to provide and support health care when distance separates the participants.*[41] *An observational study that implemented its "Treat and Teach" package at the East Africa University, Bosaso, Somalia recruiting a Somali healthcare team underscored the feasibility of implementing the Treat and Teach, a Telemedicine initiative applied in neurology and cardiology.*[42] *However, the authors highlighted the importance of sustainability through capacity building and continuous support in all sectors not merely the medical domain.*[44]

WHO recommends having a well-planned and managed maintenance program that can keep the medical equipment in a healthcare institution reliable, safe and available for use when it is needed for diagnostic procedures, therapy, treatments and monitoring of patients. An effective medical equipment maintenance program consists of adequate planning, management and implementation and should use strategies that cover procedures for inspection, as well as preventive and corrective maintenance.[43] This is not the case in Somaliland hospitals and healthcare facilities and prompts urgent interventions.

## AIM

The main purpose of the study was to investigate the human resource capacity related to clinical and biomedical training access to inform future interventions for building this capacity in Somaliland.

## METHODOLOGY

### Survey Design and Period

The survey design was cross-sectional and based on a quantitative data collection method. The survey was launched and data was collected in 4 weeks (1 month) from 1st October to 1st November 2024.

### Study Population and Sample

To ensure inclusiveness and representativeness of the sample among the target population of the study, stratifications were made where the target population was divided into main groups such as health administrators at the ministerial level, hospital directors or managers; clinicians, nurses, pharmacists, laboratory specialists, biomedical engineers and technicians, academic deans and academic lecturers, team leaders for health centers as well as public health officers.

Moreover, the private pharmaceutical importers, retailers and wholesalers were targeted who are involved in the import, distribution and sale of medical devices. Likewise, both the private and public health sectors were also targeted. Considerations were made to also include geographic regions of Somaliland and target respondents from each region.

### Data Collection Method

The study collected quantitative data using a structured questionnaire based on the online Google Forms platform. The survey was distributed through various channels such as emails, WhatsApp groups and professional networks.

The survey tool was validated before distribution by experts in the clinical and biomedical engineering field including design and delivery of BME training. The questionnaire was structured in 3 main sections as follows:

*Section 1*

Demographic and job information of the respondents such as name, job title, role and responsibilities, age, gender, professional background, educational level and qualifications related to biomedical/clinical engineering.

*Section 2*

Data related to the health facility and institutions as well as the basic information on the existence and structure of biomedical departments were collected such as the department of work, the type of the health facility, and whether it is a public or private institution.

*Section 3*

This part consisted of questions assessing the training needs such as access to current training, frequency, the source of training, areas where training is needed among the provided list of biomedical engineering training/certifications as well as the challenges associated with lack of access to the training.

### Data Analysis

The data were cleaned before analysis to ensure data quality and ensure consistency as per the survey plan. The data were entered and analyzed using the IBM SPSS Statistics, version 26. Descriptive data analysis was made and presented in charts and figures using Microsoft Excel.

### Ethical Considerations

The study did not involve the collection of data that could raise ethical concerns. All participants were provided with an explanation of the study objectives, added value, and if they are willing to participate in the survey. Participants also participated in the survey with their capacity to provide information.

## RESULTS AND FINDINGS

### Respondents

A total of 69 responses were received in the survey. The majority of the respondents were males constituting 77% (53) while females were 23% (16) as shown in Figure 1.

Figure 2 presents the age distribution of the respondents where the most frequent age range was between 30 to 40 years

