KNOWLEDGE & PLACE
Policy Report

Improving Maternal and Newborn Health and the Role of Bio-Medical Engineering

University of Salford
MANCHESTER
The Sustainable Volunteering Project

SVP Policy Report

Improving Maternal and Newborn Health in Uganda through Multi-Disciplinary Interventions: The Role of Bio-Medical Engineering

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Introduction

Despite the impetus provided by the specific attention to Maternal and Newborn Health in the Millennium Development Goals maternal mortality has continued to rise in Uganda. Health Partnerships linking Ugandan and UK health facilities represent just one type of intervention focused on improving this situation.

The Ugandan Maternal and Newborn Hub (UMNH) is a consortium of UK-Ugandan health partnerships which, together seek to promote sustainable approaches to health systems change in Uganda. One of the main vehicles for achieving this change has been through exchanges of staff between Ugandan and UK organisations and, more specifically, the placement of professional volunteers. In the past these have predominantly involved clinical staff (such as obstetricians, anaesthetists and midwives).

In 2012 the Tropical Health Education Trust awarded funding to the UMNH through the Countess of Chester Health Partnership to support a new initiative focused on medical equipment and the role that bio-medical engineers and technicians play in Maternal and Newborn health. At the same time THET provided funded to support the placement of long term UK volunteers in Uganda. Working in partnership the ‘Medical Devices Project’ (MDP) and the ‘Sustainable Volunteering Project’ with support from the British Commonwealth Professional Fellowship Scheme have contributed to a multi-disciplinary intervention aimed at improving the health and well-being of mothers and babies in Ugandan health facilities.

The project is based on a very simply logic: Improving human resource capacity through clinical training cannot improve clinical practice if the health workers lack essential equipment.

‘Many babies were dying simply because of some stupid [minor] things on incubators like temperature regulation and things. That was a shock and I felt, ‘wow this is happening?’ She was basically saying they cannot do anything because they don’t know what to do with the incubators. They know what is wrong with the child and what the child needs but they cannot do anything.’

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2 This scheme funded training stays of 4 Ugandan technicians in the UK in June 2014.
3 Full details of these projects can be found at www.lmpcharity.org
To illustrate this point, one of the SVP paediatric volunteers describes to the newly arrived bio-medical engineer volunteer, the situation she observed on a Special Care Unit.

In keeping with the SVP commitment to co-working⁴ we were aware that providing one British bio-medical engineer to fix incubators was not a solution to this problem. But deploying a bio medical engineer to build capacity amongst the existing cadre of Uganda technicians across the UMNH had much greater potential to improve the effectiveness of Uganda health workers.

The MDP commenced in January 2012 with the deployment of Dr Robert Ssekitoleko to Uganda. In order to support a focused approach in line with UMNH objectives it has focused on equipment needs in maternity, neonatal and paediatric units.⁵ And, in order to promote a sustainable approach we have taken care not to become involved in the purchase of new equipment but rather, through training and mentoring, to build the capacity of local technicians. And, in this regard we have taken an equipment ‘life-course’ perspective embracing all processes from initial equipment procurement through maintenance and repair to disposal.

⁴ See Policy Report for a discussion of the principle of co-presence in the SVP.
⁵ Our working definition has excluded IT equipment, hospital furnishings and general consumables.
MDP Budget

In order to understand the impact of the MDP in relation to its costs it is useful to summarise the budget we were working with. The THET contribution to the Medical Devices Project over 2 years totalled £30,000. In addition to this the costs of the bio-medical engineer volunteer (funded separately through the SVP for 18 months) came to around £25,000. The Commonwealth Fellowship Scheme provided an additional £8,400. Together this comes to a total income of just over £60,000. It is important to note that the project coordinators and Amalthea Trust trainers were operating in an entirely voluntary capacity. ‘In-kind’ costs are not quantified here but constitute a significant contribution.

This report describes the project and its rationale and reports on its achievements. It is divided into 3 sections.

Section 1 opens with a description of the situation as observed prior to project commencement identifying Key Challenges facing Ugandan technicians and health workers.

Section 2 then describes the MDP and the Interventions associated with it.

Section 3 presents and discusses the Results deriving from project evaluation.

Section 4 offers some Conclusions and Recommendations.

\textsuperscript{6}The SVP volunteer remains in post and is continuing to work with the technicians.
Section 1: Key Challenges facing Technicians in Ugandan Health Facilities

Like many other low and middle-income countries, Uganda is faced with the problem of managing and maintaining medical devices within health facilities. Initial assessment of the challenges facing Uganda health facilities indicated a focus on 4 dimensions (Ssekitoleko, Ackers, Hoyle and Daglish, 2013):

1. Procurement
2. Repair
3. Disposal
4. Human Resources

Challenge 1 : Procurement

Many of the problems associated with dysfunctional equipment in Uganda stem from initial procurement processes. Procurement systems function optimally when they involve multi-disciplinary interventions addressing equipment usability, durability, servicing and repair.

Such multi-disciplinary thinking is absent in Uganda. Procurement decisions take place at Ministry or Facility Level and rarely, if ever, engage with the perspectives of technicians. Indeed, it is common for technicians to learn of a specific piece of equipment only after it has broken down. On many occasions user manuals are missing or never issued.

Equipment Donations

Procurement problems are often magnified when equipment is received through donation. One hospital medical director described the problem of ‘well-meaning but inappropriate donations’. Indeed a very large proportion of equipment in Uganda facilities has not been procured through Ugandan health systems but arrives via donations.

Research suggests that 70-90% of donated equipment is never operationalised. Despite the good intentions of donors, this equipment can easily become a burden or simply junk. Typical problems are as follows:

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7 CHA Medical Surplus Donation Study: How Effective Surplus Donation Can Relieve Human Suffering, April 2011
The donation of equipment in any of these categories can initiate challenges for the receiving organisation and technicians.

**Stock Control and Spares Acquisition**

The acquisition of spare parts is problematic for both donated and locally procured equipment. Stock control and spares acquisition can be time consuming and costly. In a successful procurement process, the facilities should feel confident that parts will be supplied for a known period of time. In Uganda this information is often unknown, or items are procured with no knowledge of future provision of parts or consumables. In these instances equipment can be rendered unusable simply because of a missing part such as a fuse, as the following respondent explains: ‘It can take months to procure a fuse yet the equipment is just lying there for three months or even four and as a result you find that it even develops other misbehaviours.’

It is not at all unusual to find that equipment provided through funded projects falls into disuse simply because of a lack of commitment by facilities to provide spares. An example of this can be seen in the case of a project funded by THET to set up a High Dependency Unit project in Mulago Hospital. Following careful negotiation with senior local clinicians the decision was made to purchase 2 vital signs machines from a local provider (Joint Medical Stores). However when the cuffs for these machines became damaged in large part due to local misuse and the use of a powerful bleach (JIC) which rotted cabling the machines sat idle reported broken until the UK visitors noticed the situation and purchased replacements.

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<tr>
<td>1)</td>
<td>There is no centralised system of recording donated equipment in facilities</td>
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<td>2)</td>
<td>Donations result in a wide diversity of devices challenging the experiences of technicians and exasperating the problems of obtaining and fitting spares</td>
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<td>3)</td>
<td>Donated equipment often lacks spare parts or instruction manuals</td>
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<td>4)</td>
<td>Lack of local knowledge about how to use or maintain equipment</td>
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<td>5)</td>
<td>Donation of faulty equipment or equipment that is incompatible with Ugandan system (for example voltage/wrong plugs)</td>
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It is important when making procurement decisions to purchase equipment for which spare parts can be easily and affordably sourced (ideally in-country). The lack of standardisation of equipment across health facilities undermines this process.

This also includes the importance of a commitment amongst managers to provide a system for and cover the costs of spares. It is very common for missing spares (such as bulbs in the operating lamps) or fuses or batteries to render equipment unusable. When this happens an entire facility (operating theatre) can lie dormant for months.

These factors are among those that lead\(^8\) to much (50-80 per cent) of medical equipment in resource-poor countries to being out of operation.\(^9\)

**User Involvement in Procurement Decision Making**

As noted above, it is usual practice in Uganda not to involve technicians or biomedical engineers (or users) in procurement decisions.

In practice this means that the people ordering the equipment do not understand the needs of users in any detail and, furthermore, those people with the knowledge of equipment and its functionality in specific contexts are not consulted.

A local technician describes how he is only made aware of new equipment when it breaks down: ‘The managers are responsible [for procurement]. We only come in when it breaks down or maybe when they have brought it and it needs installation.’

There is also a tendency to buy the cheapest possible equipment. This interpretation of value-for-money as the cheapest purchase price often implies poor use of resource and serious problems with maintenance (and subsequently disposal).

The cheapest equipment often lacks information on model type, manufacturer or serial number making it difficult to obtain service manuals and spare parts. And it is impossible in such cases to enforce guarantees. Indeed, the equipment is often faulty at delivery and may never become functional.

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\(^8\)EMRO Technical discussions, “The role of medical devices and equipment in contemporary health care systems and services”, June 2006

\(^9\)
Corruption and Money Laundering

Unsurprisingly the procurement of equipment presents significant opportunities for corrupt practices especially with high cost products. Opportunities for corruption have an important influence on purchasing decisions. One respondent interviewed described a typical corrupt ‘deal’:

Say you want to buy x-ray equipment and it is going to cost you £500,000. They would want to put in a bill to the health ministry worth a billion pounds to get the other cut [making a £500,000 personal gain]. Then when they put in the one million pounds they will not even buy the £500,000 one, they would source one from China

In this process, senior officials submit a bill for an expensive equipment, yet purchase a cheaper one to generate profit. This results in imperfect procurement decisions and a loss of critical resource.

Challenge 2: Repair

Ugandan Health facilities are littered with dysfunctional equipment. It is quite normal to find cupboards and rooms stacked full of equipment that is out of use. A key challenge here is that no-one in these facilities has any awareness of whether this equipment is in need of consumables (batteries or Bulbs) or small scale repair or is beyond repair. Indeed facility managers have no records of what equipment they have and its condition.

