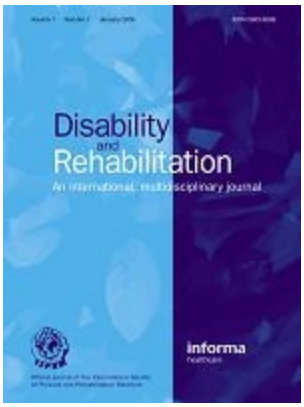

Evaluation of the current status of prosthetic rehabilitation services for major limb loss: a descriptive study in Ugandan Referral Hospitals.

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Implications for Rehabilitation

- Availability and accessibility of prosthetic services are essential to the rehabilitation and reintegration of amputees into communities in LMICs.
- For stakeholders to formulate effective plans to address issues within prosthetics service provision, quality data on the current state of services is necessary.
- Service providers should prioritise decentralisation of prosthetic rehabilitation services, especially for patients in rural areas, to improve access and reach of these services.
- To achieve optimal limb functionality after amputation for both lower and upper limb amputees, rehabilitation professionals working in LMICs should focus on delivering comprehensive multidisciplinary rehabilitation services.
- Orthopaedic personnel should ensure complete and accurate documentation of patient information following amputation to enable effective tracking and monitoring of patient care to improve outcomes of rehabilitation.

Abbreviated terms

AEA	Above-elbow amputations
AHPC	Allied Health Professionals Council
BEA	Below elbow amputations
CoRSU	Comprehensive Rehabilitation Services for People with Disability in Uganda
EVA	Ethylene-vinyl acetate
FPRRH	Fort Portal Regional Referral
HMIS	Health Management Information System
ICRC	International Committee of the Red Cross
ISPO	International Society for Prosthetics and Orthotics
LLA	Lower limb amputation
LMICs	Low-and-Middle-Income countries
MLL	Major Limb Loss
MNRH	Mulago National Referral Hospital
MoH	Ministry of Health
MRRH	Mbale Regional Referral
NGO	Non-Government Organisations
NRSTS	Non-Rhabdomyosarcoma Soft Tissue Sarcoma
P&O	Prosthetics and Orthotics
PoP	Plaster of Paris
PVA	Polyvinyl Alcohol
RRH	Regional Referral Hospital
RTA	Road traffic accidents
RTA	Road traffic accidents
STS	Soft Tissue Sarcoma
ULA	Upper limb amputation
UOTA	Uganda Association of Orthopaedic Technologists
WHO	World Health Organisation

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ABSTRACT

Background: Low-income-and-middle-income countries (LMICs) have a large burden of major limb loss. No recent study has reported on Uganda's state of public sector prosthetics services. This study aimed to document the landscape of major limb loss, and the structure of available prosthetics services in Uganda.

Methods: This study involved a retrospective review of medical records at Mulago National Referral Hospital, Fort Portal Regional Referral Hospital, and Mbale Regional Referral Hospital, and a cross-sectional survey of personnel involved in the fabrication and fitting of prosthetic devices across orthopaedic workshops in the country.

Results: Upper limb amputations accounted for 14.2%, and lower limb accounted for 81.2%. Gangrene (30.3%) was the leading cause of amputation, followed by road traffic accidents and diabetes mellitus. Orthopaedic workshops offered decentralised services, and most materials used were imported. Essential equipment was largely lacking. Orthopaedic technologists had diverse experience and skillsets, but many other factors limited their service provision.

Conclusion: The Ugandan public healthcare system lacks adequate prosthetic services both in terms of personnel and supporting resources, including equipment, materials, and components. The provision of prosthetics rehabilitation services is limited, especially in rural regions. Decentralising services could improve patients' access to prosthetic services.

Keywords

Major limb loss, Low-and-middle-income countries, Prosthetics services; decentralisation, Ugandan Referral Hospitals; orthopaedic technologists

Introduction

Major Limb Loss (MLL), defined as the partial or total severance of an extremity when done at or proximal to the wrist or ankle, is a widely recognised health challenge, especially in low-and-middle-income countries (LMICs) [1-3]. A recent report by ATscale2030 indicated that 1.5 million people are amputated annually, with up to 65 million living with amputations globally [4]. The leading causes of MLL worldwide are diabetes mellitus, trauma, and peripheral vascular diseases [5-7]. In the coming years, factors such as unhealthy diets and sedentary lifestyles will contribute to an increase in amputations related to peripheral vascular diseases, especially resulting from diabetes mellitus [8]. Several studies [3,9-11] have linked the burden of MLL with various adverse physical, psychological, social, and economic outcomes of amputations that may have devastating effects on individuals, families, and society.

Over 80% of the global MLL population is estimated to live in low-and-middle-income countries [12]. The incidence of MLL in LMICs has, until recently, been hugely dominated by trauma, primarily due to road traffic accidents, and violence-related injuries, especially domestic violence [8,13]. Despite the recent global drive to improve equitable access to health services for people with disabilities, LMICs still lag behind [14-16]. Over 30 million people in LMICs are believed to require prosthetic services, yet in some countries, only 3% have access to them [17]. The available LMIC-based services are often highly dependent on donated prosthetic devices. Despite their well-meaning intentions, donations have led to the underutilisation or complete abandonment of devices because many do not meet the users' needs and expectations [18]. The situation is even worse for people with upper-limb loss, as even in high-resource settings, rejection rates of devices are high [19,20]. Without good quality data on the

prevalence of limb loss and the state of current services, it is difficult for stakeholders to plan on how to address these issues effectively [21].