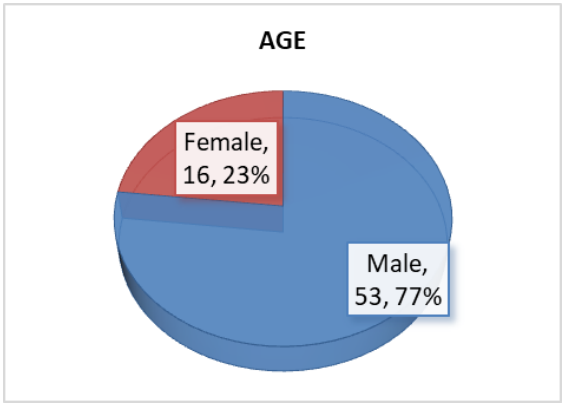


**Figure 1:** Gender distribution of respondents

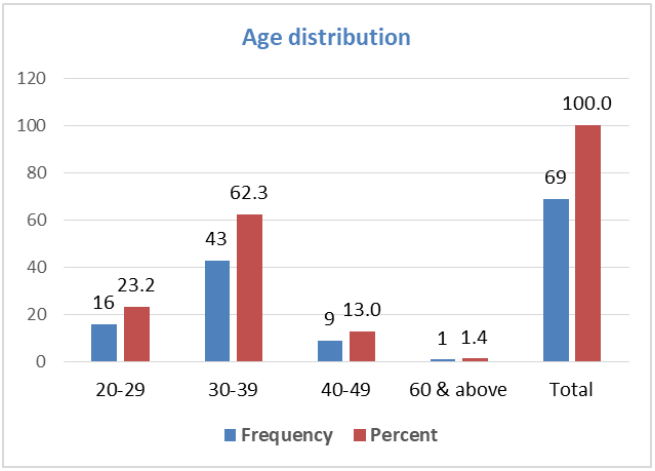


**Figure 2:** Age distribution of the sample respondents

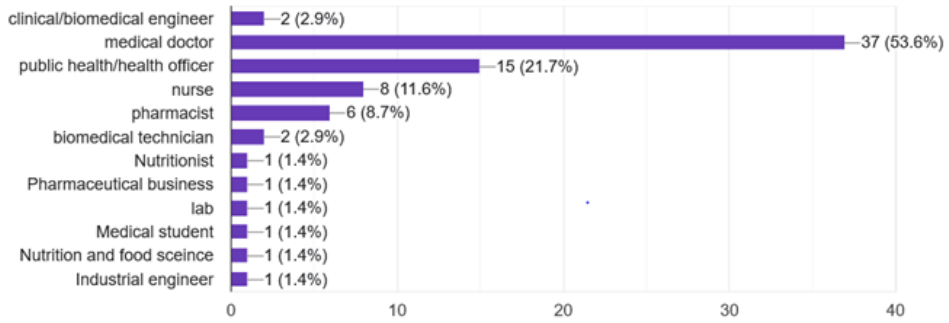


**Figure 3***:* Professional background of the respondents

among the participants constituting 43 (62.3%) followed by the 20 to 29 years age range representing 16 (23.2%) while the least group was 60 years and above 1 (1.4%).

The majority group were doctors constituting 53.6% (37) of the total respondents followed by public health officers and specialists 21.7% (15) and nurses 11.6% (8) while the least represented groups included clinical/biomedical engineers 2.9% (2), biomedical technicians 2.9% (2), laboratory 1.4% (1), nutrition and food science 1.4% (1), nutritionists 1.4% (1) and industrial engineers 1.64% (1) as depicted in Figure 3 and Table 1.

As shown in Figure 4, the majority of the respondents had a Master's level education 54% (37) followed by those with undergraduate degrees and post-graduate diplomas respectively, 36% (25) and 6% (4). This shows the large representation of well-educational professionals participating in the survey.

**Table 1:** Professional background of the respondents

| *Profession* | *Frequency* | *Percent (%)* |
|---|---|---|
| biomedical technician | 2 | 2.9 |
| clinical/biomedical engineer | 2 | 2.9 |
| Industrial engineer | 1 | 1.4 |
| lab | 1 | 1.4 |
| medical doctor | 37 | 53.6 |
| nurse | 6 | 8.7 |
| Nutrition and food science | 1 | 1.4 |
| Nutritionist | 1 | 1.4 |
| Pharmaceutical business | 1 | 1.4 |
| pharmacist | 5 | 7.2 |
| public health/health officer | 12 | 17.4 |
| Total | 69 | 100.0 |

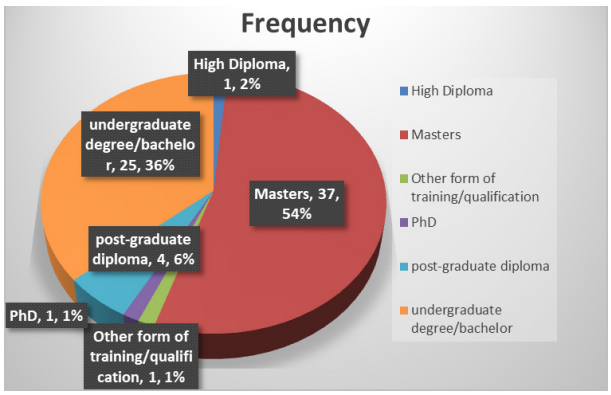


**Figure 4:** Educational level of participants presented as frequency & percentage

### Health Facility Information and Status of Clinical and Biomedical Engineering Units

The survey investigated the existence of the CE-BME units or departments in the health facilities where respondents work. Also, the basic information of the institutions or facilities such as categories and/or institutional type and in the case of hospitals, the classification as per the national health system of health facilities hierarchy was used according to the Ministry of Health Development (MoHD)'s implemented essential package of health services (EPHS) framework. This section presents the information collected through the survey.

