

# **Prosthetics services in Uganda: A series of studies to inform the design of a low cost, but fit-for-purpose, body-powered prosthesis.**

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## **Abstract**

The majority of people with upper limb absence (PWULA) live in lower, or middle-income countries (LMICs). However, efforts to develop improved prostheses have largely focused on electrically powered devices, sustainable deployment of which, in LMICs, is difficult. In the 'Fit-for-purpose, affordable body-powered prostheses' project, teams from the United Kingdom, Uganda and Jordan are developing mechanically-operated prostheses, optimised for LMICs, and establishing local methods for fabrication, fitting and evaluation. Here we first report on preliminary studies aimed at grounding the project in the reality of current prosthetics services and the experiences of people with limb absence in Uganda. Finally, we outline our ongoing work in the context of our findings.

In our first two studies we reviewed current prosthetics and associated repair services. An issue which came up repeatedly was the difficulty faced by orthopaedic technologists in accessing componentry/materials. All specialised prosthetics components and materials are imported, often at a high cost. Purchasing does not appear to be well coordinated between centres, meaning potential economies of scale are not being fully exploited. Although there is supposed to be government funding for prosthetics, in practice budgets are often inadequate and a reliance on donations is common. The resource limitations mean Orthopaedic Technologists often resort to ad-hoc solutions; unsurprisingly perhaps, failures in prostheses were reported. In particular, lamination-based socket manufacture is very difficult, given the complexity (and cost) of the processes involved. Repair services are also limited, in part also due to problems accessing materials/components. Despite (or in part, as a result of) these challenges, the orthopaedic technologists are generally an extremely

resourceful and multi-skilled group and there is genuine enthusiasm to see services improve. Further, there is a growth in interest and capabilities in the area of medical device innovation.

In the third of our studies, we interviewed 17 PWULA and present preliminary results from the analysis of a subset of five participants. Firstly, we found that only 2 of the participants reported experience with using an upper limb prosthesis, again supporting the picture which emerged from the other studies. The findings illustrate the emergence of four key themes: a) attitude towards disability; b) barriers to prosthesis use; c) coping without a prosthesis; and d) communication with other PWULA. Although attitudes to those with limb loss varied, participants reported impacts in terms of social isolation and a mixed experience of emotions that appeared predominantly negative; barriers to prosthesis use were broader than just cost and functionality, and included a lack of training and psychological support; given that it is difficult to access an upper limb prosthesis, PWULA have found ways to perform daily life activities without relying on one; finally, most PWULA find the suggestion of communicating with other people with the same experience appealing.

In our project we are addressing some of the issues found in the preliminary studies. To make socket manufacture less dependent on access to imported materials and specialised equipment, we are investigating the development of lattice-style, adjustable sockets, made from locally available materials. We are also investigating alternatives to the traditional harness-controlled, body-powered prosthetic hands. Given that clinicians have no objective means of evaluating the value of the prosthesis to their clients, we are testing the use of low-cost digital monitoring tools. We are also exploring the potential value of using mobile-phones to reduce the isolation of PWULA. Finally, we are exploring how these innovations may be translated into the Ugandan health setting.

### **Keywords**

Prosthetics; upper limb; low cost; fit-for-purpose; body powered; Uganda; manufacturing; fitting; repair; user needs; user experiences; monitoring real-world use of prostheses.

### **Introduction**

The majority of PWULA live in lower, or middle-income countries (LMICs), likely due to factors such as road traffic accidents, armed conflict and industrial accidents. By contrast, most of the studies into the consequent impacts have been carried out in high income countries. From these, it is clear functional abilities are significantly reduced, even when using a prosthesis (1), mental health may be affected (2), and quality of life may be reduced (3). In unilateral users (of myoelectric prostheses), a heavy reliance on the intact limb appears to be common (4), which may contribute to overuse injuries (5).

In wealthy countries PWULA can typically access high quality prostheses, which may be passive, electrically powered, or mechanically-operated (sometimes referred to as body-powered) (6). Despite the clear constraints on the deployment of electrically powered

prostheses in LMICs, such as the need for reliable charging points and potential difficulties with maintenance, most research in upper limb prostheses has focused on these devices. In part as a result of the dominant focus for both industry and academia on electrically powered devices, there remains significant scope for improvement to commercially available, mechanically-operated prostheses (7).