This study focuses on Uganda, a country of 48 million people [22], and reports on work carried out in a collaborative research project focused on developing improved upper limb prostheses. Approximately 12.5% of Uganda's population aged five and over lives with some form of disability, with 35.3% having loss and/or limited use of extremities and the majority living in urban areas [23,24]. In the 1990s, Uganda suffered internal conflict concentrated in its north, which left many victims of limb loss [25]. Today, the country hosts about 1.5 million refugees, especially from war-torn neighbouring countries [26]. In Uganda and other LMICs, the primary focus for prosthetic rehabilitation is on lower limb amputations (LLA), and upper limb amputations (ULA) do not receive the same attention and services. A few studies have reported on amputee demographics in the north, post-conflict, focused on the Acholi region [3,27], and two other studies reported disability statistics related to road traffic accidents in other parts of the country [28,29]. However, no study has reported on Uganda's state of public sector prosthetics services.

This descriptive study aims to establish characteristic data on the landscape of major limb loss; highlighting the upper limb and the structure of existing prosthetic services in Uganda. The findings reported in this study provide a baseline for other stakeholders and service providers to plan and develop prosthetics and orthotics (P&O) programmes and services in Uganda.

Methods

Ethical considerations

Makerere University School of Biomedical Sciences Research Ethics Committee (SBS-641) and the Uganda National Council for Science and Technology (ADM 194/212/01) approved the study. No personal identifying information was collected on the data collection forms to protect patient privacy. Collected data was coded to remove identifying information and stored on a password protected KoboToolbox server that only the researchers had access to, and only aggregate findings were reported.

Study design

The study used a descriptive approach and included a retrospective review of medical records [30] and a cross-sectional questionnaire-based survey of personnel involved in the fabrication and fitting of P&O devices.

The review of medical records was conducted at three public regional referral hospitals, including Mulago National Referral Hospital (MNRH), Fort Portal Regional Referral (FPRRH), and Mbale Regional Referral (MRRH) in central, western, and eastern Uganda respectively. A secure online/offline digital data collection form adapted from Okello et al., 2019 [3] was designed in KoBoToolbox Global Server Version 2.022.08 and deployed at each hospital. The form was used to assess patient demographics and details of amputations performed between 2015 and 2021.

The cross-sectional survey involved a quantitative exploration of the technical capacity of orthopaedic centres and personnel to provide the prosthetic services they are expected to provide. A self-evaluation questionnaire with closed-ended questions was designed based on WHO guidelines for training personnel in developing countries for

P&O services [31] and the AT2030 prostheses product narrative [4] and hosted online on KoboToolbox. The questionnaire was used to collect data on the education and professional backgrounds of personnel, their technical skills, and the availability of key resources (such as equipment, materials, and funding) necessary to deliver prosthetic services.

Sampling

During the review of patient records, a convenience sampling approach [32] was used because there was limited information about amputations. All patients who had undergone any level of lower or upper limb amputation or sought prosthetic services at MNRH, FPRRH, or MRRH orthopaedic theatre, ward or workshop between May 2015 and December 2021 were included. Instances where amputation-related information was 'not specified' were captured and considered during analysis. Patients who were recorded as only having received orthotic services and any records dated earlier than May 2015 were excluded.

Survey participants were purposively targeted [33] to ensure that a representative sample of orthopaedic personnel working in various orthopaedic workshops across the country was reached. Personnel who were registered members of nationally recognised professional bodies, namely, the Uganda Association of Orthopaedic Technologists (UOTA)[1] and the Allied Health Professionals Council[2] (AHPC), were particularly targeted. To be included, participants must have been employed as prosthetists, orthopaedic technologists[3], or orthopaedic technicians[4] at any public, private-not-for-profit or private-for-profit hospitals, or private companies nationwide. They also must have had a minimum of two years of experience providing amputees with prosthetic care.

Although ISPO has changed the terms 'orthopaedic technologist' and 'orthopaedic technician' to 'associate prosthetist/orthotist' and 'prosthetic/orthotic technician' [34], personnel still referred to themselves as 'orthopaedic technologist' or 'orthopaedic technician' at the time of data collection. The eligible population was estimated to be 500, from which a representative sample size was calculated using the Taro Yamane formula [35]. The percentage maximum acceptable error (precision level) was set to ±10%, the confidence level at 95%, and the percentage occurrence was estimated at 50%. A sample size of eighty-three participants was calculated and considered for the study.

[1] A recognised professional association for orthopaedic technologists and technicians in Uganda

[2] A regulatory body that was established to regulate, supervise, and control the training and practice of Allied Health Professionals in Uganda

[3] Clinical personnel, whose training involved completion of an approved 3- or 4-years course of education and who are authorised by the AHPC to evaluate, design, fabricate and fit orthopaedic appliances to restore the quality of life (QoL) for clients

[4] Technical personnel that have either completed at least a 4-year apprenticeship or two years of formal training with a focus on P&O device fabrication

Data collection

a) Retrospective medical records review

Data was collected in 2021. Patient medical records from the orthopaedic theatres, wards, and workshops at MNRH, FPRRH, and MRRH were reviewed by research assistants under the supervision of the lead researcher. Administrative clearance was obtained at each hospital to access patient records. Data was collected on relevant demographic information, including gender, age, residential village, and amputation characteristics, including the type of amputation (LLA, ULA), indication, and prosthesis usage. LLAs were defined as unilateral or bilateral amputations (or disarticulations)

below or above the knee, through the hip, knee, or ankle joints, or foot & partial foot. For ULA, amputations (or disarticulations) below or above the elbow, through the shoulder, elbow, or wrist joints were all considered major. Although hand or partial hand amputations were not considered major upper limb amputations [1,2], their incidences were recorded but excluded from the total frequency of levels of ULA.