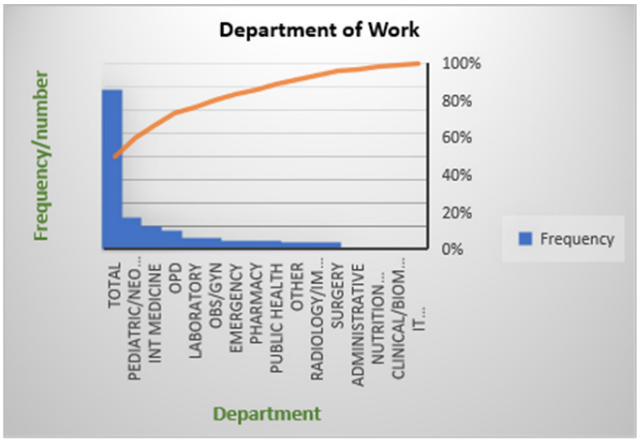


**Figure 5***:* Departments of respondents

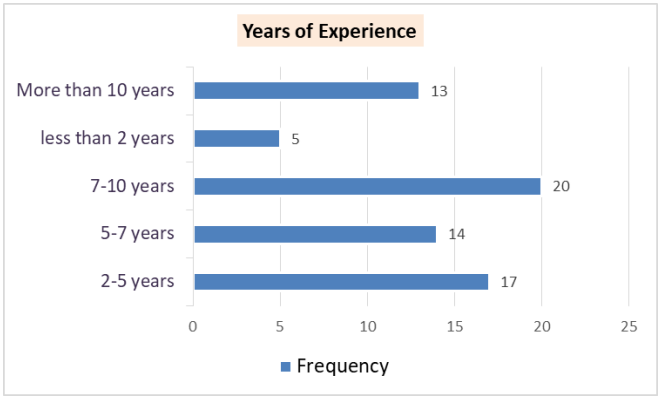


**Figure 6:** Professional experience of respondents

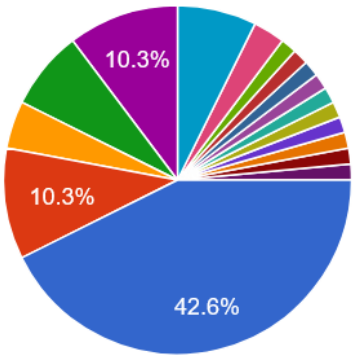


**Table 2:** Respondents' respective departments

| *Department* | *Frequency* | *Percent* |
|---|---|---|
| Administrative | 2 | 2.9 |
| Clinical/biomedical engineering | 1 | 1.4 |
| Emergency | 4 | 5.8 |
| Int medicine | 10 | 14.5 |
| IT department /logistics/administrator | 1 | 1.4 |
| Laboratory | 5 | 7.2 |
| Nutrition and Dietetic Department | 2 | 2.9 |
| Obstetrics/Gynecology | 5 | 7.2 |
| OPD | 8 | 11.6 |
| Other | 3 | 4.3 |
| Pediatric/neonatal | 14 | 20.3 |
| Pharmacy | 4 | 5.7 |
| Public Health | 4 | 5.8 |
| Radiology/imaging | 3 | 4.3 |
| Surgery | 3 | 4.3 |
| Total | 69 | 100.0 |

As shown in Figure 5 and Table 2, most of the respondents were working in hospital departments where the most frequent departments were the pediatric/neonatal, internal medicine and out-patients representing 14 (20.3%), 10 (14.5%) and 8 (11.6%), respectively. The least represented departments were the Clinical/Biomedical Engineering and IT/Logistics departments both 1 respondent (1.4%), out of the total respondents of the survey.