In some cases equipment could be brought immediately into use if spare parts were available and systems were in place to purchase them. In other cases the presence of a semi or skilled technician could restore functionality. Equipment lies un-repaired for a number of reasons including:

Process (equipment management issues)
- Lack of or failure to order spares
- Lack of or failure to order consumables
- Lack of or failure to access user manuals
- Lack of user training including training in installation and cleaning (for health workers)

Human Resource Issues
- Lack of dedicated facility technicians
- Lack of training of dedicated technicians
- Failure of technicians to work effectively (failure to attend and poor levels of motivation)
- Lack of suitable tools to test and undertake repairs
- Rotation of trained staff

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10 Requisitioning of even simple consumables or spares can often take up to 6 months
Repair is also linked more generally to equipment maintenance: properly maintained equipment is less likely to breakdown and when it does a simple problem may be easier to remedy. Much equipment in Ugandan health facilities has multiple/complex problems. This requires higher level diagnostic skills.

**Equipment Maintenance**

Most of the Regional Referral Hospitals in Uganda have a regional referral maintenance team. However, the level of equipment maintenance is very limited and only repairs are done. Little servicing (including maintenance and calibration) of equipment takes place.

Routine servicing would reduce the proportion of dysfunctional equipment. The pictures below show a pump head heavily rusted due to non-servicing. After cleaning and application of WD-40 it was restored to functionality.
A main cause of equipment breakdown is the lack of user knowledge to operate and maintain equipment. Ideally responsibility for equipment maintenance should be shared between the users, facility managers and maintenance teams.

In practice users usually have to work out for themselves (as non-specialists) how to use new equipment. This leads to equipment damage due to poor handling. Quite often only one person in a facility knows how to use a piece of equipment. This creates problems as they may not have time to train others or may themselves relocate to another facility. It is difficult to get a group of users to convene for equipment training.

Cleaning and decontamination of equipment by the users has led to many cases of equipment break down. The main cleaning agent in Ugandan health facilities is JIK (Sodium Hydrochlorite). The poor quality of equipment such as some metal beds means they corrode easily. Cleaning with JIK makes the problem worse (Figure 3). Purchasing poor quality beds (or other equipment) often results in continual maintenance and eventual de-commissioning within a year.

There are guidelines on using JIK for cleaning medical equipment but it seems that they are not followed. A good approach would be to convince the manufacturers to have them in the correct concentrations for the hospital use. However, this might take a long time and a quicker solution would be to routinely train the equipment users and cleaners. In some hospital units where staff are trained well to clean the equipment, JIK does not cause damage.
Challenge 3: Disposal

When interviewed ahead of a formal training session five out of the six technicians mentioned non-functional equipment lying around in a certain area of the hospital one saying that there was ‘apparently no system’ for disposal.

Hospital staff are generally aware of government guidelines on appropriate disposal of equipment. However, most of them have big collections of equipment with different views on what should be done with them. Some believe that they can be used for spares and therefore they should be kept until a good use is found. A technician from the National Referral Hospital, when asked about disposal methods, responded: ‘We don’t really have a disposal system in that when equipment breaks down it is sold off as scrap.’

The pictures below show the consequence of this situation and the resulting congested and disorganised facilities. It also means that the facilities cannot be used for their intended purpose (operations) but rather as store rooms.

Most facilities have stock piles of equipment. In some cases this litters already congested wards, on occasions blocking whole rooms from use and in others (most) cases causing congestion and infection control hazards on hospital wards. Less valuable materials tend to be ignored and can become problematic.

Donated equipment, which as noted above is often unsuitable for use, poses particular problems as fears that donors will come to audit donations and potentially assume that missing equipment has been stolen (via corruption) leads to a marked reluctance to dispose of large volumes of unused or unusable equipment. On some occasions this equipment is retained in the hopes that returning donors may be able to restore it or provide spares.
Challenge 4: Human Resources

Critical failures in human resource management lie at the centre of health system functionality in Uganda. These failures affect equipment management as much or perhaps more than clinical areas. Indeed, bio-medical engineering is one of the deprioritised and neglected ‘Cinderella’ professions. Human resource management is a broad concept encompassing a number of areas such as:

- Employment: Quantity and Quality of Personnel
- Leadership
- Communication
- Role Confusion

Employment: Quantity and Quality of Personnel
It is important to consider both the quantity and quality of human resource. It is all too easy to assume that HR problems in low resource settings are a simple reflection of inadequate resources resulting in low levels of staffing. This is by no means an accurate or complete picture.

Overall numbers of staff in any field need to be considered alongside issues of quality and management.

Certainly in the field of equipment management there are often inadequate levels of staff to cover the facilities and responsibilities they are tasked with.

A typical Regional Referral Hospital (such as Hoima for example) will have X staff (Robert). Health Centres in Uganda do not have dedicated technicians based in the facilities. In theory a pool of technicians are employed centrally and deployed to health centres as and when required. In practice most Health Centres receive no technician support at all. In some cases they contact privately employed technicians on a cash payment basis. But they do not have dedicated budgets to purchase technical support.

This generates a serious problem of workload for those technicians that are in public employment:

\[ 'The\ situation\ will\ always\ be\ this\ way\ simply\ due\ to\ the\ amount\ of\ jobs\ that\ we\ need\ to\ go\ through\ on\ a\ daily\ basis.'\]

\[ 'He\ does\ not\ have\ time\ because\ he\ covers\ 15\ different\ hospitals,\ the\ regional\ referral\ hospital\ and\ about\ maybe\ 50\ health\ centre\ IVs.\ Just\ one\ guy.\ He\ does\ not\ have\ time\ and\ I\ don't\ know\ whether\ he\ has\ found\ the\ best\ way\ to\ prioritise\ what\ needs\ to\ be\ done'\]

These examples illustrate both the immense workload pressures on a small number of employed technicians but also the challenges this presents in terms of workload management and organisation.

\[ ^{11}\text{For further discussion see Policy Report X}\]
In addition to staff shortages is the issue of quality – the competences of employed technicians. Prior to the commencement of the MDP the concept of ‘bio medical engineer’ was largely unknown in Ugandan health facilities.

Whilst most hospitals employ at least one ‘technician’ these are general purpose technicians who struggle to manage medical equipment in addition to their existing duties. Many of them have received no formal training at all or have trained mainly as electricians: ‘We are electricians but people expect us to be able to repair everything in the hospital.’

The lack of formal training was a concern in many facilities amongst both the technicians themselves but also management: ‘That was the excitement I got when I heard that there is a project to help and train somebody…. I knew it was going to go a long way to reduce some of our challenges’

Indeed, awareness of the need for a more professionalised approach to equipment management formed the impetus behind a decision, by the Ministry of Health to set up a Diploma in Biomedical Engineering at Kyambogo University, Kampala in 2010.

With support from MeduProf and the United Nations Economic Commission for Africa (UNECA) who helped with curriculum design. This was further developed by the Amalthea Trust with funding from Hilditch Group Ltd. The Amalthea Trust use UK engineers (generally from the NHS), who travel to Uganda for 2 weeks to teach their speciality. About 4 different volunteers visit over a period of 8 weeks, twice a year, giving the students around 16 weeks of training by the UK volunteers.

The Diploma in Biomedical Engineering runs for 2 years, during which time the students gain enough theoretical and practical knowledge to service and repair a wide range of medical equipment, whilst gaining the confidence and experience necessary to manage the life-cycle of equipment, from procurement, training, servicing, and disposal.

The Diploma represents a significant step forward in terms of recognition of the need for capacity building, raising the status of bio medical engineering as a profession and encouraging the next generation to consider bio medical engineering as a career. However, greater attention needs to be paid to facilitate access to training amongst technicians currently working in Ugandan health facilities who need continuing professional development.

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12 [http://meduprof-s.nl/](http://meduprof-s.nl/)
13 The Amalthea Trust were partners in the MDP playing an active role in the provision of training [http://www.amaltheatrust.org.uk/](http://www.amaltheatrust.org.uk/)
Measures to ensure that appropriately trained biomedical engineering staff are employed in Ugandan health facilities would indicate significant progress. In practice the impact of even these measures would fail to bring about marked improvements in practice in the absence of effective human resource management and leadership.

Leadership is itself a complex concept spanning issues of role delineation, team working; effective communication and instruments to prevent corruption. Ugandan health facilities lack clearly defined management systems and reporting structures that hinder effective decision-making. The following respondent explains the confusion that exists around reporting structures: ‘The nurses would report to [the local technician] and maybe another nurse will report to the regional workshop technician’

In equipment management uncertainty about line management and reporting structures causes confusion between clinical staff, technicians and management: ‘The workshop technician does not think that he should reporting to anyone in the hospital’

In the following example, the lack of communication between a local and regional technician results in confusion:

‘It was an anaesthetic machine that [the local technician] had looked at. Then later [the regional workshop technician] came and fixed it but [the local technician] had no notification that it was fixed. So when [the Director] asked us to go to his office to say whether it was fixed we had no clue and later we found out that he had come. The Director was a bit annoyed. How can he come in the hospital and not even let the technician know?’

The SVP biomedical engineer highlights a similar problem: ‘The [Local Technician] will come and look at the equipment and at the same time [the Regional Workshop Engineer] will go and look at the equipment. So it is like there is no communication.’

In cases such as these it is not so much a lack of staff or training but poor management resulting in inefficient use of scarce resources. As noted above effective management of both physical and human resources is deeply affected by corruption. And this is a very serious problem when dealing with highly marketable equipment and consumables.

Procurement and the associated supplies of consumables and spare parts generates unique opportunities for bribery and corruption. This environment makes it particularly sensitive and at times uncomfortable and dangerous for external volunteers.
Summary

Section 1 has described the context within which equipment management takes place in the Ugandan public health sector. Its purpose has been to outline key challenges facing any intervention in this area. It has outlined the importance of understanding processes from equipment procurement through maintenance and repair to disposal and identified key factors affecting human resource capacity in biomedical engineering. Taken together these dynamics suggest the lack of leadership and of an effective system for managing equipment.
Informed by the analysis of the local context described above, the MDP planned a series of interventions. These commenced with a period of audit to assess the situation in each Facility and provide opportunities for evaluation. The audit was followed by a series of 3 formal training interventions. Each formal training intervention was followed-up on the ground through on-going site visits providing mentoring by the SVP engineer to help technicians to apply the skills they had learnt and identify further training needs. The project also included a series of workshops to support lesson learning and knowledge sharing within the project and with external stakeholders. Every component of the MDP has been subject to detailed evaluation.

Summary of MDP Activities

- Audit and Inventory Taking Processes
- Formal Training
- On-the-job one-to-one mentoring and support
- Community-building and dissemination

Section 2 describes the activities as they took place.

Audit: Inventory Taking Processes

Comprehensive, updated, records are essential to the effective management of medical equipment, from procurement, through servicing and repairs to eventual decommissioning and disposal. In that respect audit underpins all of the identified ‘Challenges’.

