Focus on POCUS: Assessing Need, Feasibility & Cultural Implications of Implementing Portable Ultrasound in Namibia

Brynn Cardozo, Hannah Hill, Bonham Pierce, and Nathalie Zakrzewski

FOCUS ON POCUS:
ASSESSING THE NEED, FEASBILITY& CULTRAL IMPLCATIONS OF IMPLEMENTING PORTABLE ULTRASOUND IN NAMIBIA

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Submitted to:
Project Liaison: Ernest R. Greene, NMHU Professor, PON Visiting Professor
Project Advisor: Holly Ault, WPI Professor
Project Advisor: Tom Robertson, WPI Professor

Submitted by:

Brynn Cardozo

Hannah Hill

Bonham Pierce

Nathalie Zakrzewski

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Abstract

This project aimed to assist a coalition of Namibian institutions with improving public healthcare in Namibia by assessing need for medical imaging technology. We collected data on available resources in the public health sector by visiting healthcare facilities and conducting interviews with medical experts. This data illustrated a national need for imaging technology for which we recommend implementing point-of-care ultrasound (POCUS). Case studies suggest that this frugal technology would have positive effects on Namibian healthcare. Having considered possible cultural implications, data will be presented to the MHSS in a proposal to fund the implementation of POCUS technology in Namibian public healthcare system through the 2015 UNAMSOM graduates.

Acknowledgements

Executive Summary

"Disease is a threat to life and you can't have any rights if you are dead."
- Dorkas Phillemon, Media Liaison Officer of Namibia's National Society for Human Rights

Introduction

Globally, 1.3 billion people lack access to effective, affordable healthcare (Bale, 2014). Economic deficiencies in developing countries result in healthcare systems that cannot provide medical care to the people who rely on them (Frenk, 2004). For example, Namibia has one of the most unequal economies in the world. Insufficient spending and ineffective distribution of funds result in a scarcity of practitioners and technological resources in the public sector. UN Secretary General Kofi Annan claims, "The biggest enemy of health in the developing world is poverty" (Dying for Change, 2005).

According to Professor Ernest Greene, a visiting research associate at the Polytechnic of Namibia, the foremost issue that impedes the improvement of Namibian public healthcare is a lack of information on the resources available to health facilities. Confirming this knowledge gap, Dr. Norbert Forster, Deputy Permanent Secretary of the Ministry of Health and Social Services stated, "The Ministry has NO up-to-date inventory of medical equipment." Recent census information exposes the existence of less than one (0.34) health professional (physicians and nurses) and 0.005 advanced imaging devices per 1,000 inhabitants (compared to the 3.1 physicians and 0.011 imaging devices per 1,000 inhabitants in Botswana) (Namibia Demographics Profile, 2014; WHO, 2010b; African Health Observatory, 2008). As it stands, the Namibian public healthcare system is unable to properly treat its people due to a lack of diagnostic technology and a lack of documentation of where the few devices are used.

However, there is a form of medical imaging technology that could help alleviate Namibia's healthcare problems. Portable ultrasound technology, a single small device, offers a wide range of medical applications (Moore and Copel, 2011). Pilot studies have demonstrated the helpfulness of POCUS in triage and emergency situations (Kobal, et al., 2004;Spencer & Adler, 2008), cardiovascular disease (Wiley, et. al, 2014), infectious disease (Dr. Günar Günther M.D., 2015), and maternal care (Sippel, 2011), especially in resource-limited environments.

However, POCUS effectiveness depends heavily upon acceptance from local communities and effective physician training with the technology (Muller-Rockstroh, 2012; IFEM, 2014).

To improve the availability and quality of healthcare in rural Namibia, the Polytechnic of Namibia, School of Health and Applied Sciences has partnered with the University of Namibia School of Medicine (UNAMSOM) to introduce POCUS technology into rural Namibian health clinics and medical centers. This project collected data from public healthcare facilities in an effort to address the information gap and demonstrate the need for effective medical imaging technology in the Namibian healthcare system. From collected data, recommendations for an implementation strategy were created as well as a stratified list of regions for the distribution of POCUS devices created.