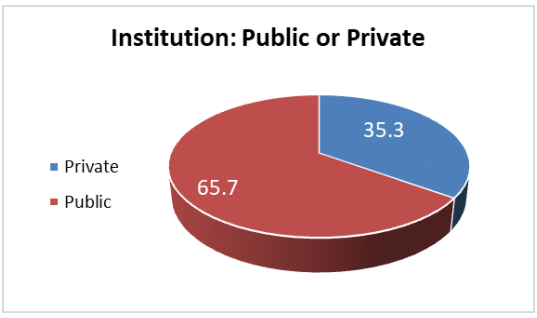


**Figure 7:** Affiliation of institution in proportions

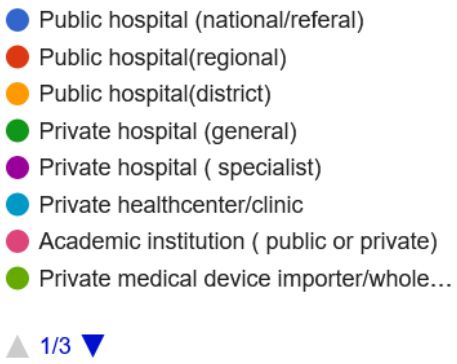


**Figure 8:** Institutional/health facility category

Figure 6 presents the professional experience of participants in years where the most frequent group was 7 to 10 years of experience representing 20 participants (29%) followed by those with 2 to 5 years of experience 17 (24.6%) while a large share had more than 10 years of experience, 13 (18.8%).

Figure 7 depicts the institutional affiliation where the majority of the respondents were working at a public institution, 65.7%, while the rest were from the private sector, 35.3%.

As shown in Table 3, the majority of the survey participants were working at public hospitals where 29 (42%) were from the national referral public hospital located in the capital city of Hargeisa, the Hargeisa Group Hospital; while also 7 (10%) were from a regional public hospital and 3 at district level hospitals. Moreover, a large share of the participants was from the private sector health facilities where a total of 12 respondents were from private hospitals, particularly specialist hospitals providing specialized healthcare 7(10%) and general private hospitals, 5 (7.2%). Also, the facility details information is presented in Figure 8 for more infographic display.

Respondents were asked to describe to rate the level of importance of biomedical and clinical engineering knowledge in their respective daily duties of work on a scale of 4 (very high, high, intermediate and very low). This can help to understand the relevance of this knowledge to the participants. The findings are presented in Figure 9, where 34 respondents (49.3%) rated this knowledge as very high/priority, followed by those reported as high, 27 (39.1%), and intermediate, 5 (7.2%).

Moreover, participants were asked how frequently they apply this knowledge to their daily duties at work, also on a scale of four categories (very frequent, frequent, occasional, or sometimes and rarely used). This information is shown in Figure 10, where most of the participants rated this as very frequent 32 (46.4%) followed by those reporting it as frequent 30 (43.5%).

The respondents were asked whether their institutions or hospitals have designated biomedical and clinical engineering units or departments. The aim of this question was to collect basic information about the existence of these specialized units in health facilities and health institutions in Somaliland. As shown in Figure 11, the majority of the institutions did not have a biomedical and clinical engineering department, representing 77.3%.

In addition, the survey asked the participants to provide basic information or description about the organization of the unit, if existed and the answers of the respondents are presented in Table 4.

## Training Needs Assessment

This section of the survey findings covers the assessment of the access to training among the participants as well as the areas of training need, the source of training and training interests of the respondents including the training modality preference.

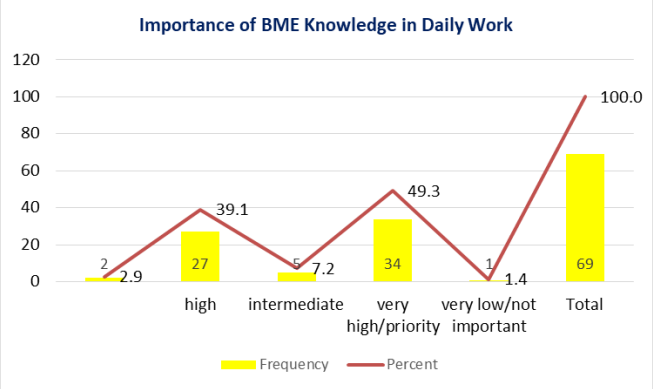


**Figure 9:** Importance of knowledge to participants' work

**Table 3:** Institutional details and category

| *Category* | *Frequency* | *Percent (%)* |
|---|---|---|
| Other | 2 | 2.9 |
| Academic institution (public or private) | 2 | 2.9 |
| Ministry of Health | 3 | 4.3 |
| NGO/humanitarian org | 4 | 5.8 |
| Private health center/clinic | 5 | 7.2 |
| Private hospital (specialist) | 7 | 10.1 |
| Private hospital (general) | 5 | 7.2 |
| Private medical device importer/ wholesale and distribution | 2 | 2.9 |
| Public hospital (national/referral) | 29 | 42.0 |
| Public hospital(district) | 3 | 4.3 |
| Public hospital(regional) | 7 | 10.1 |
| Total | 69 | 100.0 |