Section 1 illustrated the lack of systems in equipment management in Uganda and the practice of stock piling equipment in facilities. It referred to the problems associated with donated equipment arriving in facilities often directly onto wards; the weaknesses of the procurement processes which lead to equipment arriving directly on wards without going through a centralised equipment management process; the challenges involved in sourcing consumables and spares necessary to maintain equipment use and, finally, the failure to identify and dispose of irreparable equipment. These are complex problems.
The MDP took the decision to focus the initial stages of the project on audit. The SVP engineer undertook site visits to each facility focused on ‘inventory’ processes. The objective was twofold: (1) to establish a clear record of the quantity and quality of equipment in any location and (2) to facilitate and embed an audit process.

**Inventory Objectives:**

- To determine what equipment each health unit has use of
- To test and record equipment condition
- To mentor local technicians on how to create and maintain inventories

The first phase involved the creation of inventories for participating health facilities. These were used to demonstrate the state of medical equipment in the facilities and as a tool to encourage on-going audit.

The initial site visits established some diversity in practice. Some facilities used ‘job cards’ to keep track of repairs and had systems to report equipment repairs. However, only one hospital followed the system effectively (Robert can we say which – why that one had?)

The SVP engineer mentored local technicians in inventory taking and the benefits of record keeping.

Inventories were created in 7 facilities recording the presence and condition of all equipment used in the assessment and treatment of mothers and new-borns. Local technicians learnt that the inventory process is an effective tool in establishing the volume and quality of equipment in their facility and recording the need for spare parts and user/service manuals.

![Example of an Inventory](image-url)
Early in the MDP we found that a Japanese NGO (the Japanese International Corporation Agency or ‘JICA’) had been active in Ugandan facilities and had established a grading scale (in liaison with the MOH). Rather than introduce further complexity the MDP adopted this system (Table 1):

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<td>A</td>
<td>Good in use</td>
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<tr>
<td>B</td>
<td>Good/not in use</td>
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<tr>
<td>C</td>
<td>In use but needs repair</td>
</tr>
<tr>
<td>D</td>
<td>In use but in need of replacement</td>
</tr>
<tr>
<td>E</td>
<td>Out of use/Repairable</td>
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<tr>
<td>F</td>
<td>Out of use/Replacement</td>
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Table 1: The JICA equipment grading scale

According to this scale, equipment graded below B is considered malfunctioning. A designation of category B means that the equipment is not being used despite being in good working condition. Ideally, all equipment should be classified under category A.

Overall, the initial inventories recorded the condition of 985 pieces of equipment. The results indicated that a high proportion of malfunctioning equipment in facilities. Figure 1 represents the proportions of equipment in each condition (A – F) for Mulago National Referral Hospital and Hoima Regional Referral Hospital (by way of example).  

Details of all the Inventories can be found at XXXX
If we take the Mulago example. The first inventory indicated just under half of equipment in the area of obstetrics as ‘good and in use’ with a small but significant proportion good but not in use; a staggering 40% in need of repair and 10% out of use.

Figures X-Z illustrates the diversity in different contexts. Fig X shows the data for the Special (neo-natal) care Unit at Mulago Hospital. In this context the majority of equipment is ‘in use but in need of repair’ – with much of this being incubators. This contrasts with one of the facilities managed by a UK NGO. Kabbubu Health Centre IV (Fig. Y) has relatively little equipment compared to the other facilities but most of it is in working order. Fig Z represents the situation at another UMNH facility – a Mission Hospital in Kisiizi. Once again the condition of equipment is generally in better condition here than in public facilities. However 19% of equipment here is good but not in use – probably reflecting a high volume of donations.
The challenge with the inventory is that a large proportion of equipment does not come through established hospital guidelines (as noted in Section 1). In some facilities, where inventories are maintained this is done by the procurement or accounts team rather than a specialist (technician). Conducting the process in this fashion fails to capture more technical information that would be useful to the technician when equipment needs repair. The SVP biomedical engineer persuaded local technicians of the importance of maintaining updated inventories to support improved equipment management.

One of the main challenges facing the MDP and the volunteer engineer in particular was the expectation amongst Ugandan health workers and managers that the project would involve the donation of equipment. The engineer had to deal with this ‘assumption’ repeatedly to establish over time the objectives of the MDP. He describes the way he overcame this challenge:

‘The best approach was really to explain to the technicians that we are here just to take an inventory and not to give you new equipment because that is the first thing that comes into their heads. They are usually straight forward with what they don’t have instead of what they have and what is wrong with it. And the technicians have been great at explaining what we are about because I usually sit them down and explain to them what we have come to do.’

The engineer faced another challenge at this point in the project – namely a suspicion that the production of inventories was a way of exposing facilities and embarrassing managers.

In one case a defensive response arose as a result of the publication in local media of equipment problems. This was an entirely coincidental occurrence but caused locals to become suspicious of the inventory process. The respondent described local staff ‘feeling immediately upset’ with members of the MDP but later realising that on the ‘front page in the newspaper was a photograph of the [unit] saying that one of the incubators work’. These were the same incubators that had been part of the inventory, and the volunteer believes that staff may have connected the two occurrences.

The SVP engineer also met with some resistance from facility managers which arose as a result of previous inventory processes often involving other international NGOs. This reflected some of the communication problems described above:

It was not until [the SVP Engineer] had almost completed the inventory work that he was advised of these other inventories and although management were not keen for him to complete he did so.
These problems are common in international development with a myriad of uncoordinated NGOs developing parallel interventions. These may result in simple (but wasteful) duplication or, quite commonly, in forms of conflict and territorial behaviour. The SVP engineer describes one example of NGO ‘conflict’:

The [international NGO] engineer does her own thing. She has her own inventory which is different from the one that [the Engineer] from the regional workshop has. It captures the same information but when I asked the guys whether they have an inventory the Director called me and said, ‘We have an inventory of everything in the hospital and not just the equipment. This inventory basically says that we have a table in the director’s office and this is how much it costs’. It was difficult to explain to him that that is not the type of inventory we are interested in. We are interested in knowing the model, the serial number and the manufacturer.

‘The problem was that the [Ugandan hospital leadership] didn’t know that that inventory had been done by the [International NGO] engineer and they didn’t know that the regional workshop also has an inventory. There are so many things going on independent of each other. I had a very long discussion with [the international NGO volunteer]. The [international NGO] had one more year to go and I felt it had not really educated the local guys.’

The above example illustrates the level of duplication and confusion about inventories that generated serious challenges for the MDP inventory process. For the hospital manager an inventory is effectively a form of budgetary audit recording all equipment and furnishings in the facility primarily to guard against theft rather than to monitor and management medical equipment.
Capacity Building through Formal Training

In response to the concerns expressed in Section 1 about skills and the lack of initial training and continuing professional development, the MDP introduced elements of formal (classroom-based) training. This included two courses in Uganda and subsequent training visits to the UK sponsored by the Commonwealth Professional Fellowship Scheme.

**Training objectives**
- To assess the core competences of the Ugandan technicians and identify skills gaps
- To teach key skills
- To encourage technicians to know each other and build a sense of professional community
- To provide a safe, exploratory, learning environment

**Formal Training Component 1 (Kyambogo University April 2013)**

The first phase of training involved project technicians from six facilities coming together in Kampala for a two week residential training session to learn how to effectively manage medical equipment. The course started with a needs assessment to gauge the skills and experience of technicians from quite diverse facilities and contexts.

The training was delivered in collaboration with the Amalthea Trust at Kyambogo University in Kampala. It was designed as a free standing module to facilitate the technicians who had different skills with key knowledge in equipment management.

**The curriculum included:**
- Electronic and electrical engineering.
- Electrical safety testing of medical devices.
- Management of medical devices, and how the technicians should be involved in the whole life cycle of medical devices from procurement, through to regular maintenance, and disposal.
- Maintenance and testing of pre-term incubators.
- How to use and service cardiovascular monitoring equipment.
Formal Training Component 2: (Kyambogo University April 2014)

Feedback from the technicians after the first training sessions and during subsequent site visits by the SVP engineer indicated the need for further hands-on experience particularly with specialised equipment such as ultrasound and X-ray machines. When such high tech equipment fails, facilities may need to fly technicians in from abroad at huge cost. Most often this does not take place and equipment lays idle. A UK biomedical engineer volunteering via the Amalthea Trust and with over 25 years of ultrasound experience delivered specific equipment training.

The course also focused on an area that has emerged as a real need; namely user training. Much equipment in Uganda arrives on the wards with no prior training for users either in how to use it or how to clean and maintain it. This results in equipment either not being used effectively (or to its full potential); not being calibrated on a regular basis or being damaged through misuse and cleaning-related damage.

A specific module on infection control was delivered by a Ugandan nurse who had been working in infection control and trained in the UK with the support of a Commonwealth Professional Fellowship (in 2012). The involvement of this experienced nurse in the training of technicians marks an important step in multi-professional practice. This was remarked upon by one of the technicians:

It’s unusual to have a combination of technicians and nurses.

<table>
<thead>
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<th>The curriculum for the second residential training included:</th>
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<tr>
<td>• Training for Trainers of Equipment Users</td>
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<tr>
<td>• Infection Control for Users and Trainers</td>
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<tr>
<td>• Reporting and Auditing for Technicians</td>
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<tr>
<td>• Trip to International Hospital Kampala</td>
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<tr>
<td>• Patient Monitor / Troubleshooting</td>
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<td>• Pumps</td>
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<td>• Ventilators</td>
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Whilst the second phase of training was focused on the emerging needs of the original cohort of technicians, it also enabled a new technician to take part (who had been receiving mentoring from the SVP engineer).
Formal Training Component 3 (Amalthea Trust and Mentoring at UK Partner Institutions)

Building on previous successful applications, the MDP identified the Commonwealth Professional Fellowship Scheme as a potential mechanism to take the technicians training a step further. Applications were made via the Liverpool-Mulago-Partnership (LMP) to support a tailored 5-week training program in the UK (with the Amalthea Trust) along with mentoring on-the-job in Health Partnership hospitals (in Winchester, Wales, Liverpool and Chester).

The UK-based training was designed to provide hands-on experience (which is something the technicians requested after training 1 and 2). The training started with a week’s training at the Hilditch Headquaters in Malmesbury. This was conducted by the Amalthea trust and it included hand-ons experience (functional and safety) of a range of medical equipment including ECG, Vital signs monitors, resuscitation station, and incubators. It also included detailed electrical safety training as well as introduction to electronics. The technicians then went to their respective hospitals to learn on how the medical equipment are managed. In their placement hospitals, they observed and learnt about fault-finding, stock piling of spares, routine maintenance, record keeping among many other skills. The technicians also learnt about resuscitation which is a great skill to have especially when working around a hospital environment.