Project Goal

This project aimed to assist the Polytechnic of Namibia, School of Health and Applied Sciences and the University of Namibia School of Medicine in assessing the need, feasibility and social impact of implementing POCUS technology in the Namibian public healthcare system.

Objectives

1. Assessed the potential need for POCUS technology in Namibian public healthcare facilities.
2. Assessed the logistic and economic feasibility of implementing POCUS technology in Namibian public healthcare facilities.
3. Assessed the cultural dimensions of implementing POCUS technology in Namibian public healthcare facilities.

Methodology

To accomplish these objectives, we used four methods to collect data. First, we visited facilities across Namibia and conducted informal interviews with medical staff to document the resources available to each healthcare facility and discover how patients pay for their visits. Second, we consulted medical experts experienced in both the Namibian public healthcare system and POCUS technology to learn about required resources for POCUS use, cost of POCUS devices and how patient copays are affected by the use of technology during clinic

visits. Third, informal interviews with the aforementioned medical professionals provided insight on possible social impacts of implementing POCUS technology in the Namibian public health sector. Finally, a student survey at the Polytechnic of Namibia informed us about cultural views on these possible social impacts.

After collecting data from each facility, we compiled the information in a database and analyzed it by grouping responses together in categories. We used criteria for ranking regions based on factors that demonstrate a need for medical imaging technology to determine where POCUS was most needed. Information on economic and social impacts was considered when creating recommendations for POCUS implementation.

Figure 1 Visits at public healthcare clinics in northern regions of Namibia, Erongo and Kunene.

Figure 2 Interviews with medical professionals and a survey of Public Health students from the Polytechnic of Namibia.

Findings

1. Despite a high infectious disease burden, specifically in TB and HIV/AIDS, and a high demand for antenatal and trauma care, Namibian public healthcare facilities lack basic diagnostic technology, demonstrating a need for imaging devices.

2. All Namibian public healthcare facilities possess the resources required for POCUS operation: power supply, access to coupling agents, access to water and staff.

3. The revenue generated from patient copays at public healthcare facilities cannot offset the cost of a POCUS device.

4. The possible economic impact of POCUS implementation in Namibia's public healthcare system is complex and difficult to predict due to confounding factors such as referral rates, diagnostic rates and patient's preference to attend facilities equipped with imaging technology.

5. The implementation of POCUS technology as a diagnostic tool in public healthcare facilities could result in changes in workplace dynamics among medical staff based on differences in training and new work roles/responsibilities.

6. Namibians would rather be seen by a doctor than by nurse and are excited by the prospect of Namibian-trained doctors entering the public healthcare system.

7. The implementation of POCUS technology as a diagnostic tool in public healthcare facilities might create two social shifts: the first, on social stigmas associated with TB thought improved diagnostic capability and the second, on attitudes towards abortion through better antenatal care.

Recommendations

1. We recommend that a one-year pilot study of POCUS technology be conducted by equipping each 2015 UNAMSOM graduate while they complete their internship in the public health sector.

Distribution to UNAMSOM graduates has a number of benefits that fall under four categories: training, cultural variables, people rather than facilities, and geographic distribution.

Training: Prior training at UNAMSOM alleviates problems that could arise in attempts to teach current medical staff how to use POCUS technology, such as leaving rural clinics unmanned and social tension between staff with varying levels of training and background.

Cultural Variables: Because the majority of UNAMSOM students are from the regions in which these public healthcare facilities operate, they are aware of local customs and could be more culturally considerate than an outsider.

People rather than Facilities: Equipping the UNAMSOM interns personally with a device instead of distributing directly to facilities ensures that the device is not misused or damaged by individuals that do not know how to operate it properly and avoids the issue of unused equipment being left "to collect dust" because the practitioner trained to use it has left the facility.

Geographic Distribution: For their internships, the UNAMSOM interns must go where the University decides to place them in the public sector, thus the managers of the pilot study can geographically distribute devices such that the data collected is representative of full nationwide POCUS implementation.