Patient records at MNRH were retrieved from patient registration manuscript books at the orthopaedic workshop, hospital-issued registration books at the orthopaedic trauma theatre, and Ministry of Health (MoH) patient database logbooks at the trauma ward. At the time of the study, there was no operational orthopaedic theatre or ward at FPRRH. Records were obtained from the main operating theatre Health Management Information System (HMIS) logbooks, and clinical notes recorded in the general surgical ward report manuscript books. FPRRH orthopaedic workshop records for January to December 2021 were retrieved from a computerised record system and earlier records from an HMIS patient registration logbook. At MRRH, information was collected from the orthopaedic workshop's HMIS outpatient registers, the orthopaedic ward's rounds report manuscript books and an online reporting system implemented at the orthopaedic operating theatre.

Google Maps was used to estimate and calculate the shortest road distance in kilometres (km) from each patient's residential village to the orthopaedic department where they received services. All this data was collated onto an online server hosted by KoboToolbox via the data collection form. Latitude (Y) and longitude (X) coordinates were obtained from Google Maps and tabulated into spreadsheets.

b) Cross-sectional self-evaluation survey of orthopaedic personnel

The survey questionnaire was sectioned into three profiles: the personnel, services and

resources, and the skillset.

(1) The personnel profile was used to collect data on participants' educational and professional backgrounds and identify accreditation and professional development pathways.

(2) The services and resources profile explored decentralisation models of P&O services [4], funding pathways and commonly used supplies (*specifically materials*), and availability of essential equipment at orthopaedic workshops (adapted from the *WHO Medical Equipment List for Typical District Hospital, Kenya* [36]).

(3) The skillset profile applied a 5-point Likert scale to rate the technical capacity of personnel to perform tasks including; clinical assessment, design, fabrication, fitting and alignment of P&O devices, among others, as predetermined by *WHO/International Society for Prosthetics and orthotics (ISPO) Category I, II, and III guidelines* [31,37].

Information about the survey was presented at the UOTA Annual General Meeting in October 2021. A link to the online questionnaire was distributed to members via the association president, who had access to a member contact database. Additionally, a research assistant provided paper-based questionnaires at the orthopaedic workshops during records review and later uploaded the responses to the online KoboToolbox server. Before enrolling in the survey, informed consent was obtained from each respondent. Contact information of the local ethics committee chairperson and the lead researcher was provided to participants in case they had any questions or concerns about the study or their rights.

Data analysis

Data was preliminarily analysed using graphs and figures in an automated report generated by KoBoToolbox. Records review data and returned surveys were exported from KoboToolbox and collated into two separate spreadsheets. The sheets were checked for duplicates and incomplete datasets, which were excluded from the analysis. The data was then labelled and statistically analysed in Microsoft Excel Version 2205. Descriptive data were used to establish trends, presented as frequency, percentage, and graphs, from which gaps in service provision were identified and discussed. Latitude and longitude spreadsheets were imported into ArcGIS Pro 2.8.0, which was used to map the locations onto a base map and shapefile obtained from the Humanitarian Data Exchange database [38].

Results:

Retrospective medical records review

A total of 634 records of patients who had undergone major limb amputation between May 2015 and December 2021 were considered for analysis. Most patients (265; 41.8%) were in the age range of 36–65. Male patients made up 425 (67.0%) of all patients, with a female-to-male ratio of 2:1 (Table 1).

Upper limb amputations accounted for ninety cases (14.9%) of all amputations, while lower limb amputations accounted for 515 cases (85.1%), giving a 6:1 ratio between LLA and ULA. Twenty-nine patients had missing data on the type of amputation. Nineteen of the 90 upper limb amputations were partial hand amputations and were excluded from the total frequency of the levels of major ULA. Seven non-specified levels of ULA were also excluded. Of the 64 major occurrences of ULA, 38

(59.4%) were above the elbow (including shoulder disarticulation; n=15, and fore quarter; n=1), while 26 (40.6%) were below the elbow (including wrist disarticulation; n=8). Table 1 summarises the detailed analysis of this dataset.

Table 1 here

Of the 634 patients, only 266 (42.0%) had residential information recorded, while the majority, n=368 (58.0%), did not. Patients travelled a mean distance of 65.4 km to any referral hospital (a range of 0–554 km). While most of the patients, 156 (58.7%), travelled between 0 and 49 km, six patients (2.3%) moved over 300 km to access an orthopaedic service at MNRH, FPRRH, or MRRH. *Figure 1* illustrates the population distribution of patients from the referral hospitals where they accessed orthopaedic services.