Mechanically operated devices offer a potentially appropriate alternative to electrically powered prostheses, particularly for those living and working in rural areas. Our team were awarded £1.4 million from the United Kingdom Global Challenges Research Fund to design and test a low-cost mechanically operated prosthesis, optimised for LMICs, and establish local methods for fabrication, fitting and evaluation. The project, entitled 'Fit-for-purpose, affordable body-powered prostheses' (abbreviated to F4P in this paper) is led by the University of Salford, in collaboration with the University of Jordan, Makerere University, the universities of Portsmouth and Southampton, and University College London. In order to better understand the context for the work, and to ensure that any new developments are 'fit for purpose', we have carried out a series of scoping and exploratory studies on prosthetics services in both Jordan and Uganda. In this paper we report on the findings from the studies carried out in Uganda and outline how the ongoing work may help to address some of the identified challenges.

Uganda's population is approximately 41 million, with a gross national income/capita of ~USD1300 (<https://www.who.int/countries/uga/en/>). Health expenditure is low, both in absolute terms (~USD130 per person, per year) and as a proportion of GDP (~7%). However, significant improvements in a number of key health indicators, including life expectancy and infant mortality rates have been seen over recent decades. Nevertheless, the prevalence of disability appears high (8).

However, in common with many other LMICs, data on the demand for prosthetics and the extent to which it is being met are poorly understood. There is no limb loss or absence registry in Uganda, nor a legally recognized association or society of prosthetic users, although an informal community group of people with limb absence exists in the Busoga region and there are associations of people with disabilities. A recent retrospective study of clinical notes from hospitals in the Acholi region (9) highlighted the lack of national limb loss/absence prevalence data and provided an interesting insight into some of the challenges faced by clients and clinicians. For example, in a region with poor transport infrastructure, the average distance from a client's home to the referral hospital where they were seen was 91km. Further, less than 1% of clients were formally referred to rehabilitation services.

## **Objectives**

The objectives of the studies presented here were to better understand the current state of prosthetic services in Uganda, from both the clinician and client perspective, with a view to informing and underpinning the F4P project.

## Methods

We adopted a Patient and Public Involvement (PPI) framework to understand the context and inform the development of methods for subsequent studies, in collaboration with our partners and involving PWULA. This flexible approach enabled us to engage the users and wider stakeholders to help focus our efforts on technological developments likely to meet the user's needs. In the first section we present the findings of two studies on Ugandan prosthetics manufacturing and fitting services. The second section summarises a study on the state of prosthesis repair services. Finally, we report preliminary data from a series of interviews with PWULA on their needs and experiences regarding prosthetics.

## Findings

### *Section 1: reviews of prosthetics manufacturing and fitting services*

This section summarises findings from two PPI exploratory and scoping studies that investigated prosthetics manufacturing and fitting services in Uganda. In the first study, members of the F4P team visited: The Mulago National Referral Hospital and the partner orthopaedic workshop and training school (referred to as Mulago in this paper); two non-governmental organisation-run facilities; and a private workshop. The team also met with PWULA and visited the Ugandan Industrial Research Institute. In the second visit, two students studying Prosthetics and Orthotics spent 1 month in Uganda, visiting Mulago, Makerere University, Katalemwa Cheshire Home for Rehabilitation Services (referred to in this paper as Katalemwa), Orthotech & Physical Rehabilitation International and Fort Portal Regional Referral Hospital (referred to in this paper as Fort Portal). The findings have been discussed in detail with co-authors who work at two of the clinical centres.

The clinical facilities visited varied considerably in their ability to provide services, from rather poorly resourced public facilities to better-resourced private/NGO-funded facilities. Due to space limitations in this paper we will focus on one example of a public hospital (Mulago) and one NGO-run clinic (Katalemwa)

The Mulago workshop has 13 staff (orthopaedic technologists) and was founded in the 90's with the help of the International Committee of the Red Cross (ICRC). From 1989 to 1996, both the workshops and associated supply of materials were managed through the British Red Cross. However, support for the Mulago workshop from the ICRC and British Red Cross was withdrawn in the 1990s and the responsibility was passed to the Ugandan government.