At the end of their UK placements, the technicians agreed on a range of recommendations that they would feed back to their own hospitals.

15 http://cscuk.dfid.gov.uk/apply/eas/applicants/professional-fellowships/
16 Five fellowships were initially applied for and three were successfully granted. Discussions with THET allowed the project leaders to realign the original budget to fund all 5.
17 www.lmpcharity.org
Mentoring and ‘Learning through Doing’

Section 1 referred to the principle of ‘co-presence’ that guides the roles of SVP volunteers. As with all volunteers the biomedical engineer was under pressure to roll his sleeves up and engage in service provision. Indeed, the expectation that he could arrive at facilities and either produce equipment or repair vast hoards of malfunctioning equipment represented a real challenge to the SVP engineer. His role was set out from the outset as one of capacity-building through training and mentoring and role modelling as he describes: When I come into every hospital, each day I am not working by myself because it’s pointless for me to work by myself. (SVP engineer)

Before commencement of the project a manager of a regional referral hospital expressed concern regarding the level of training of Ugandan technicians prior to the project and highlighting the importance of mentoring: He does not have somebody to support him….my wish is that he could be mentored more or trained more or it could be another opportunity to enhance his career.

The Technicians working in the UMNH came from a variety of backgrounds some with little prior experience and no training at all – whilst others were qualified electricians. In such situations, mentoring provides an individual solution tailored to the differing needs of each technician.

The site visits were focused on this task:

Objectives

- Assist the technicians in implementing what was taught in the formal training
- Help to advise on best practices according to how things are done in the UK
- Train users and develop guidelines
- To train technicians on daily recording of activities

The SVP engineer was deployed to Uganda for the duration of the MDP 18 in order to ensure effective analysis of needs, identify and support formal training and optimise opportunities for the implementation of skills and policies. The SVP engineer was given an office at the Mulago National Referral Hospital engineering workshop and made routine visits to the other UMNH facilities which are spread across Uganda. Every visit had a particular focus.

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18 In practice he is remaining in Uganda until the end of the SVP (March 31st 2015) to provide continued support and follow-up.
The first site visit focused on training and mentoring technicians on equipment inventory taking and why it is useful. During this time, inventories of equipment in the units under the project were taken. This visits lasted for about five days in each site. The second visit was after the inventory was analysed and the engineer made recommendations on how equipment management could be improved. Mentoring work was on a demand basis rather than through a structured rota.

Between site visits the SVP engineer maintained on going communication through regular phone calls as and when required. The engineer was often able to source skills and knowledge through his network in the UK and Uganda. He also worked as an emergency engineer to help other technicians overcome a challenge they didn’t know how to solve. Where necessary, the SVP engineer provided supplementary informal tuition in areas where technicians needed to improve their knowledge.

Engaging with Other Volunteer Engineers
Over the course of the MDP other engineer volunteers have worked with the SVO engineer. This includes a number of short term volunteers from the UK and the Rotary club in Canada. Working in partnership in this way encourages continuity and enabled the SVP engineer to encourage a focus on knowledge and skills transfer and co-working with Ugandan technicians.

Some Concerns
When the SVP engineer was asked whether he has experienced any challenges in mentoring technicians he highlighted the overarching influence that money and workload had on knowledge transfer: I have felt like some of them still have lots of work to do and me coming in to give them more things to do is really just not helping because anyway their salary is not going up at all.
Providing Opportunities (to Utilise Skills)

Creating Opportunities for Skills Utilisation: Toolbox Provision

Building capacity through training can improve skills (capabilities). The ability to utilise those skills effectively is dependent upon having the essential tools (opportunities) (Michie et al, 2011). At the outset of the project we were aware that technician in Uganda health facilities rarely possess the basic tools to enable them to repair equipment. Indeed, in many cases repairs are conducted using razor blades and knives.

Focused on sustainability and conscious of the pitfalls (unintended consequences) of being seen to donate equipment, the project was very clear that it was not about providing equipment but building capacity in equipment management. A small budget was available for essential spare parts. In addition to this provision was made for the purchase of a basic toolkit for each technician. The following tools were included:

- Labelling machine
- Label on coil
- Soldering Iron and Solder
- Screwdriver set
- WD40 Spray tin
- Different sized wrenches
- Set of Imperial Allen Keys
- Set of Metric Allen Keys
- Torx set
- Wire stripper
- Retractable Knife
- Locking pliers set
- Non-contact voltage indicators
- Engraver
- Submersible temperature probe
- Desktop stopwatch
- Piece electronic kit
- Flexible steel rulers
- Busman fuse checker
- 10 inch chrome wrench
- Multimeter

Each toolbox cost £146 and was designed for durability and security. It was built in Uganda since this worked to be the cheapest option. Its size means that it is hard for someone to walk away with it. It has two lockable access ports with padlocks to keep the tools safely.

19 This is also a resource issue. At the outset of the project a hospital manager requested an anaesthetic machine which would have cost more than the whole project budget.
The total cost of the tools excluding the toolbox for each health facility was £700 per technician. The tool list was compiled by the British volunteer engineer in consultation with the Amalthea Trust and an engineer from Countess of Chester hospital.

The tools were not provided at the outset as we wanted the SVP engineer to do a careful assessment of what was needed in the site visits and use what limited resource we had as carefully and sustainably as possible. Once the decision was made about which tools to purchase further delays occurred as we attempted to procure high quality tools in-country. This proved impossible and we made the decision (reluctantly) to purchase in the UK. This then resulted in extensive delays as they were held by customs for some time and, in the end, the project was given no option but to pay a significant fee to release them. This situation is commonly experienced by NGOs attempting to ship essential equipment to Uganda.

Finally further delays took place as the SVP engineer commissioned the manufacture of secure store cupboards for the tools to mitigate the risks associated with theft. The tools were finally distributed to technicians in July 2014.

Community-Building and Dissemination

In addition to the 3 residential courses which themselves provided critical opportunities for community-building between technicians the MDP was involved in a series of workshops in Kampala with presentations taking place at each of the 4 SVP bi-annual Project Workshops.

The MDP took the decision in May 2014 to hold its own dedicated bio-medical engineering workshop on the day prior to the SVP Workshop.

The UK-based training culminated in a dedicated Workshop held at the Countess of Chester Hospital in June 2014. The all-day workshop provided an opportunity for the technicians to present their work and outline what they felt they had gained from the project as a whole and the UK training in particular.
Section 3: Results and Impacts of the MDP

Promoting Human Resource Capacity in Bio Medical Engineering: The Results of the MDP Training Interventions

Technicians involved in the training interventions were tested and interviewed during each of the 3 programs. The final training program in the UK culminated in a dedicated one-day workshop (supported by the Commonwealth Professional Fellowship Scheme) designed to elicit the views of the technicians on what they had learnt during the MDP.

The initial training program commenced with a skills assessment to ensure that training was tailored to the needs of the technicians. The test assessed electronics, medical safety, and understanding of a set of medical devices that would be included in the training. The test was repeated after the second training session. Figure 1 shows the results of the tests.

The bar graph shows the same test that was undertaken by the technicians during different stages of their training and mentorship. Test 1 was taken in May 2013 during the first two-week training. Test Two was taken in April 2014 during the second two-week training. Test three was taken in June 2014 during their placement in the UK. Test 1 and Test 2 were given without telling the technicians to prepare and Test 3 was given after the technicians were taught and then given five days to prepare.

The scores show a general increase in the results except for Technician 1 who got lower results for his second test than the first. He however, improved in the third test. This can be used to demonstrate that continuous training and professional development is important for the technicians. This is usually completely missing for the majority of the technicians in the country.
During the final (UK-based) workshop the technicians were asked to rank on a scale of 1-10 the impact that the project had had, as a whole, on their skills. Of the 4 technicians, 1 gave a score of 8; 2 gave a score of 9 and one gave a score of 10.

Technicians spoke very positively of the impacts of the MDP:

I would like to thank the project coordinators that what they are trying to do for us is not just for the project but for entire Ugandans because many patients get referred here. So what the project is trying to do for us will be of great benefit.

The area I have gained most is management of medical devices. That is something that my eyes had never opened to and the way they explained it to me, I saw that there is a very important area that needs to be developed in our hospital, because equipment has been breaking down and thrown away and no one knows what to do with it. In most cases we come to know about them because I’m an electrician. I didn’t think I was very fit (skilled) to go into details but I will help and whenever it was an electrical problem, I would fix it. If it went beyond that, it was nothing to do with me.

They also referred to the quality of the teaching they received: Yesterday was very helpful... The whole of the week. All the sessions. [The trainer] is very knowledgeable.

The qualitative feedback from technicians indicated positive impacts in the following areas:

- General improvement in equipment repair skills
- Procurement
- Inventories and Database Management
- Safety Testing and Calibration
- Equipment Cleaning
- Confidence, Trust and Status
- Presentational Skills

General improvement in equipment repair skills

‘I am a technician by hands on training. Since Kyambogo I can really manage and troubleshoot. I opened and dissembled equipment to see how it functioned and was taught how to find faults with scales and suction machines. I trained on incubators too and had to open and fix problems. I have also got a certificate in asbestos training. My work with electrical connections was really not good but now I have been here [UK] they have told me how to open it and troubleshoot it.’
Senior colleagues also commented on the impact the training has had on the individual technicians but also the successful spreading on knowledge. In relation to the project aims of improving knowledge, transferring skills and beginning to tackle the numerous equipment issues senior colleagues express a huge improvement on a personal level and hospital wide: *There has been great improvement; [the technician] has developed improved skills in maintaining equipment.*

**Inventories and Database Management**

I’ve learned medical equipment management with some work on the use of databases in medical equipment management.

‘We learnt about equipment management. We learnt about a database like an inventory to keep track of equipment on and off the ward. You need to have a store, basically.’

‘I learnt how to create a database and systems of medical device classification – when I look at this symbol I can easily know that this is double insulation.’

Asked whether he had gained in knowledge as a result of coming to the UK one technician replied:

‘I knew about everything but not deeply. I was introduced to electrical engineering testing. I have learned things to do with databases here and shown how to design one in access.’

**Safety Testing and Calibration**

‘I’ve learned electrical safety testing. Yesterday was very, very helpful actually.’

‘We learnt how to calibrate equipment in case it’s faulty.’