Figure 1 here

Indications for amputation

From the entire dataset, the indication for amputation was recorded for 416 patients (65.6%). Amputations were predominantly caused by (30.3%), followed by road traffic accidents (RTA) (15.9%), diabetes (12.0%), trauma (7.2%), sarcomas (6.7%), and septic wounds (6.3%). Other indications accounted for a total of 21.6%. Trauma-related amputations were defined as those caused by crush injuries, machine injuries, accidental falls, and bicycle accidents, excluding RTA. While RTA is one of the major causes of trauma, it was excluded from the overall total of trauma-related amputations due to its substantial frequency. Osteosarcoma was the most prevalent malignant tumour. Figure 2 shows the distribution of indications. From the figure, many of the indications (n=218, 34.4%) were not registered in the patient records, suggesting the need for improved

documentation practices.

Figure 2 here

Results from self-evaluation survey of orthopaedic personnel

A total of nineteen responses were received from private and public sector organizations, including Orthotech and Physical Rehabilitation Limited and CoRSU Hospital, as well as MNRH, FPRRH, MRRH, Lira RRH, Gulu RRH, school of orthopaedic technology, and Chieftaincy of Mubende rehabilitation centre: a military rehabilitation centre. The majority (n=17) worked in public-sector hospitals. Fourteen orthopaedic technologists, four prosthetists/orthotists, and one orthopaedic technician participated in the study. Ten participants held bachelor's degrees in fields unrelated to orthopaedic technology, including pharmacy, health administration, and biomedical lab technology, eight had diplomas in orthopaedic technology, and one had a master's degree in public health. The majority had more expertise in providing lower limb prosthetic services as compared to the upper limb. Table 2 shows data on the education and professional profile of the participants.

Table 2 here

The services provided and resources available at orthopaedic workshops are summarised in table 3. Most of the participants indicated that decentralised orthopaedic services were offered at their workshops, although four said that none of the services were provided at their workshops. Figure 3 below shows how participants self-rated their ability to perform tasks required for optimal P&O service provision. All participants were confident in their ability to provide essential orthopaedic services and support services including physiotherapy, paraplegic support, fabrication of club foot

orthoses, and psychological counselling to patients. Plaster of Paris and plastics, among other commonly used materials were imported from Germany, India, South Africa, and others. Ottobock (Germany), the International Committee of the Red Cross (ICRC), and Endolite (India) were the leading international suppliers. Some materials, such as wood, buckles, rivets, and EVA could be purchased locally from Orthotech and Physical Rehabilitation Ltd., Joint Medical Stores, and Leos Orthopaedic Centre Ltd. Most of the essential orthopaedic equipment required for P&O service provision, including P&O kits, vacuum laminating machines, air compressors, and PVA sealing machines were reported lacking from the workshops. The government, through the MoH (12/19; 63.2%) and non-governmental organisations (NGOs) (10/19; 56.63%), were the primary sources of funding for the orthopaedic workshops.

Table 3 here

Figure 3 here

Discussion:

Broadly consistent with the findings of Okello et al. [3] in Northern Uganda, Chalya et al. [39] in Tanzania, and Yempabe et al. [16] in Ghana, most of the amputees were male (67.0%), between the ages of 19 and 65. A significant part of this distribution can be attributed to the fact that relatively young men of working age are more prone to engaging in activities like motorcycling (locally referred to as 'boda-boda'), and operating heavy industrial machinery, which increases their risk of sustaining traumatic injuries that may result in amputations [40,41]. Also consistent with other reports, the majority of amputations performed at these hospitals were for the lower limb [1,3,16,42-45]. The ratio of LLA:ULA found in this study is similar to that reported by

Chalya et al. [39] in Tanzania. The relatively low known prevalence of ULA likely contributes to the limited advancements in upper limb prosthetics compared to lower limb prosthetics globally, especially in resource-constrained settings [46]. The bias in caseloads favouring LLA may also suggest that orthopaedic personnel become more competent in practising lower limb prosthetics [47]. The most common level of upper limb loss was above-elbow amputations (AEA) (59.4%), followed by below-elbow amputations (BEA) (40.6%), and a similar trend was seen in studies done in Malawi, Nigeria, Ethiopia, and Rwanda [1,10,40,48].

The distance patients travel to hospitals is relevant to healthcare planning, particularly for access to services. Understanding how far patients are willing to travel to access orthopaedic services may be indicative of the availability of adequate access to these services. In this study, patients lived a mean distance of 65.4 km from the hospital where they accessed orthopaedic services. Six patients travelled over 300km to access services at a RRH outside their home region. Travelling longer distances to receive orthopaedic services would be expected for MNRH, as it is the convergence point of all referrals. However, for the RRHs, this phenomenon may be driven by the limited availability of specialised rehabilitation services at nearby hospitals. Interestingly, some studies showed that mothers in rural Tanzania and Eastern Uganda seeking obstetric service delivery would bypass nearer facilities due to inadequate human or supporting resources, including infrastructure, medical equipment, or medicine [49,50]. This finding has an important implication for the healthcare system and clearly shows the need to improve orthopaedic service delivery at even the higher hospital levels to overcome barriers to rehabilitation, such as high transportation costs and geographic distance.