The Orthopaedic Technologists are multi-skilled clinicians and technicians who essentially fulfil, what in the United Kingdom would be multiple roles (Prosthetist, Orthotist, Technician and, to some degree, Occupational Therapist). They are also responsible for the sourcing and obtaining of materials and componentry and, in many cases, negotiating costs with clients. Most of the workshop machines are quite old and some are faulty (the parts to repair them are not easily available). While the facilities for manufacturing of metal-based and wooden products are quite functional, the prosthetics workshop is less so. For instance,

much of the equipment needed for the fabrication of laminated sockets is in a poor state of repair. While Mulago has a rehabilitation service, it was reported to be under-staffed and under-used and few-referrals are made from the prosthetics team to the occupational therapists.

In terms of materials, thermoplastics are locally sourced; however, polypropylene is in constant low supply and difficult to acquire. Indeed, during one of the visits, the team were told there was no polypropylene available in the whole of Uganda. However, leather, wood and common metals, such as mild steel, can be readily acquired locally. Lamination materials are generally available (lay-up material, resin – mainly sourced from India) however they have a specific difficulty in acquiring PVA bags. Mulago is also heavily dependent on donations of components, which come at irregular, unpredictable intervals, making scheduling of appointments and planning of services very difficult.

Mulago see approximately 30 people with lower limb absence a month, and around 10 with upper limb absence and the main cause is trauma (primarily road traffic accidents, followed by tumours). Previously the staff at Mulago undertook outpatient clinics in villages but they no longer do so as funding and transport are both a problem.

A typical client journey through Mulago is described here. When a client (primary or pre-existing) requires a new prosthesis they move from amputation surgery (in the case of primary patients) through to in-patient recovery and referral to the Orthopaedic Workshop for prosthetic fitting. However, a critical part of the fitting process is the negotiation between client and orthopaedic technologists over both the availability of materials and components, and the cost. Typically, an attempt is made to acquire the required components via their, or colleagues' donated stock. When/if the components can be acquired the client will be contacted and the cost discussed before the components are ordered. When componentry is acquired, it is not often compatible with other components and hence ad-hoc mechanical adaptations may be needed. Although there is supposed to be government funding for prosthetics, in practice budgets are often inadequate and so, if the client cannot afford to pay for the materials/components which are both suitable and available, they go onto a waiting list until alternatives can be found. Although costs vary, upper limb prostheses (cosmetic or basic mechanical devices) are of the order of USD400-USD945 (lower limb prostheses may cost up to around USD400). To put this figure in context, the average monthly income per household in Uganda in 2016/17 was reported to be under 0.5 million Ugandan shillings (<USD133) (10).

By contrast to the Government run Mulago centre, some NGO facilities have better access to working machinery and appear to be somewhat better positioned to meet the needs of clients. Below we present a brief review of the Katalemwa Cheshire home.

Katalemwa is a non-profit organisation founded in 1970, providing comprehensive rehabilitation services to children with disability. Katalemwa's orthopaedic workshop was started in 1999 under the support of the Christoffel Blinden Mission (CBM). The workshop

has 12 staff (4 orthopaedic technologists, 2 leather technicians, 2 carpenters and 4 welders/metal technicians). It fabricates assistive devices including wheelchairs, special chairs, orthoses and prostheses.

With the support from the CBM and other donors, in terms of machinery, tools, and resources, the workshop is functional, with the ability to provide services to the children with disabilities at a relatively low cost. For example, a lower limb prosthesis fabricated out of local materials, such as mild steel joints and a Solid Ankle Cushioned Heel (SACH) foot made of rubber, may cost around USD130. Fabricating a similar device out of imported components costs on average USD360. However, the Katalemwa team recognise that the robustness of a prosthesis made in a small workshop, from local materials may be somewhat less than an equivalent imported device. Upper limb prostheses are all made from imported components, making them expensive.

Katalemwa sees approximately 130 people with limb absence a year using its community-based and centre-based approaches (20% of these have upper limb absence). The main cause of amputation is trauma, followed by congenital anomalies and vascular diseases. Most of the prostheses fitted at Katalemwa are paid for by a donor, such as Mobility Equipment for the Needs of the Disabled New Zealand, banks and well-wishers; this is a less than fully sustainable solution, particularly when repairs are required (see next section), or in cases where the donor withdraws their support. Out of the 130 clients seen each year, around 95 get prostheses. Cost is one main reason why a client may not receive a prosthesis after being referred.