‘We’ve learnt that when you work on equipment, before you take it back [to the ward] you need to do some tests. When I reach the unit it does not work. There we have learnt when you are working on equipment you should make tests and observations before sending it back to the ward.’

**Equipment Cleaning**

‘And we learnt how to clean equipment. Basically we learnt how to clean certain equipment’
Confidence, Trust and Status

When the SVP engineer was asked to describe successes in terms of equipment repair, he suggested that one change has been in the confidence and attitudes of the engineers, being more assertive with management.

‘Increasing confidence of engineers to speak to management about the importance of repair. Before that they would ask once, management would say that they don’t have funds and that would be it. Now they speak to management and won’t stop until something happens.’

‘You are the expert on the machine now not the clinician, before you asked clinician to do it and you watched.’

‘Now that I have the confidence at least I know where to start and how to handle [equipment].’

‘Before the project we wouldn’t be allowed to test medical equipment. After the Kyambogo training we were allowed to.’

‘Before the training the doctors would just call an electrician from outside because they wouldn’t trust someone like [us]. These days they are so happy with our work they just use our numbers.’

‘People have now started trusting us with their equipment they now have confidence in what we are doing unlike before.’

‘You guys have built my confidence so much without fearing this is a medical device.’

‘People have now started trusting us with their equipment. They now have confidence in what we are doing unlike before. Before they used to categorize us as low standard but now that we have a biomedical engineer on board they now have trust in us. Initially they used to ask us whether we have ever handled such a machine before and when we answer no then they would refuse us to touch them. But right now they even give us the machine manuals so that we may begin with them before handling any machine to repair it.’

Interviews with senior colleagues suggest that they too had noticed these increases in confidence:

‘His involvement in the biomedical engineering project has helped him to discover his potential.’

‘He has gained a lot when you look at the expertise he has now as compared to how he was before and he wants to share he will show you some pictures he took from the other side and tells you this is how we handled it and this is how we went through it. And you see that really there are some good things in him. He has gained a lot of experience.’
I’m now trusted with the Hospital equipment. The project gave the confidence to prove to my seniors that with or without their presence, I can handle any equipment successfully. The project proved the Hospital that training technicians is vital as they are the ones managing them in the daily operation. The project has opened up chances for technicians like me, who have been again given chance to go to India to train Equipment maintenance course. This would not have happened if the project did not display my characteristics by training me. The project has given confidence and courage to challenge any fault as far as equipment is concerned.

This new found confidence and respect by senior colleagues increased the status of the technicians giving them greater authority in the facilities:

Did this enable you to have more credibility?

‘Yeah, because at first I was requested to go to management. Management rang me and said there is a visitor to come; he didn’t used to call me before.’

‘It was the first time I went in the office of the director. Since the meeting, he is my friend!’

‘Before I was not even known by top management, but now I can go to the deputy director’s office and we have a talk. [The SVP engineer] introduced me to her.’

Presentational Skills

The MDP has engaged the technicians in a series of workshops both in Kampala and in the UK. For all of the technicians this represented a first opportunity to present their work in a public arena.

All of the technicians felt that this had a significant impact on their confidence and also, in empowering them as engineers. More specifically, it also involved developing their IT skills and use of PowerPoint.

‘The UK colleagues taught me how to make a PowerPoint presentation.’
Future Use of Skills

Technicians were asked if they would be able to use the skills they had gained in the future. In the first case cited the technician is referring to his skills in presentations: *I have my supervisor...what I am interested in...he likes such activities.*

In another case the technician was asked whether he will share his knowledge with his colleagues: ‘*Definitely...As long as anyone is interested, I don’t get tired.*’ During the final (UK) workshop technicians were asked if they felt they would retain the relationships they had established with UK engineers when they returned to Uganda. They all replied that they would retain those links:

‘*[When contacting them] you will have to describe the model and type and it depends if he can advise and on the software. Back home we do not have manuals; these UK engineers may be able to find them for us.*’

They were also asked if their felt the knowledge gained in the UK could be applied to Uganda:

‘*Some of these things can be taught in Uganda. But I think there is that element of experience. At the moment there is nowhere you can find this (hands-on) experience. Before Kyambogo no one had basic training. The training in the UK has removed the fear of opening equipment. It’s fantastic - building you from 0 to somewhere. This UK thing... we are not so far from you... Here equipment is a bit more advanced. We have not reached that level but we are close so it does not seem like an unattainable goal. I feel we could achieve the same level.*’

During this final workshop technicians were also to identify future needs. They all expressed a desire for continual training and, in particular accreditation of that training:

*I’d look for more accredited training.*

‘*Since this is a new department in Uganda, if I do a Diploma I will love it, they are seeing its importance.*’

Increased Pressure on Trained Technicians: Workload Issues

In addition to all the benefits reported above the technicians referred to a potentially negative impact associated with his enhanced skills and more importantly, awareness of their new and proven abilities. One suggested that when a problem arises he is now expected to deal with it. In this case he is one of a number of technicians working in a very large facility:

‘*You are the one who’s been trained so you go and do that.*’

‘*If you know it why are you teaching us, why don’t you do it yourself!*’
The SVP engineer also expressed concerns that technicians faced inflated workload and became depended on by others:

‘Just because we picked one person does not mean that they will be the only guys doing everything because they can come back and train the whole workshop.’

This concern has led to an interest in training other colleagues:

I would prefer to share this knowledge with my colleagues

‘Some of them don’t have the knowledge we have now. So if they are called upon in the world and they don’t have an idea. We are now able to train.’

‘My supervisor is so good. When I go to look at something he says lets go together.’

Procurement
Section 1 identified key challenges with procurement processes in Ugandan health care including the highly centralised quality of decision-making (often at Ministry level), the lack of involvement with technicians on the ground and even facility managers, and the pernicious and endemic influence of corruption.

In this environment this aspect of equipment management and its multiplying and ripple effects (into equipment repair and sourcing spares) cannot be dealt with through training alone. It is not so much capabilities that are at issue but leadership.

With that in mind the MDP sought to improve procurement through increasing expertise at technician level and through advocacy work to increase the status/voice of the profession and encourage their participation in procurement decisions.

One of the technicians, when asked if he felt able to implement any of his knowledge on procurement responded:

‘It’s a big question, I am lucky with my immediate supervisor - he sits on the committee, and through him maybe we can try and advise. I will introduce to him the idea of including me on the committee.’

This suggests vital relationships are being built providing opportunities for technicians to share their experience. Other technicians describe their emerging roles in procurement processes:

‘The administer called me and my team to come to his office; ‘Now we want to get some operating lights and we want you to go and look at them’. I think it was good. I’m not sure it was a result of the training but that was my first time. We were not making the overall decision but we made some contributions. I think we can make some good contributions.’
‘Before [the MDP] I was not involved in this. Doctors really expected that they have the wise ideas. Now, I know that they think that what I tell them is actually the right thing.’

Asked, ‘if they wanted to buy something, would they ask you?’ the technician replied. ‘Of course, they consult us, but the final decision is up to them.’

Whilst technicians accepted that their impact on the purchase of expensive items would remain limited they were also now more likely to be informed of its arrival in the facility:

Asked, ‘Even if you don’t have control about who buys it do you know what’s coming on the ward?’ a technician answers:

‘For the first time I was called into the procurement process. Maybe they will just start’. He adds (with respect to donated equipment): ‘I always remember two scenarios - when a white volunteer doctor brought something on the ward she ensured that it came to me first.’

This represents an important step forward in equipment management systems. Marked improvements in the management of equipment entering the hospital have been seen in the case of Mulago Hospital since the start of the MDP:

‘In Mulago when equipment is bought or donated it is supposed to be checked by engineering department. They don’t let you specify the type or quality, but if the quality is bad they give you the chance of denying it.’

In another facility clear evidence exists to show the impact of the project on procurement processes. The following technician describes his involvement in a multi-disciplinary team during the procurement of anaesthetic machines:

‘We tried to introduce and involve technicians in the process of purchasing this equipment. We received donations for anaesthetic machines. It involved the anaesthetists, the unit head and the technicians the process of purchasing those equipment. We were able to advise and we also got other people’s opinion about the machines which was not possible before (the SVP Engineer) came on board. Initially it would involve only doctors, and the supplier would bring the equipment put it in power and that was all but this time around we had to check these anaesthetic machines and we found out that they had a leakage but it took us four hours to identify this leakage.’
Despite the progress made in involving technicians in procurement, regional referral technicians continue to identify challenges in procurement due to hospital structures. The project is beginning to influence systems, but there is still a lot more work needed:

‘Procurement is still a big challenge in the way that they don’t involve us in the procurement of equipment but they quickly call us when it is broken down. And the truth is I would not have recommended buying such equipment if they had involved me from the start.’

We have noted the impact of corruption and its particular role in procurement. Hospital managers and clinical leads are fully aware of the implications of corruption within procurement systems. And the Dr recommended the approach taken by the project of working with ‘keen’ individuals on the ground level is the best approach:

[Dr in charge] thinks that the main issue is that everyone wants money for their pockets with any project that comes to Uganda. He says that communication of key issues doesn’t reach people known to fight against corruption. He gave me an example of 230 anaesthetic machines being bought without consulting any senior consultants. He says that the best way is to work from the ground and influence smaller units with very keen individuals. I told him that it is the approach of the MDP.

Whilst this very grounded approach is proving successful untimely macro-level systems changes are required to prevent corruption in equipment procurement. This would mean that higher quality equipment purchased could be maintained effectively by trained technicians.

Procurement of Consumables and Spares Acquisition

Procurement does not only affect the purchase of equipment; it also influences access to spare parts and essential consumables. These are essential to the maintenance and repair of equipment. Lack of spare parts plays a major role in preventing reductions in 2 of the categories shown on the inventory pie charts (‘C’ – in use but needs repair; ‘E’ out of use/repairable)

Despite significant efforts made by the technicians - as noted in the Case Studies (p. XXX) – availability of spare parts and the time taken to procure them remains a major problem. One senior manager interviewed as part of the evaluation felt that this may restrict the ability of technicians to implement the skills they have gained during the MDP: ‘He can open up equipment now. He knows what to do but he is let down by the fact that there is no money for spare parts’
Evaluation of Tools

Section 2 noted the delays in providing tools to the technicians. The provision of tools has significantly increased the opportunities available to technicians to utilise their skills. It is very clear that technicians possessed few tools prior to this intervention and, when they did have tools, these are purchased at their own personal cost. Prior to the arrival of the tools technicians reported that between 25% and 75% of equipment was not repaired because they lacked the tools. Technicians reported marked improvement in their ability to undertake repairs once they were in possession of basic tools.