Although the indication for amputations varied between hospitals, gangrene was the leading indication, accounting for 30.3% of cases where the cause was documented. This finding that gangrene was the most common cause of limb loss was also reported by Onwuasoigwe et al. [2], Salawu et al. [51], and Agu & Ojiaku [52] in Nigeria, Grudziak et al. [10] in Malawi, and Murwanashyaka et al. [48] in Rwanda. It should be noted that gangrene is a secondary condition that results from necrosis in a limb due to lack of blood circulation, injury, or infection and can result from diabetes or infection of trauma injuries [53,54]. As the global burden of diabetes has increased significantly in recent decades [55], it indicates that the number of diabetic patients who develop gangrene may also increase. The present situation suggests a serious threat to the healthcare system and calls for governments and other stakeholders to take immediate action. Although there is a lack of information on the prevalence of diabetes in Uganda, with a 2016 study [56] estimating the overall prevalence to be low (1.4%), rapid changes in lifestyle and economy could increase the risk and prevalence of diabetes [57].

Key information (such as residential area, indication for amputation) necessary for patient follow-up, and monitoring was either partially registered or not registered at all in the patient records. For example, only rarely was any information registered in the records for the cause of gangrene. The unsatisfactory quality of clinical record-keeping uncovered in this study highlights the need for improved documentation and record-keeping practices to enhance the provision of comprehensive patient care. Well-controlled prospective studies are needed to fully understand the major causes of limb loss in Uganda. The study also indicates considerable scope for improvement in wound management practices.

The majority (n=14) of respondents were orthopaedic technologists. In many LMICs, orthopaedic technologists are at the centre of P&O service delivery for patients, especially post-amputation. Integration of comprehensive multidisciplinary rehabilitation services, including the availability of a sufficient number of trained rehabilitation physicians or physio/occupational therapists to facilitate the transition of patients back to their communities, is lacking in P&O healthcare systems, especially in LMICs. Consequently, technologists are left responsible for providing comprehensive services to patients following amputation, including occupational, physical, and psychological aspects of rehabilitation [58]. Given the potentially huge patient load and minimal resources available, this may in turn adversely affect the quality of care and outcomes of rehabilitation for patients.

All participants in this study were practising P&O personnel in major rehabilitation workshops in Uganda, and it can be reported that they have all received some form of training in orthopaedic technology. Just under half of the participants had been trained at the School of Orthopaedic Technology, the only specialised training centre in Uganda that offers a Diploma in Orthopaedic Technology. Even though the MoH and the Uganda National Council for Higher Education recognise the school, it is not an ISPO-certified training institute. Only eight participants had received training from the Tanzania Training Centre for Orthopaedic Technologists (TATCOT), a certified ISPO Category-II training institute established to provide regional training. However, the diploma course in orthopaedic technology at TATCOT can admit only 15 students each year, which is insufficient to meet the demands for skilled personnel in East Africa[59]. Although there is very little evidence on the direct effect of education of P&O personnel on their service provision [60], it can be argued that the level of training and skills imparted during that training may greatly impact the quality of

services personnel can provide. Many of the participants said they had been working in the field of orthopaedic technology for over ten years, with thirteen participants specialising in the lower limb and only 3 in upper limb prosthetics. There is a significant gap in provision of services for upper limb amputees, even though upper limb amputations are more challenging to manage.

Decentralisation of P&O services through outreaches, mobile clinics, and telerehabilitation and integrating them into lower levels of healthcare systems could be the answer to bringing these services closer to users. However, these decentralisation models are not without challenges in scaling, quality control and cost-effectiveness [4]. From this study, it was clear that respondents were well conversant with service outreaches, while the other decentralisation models were less famous. Participants were confident in providing services aimed at reskilling patients to return to work or addressing quality of life issues. However, factors like resource constraints mean these services cannot be brought closer to patients, and those living in rural areas have to incur high transport costs to be seen [61]. This situation was made much worse during the COVID-19 pandemic when patients could not have face-to-face interactions with the technologists, and as a result, service provision was constrained [62].

To fabricate high-quality prostheses most efficiently, P&O service units require a consistent supply of high-quality components, materials, and consumables [63]. In Uganda, and many other LMICs, access to these components is often limited [58], and it is difficult to manufacture durable, serviceable prostheses due to the high production costs. One of the respondents noted that a patient would have to be referred if the materials required were unavailable at the facility. Numerous studies in South Africa, Tanzania, Malawi, Sierra Leone, and Ghana have highlighted the difficulties associated with the provision of amputee rehabilitation services due to the limited resources

available [64-67]. This study showed that international material suppliers outperform the local capacity, availability, and reliability in supplying quality P&O supplies. Additionally, as each user is likely to purchase these materials independently from a supplier outside the country, excessive costs and lengthy delays hamper service provision. This suggests great scope for improvements to be made via a more integrated supply chain system for P&O supplies.

Participants reported that most of the orthopaedic workshop funding came from the government and non-governmental organisations. However, data on the Uganda National Health Expenditure [68]showed that rehabilitation care had no budget allocation in the financial year 2018/2019. This means orthopaedic workshops depend heavily on NGOs [58] to provide financial support, materials, and assistance. Even in public sector hospitals, it is common for patients to be asked to pay for components, which is often a barrier to accessing services [61,69]. Of equal concern, we found that some of the essential equipment needed to deliver adequate prosthetic services were either missing or in a poor state of repair at the workshops. Based on their self-evaluation, participants were competent in applying many of the skills recommended in the ISPO training curriculum for Category I and II professionals. However, because there is a lack of emphasis on research-oriented practice, orthopaedic personnel are not geared toward research and design of fit-for-purpose cutting-edge technologies for patients [70,71]. Without maintained and serviced equipment and a reliable supply system of necessary P&O materials, the skillset of orthopaedic personnel cannot be fully utilised, and patients receive poor service.