### *Section 2: prosthetics repairs*

This section reports on a study investigating how people in Uganda get their prostheses repaired. To understand the technical perspective three workshops were visited: Mulago, Katalemwa, and Fort Portal. According to the technologists, the biggest issue facing all 3 workshops was access to components and materials. Basic adjustments and repairs can be completed for free, however clients are required to cover the costs of any new materials or components which are needed. The challenges with sourcing components in Uganda translate into high costs which are often unaffordable to clients. In these cases, the prosthesis is not repaired, or an improvised repair is completed to allow use of the prosthesis while the client saves money or finds a sponsor to cover the cost. During the study it was observed that the technologists were very resourceful with materials, such as repurposing plastic from Jerry cans to reinforce failed socket-pylon interfaces, and the technologists re-use materials and components as much as possible.

To understand the client perspective on repairs, semi-structured interviews were conducted with prosthesis users from Mulago and Fort Portal hospitals. 13 people were interviewed (7 female, age: 22-48 years), of which 11 had a lower limb loss (5 below knee and 6 above knee) and 3 had upper limb loss (all above elbow) (note: 1 interviewee had both upper and lower limb loss). All clients were experienced prosthesis users, and on average they had

their prosthesis for 11 years at the time of interview (range 4-29 years); 2 out of the 3 PWULA had a cosmetic upper limb prosthesis; the third did not have a prosthesis, reportedly because his stump was too short.

11 out of 13 interviewees had experienced at least one failure of their prosthesis (4 had experienced 3 or more failures). Clients get their prosthesis repaired in one of four ways: 1) returning to the original workshop where their prosthesis was provisioned, 2) going to a local trades-people, such as a mechanic, 3) completing the repair themselves or 4) not getting the prosthesis repaired. All but 2 of the clients had returned to the original workshop at least once for a repair. However, this may not be representative, because, for practical reasons all those interviewed lived near the workshop. Their average travel time to the workshop was 63 minutes (range 5 minutes - 2 hours), very different to the average distance of 91km reported in the Acholi region (9). It is suspected that clients who live further away are more likely to try to repair the prosthesis themselves or go to local trades people.

Clients typically initiate the repair process by contacting the orthopaedic technologists who fitted the prosthesis to be assessed. Clients reported inconsistent costs for repairs; some reported that maintenance was usually done for free, while others had been charged. This contributed towards client's reluctance to attempt to get their prosthesis repaired, as they reported they were hesitant to pay for travel if they were not sure it would result in getting their prosthesis repaired. The payment negotiation process takes time and may not result in a successful outcome, due to availability of materials and/or components and what the client can afford. More than one visit to the workshop is often needed, to allow the technologists to source the relevant materials. Clearly, travel to/from the clinical centres for repairs may be particularly challenging. Perhaps partly as a result of these challenges, two of the interviewees had completed their own repairs on their prostheses.

In summary, from the technologists' perspective, almost all the technologists interviewed said their biggest challenge was poor access to resources. From the client's perspective, their biggest concern was cost, with many of them struggling to pay for transport to the workshop, even if the repair itself would be free. These are both systemic problems which will be difficult to overcome, but they will need to be considered in the design of any new prosthesis if it is to be introduced in a successful and sustainable way.

### *Section 3: User needs and experiences regarding prosthetics*

This section summarizes the preliminary findings of a study aiming to gain an in-depth understanding of the user's perspective that will underpin each of the work packages, as well as linking and synthesising other stakeholder perspectives throughout the duration of the study. As 'many technologies and scientific interventions continue to fail due to a lack of understanding of their social and cultural and historical context and the likely reception by the people and societies that are intended to benefit', user engagement throughout will focus our work on developments which are fit-for-purpose from the user's perspective (11).

We used a flexible qualitative approach that involved the use of semi-structured interviews. Working in partnership across countries and institutions, we constructed a semi-structured interview schedule that focused on daily experiences with or without a prosthesis, perceptions and expectations of prostheses, challenges in relation to the amputation and access to prosthetic services, social inclusion and design characteristics of prostheses. Reflecting the importance of understanding the social and cultural issues the interview schedule was translated into various languages spoken in Uganda. The interviews were carried out by four members of the Ugandan team (biomedical engineers, prosthetics and orthotics technicians and community rehabilitation experts). They were new to the field of qualitative research and therefore undertook training run by members of the United Kingdom team within a co-researcher and co-production framework.