2. We recommend that funding for POCUS devices in the pilot study come from the MHSS.

The Namibian public health sector is under MHSS jurisdiction. The revenue generated from patient copays at public facilities cannot offset the cost of a POCUS device because many patients do not pay for their care. The MHSS must fund the POCUS devices if they are to be implemented in the public healthcare system. This method would not only assure that the devices were funded in accordance to governmental processes and regulations, but also create confidence in the MHSS in their ability and commitment to improve Namibia's public healthcare (Haufiku, 2015).

3. We recommend that two UNAMSOM interns, and therefore two POCUS devices, be located in each of Namibia's fourteen regions. Additional distribution of devices and interns can be based on the data we gathered on regional need for medical imaging and staff.

The UNAMSOM graduating class of 2015 will be composed of forty interns. The fourteen regions of Namibia can therefore each receive at least two POCUS devices. Further distribution of devices should follow the following criteria for regional ranking:

- Available imaging: first ultrasound, then x-ray
- Referral distance highest to lowest
- Disease burden highest to lowest
- Number of doctors, lowest to highest

4. We recommend that POCUS training be expanded to consider possible social implications, such as stigmas associated with TB and abortion.

POCUS implementation may create two social shifts: the first, on social stigmas associated with TB and second, on attitudes towards abortion. Neither is addressed by the curriculum for POCUS training at UNAMSOM, and is only covered by each student's personal experiences. Formalized education on these issues will allow interns to properly counsel their patients on these potential issues.

Conclusion

Our results suggest a significant need for POCUS throughout Namibia. This feasible and frugal technology can be initially implemented with the new, POCUS trained, native Namibian interns who will be working out of district hospitals. From our experiences and data, we suggest that POCUS is an appropriate and cost effective medical imaging technology that could improve diagnostic capabilities in the Namibian healthcare system.

Authorship

APPENDIX

Completing this project required many roles outside of the writing and editing process. The following are descriptions of team participation in other areas of this project.

Brynn Cardozo, who according to Prof, "takes no prisoners," was the primary formatter of our report document, and team motivator. The one week she had a concussion, the team took a few too many naps. She also acted as the POCUS "expert", fully capable of giving a technological lecture on all the wonders of our favorite ultrasound device at any given moment. Brynn took impeccable pictures of sunsets while hanging out the window of our vehicle during our adventures to neighboring regions. She was sure to remind us when coffee time was, and whenever we ran out of chocolate. While our truck was stuck in Sossusvlei, Brynn dug in the sand for two hours because she had no intention of dying in the Namib Desert.

Hannah Hill, known by Prof as "the Steady Hand," kept everyone on track with her detailed minutes and recording abilities. Hannah made sure that the team met every deadline and was the primary photographer of the facilities, taking excellent pictures that Brynn always insisted were black and white for the presentation. Hannah covered the difficult socio-cultural implications of this project with grace and respect for the local people and the sensitivity of the topics covered. Even though she talked like a robot during presentations, her excellent hat wearing abilities made

us quite jealous. While stuck in Sossusvlei, Hannah was unable to climb the nearest dune because the sand burned her feet.

Bonham (BO) Pierce, who according to Prof was "the Enthusiasm", was in charge of talking. He spoke to any strangers that needed to be interacted with along the way, especially cab drivers. He formed the closest relationship with the sponsor by sitting in the front seat of the car and playing rugby for the Polytechnic of Namibia. With regards to data collection he co-lead the survey of students with Nathalie and served as chief navigator, helping us find our way across the Namibian countryside and our way through streets of Windhoek. While stuck in Sossusvlei, Bo decided to become one with sand of the Namib Desert.

Nathalie (NAT) Zakrzewski, known by Prof as having "the European Touch" was the primary interviewer when visiting Namibia's public healthcare facilities. Nat was also the one to make every phone call because she was the only one who could get an answer, even if Bo called just a minute earlier from the same phone. While editing the paper, Nat loved to highlight the entire google document and change the font size, causing the entire group to have mini heart attacks. Despite this, she had an excellent eye for spotting instances in the paper where "clinics" needed to be changed to the more appropriate "facilities." During our trips she was the expert on when it was snack time, making sure we all ate enough. She also made it known what days were perfect for tanning. While our truck was stuck in Sossusvlei, she acknowledged that tanning was a better idea than digging and suggested we just try to pick up the back of the truck to get out.