The Results of the Inventory Process

The most significant finding here is that the equipment inventory process is continuing to take place and will hopefully become embedded within facility practice. Improving the quality of audit procedures in itself will necessarily identify a higher proportion of equipment in disrepair. This needs to be taken into account when analysing the actual results. As one technician put it:

‘[The condition of equipment] was not that clear because it [an equipment management system] had not been established, but then when the MDP began it was introduced.’

The pie charts presented below give an impression of the overall impacts of the MDP in terms of the condition of equipment in facilities. It is important to emphasise that the MDP is only one of a number of variables impacting on equipment especially in larger more complex facilities. Some facilities have shown a more marked improvement than others. Those facilities existing outside of the public health system have generally shown greater improvement. This may reflect their stronger resource base, greater autonomy (to institute changes) and smaller size. Kabubbu HCCI is a case in point. This is a small facility with a relatively small amount of equipment. Prior to the MDP they did not have a technician as such but tended to transport equipment to Joint Medical Stores for repair. The first pair of charts suggest a small decline in the proportion of ‘good in-use’ equipment and in the proportion of equipment that is in use but needing some repair. However, it appears that there is no longer equipment in the facility that is ‘out of use’. In such a small facility one or two pieces of equipment can easily influence overall figures:

Condition Key
A: Good in use
B: Good/not in use
C: In use but needs repair
D: In use but in need of replacement
E: Out of use/Repairable
F: Out of use/Replacement
Kisii Mission hospital shows greatest improvement with a marked increase in the proportion of ‘good in-use’ matched by a decline in the proportion of equipment needing repair. 12% of equipment here remains out of use but repairable:

The situation at Hoima Regional Referral Hospital remains much the same. Here the main change appears to be a more effective disposal policy reducing the proportion of ‘out of use replacement’ equipment but with a higher proportion of out of use but repairable equipment:

The final case presented here (Mbale) indicates slight fall in the proportion of A rated equipment and equipment that is good but not in use with a commensurate increase in category C which is in-use but needs some repair:

Condition Key
A: Good in use
B: Good/not in use
C: In use but needs repair
D: In use but in need of replacement
E: Out of use/Repairable
F: Out of use/Replacement
Summary of Training Interventions by SVP Engineer

Appendix 1 summarises the breadth and nature of training interventions involving the SVP engineer. Table 1 illustrates the multi-disciplinary engagement and impact of the intervention involving a wide range of staff including technicians, nurses, doctors, diploma and degree level students and a range of managers and policy makers. In total the table identifies 154 training or mentoring episodes. This includes different interventions with the same cohort of technicians. It also naturally does not capture the intensity of his continuing relationship with the technicians over the 20 month period embracing not only face to face encounters but also constant virtual communication. Table X also shows the breadth of topics covered (reflecting the activities described in this section) and including inventory work; equipment management and maintenance; cleaning and infection control; electrical and safety testing; audit; management; and more specialised training in bio–instrumentation for the degree students. Assessments indicated a very high level of take-up and improvement in performance (100% overall with only 1 incidence of a technician failing a test). The final column gives evidence mainly gained through observation of practice of utilisation of newly gained skills and competence in ALL cases (100%). This includes the ‘management’ category where the engineer notes the ‘increased awareness of biomedical engineering as a profession in Uganda’. It is interesting to observe the gender dynamics of training with all of the technicians being male and all the nurses female. The students groups were more mixed with 9 males and 3 females in the diploma group and 34 males and 13 female in the degree cohort.

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20 The SVP collect this data via Monthly Reports. The data here only captures training provided by the SVP volunteer and as such excludes the important contribution of the Amalthea Trust.
Policy Innovations

The following section presents a series of short case studies illustrating specific interventions made by technicians as a direct result of the MDP.

Managing Spare Parts More Effectively

Section 1 noted the problems in Uganda in accessing spare parts and the consequences of this in terms of the proportion of otherwise usable equipment lying idle. One of the technicians who had experienced real problems in accessing spares took his own initiative following the Kyambogo workshop to set up a spares ‘library’. He kick-started this process by requesting some (quite small) funds combined with his own funds to open up a small library (storeroom) containing the spare parts that were most needed, such as sockets and fuses:

I bought lots of each and kept them in the library. Most problems can be fixed by a fuse or socket. I also added in some things for preventative measures - blowers to blow dust away. The idea came directly from the Kyambogo Training. And it is working successfully, so much.

The SVP engineer observed this scheme in action and commented: I was very impressed. I was fixing a concentrator that needed a lead and I didn’t have to wait to fix it.

Asked whether this system was sustainable the technician answered ‘yes it is.’

Keeping Babies Warm

In another example, one of the technicians had spent time in Liverpool Women’s Hospital after the formal training with Amalthea Trust. During this time he worked alongside a UK engineer who was designing and setting up a mobile incubator trolley. He describes his involvement in designing an incubator trolley; ‘I helped them design and build something that doesn’t actually exist’. Asked at the final workshop prior to his return home, how he might be able to utilise those skills he replies: ‘You can use the little facilities you have... Based on this idea I can modify...there it will help.’
Several weeks after returning he emailed the team to explain how he had indeed put his skills into practice:

‘I am so happy to inform you that the fruits of my visiting the UK for the knowledge exchange are beginning to yield. When I came back I found a baby warmer in the special care unit which was not working and they had disposed of it. I picked it and designed a baby coat from it after checking it was working and now I am changing the casters to make it look nice. When I am done with it, I want to first show it to the Senior Hospital Engineer before I take it to the unit. I am so happy that I did this work with a lot of confidence and successfully worked out the way I expected it. The work I did Liverpool Women’s Hospital helped me achieve the skills of being innovative and am going to keep it up because according to my plan I want also to design a Transport trolley.’

Infrastructural Changes: new biomedical engineering workshops

The MDP has directly lead to major infrastructural developments in two facilities. The first of these, involves the creation of a new biomedical engineering workshop at Kisiizi Hospital. This development builds on key human resource investments at Kisiizi hospital. Before the MDP started in Kisiizi Hospital, medical equipment management was being overseen by the power company which is responsible for generating and supplying electricity to the hospital and the local community. The SVP biomedical engineer recommended a few changes including getting a separate workshop for the medical equipment as well as getting someone to look after them. In April 2014 a biomedical technician was recruited and a dedicated workshop was allocated to the medical equipment.

Similar developments have taken place in Kabubbu HCIII. In this case there was no dedicated technician prior to the MDP. However a maths teacher was identified who had an interest in looking after equipment. The MDP has given him the basic skills to enable him to rise to this task:

‘Following the training we have been able to put in place a new workshop which we are equipping. And we have been able to look at some junk that we are keeping and we have been able to dispose of some as scrap and keep some as spares as a result of that training. We have also been able to develop an inventory.’
Repairing Broken suction machines at Mbarara Regional Referral Hospital

The following example shows how the MDP has encouraged team working and knowledge sharing within the biomedical engineering community. A common problem with suction machines in Ugandan hospitals is that they overfill and fluid enters the electronics and pump. This can cause a short circuit causing a fuse to blows or damaging circuit boards. Replacing a fuse is straightforward but the problem is that it is very difficult to find these fuses outside Kampala (200 miles away). Replacing other electronic components on the circuit board or the entire circuit board is even more challenging. In most cases these are sourced outside of Uganda and the cost of buying and shipping just one is too high. When fluid gets in the pump it clogs and after drying the pump cannot rotate. This basically means that the machine motor will not be able to rotate.

The technicians at Mbarara know these challenges too well. They had little experience in repairing suction machines and asked the SVP engineer to help. The engineer put together a team of people to tackle this problem including a technician from Kisiizi, a technician from the International Hospital in Kampala (IHK) and the SVP engineer himself. Eight machines were reported not working and after a two-days visit, six were fixed plus an ultrasound machine. The two that were not fixed needed some spares and the Mbarara technician was now more confident how to fix them.

Suction machines being fixed at Mbarara Regional referral Hospital
Working in Multi-Disciplinary Teams: Re-Functionalis-
ing Kisenyi maternity unit

The next example shows how the involvement of technicians/engineers with the wider SVP team can play a role in re-functionalising Health Centres many of which are not used. This was done as a multi-disciplinary team approach where the SVP volunteers from Kampala cluster gathered together to get the maternity unit at Kisenyi health centre IV working. The biomedical engineer fixed a few devices including an operation table, infant warmer and an anaesthetic machine.

Advocacy and Policy Change

Objectives:

- To make the project findings public
- To encourage policy makers to make changes based on the project findings

In addition to the immediate substantive objectives – of supporting the enhancement of the capabilities of a small group of UMNH technicians – the MDP sought to develop an intervention model that could be rolled out and applied in other settings.

In the Ugandan context we were acutely aware that enhancing the skills of a small cohort of technicians would achieve little and, indeed, could create certain tensions for the individuals concerned in the absence of broader organisational and systems change. The Sustain-
able Volunteering Project is committed to health system change and recognises the importance of multi-disciplinary and inter-professional engagement to begin to take this forward.

With these objectives in mind the MDP sought, from the outset to build a community of technicians and, through advocacy work, to begin to empower that community and increases its professional status. As noted above, achieving change in all areas – but particularly procurement and disposal process requires higher level managerial buy-in.

At mid-stage the SVP engineer managing the project in Uganda expressed concern at his inability to engage key stakeholders:

‘The British Engineer has found it particularly difficult to arrange meet-
ings with senior representatives. He regularly includes them in emails but with little response. All senior (influential) people have been invited to the workshop and it is hoped that by involving them that we will get answers to some of the unresolved issues.’
Whilst the project has been successful in implementing behaviour change at the bottom of the hospital hierarchy, addressing the overriding issues with management that effect work that on a lower level has been extremely challenging. A SVP volunteer from a similar project describes this challenge:

‘It’s really hard. And I think we all know that unless the government changes, we’re waiting for it to infiltrate down. If the top doesn’t change, it has to feed down in that way, I think it will never ultimately change unless the government or the ministry of health actually makes a change. I think if they make sure the pay is on time and everyone gets paid and the budget is correct, once they’ve made that step I think people would actually come to work because they know that they will get paid for what they have come to do.’

Since the technicians trained by the UMHN are not directly involved in developing policy, it was important that the different managers at all levels were informed of the progress and benefits of the project. A series of mechanisms were planned to promote community-building and policy engagement.