We interviewed 17 PWULA, 11 of whom were amputated above the elbow. The main reason for amputation was road traffic accidents followed by violence, fire accidents, illness and occupational accidents. The time since the amputation ranged from 20 years to five months and only two people had experience of using a prosthesis, illustrating the issues with access described in the previous sections. We are analysing the data using thematic analysis and here present preliminary findings from a subset of five participants. These findings illustrate the emergence of four key themes:

*Theme 1: attitude towards disability*

There was a mixture in attitudes towards living with upper limb loss from the individuals themselves and how they viewed their own disability, as well as their views of social perceptions and attitudes towards upper limb loss. For example, participants shared stories and experiences of ableism, which was illustrated in terms of heightened staring, heightened pity, reducing the humanity of people with limb loss, intense and cumbersome curiosity with intense questions, exclusion, discrimination and social pressure to seek a prosthesis as a means of covering up the limb loss as fast as possible.

The impact of ableism is observed in the form of social isolation and a mixed experience of emotions that appeared predominantly negative and damaging to the wellbeing of people with limb loss. Although we found exceptions where close friends and family members were supportive towards people with limb absence, some participants expressed concerns about what they may say about their disability when they are not with them.

*Theme 2: barriers to prosthesis use*

Barriers to prosthesis use appeared to be multidimensional and not limited to the physical properties, cost and functionality. These barriers are related to inadequate or insufficient: training to use the prosthesis, and psychological and social support to overcome the often-traumatic nature of becoming a PWULA. Prostheses are also considered too expensive and some participants said they would have to sell their land or family home to finance one. Prostheses are perceived as heavy, becoming a key reason to not using one. These factors were also linked to wider frustrations following the physical and psychological

trauma of the amputation, such as feelings of ambitions being shattered and the realisation that a prosthesis will not replace their own arm.

### *Theme 3: coping without a prosthesis*

Given that it is difficult to access an upper limb prosthesis, PWULA have found ways to perform daily life activities without relying on one. Some of them have reached a level of independence and do not consider that they need an upper limb prosthesis. The coping techniques identified were: relying on other parts of their body, relying on other people, relying on other devices that are not a prosthesis. In addition, they have shared strategies that are relevant to communication and management skills. For example, consult an occupational therapist to strengthen muscles of healthy arm and plan activities ahead, since performing tasks with one arm takes longer than with two.

### *Theme 4: communication with other people with upper limb loss*

Most PWULA find the suggestion of communicating with other people with the same experience appealing. However, they report not to have the opportunities to start such communication (cannot afford a prosthesis therefore do not visit an orthopaedic workshop as often). People with limb loss have identified various potential benefits of being able to engage with people with the same experience and one risk. Identified benefits are: obtain information of where other people get their prosthesis, help others to get a prosthesis, share the living experience of limb loss, share advice and listen to other people's struggles and how they have overcome them. The only risk identified in this preliminary analysis is meeting other people using a prosthesis that they cannot afford and the subsequent frustration and sadness.

After we have finished the analysis and identified final themes, in addition to gaining an in-depth understanding of the user views, we will also be able to use this inductive set of results as a framework for more deductive analysis for the related work packages.

## **Discussion**

The findings from this series of studies paint a rather bleak picture of the state of prosthetic services in Uganda. A few key points emerged from the studies and these are discussed below.

An issue which came up repeatedly across all our studies was the difficulty faced by orthopaedic technologists in accessing componentry/materials. All the sites we visited faced resource difficulties and hence often sought donations from well-meaning organisations or individuals. A reliance on donated materials/components makes predictability and sustainability of supply difficult and, in turn, impacts on the scheduling of appointments. Indeed, interactions between orthopaedic technologists and clients due, either directly, or indirectly to uncertainty in supply, places a burden on clients and leads to frustration on the part of the clinicians. Further, the heterogeneous nature of donated componentry presents the orthopaedic technologists with major challenges often requiring bespoke solutions to

assembly of prostheses, which in turn may compromise their robustness. Even when funding is found to purchase materials, accessing high quality plastics, particularly polypropylene, is an ongoing challenge. A continued reliance on charitable donations is at odds with a number of the Sustainable Development Goals (SDGs) (12).

As Uganda has no prosthetics industry, all specialised componentry/equipment is imported. Very recently, a new supplier which has a local distributor in Uganda, has made ordering componentry and materials easier; nevertheless, the budgets particularly in government run facilities are not sufficient to meet demand. Further, as the purchasing process is not centrally managed, centres cannot take advantage of the potential economies of scale which would come with a coordinated approach. Maintenance of machinery is also an ongoing problem.