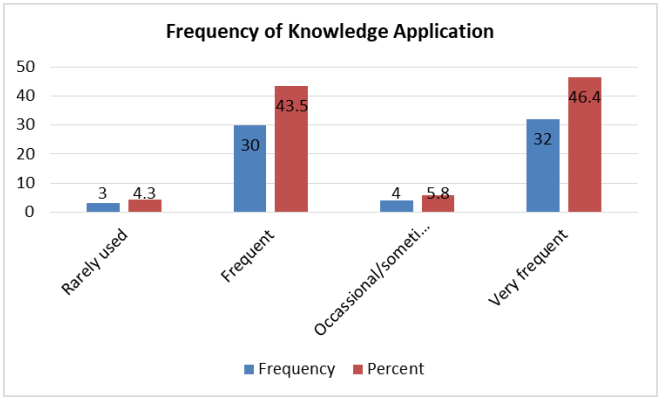


**Figure 10:** Frequency of knowledge application

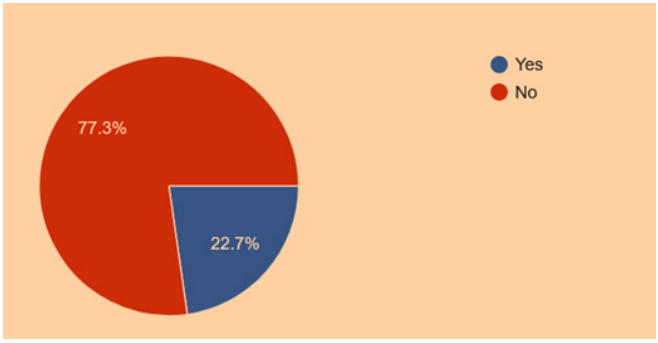


**Figure 11:** Is there a BME unit at your institution/hospital

**Table 4:** Current status of biomedical engineering units at major hospitals

| *Description* | *Frequency* | *Percent* |
|---|---|---|
| Not responded/ or applicable | 54 | 78.3 |
| Depart of Biomedical Engineering in the School of Engineering | 1 | 1.4 |
| Department has head, vice head and secretary. Each and every has their own role and duties. | 1 | 1.4 |
| director-admin and finance-medical coordinator and department in-charges | 1 | 1.4 |
| Endoscopy unit | 1 | 1.4 |
| Few technical staff that service operation theater sterilizer or other machinery | 1 | 1.4 |
| Imaging instruments need biomedical engineering | 1 | 1.4 |
| Maintenance department, hospital has department for maintenance of medical instrument | 1 | 1.4 |
| Medical care for patient in pediatrics and internal med | 1 | 1.4 |
| my unit is clinical coordinator of hospital | 1 | 1.4 |
| No | 1 | 1.4 |
| No. | 1 | 1.4 |
| There is a basic department. | 1 | 1.4 |
| The hospital has medical coordinator that coordinate medical activity of hospital also have matrome (HR person) that responsible of unit's activity include nurses and cleaner activity. Hospital has no BME unit. | 1 | 1.4 |
| There small unit at the hospital, which chaired by Biomedical technician. The hospital has Oxygen plant, and other important devices (anesthesia, X-ray, Ultrasound etc.). | 1 | 1.4 |
| Yes, Hargeisa group hospital department of laboratory | 1 | 1.4 |
| Total | 69 | 100.0 |

The first question of this section of the survey asked respondents whether, currently, they have had access to training. As shown in Figure 12, the majority of the respondents, 44 representing 63.8% of the total respondents to the survey reported "yes" to this question.

When asked about the frequency of such training over a period of time in four categories (quarterly, bi-annual, annual, or no schedule/random), participant responses are presented in Figure 13, in which, 25 of them representing 36.2% reported there was no schedule for the training followed by those attending annual trainings. Moreover, about 33% of the survey participants did not respond to this question, as they had no access to any form of training.

As depicted in Figure 14, NGOs are the major source of training according to the participant's responses (37.2%) followed by the institution/department and Government/ Ministry responses representing 34.9 and 32.6%, respectively.

The major barrier to accessing training was due to lack of funds, with 21 responses representing 31.8% of the total, followed by either institution could not provide the training or lack of awareness and understanding among the institution/ or its leadership on the importance of the training, 19.7 and 16.7%, respectively. Also, a notable reason was lack of time or too much staff workload, 13.6% as shown in Figure 15.

Survey participants were also asked whether they were interested in attending biomedical and clinical engineering training and the majority of them, about 94.2%, shared their interest in such training as presented in Figure 16.