These included active participation of all actors in a series of workshops in Uganda. In the first instance these were an integral part of the SVP bi-annual workshop. However in May 2014 the decision was made to hold an independent bio-medical engineering workshop involving hospital directors, private companies, representatives of the Ministry of Health, the Uganda National Advisory Committee on Medical Equipment (NACME), the Uganda National Association of Medical and Hospital Engineers (UNAMHE) and UMNH trained technicians. The focus for this workshop was to discuss challenges in medical equipment management and what were the possible solutions. This presented, for the first time in Uganda, an opportunity for multi professional collaboration in the field of bio-medical engineering.

Participants appreciated the benefits of this process:

‘It got people in different positions to discuss some issues. What was interesting was that the clinicians, ministry and technicians on the ground all had the same views. So we have defined some action points on what needs to be done on the issues. [One of these includes] 6 monthly meetings organised by technicians with hospital and clinicians, to see how they can help them.’

The first of these is planned to take place in Kisiizi:

‘For the technicians we have a meeting (6 monthly) planned in Kisiizi. The meeting will be chaired by the host technician, hospital management and in-charge and Drs will be invited. It won’t purely be focused on the technicians. We need support from management and Drs and nurses and need to raise our profile.’

Asked whether they had ever met together like this before one participant replied: ‘All in one room - directors and technicians in one room - no, physically no, I had heard the names. It was really good for me to know them, what they do’
They also felt that this would be a start of an on-going process: ‘Yes because they committed themselves that we should introduce ourselves to them.’

The active engagement of trained Ugandan biomedical engineers employed in the private sector at the workshop has led to their involvement in subsequent training. Evidence of the outcomes of this advocacy process can be seen at a number of levels. On a general level it has heightened awareness amongst technicians themselves of the existence of (albeit) imperfect systems and the values of engaging with these. In Uganda, specific equipment management systems are uncommon. One technician identified the project (and the SVP engineer’s presence in particular) as a catalyst encouraging the use of a system and noticed the need for further improvement in system implementation:

‘Today I realised that there was a system in main theatre of keeping the faulty equipment – there is a workshop at main theatre – so when a machine breaks down, it is kept there, repaired and then it is returned. And there is book-keeping...When I go back (to Ugandan) we are going to improve it.’

More specifically, in Mulago Hospital, the support of the Deputy Director has led to the development of a new policy on equipment management to increase the visibility and control over equipment coming into the hospital. The new policy requires that all procured equipment now goes through the Deputy Director’s office. Beforehand, equipment would appear on the ward through donation and procurement and sometimes without the knowledge of management and there was no way of monitoring equipment entering the hospital.

In Kisiizi Hospital the appreciation of hospital management has been evidenced through the provision of a dedicated engineering workshop and the recruitment of a second technician.

On a much broader level the bringing together of quite an isolated cadre of Ugandan health workers through residential training in Kyambogo and then in the UK has helped to build a stronger sense of identity amongst technicians. This sense of community has blossomed beyond a simple ‘self-help’ group to foster the emergence of a new professional identified as biomedical engineers.

When the MDP commenced the professional organisation representing biomedical technicians/engineers (Uganda National Association of Medical and Hospital Engineers) was quite inactive in Uganda as the SVP engineer notes: ‘It is very dormant. Our idea is to make biomedical engineering active. When we have meetings we will plan with the organisation and get them active again.’

Discussion, at the final workshop suggested a very positive commitment to taking this forward: ‘There is a new profession growing in Uganda - a big step. What we need is hospital managers and senior clinicians to also recognise technicians as professionals, not ‘odd job men’
National and International Dissemination

The MDP has played an active role at national level in the UK and Uganda in terms of raising awareness of the project and the challenges facing biomedical engineering in Uganda. In addition to this the MDP and SVP have actively facilitated the attendance of the SVP engineer to present the project to a range of international conferences and events.\(^\text{21}\) The SVP biomedical engineer also attended a number of international conferences including Euip’aid in France, 2nd Global forum on Medical equipment organised by WHO. At these conferences papers were presented and many new relationships were developed.

Challenges to Implementation and Systems Change

Unsurprisingly the MDP has met with some resistance to systems change. Despite an explicit focus on building relationships at all levels of organisations and with the MOH and despite an apparent consensus on the need for change, this has often failed to translate into effective implementation. This ‘implementation gap’ appears to reflect both a failure of those with author to communicate effectively and an absence of action from those on the ground.

The problem is described as follows:

It is good you have written the policies but how do you implement? How do you make sure that the people on the ground actually know these policies? I honestly know that the people on the ground don’t know about them.

In order for future projects to begin to alter systems and implement change is it necessary that these barriers to policy implementation and systems change are broken down.

In relation to the biomedical engineering project lots of the human resource problems could arguably be attributable to the fact that staff are no getting paid on time or at all. The issue of salary not being paid at all or sporadically can be seen across all aspects of the project and is arguably something that if addressed could improve the success of many projects. At this stage it still remains a significant barrier to success and change.

\(^{21}\) Details can be found on the website. www.BME.Impcharity.org
A senior colleague of a technician describes of monetary motivation could be affecting local technicians in the project:

‘The other one is to do with money. He also needs to be motivated, he has challenges as a young man he also has other things to do. And when he comes and there is no hope like now in our country at times you get no salary yet you have worked for the whole month, at the end of it all you go to the bank and there is no money. You cannot talk to your boss but to wait for the next month. So how can such a person survive?’

The Effect of Corruption on Policy Change

As noted above, dealing with the purchase and disposal of expensive equipment and consumable supply chains inevitably facilities corruption. Corruption in this area is endemic in Ugandan health facilities. The MDP, as with the SVP, has faced problems with corruption across the spectrum. Despite projects being affected negatively by corruption, volunteers often avoid addressing it.

Volunteers working in externally funded, international, projects (such as the MDP) are acutely aware of the effects of corruption in blocking progress towards improved maternal and new-born health. However, expressing disapproval or challenging corrupt behaviour can be extremely difficult for ‘outsiders’ and may put volunteers at personal risk.

In a corrupt environment volunteers’ attempts to implement change could be seen as interference inhibiting progress and damaging relationships. The SVP engineer was himself put in some difficult situations during the project:

‘I am trying to write reports per hospital but this is taking a bit of time. I feel a bit scared about how to actually bring it out there because I want to put in all these concerns as well. You being there will actually means that you are interfering.’

Indeed at the very start of the project the SVP engineer was warned about his potential efficacy due to corruption:

‘I met [Dr in charge] who is very passionate about improving efficiency in the hospital. His unit is fully equipped and very clean. He is not convinced that our involvement will be very successful. His point is that corruption is at many levels in Uganda and that people don’t always mean what they say.’

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Volunteer Development

Objectives

- To ensure that the project is mutually beneficial for the host country and the volunteer
- To allow the volunteer to develop professionally and personally
- To allow the volunteer to develop transferable skills and experience an usual but enriching work environment

As noted above, the MDP represents a partnership (see note x). The bio-medical engineer volunteer (Robert Ssekitoleko) was recruited via the Sustainable Volunteering Project and has been managing the project in Uganda for over 18 months. The SVP is concerned not only to support capacity-building and systems change in Uganda but also to support the career development and skills of British volunteers.

Despite the notion of ‘win-win’ returns to professional voluntarism (Crisp, 2012), in some cases these goals may lie in some tension. And biomedical engineering presented a specific challenge in this regard not least because the UK volunteer was very highly qualified having completed a doctorate prior to the commencement of his placement. The marked difference between the technology in the UK and Uganda and the impact of this on the role of engineers in health facilities was predicted to reduce the returns to the UK volunteer in terms of relevant and usable skills/experience.

In practice this proved not to be the case at all. Dr Ssekitoleko reports significant gains both professionally and personally and the acquisition of skills that may have been difficult to develop within NHS structures. These include:

1. Practical analysis
2. Learning how to adapt engineering skills learnt in the UK to resource poor environments
3. Publications
4. Conference attendance
5. Co-ordination and project management
6. Opportunities for professional networking
7. Opportunities for seniority and leadership

In terms of ‘practical analysis’, he describes the value of going ‘back to think about things in their fundamental’ manner and understand the ‘physics’ behind equipment. This experience has increased his awareness and value of his core knowledge (fundamental basic science) which he has both used and developed during his placement. This ‘fundamental science’ component of training he suggests is sometimes overlooked in the UK education system.
Dr Ssekitoleko also describes learning how to adapt engineering skills learnt in the UK to a resource poor environment and how to be resourceful and go back to basics: *I am also learning because the equipment we have in the UK is a lot more advanced.*

In terms of career progression and CV-building the project has provided valuable opportunities to present and publish papers at national and international fora. Being part of a unique project and having achieved interesting results has generated opportunities for professional networking including participation in the Uganda-UK Health Alliance meetings and the organisation of high level workshops involving senior stakeholders in Kampala: *‘For the first time I am in charge of organising an important workshop.’*

Most SVP clinical volunteers identify improvements in teaching/presenational skills and confidence in using these. Dr Ssekitoleko’s role in this area has blossomed from occasional teaching (on the Kyambogo course for example) to the offer of a part-time lecturing position in the School of biomedical sciences at Makerere University.

The degree program in biomedical engineering degree started three years ago and represents a major capacity-building initiative in Uganda. The offer of such a position represents recognition of his expertise and a unique opportunity to contribute to initial training of the next generation of biomedical engineers in Uganda. He describes this aspect of his role as follows:

*‘This is good exposure (for me). Originally I had a bit of teaching experience in Queens Mary’s (London) after my Masters, but this has given me an opportunity to carry on teaching. Being in a top Uni in Uganda has opened doors. Now international leaders are contacting me to collaborate on projects. Teaching is a way to keep my knowledge and skills up-to-date. I am going to be meeting 2 professors that are interested in setting up a research lab. in maternal and new-born health; they have been in Oxford for years. This is quite exciting. Doors are being opened and I can see potential in having affiliation with Makerere University.’*
Dr Ssekitoleko also identifies significant skills gains in leadership including project and human resource management and communication: ‘I am still improving in dealing with people with differing objectives.’ The volunteer feels that he has much more responsibility than he would have had at this (early) stage in his career in the UK:

‘I think I’ll be stronger from here, professionally. I feel like I am actually benefitting a great deal from coordinating for different people, you are meeting these guys and we are meeting people even up to directorship level who are inputting lots of quite useful ideas into me and I’m meeting guys who are meeting at a technical level within a low-resource setting which is something that I was never used to, so this is also quite beneficial to me professionally.’