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IFEM: International Federation of Emergency Medicine
MHSS: Ministry of Health and Social Services
OECD: Organisation for Economic Co-operation and Development
POCUS: Point-of-care Ultrasound
SAP: Structural Adjustment Programs
TB: Tuberculosis
UNAMSOM: University of Namibia School of Medicine
WHO: World Health Organization
WPI: Worcester Polytechnic Institute

1. Introduction

"Disease is a threat to life and you can't have any rights if you are dead."
- Dorkas Phillemon, Media Liaison Officer of Namibia's National Society for Human Rights

Globally, 1.3 billion people lack access to effective, affordable healthcare (Bale, 2014). Residents of low and middle-income countries, such as India and Angola, bear 93% of the world's disease burden, yet account for only 18% of world income and 11% of global health spending (Bale, 2014). Economic deficiencies in developing countries result in healthcare systems that cannot provide medical care to the people who rely on them (Frenk, 2004). The residents of these countries have higher mortality rates than those in the developed world because treatable illnesses go untreated (World Health Organization, 2010). People are needlessly dying. UN Secretary General Kofi Annan claims, "The biggest enemy of health in the developing world is poverty" (Dying for Change, 2005).

No country demonstrates the link between unbalanced economies and inefficient healthcare more clearly than Namibia. Namibia has one of the most unequal economies in the world, (Frenk, 2004). National public spending on health is still below the 15% of the budget recommended by a recent African Union Declaration even though 85% of the Namibian population depends on the public healthcare system (World Health Organization, 2010). In addition, regional experts, such as the Minister of Health assert that this minimal public funding is often allocated inappropriately (Haufiku, 2015).

According to Professor Ernest Greene, a visiting research associate at the Polytechnic of Namibia, the foremost issue that impedes the improvement of Namibian public healthcare is a lack of information on public healthcare facilities. Confirming this knowledge gap, in 2015 Dr. Norbert Forster, Deputy Permanent Secretary of the MHSS stated, "The Ministry has NO up-to-date inventory of medical equipment." Without knowing what healthcare facilities have available in terms of resources and staffing, effective improvements cannot be made. Insufficient spending and ineffective distribution of funds results in a scarcity of practitioners and technological resources in the public sector. A recent World Health Organization census exposed the existence of fewer than one (0.34) health professional (physicians and nurses) and 0.005 advanced imaging

devices per 1,000 inhabitants (Namibia Demographics Profile, 2014; WHO 2010b). These are shockingly low numbers compared to the 3.1 physicians and 0.011 imaging devices per 1,000 inhabitants in Botswana (African Health Observatory, 2011). As it stands, the Namibian public healthcare system is unable to treat the ailments of its community.

Studies in Mexico and other developing countries have shown that introducing frugal, compact, and multi-purpose technology can alleviate the disparity between public and private sector healthcare systems (Kobal et al., 2004). Ultrasonography can rapidly provide diagnostic images as a supplement to clinical observations and decrease medical errors (Moore and Copel, 2011). Recent technological advancement has opened the door for bedside-operated, or point-of-care ultrasound (POCUS) technology (Moore and Copel, 2011). Pilot studies have demonstrated the helpfulness of POCUS in triage and emergency situations (Kobal, et al., 2004; Spencer & Adler, 2008), cardiovascular disease (Wiley, et. al, 2014), infectious disease (Dr. Günar Günther M.D., 2015), and maternal care (Sippel, 2011), especially in resource-limited environments.

In addition, POCUS effectiveness depends heavily upon acceptance from local communities and effective physician training. Cultural differences can affect the way technology is adopted; ultrasound in the U.S. fueled the abortion debate and ultrasound in India created a cultural shift from female infanticide to feticide (Muller-Rockstroh, 2012). Because different cultures have contrasting traditions, history and biases, underlying factors such as practitioner education and reception by the community must be examined carefully when implementing new technology (Spencer & Adler, 2008; Henwood, et al., 2014).