Moreover, when asked about areas or skills in which the participants would like to have training related to clinical and

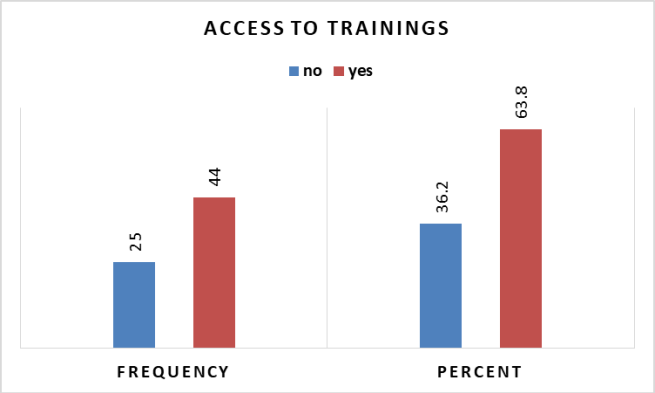


**Figure 12:** Participants' access to training

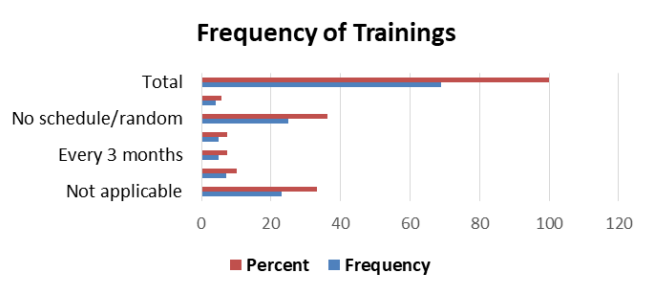


**Figure 13:** Training frequencies

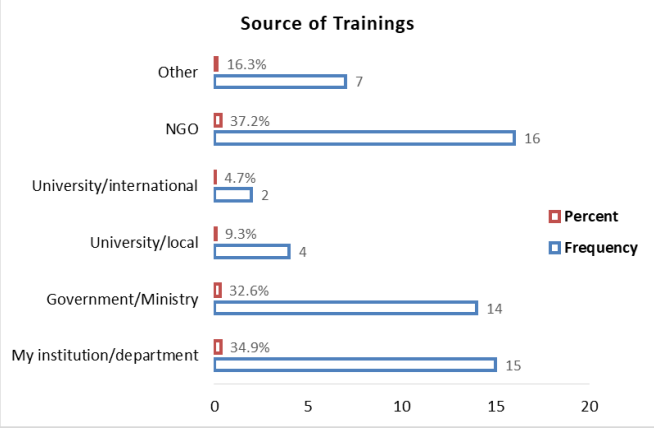


**Figure 14:** Who provides the training

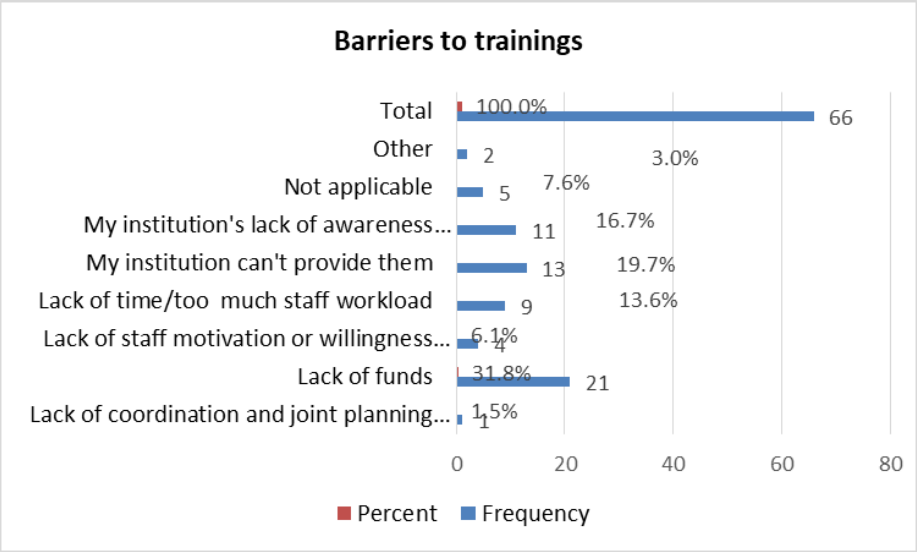


**Figure 15:** Major obstacles to having training access

biomedical engineering, among a set of provided training options in the questionnaire, 21 respondents representing 30% of the total, opted for maternal and child health equipment; followed by radiology equipment and critical care equipment, 29 and 25%, respectively. Also, many participants showed interest in attending a certified biomedical maintenance certificate course, 20%, and medical device quality standards training, 17%, as presented in Figure 17.