With regard to repairs, again we found this process to be both time consuming, sometimes requiring multiple visits to clinical centres; and frustrating, with no guarantee of a positive outcome in the end. Clinicians' extremely tight budgets and difficulties in accessing materials and components means they are often forced to attempt ad-hoc repairs using whatever resources are available to them; perhaps as a result, clients sometimes attempt repairs themselves. It was noted that repeated failures appear common.

Despite (or perhaps, as a result of) these challenges, the orthopaedic technologists are generally an extremely resourceful and multi-skilled group and there is genuine enthusiasm to see services improve. Further, the establishment of a degree course in Biomedical Engineering at Makerere University has led to a growth in interest and capabilities in the area of medical device innovation.

In the third of our studies, we interviewed 17 PWULA and present preliminary results from the analysis of a subset of five participants. Firstly, it was notable that of the 17 participants, only 2 had experience of using an upper limb prosthesis. Further, the themes which emerged pointed to the extremely difficult situations that these people face, from a lack of access to prostheses and associated support services to social isolation and negative attitudes from people they encountered. Coping strategies included finding ways of performing activities without the prosthesis. Finally, they expressed interest in being put in touch with people in similar situations as a means of sharing advice, experiences, and coping strategies.

#### *Ongoing work*

Below we discuss our ongoing work to develop new designs and methods, which we hope may go some way to addressing the current situation.

*Sockets.* At present, sockets in Uganda are either fitted and fabricated using a lamination process or draping of plastic sheets. Neither approach is an ideal solution for Uganda; lamination-based socket manufacture requires the unusually encountered situation where skilled personnel have access to multiple different materials, a reliable electricity supply, and (working) specialised equipment. Further, a monocoque design is hot and fails to

accommodate fluctuations in limb volume. We are developing a low-cost, adjustable lattice-style socket, which could be fabricated locally, using locally sourced materials, and which may be amenable to repair (ideally in a typical 'bicycle repair shop', rather than a prosthetic clinic).

*Prosthetic hand and wrist.* We encountered a small number of instances where people had received harness-controlled, body-powered prostheses. These were generally in a poor state of repair and were reportedly not used functionally. We are exploring alternative approaches to the traditional Bowden cable-controlled device, including semi-passive hands and solutions based on the use of hydraulic transmissions. We are also exploring the potential to develop a low-cost wrist unit.

*Mobile phones for social inclusion.* Preliminary analysis of our data has indicated that Ugandan PWULA generally do not use mobile phones for peer support, although they would like this to happen. When F4P first started, we devised methods to support PWULA to establish communication with other PWULA to understand how best to use communication technology and how it could impact on their experiences as PWULA. Fortuitously we discovered a small group of PWULA led by one person (holding the contact details of around 50 other PWULA). To capitalise on this, we will carry out a study using ethnographic methods; first we will perform semi-structured interviews with members of the existing group of (50) PWULA and others. We will lend mobile phones to whoever cannot afford one, give them the contact details of others in similar situations, ask them to keep a diary of their experiences and communications. The resulting data will be analysed using thematic analysis and triangulation. This study is expected to start shortly.

*Real-world monitoring.* Once a client leaves the clinic with their prosthesis, there is no objective means of evaluating whether the prosthesis is of sufficient value to the user for it to be used in their everyday life. As the acid test for any assistive technology is whether, or not the person chooses to use it in their everyday life, we are providing clinicians with the tools to objectively and simply record these data using wrist-worn sensors. The approach builds on our recent work (4), which demonstrated the value of such data.

*Translation.* One of the challenges faced by aspiring Ugandan medical device manufacturers wanting to commercialise new devices has been an absence of a well-defined regulatory system. However, work by the Ugandan Industrial Research Institute to develop and bring through regulatory approvals, an infusion controller, has shown the potential opportunities for medical device innovation. A PhD student, based in Uganda, is working with the project team and others on the translation of the results towards the market.

Finally, none of our studies attempted to characterise the demand for services, and high-quality data on this is not available. Researchers from the University of Manchester and Gulu University in Uganda are studying the distribution of people with limb absence in the Acholi region of Uganda, through the creation of detailed maps using satellite images and Open Street Map, combined with house-house health surveys

(<http://huckathon.org/about.html>). Clearly, such information will be of value when planning prosthetic services and if this could be extended country-wide and include mapping of clinical and repair facilities, this would be a major step forward.

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