On a more general note he refers to the impact of the placement on his ability to actively help vulnerable populations: ‘I care about people being well [...] if I can solve the problem of the incubators I can make such a huge impact (on neonates).’

The Impact of Corruption on Volunteers

The biomedical engineer volunteer was warned early on in his volunteer placement of the risks of ‘disrupting’ corrupt relationships: 24

‘I have been warned that in Uganda even if you are trying to do a good thing people in high places will stop you because you are doing the right thing and right things don’t usually have a lot of money attached to them.’

This dynamic effectively excluded the SVP engineer from whole areas – where high priced equipment was in use. Local leaders are often very aware of this situation but powerless to intervene and can only recommend that the UK volunteer withdraws from these ‘no-go’ areas: ‘He was shouting at me and almost even wanting to beat me up.’

In this instance the respondent spoke to other management, who were aware of the corrupt practice and resistance. The volunteer was informed to ‘just leave that’ area. The same hospital area has also caused barriers to progress with similar capacity building efforts.

‘I remember a year ago [British Project Leader] tried to bring in some of the students from Kyambogo and they wanted to do some training [with these machines]. He came several times and he just would not let him. I think they even reported the machine broken but they still wouldn’t let them in.’
Corruption is a complex and largely invisible process – especially for ‘outsiders’. It creates serious tensions for international volunteers attempting to improve procurement processes, as they are immediately ‘interfering’ in corruption syndicates. One of the ‘methods’ of corruption taking place in equipment procurement is described below:

‘Being there will actually mean that you are interfering... because you come in and say, ‘I will get you a very quality machine from Germany costing maybe 300,000. They put in a one million quote and they are pocketing the 700,000. And they still buy the fake equipment.’

‘My goodness the resistance I got there! Just as we said who we were you could see even from his face that he did not want anything to do with any disturbance. I went back to [senior manager] and he said, ‘just leave that [area].’
Summary of Progress

This report has described the challenges identified prior to commencement of the MDP intervention. These challenges are complex and systemic and deeply entrenched. Equipment management is an area rarely touched in the past by UK health partnerships and international partners. It has indeed been relatively neglected in comparison with other areas of clinical capacity-building.

In that sense the MDP represents a unique intervention. The reports describes the intensity of the training intervention focused on the UNMH technician community including both formal training and informal mentoring. It is very clear from the results that this cohort of technician have received and responded positively to a significant amount of training. The training was tailored to their specific needs at the start of the project and has enabled each technician to make significant progress in their own learning and skills base.

Perhaps as importantly as the capabilities gained, technicians unanimously report marked improvement in their confidence and this confidence, together with external recognition of their heightened skills base has enabled to achieve a level of recognition and trust from key actors in facilities. This includes clinicians on the wards (nurses and doctors) and hospital managers. These improvements in skills, confidence, trust and recognition together have led to increased efficacy in terms of equipment audit, maintenance and repair and an enhanced role in procurement decision-making.

The areas of procurement and disposal have been identified as areas where decision-making has been highly centralised and generally remote from the key actors on the ground (facility-based technicians and engineers). Over the course of the project we have identified some incremental but critical changes in these process at least in relation to procurement. The pie charts also suggest some improvement in the disposal of dysfunctional equipment at least from clinical areas (if not from stockpiles).

The project has also witnessed significant elements of systems change. These include the embedding of an inventory/audit processes; the establishment of dedicated workshops where these did not previously exist; interesting initiatives to ensure the supply of spare parts and consumables and highly successful examples of team working both within the emerging biomedical engineer community and in multi-disciplinary interventions.

Finally, from an advocacy perspective, the MDP has played a vital role in building a self-conscious community in Uganda and raising the profile of biomedical engineering as a profession. The involvement of the SVP volunteer in diploma and degree level education at Kyambogo and Makerere University builds on the continuing professional development work described above to play a role in nurturing the next generation of biomedical engineers in Uganda.
The willingness of senior policy makers at Facility level and in the Ministry of Health to engage with the project and directly with the technicians suggests that important ground has been made in establishing a more positive future for biomedical engineering in Uganda.

It is important that this momentum is not lost at this quite early stage in community building and capacity generation. Ensuring that these gains provide the basis for more widespread improvement through knowledge transfer requires continued support.
Recommendations

Building Continuity in Support
The MDP team recommend continued support for the MDP to ensure that the gains made are not lost and that further progress can be achieved. This support should be focused on continuing to support the existing community of technicians and build on the advocacy work to continue to raise the profile of the profession.

Relationships: Uganda health Workers and UK Volunteers
The MDP has shown the value and possibility of building and sustaining co-presence. The SVP engineer has worked tirelessly to support the community of technicians at all times focused on enhancing their competence, confidence and efficacy. This approach has ensured effective skills transfer and sustainable capacity building. It is important that all international volunteers engage in such sustainable practices and we look to Facility managers and the MOH to ensure systems are in place to embed this principle.

Extending the Community and Spreading Expertise
The report has noted the potentially negative impact on UMNH technicians in terms of workload. It is important develop mechanisms to spread this learning using the skills of the existing cohort of technicians supported by volunteer involvement where possible to increase the population of trained technicians and offer further opportunities for skills enhancement (as an on-going activity).

Raising the Status of the Profession
Work has commenced to raise the status of the profession but this needs embedding and developing. A failure to continue to provide support risks some slippage. Advocacy work linking senior facility managers with technicians and the MOH requires continued support to maintain and build momentum.

Inventory Processes
The inventory processes need to be fully acknowledged by key stakeholders to encourage their use across all Uganda health facilities.

Ensuring Reliable Supply Chains: Spare Parts and Consumables
The MOH and Facility managers need to pay attention to the critical issue of ensuring the reliable and timely provision of spare parts and consumables. Facility Technicians should be given control over small budgets for the purchase of spares parts and consumables subject to rigorous audit (via inventories). This should include provision of secure store rooms.
Tools

Key Stakeholders at facility and Ministry level should pay attention to the importance of providing tools to technicians. Without tools technicians are unable to utilise their skills. Systems need to be put in place to ensure that tools are of high quality and risks of theft can be minimised.

Reducing Opportunities for Corruption

The high monetary value of equipment and spare parts /consumables makes this area of Ugandan health system highly susceptible to corruption. Corruption damages equipment management systems in complex ways. Procurement remains a key challenge as decisions on the purchase of equipment are often made without the involvement of biomedical engineer specialists (or users) and under the heavy influence of corruption. This is a priority area that demands attention at the highest levels. The development of inventories presents opportunities to increase transparency and audit.
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Presentations

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Robert Ssekitoleko: The Bio-medical Engineering Project; Building Capacity in Equipment Maintenance and Repair; UMNH ‘Sustainable Volunteering Project’ in Partnership with the Royal College of Paediatrics ‘Global Links’ Project Workshop; Partnering for Maternal and Newborn Health; 24th June 2013; Mulago Guesthouse Conference Centre; Kampala, Uganda
Robert T Ssekitoleko and Patrick Semata; Equipment Management Capacity Building through the biomedical engineering project; The UMNH & The Sustainable Volunteering Project Workshop; 14th August, 2013; Mulago Guesthouse Conference Centre; Kampala, Uganda
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### Appendix 1

Table 1 showing Volume and Quality of Training and Mentoring Interventions by the SVP Engineer between January 2013 and September 2014 (20 months)

<table>
<thead>
<tr>
<th>Cadre</th>
<th>Number trained or mentored**</th>
<th>Number showing improved capability or motivation</th>
<th>Evidence of capability or motivation</th>
<th>Number showing improved performance</th>
<th>Evidence of performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td></td>
</tr>
<tr>
<td>Technicians</td>
<td>8</td>
<td>8</td>
<td>The technicians repeated the inventory one year after the first one</td>
<td>8</td>
<td>Improved documentation</td>
</tr>
<tr>
<td>Nurses</td>
<td>10</td>
<td>10</td>
<td>Demonstration of improve skills in using incubators</td>
<td>10</td>
<td>Reduced calls to the technicians for fixing small problems</td>
</tr>
<tr>
<td>Nurses</td>
<td>14</td>
<td>14</td>
<td>Each demonstrated capability to use the resuscitation unit effectively when they did a practical test after the training</td>
<td>14</td>
<td>Reduced reports of problems with the unit and the trained staff training others</td>
</tr>
<tr>
<td>Nurses</td>
<td>3</td>
<td>3</td>
<td>Confidence in using all the functions of the monitor</td>
<td>3</td>
<td>No more reports due to wrongly attaching BP cuffs, Less reports of damages to SPO2 probes</td>
</tr>
<tr>
<td>Biomedical Engineering Diploma Students Kyambogo University</td>
<td>3</td>
<td>9</td>
<td>Exam given was passed very well</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technicians</td>
<td>7</td>
<td>6</td>
<td>Collecting of manuals</td>
<td>5</td>
<td>Some have started keeping the user manuals in their workshops</td>
</tr>
<tr>
<td>Technicians</td>
<td>6</td>
<td>17</td>
<td>Passed tests</td>
<td>5</td>
<td>Improved practices in own hospitals such as stocking of sparing, dedicated medical devices workshop</td>
</tr>
<tr>
<td>IT technician</td>
<td>1</td>
<td>1</td>
<td>Effective inventory taking during observation</td>
<td>1</td>
<td>Took more inventories without supervision</td>
</tr>
<tr>
<td>Technicians</td>
<td>4</td>
<td>4</td>
<td>Passed the practical tests</td>
<td>4</td>
<td>Functional tests done on new and repaired equipment</td>
</tr>
<tr>
<td>Technicians</td>
<td>7</td>
<td>7</td>
<td>Passed test</td>
<td>7</td>
<td>Improved visibility in their respective hospitals</td>
</tr>
<tr>
<td>Biomedical Engineering 3rd year Degree Students Makerere University</td>
<td>5</td>
<td>14</td>
<td>5</td>
<td>12</td>
<td>Passed Continuous assessment and end of semester exam</td>
</tr>
<tr>
<td>Biomedical Engineering 2nd year Degree Students Makerere University</td>
<td>8</td>
<td>20</td>
<td>8</td>
<td>20</td>
<td>Passed Continuous assessment and end of semester exam</td>
</tr>
<tr>
<td>35 different expertise, including doctors, hospital directors, ministry of health commissioners, associations representatives</td>
<td>10</td>
<td>25</td>
<td>10</td>
<td>25</td>
<td>Active involvement of everyone at the workshop</td>
</tr>
</tbody>
</table>