Participants were also asked in the questionnaire their preference of training modality and whether it's online or in-person/physical format. As shown in Figure 18, a majority responded "yes" to attending the in-person mode, 44 (63.8%) while also a large share opted for the online modality, 25 (36.2%).

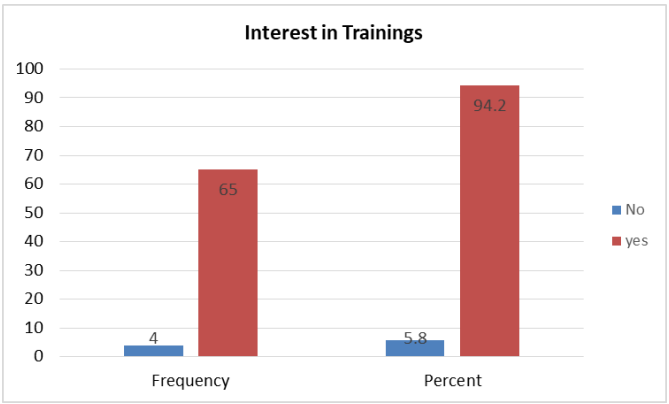


**Figure 16:** Future training interest among participants

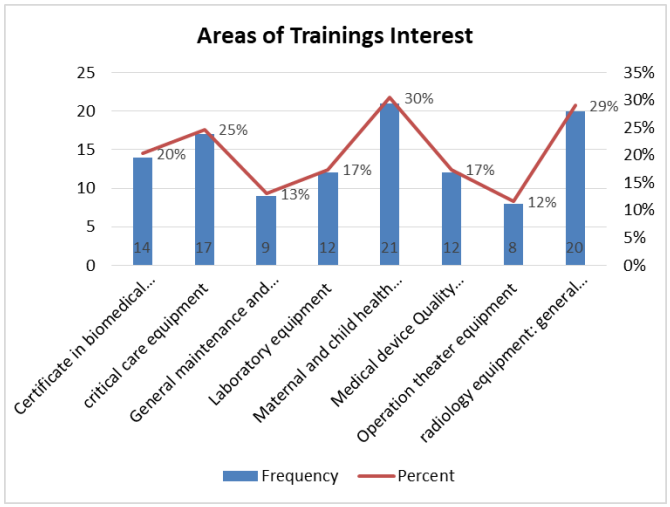


**Figure 17:** Respondents' choice of training area/skill

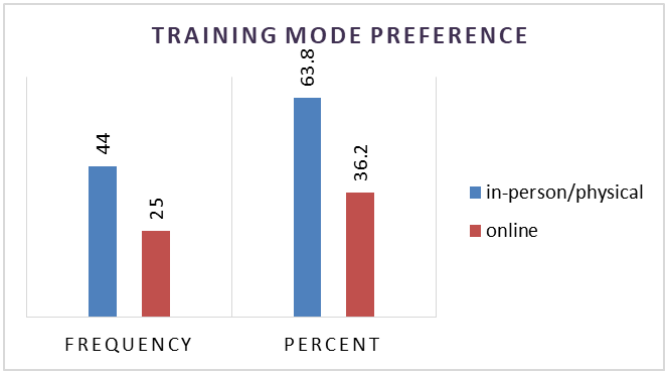


**Figure 18:** Participants' preferred training format

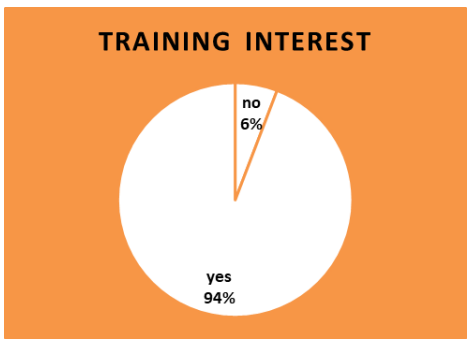


**Figure 19:** Interest in attending international training

Moreover, the survey investigated the interest of the respondents in the participation of an online series of trainings delivered by international organizations and related to the biomedical and clinical engineering field. This question was intended to help understand the willingness of the survey respondents to such training if organized with international organizations and also help plan for the training in the future. As presented in Figure 19, about 94% or 65 of the respondents showed interest in attending such training.