Limitations

It was observed that key patient information was missing from record files. For

instance, patient residential villages were missing for 58.0% of the records reviewed. The problem was particularly acute at MNRH, where healthcare personnel only recorded observations or information they regarded as important. Also, data on whether patients had received prostheses from orthopaedic workshops was not correctly registered and could not be included. Similar poor levels of record-keeping have been reported in studies of nurses in Ugandan hospitals [72,73]. Reasons for this consistently observed problem may comprise organisational issues, high patient numbers resulting in fatigue on the job, the high volume of often difficult issues that need to be solved to deliver services, and a lack of continuous monitoring and incentive systems. Omission of patient information could result in communication pathways breaking down amongst health professionals, a lack of follow-up mechanisms to track care decisions and goals, a lack of clear planning and budgeting, and excessive amounts of time wasted during care provision. Additionally, the subjectivity of the responses from participants was a limitation, particularly when it came to reporting their experiences and skillsets.

Conclusion

The Ugandan public healthcare system lacks adequate P&O services both in terms of personnel and professional training, and supporting infrastructure and resources, including equipment, and supplies including materials and components. The provision of prosthetics and general orthopaedic rehabilitation services is limited, especially in rural regions, contributing to increased poor outcomes of amputation. Decentralising orthopaedic workshops and strengthening supply chains could improve access to these services and encourage collaboration between healthcare workers and the community, which is vital to improving the long-term outcomes following major limb loss. Additionally, providing comprehensive multidisciplinary rehabilitation services for both

lower and upper limb amputees can improve patient outcomes and the chances of achieving acceptable levels of functionality following amputation. There is an urgent need for clinical personnel to improve the quality of patient record keeping. This will provide a solid foundation for adequate research in the future and ensure that complete and accurate data is available for analysis.

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Table 1: Distributions of patient characteristics based on recruitment, age, gender, type and level of ULA, between May 2015 and December 2021.

	Frequency, f (Percentage, %)			
	FPRRH *f (%)*	**MNRH** *f (%)*	**MRRH** *f (%)*	**Total** *f (%)*
Age				
Adult (36-65 years)	97 (15.3)	75 (11.8)	93 (14.7)	265 (41.8)
Youth (19-35 years)	57 (9.0)	100 (15.8)	39 (6.2)	196 (30.9)
Elderly (>65 years)	33 (5.2)	34 (5.4)	25 (3.9)	92 (14.5)
Child (1-18 years)	32 (5.0)	31 (4.9)	18 (2.8)	81 (12.8)
Total	***219 (34.5)***	***240 (37.9)***	***175 (27.6)***	***634 (100)***
Gender				
Male	132 (20.8)	180 (75.0)	113 (64.6)	425 (67.0)
Female	87 (13.7)	60 (25.0)	62 (35.4)	209 (33.0)
Total	***219 (34.5)***	***240 (37.9)***	***175 (27.6)***	***634 (100)***
Type of amputation				
Lower limb amputation	183 (30.2)	201 (33.2)	131 (21.7)	515 (85.1)
Upper limb amputation	36 (6.0)	37 (6.1)	17 (2.8)	90 (14.9)
Total	***219 (36.2)***	***238 (39.3)***	***148 (24.5)***	***605 (100)***
Not specified [a, b]	0	2	27	29
Level of amputation (ULA)				
Above elbow amputation	8 (12.5)	12 (18.8)	2 (3.1)	22 (34.4)
Below elbow amputation	12 (18.8)	2 (3.1)	4 (6.3)	18 (28.1)
Shoulder disarticulation	4 (6.3)	8 (12.5)	3 (4.7)	15 (23.4)
Wrist disarticulation	2 (3.1)	5 (7.8)	1 (1.6)	8 (12.5)
Fore Quarter amputation	0	1 (1.6)	0	1 (1.6)
Total	***26 (40.6)***	***28 (43.8)***	***10 (15.6)***	***64 (100)***
Partial-Hand Amputation [b, c]	9	8	2	19
Not specified [b]	1	5	1	7

[a] Recorded as '*amputation*', or only indication of amputation recorded

[b] Excluded from percentage distribution calculation

[c] Hand or partial hand amputation was not considered major ULA

Table 2: Characteristics of personnel providing prosthesis services. Education and professional profile of participants

Characteristic	Frequency (%)**
Job description	
Orthopaedic technologist	14 (73.7)
Prosthetist & Orthotist	4 (21.1)
Orthopaedic technician	1 (5.3)
Total	***19 (100)****
Maximum level of education	
Bachelor's degree	10 (52.6)
Diploma (or equivalent)	8 (42.1)
Master's degree	1 (5.3)
Total	***19 (100)***
Training school	
School of Orthopaedic Technology	10 (52.6)
TATCOT	4 (21.1)
Both	4 (21.1)
Others	1 (5.3)
Total	***19 (100)****
Expertise	
Lower Limb prosthetics	13 (81.3)
Upper Limb prosthetics	3 (18.8)
Total	***16 (100)****
Not Specified*	3
Years of experience	
2 – 10	2 (12.5)
11 – 20	11 (68.8)
> 20	3 (18.8)
Total	***16 (100)****
Not Specified*	3