## DISCUSSION, CONCLUSION AND RECOMMENDATIONS

This study highlighted the current state of biomedical and medical device training availability where access to training is limited and most hospitals don't have basic biomedical engineering departments. This is in agreement with other studies assessing biomedical engineering capacities in low-resource settings. A study by Pietro *et al.* found a lack of funding, expertise, and a well-established maintenance program as some of the major challenges facing assessed hospitals in Benin and Uganda.[44] It is essential that health technology (HT) be strategically guided and optimally managed.[45]

It also illustrates the overall CE system needs to be built from scratch to address the current gaps in capacity and ensure access to capacity-building training, and thus, improve the state of medical device handling, use and maintenance in the country. The African continent shares the limited capacity related to medical device maintenance and handling. According to the United Nations Economic Commission for Africa, the majority of countries in Africa rely on foreign expertise to install, upgrade and service most of the imported devices[46] Moreover, many studies have found such gaps in clinical engineering capacity.[18-20] The survey findings also pointed out the high interest in attending biomedical and clinical engineering training among the participants who are health professionals of various disciplines and working in major hospitals and health institutions in the country, both public and private sectors.

As per the responses from the participants, the survey also highlighted core areas of training such as maternal and child health equipment, radiology and critical care equipment. Based on the responses, medical technologies for child and maternal health are considered the most relevant for LMI settingsFuture training programs could incorporate such areas in their curriculum to address the current biomedical and clinical engineering training needs in Somaliland.

Moreover, major barriers to access to training were: lack of funds, institutions' lack of capacity to deliver the training and lack of awareness and understanding among the institutional leadership on the importance of the training.

Further research studies are needed in Somaliland to conduct a more comprehensive assessment of the Clinical and Biomedical Engineering Capacity, i.e. identify current state and gaps of infrastructure, resources, etc. and inform decision and health policy making.

The following are some of the key actions and interventions that can address the current gaps in the Clinical and Biomedical Engineering sector in Somaliland based on the study findings as well as views from the author/s and experts in the field:

1. Establishing Clinical and Biomedical Engineering Units in each hospital.
2. Building the human resources technical capacity:
   A. provide basic training for technicians, radiologists and those dealing with device use through various training modes such as on the job and certified courses in short terms 1 to 2 years,
   B. Establish educational programs also involving local universities through a partnership model" tertiary education program such as diploma or undergraduate bachelor's degrees within longer 3-5 years period to enhance national CE/BME technical capacity. These training should be delivered both in person and online to suit the current demanding busy schedules for many healthcare professionals who can participate after job training sessions, i.e. evening classes or self-paced training courses.
   C. Develop customized and country context curriculums for these training programs while reflecting the training needs as can be informed by this study and/or future related research.
   D. Online training and webinars: both non-structured/certified and certified courses as well as short webinars delivered online can also provide awareness, and updates to the biomedical/clinical engineers and other health professionals in the country on key professional updates such as new guidelines or evidence-based interventions and new research or technologies in the field regarding medical devices or other health technologies including invitro-diagnostics, amongst other areas.
   E. Certification of the local CE/BME training after the introduction of the training programs. Also, the international training offered by any relevant institution should be accredited with credit hours and comply with internationally acceptable standards of quality.
3. Strengthening organizational and management structures and frameworks: this mainly involves regulatory and HTA capacity at the Ministry of Health level. This is vital and will allow the MoH to have the regulatory capacity to assess the quality, safety and effectiveness of medical devices and invitro diagnostics, issue and assess marketing authorizations and applications (product licenses) as well as conduct post-marketing device safety (medical device vigilance) and quality surveillance in Somaliland.
4. Conducting an in-depth and large country-wide capacity assessment, i.e. infrastructure, frameworks, HTM, resources, HR, the status of medical devices currently in use in health facilities and maintenance procedures, if any, etc. to inform plans for building the national biomedical engineering sector capacity is warranted.

5. Develop a strategic plan to build the country's CE capacity for 5 years. The plan should have a clear M & E plan to monitor the progress of achievement. Also, adaptive implementation and intra-action reviews should be considered to aid the incorporation of real-world experiences.
6. Mobilize adequate funds through donors and government-led initiatives to finance the implementation of the strategic plan.
7. Building collaborations and partnerships among the key stakeholders at the national, regional and international levels will also be vital to unite efforts and resources, incorporate participatory and inclusiveness approaches as well as prevent potential duplication of resources, thus enhancing efficiency.

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