* Excluded from percentage calculation

** Percentages have been rounded and may not total to 100%

Table 3: Orthopaedic services and resources available for P&O service provision

	Frequency (%)**
Decentralisation models adopted by facility	
Orthopaedic services and outreaches	13 (68.4)
Tele-rehabilitation	8 (42.1)
Mobile orthopaedic clinics	5 (26.3)
Satellite services	2 (10.5)
None of the above	4 (21.1)
Services offered by individuals	
Prosthetic and assistive devices fabrication and assembly	19 (100)
Bracing, casting and splinting	19 (100)
Maintenance, repair and follow-up	17 (89.5)
Counselling	16 (84.2)
Orthopaedic shoe making	11 (57.9)
Education	10 (52.6)
Reskilling	5 (26.3)
Others	3 (15.8)
Commonly used materials	
Plaster of Paris	18 (94.7)
Plastics and other polymers	17 (89.5)
Leathers	17 (89.5)
Metal and metal alloys	15 (79.0)
Wood	9 (47.4)
Fabric	8 (42.1)
Others	7 (36.8)
Access to materials	
Mostly imported	16 (84.2)
Locally available	3 (15.8)
Major Funders	
Government (MoH)	12 (63.2)
NGOs	10 (52.6)
Private sector	4 (21.1)
Donors	5 (26.3)
Clients	5 (26.3)
None of the above	2 (10.5)
Others	4 (21.1)

** All percentages have been calculated based on 19 responses

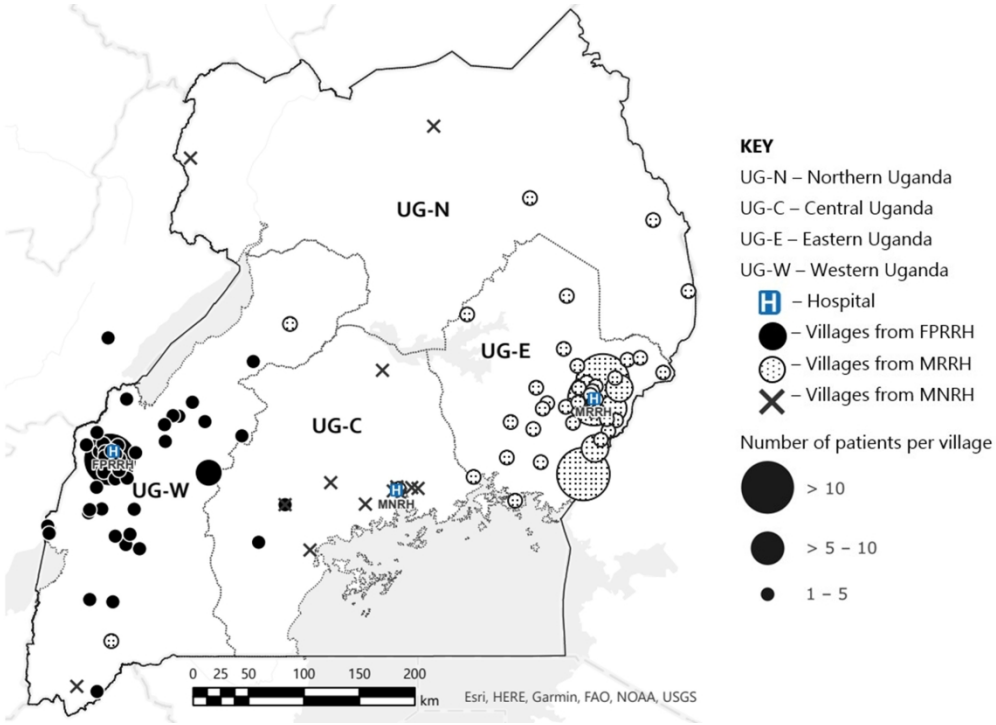

Figure 1 Caption: A map of Uganda showing population distribution of patients from the hospitals where they receive orthopaedic services.

Figure 1 Alt Text: A map of Uganda illustrating the population distribution of patients who received orthopaedic services from regional referral hospitals in the central, eastern, and western regions of Uganda. The number of patients per village and the distance between hospitals and patient villages are used to group patients.

179x129mm (330 x 330 DPI)

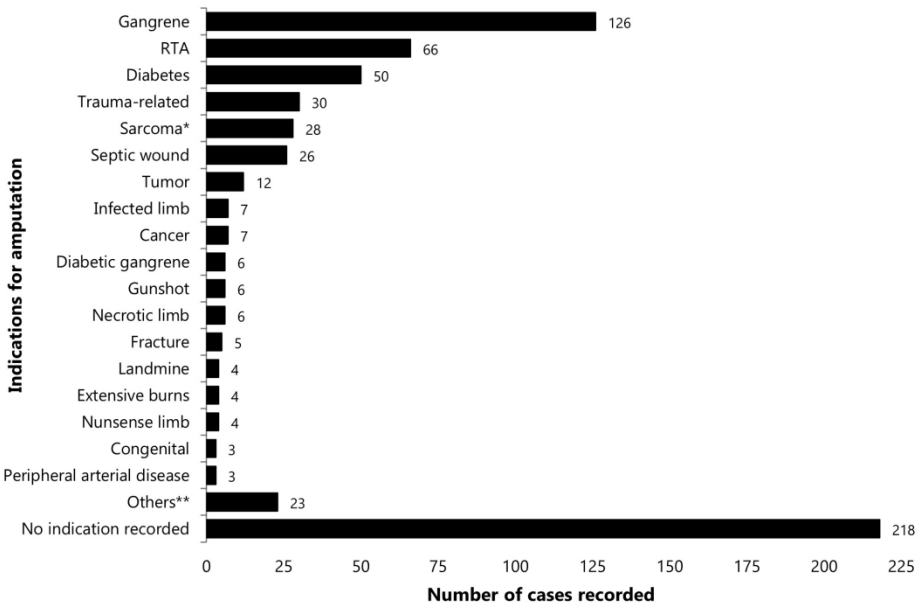

Figure 2 Caption: Indications for amputation. Distribution of amputations by frequency of occurrence. %"* Sarcoma included osteosarcoma(18), fibrosarcoma(2), NRSTS(1), Rhabdomyosarcoma(1), Kaposi's sarcoma(3), STS(1), synovial sarcoma(2). ** Others were assault, human bite, foot ulcer, pathology, domestic violence, self-injury.%"

Figure 2 Alt Text: A clustered bar graph of indications for amputation (y-axis) versus the number of amputation cases recorded due to those indications. Gangrene is the leading indication (n=126), followed by road traffic accidents (66), diabetes (50), trauma-related (30), sarcomas (28), septic wounds (26), tumours (12), infected limbs (7), cancer (7), diabetic gangrene (6), gunshot (6), necrotic limb (6), fracture (5), landmine (4), extensive burns (4), Nunsense limb (4), congenital (3), peripheral arterial disease (3), and other indications (23). Most indications were missing from the records (n = 218)

170x105mm (330 x 330 DPI)

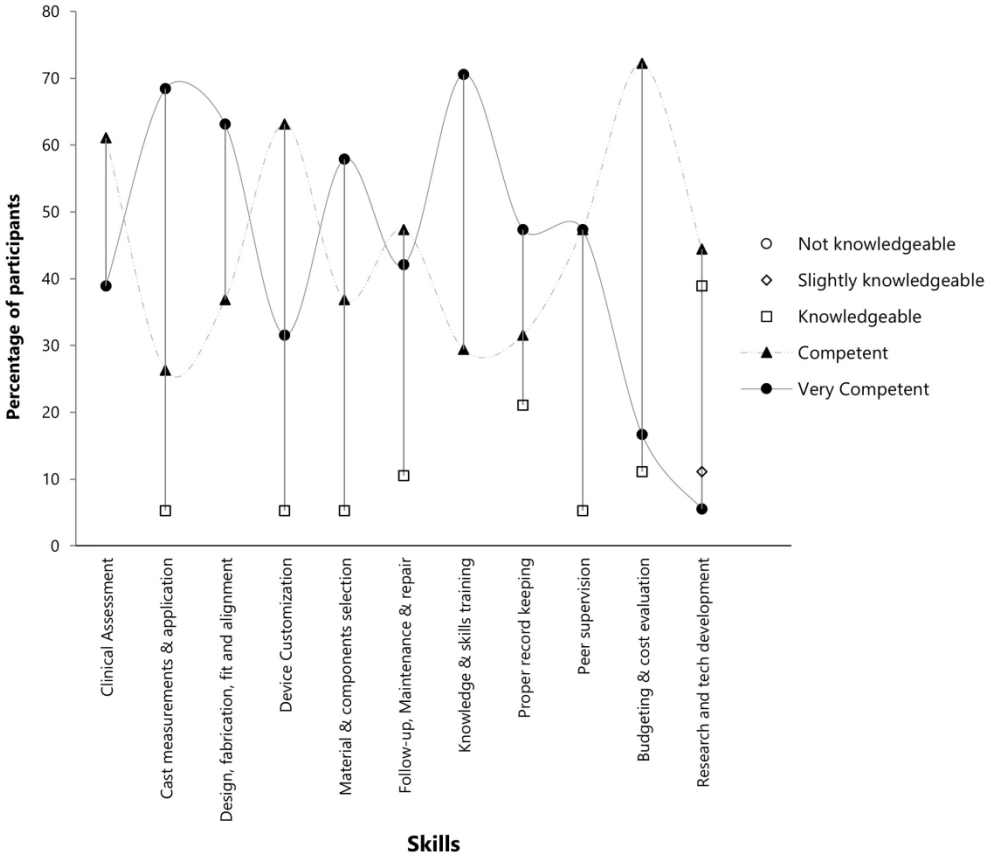

Figure 3 Caption: A graph illustrating participants' self-rating of their ability to perform tasks required for optimum P&O service provision.

Figure 3 Alt Text: A marked scatter plot with an x-axis showing the percentage of participants who rated a given skill and a y-axis showing the skills. It is a Likert scale rating (from very competent 5, competent 4, knowledgeable 3, slightly knowledgeable 2, to not knowledgeable 1) of participant skills including research and tech development, budgeting and cost evaluation, peer supervision, proper record keeping, knowledge and skill training, follow-up maintenance and repair, material and component selection, device customization, design fabrication fit and alignment, cast measurements and application, and clinical assessment. The plot shows that respondents were mostly competent and very competent.

173x155mm (330 x 330 DPI)