In an effort to improve the availability and quality of healthcare in rural Namibia, the Polytechnic of Namibia, School of Health and Applied Sciences has partnered with the University of Namibia School of Medicine (UNAMSOM) to introduce POCUS technology into public Namibian health clinics and medical centers. This project aimed to collect data from public healthcare facilities in an effort to address the gap in information and demonstrate the need for effective medical imaging technology in the Namibian healthcare system. To do this we:

1. Assessed the potential need for and benefits of POCUS technology in Namibian public healthcare facilities.
2. Assessed the logistic and economic feasibility of implementing POCUS technology in Namibian public healthcare facilities.
3. Assessed the cultural dimensions of implementing POCUS technology in Namibian public healthcare facilities.

We hope that our data collection quantified the need for medical imaging technology in Namibia, assessed the feasibility of fulfilling that need with POCUS technology and guided a culturally considerate implementation strategy for the Namibian people

2. Background

Today, Sub-Saharan healthcare systems struggle to provide their patients with adequate healthcare. Specifically, the Namibian healthcare system demonstrates a large divide between the public and private health sectors. POCUS technology, implemented with a training strategy tailored to the region in question, can lessen this divide by providing improved triage and clinical diagnosis.

However, the answer to the healthcare crisis in Sub-Saharan Africa is not to simply airlift advanced equipment to threadbare clinics. Not only does technology impact society, but sociocultural factors influence the way technology is implemented. POCUS offers a tool by which medical care can be made more accessible to the Namibian people, but it is these people who determine its success.

This chapter will investigate the many factors to be considered when introducing a new medical technology into the public Namibian healthcare system by examining:

1. The unequal healthcare systems in Sub-Saharan Africa and specifically Namibia.
2. The advantages of POCUS technology in resource-limited environments and effective training techniques necessary for successful implementation.
3. The sociocultural context of Sub-Saharan Africa and its possible effect on the implementation of medical technology.

2.1 Sub-Saharan Africa's Ailing Healthcare System

Nowhere in the world do people rely more on ineffective healthcare systems than in Sub-Saharan Africa (Appiah, 2010). This section will identify the problems that prevent Sub-Saharan Africa's healthcare system from providing adequate medical care to the population as well as the drastic inequality of available resources between the private and public sectors.

What does it cost to be healthy?: In 2000, the World Health Organization's (WHO) Millennium Declaration set three goals regarding global healthcare:

- To reduce the mortality rate of children under 5 by two-thirds
- To reduce maternal mortality by three-quarters
- To halt and reverse the spread of HIV/AIDS, malaria and other infectious diseases

In 2007, the African Health Monitor evaluated the progress of Sub-Saharan African countries. It found that these countries were not on track to meet the goals (Tumusiime, 2014). The five countries furthest from meeting their goals were all in this region.

Unfortunately, these results were not due to a lack of effort. In Sub-Saharan Africa there have been "proven and cost-effective interventions implemented against the targeted health problems [that] are known and well understood" (Disease Control Priority Project, 2007). Yet, the reality is that these interventions are not properly implemented and the existing healthcare systems may not be equipped well enough to execute them to scale.

Public healthcare systems cannot provide proper care while government spending decreases and the number of people depending on it increases (WHO, 2010a). After many African countries' economies collapsed in the mid-1980s, the World Bank introduced Structural Adjustment Programs (SAPs), which are conditions on further borrowing that restructured these countries' federal budgets (Appiah, 2010). Public healthcare spending declined. To combat this, companies established private healthcare facilities. The influx of private funding is a double-edged sword; the improved quality of care is a blessing for those who can afford it, but the annual average expenditure on healthcare per capita in Sub-Saharan Africa is only $101 international dollars (World Bank, 2013). This is not enough to pay a private physician for even one visit. A few countries in this region have much higher health expenditure, such as South Africa ($915 international dollars). This is misrepresentative. The majority of the population relies on less than half of that and are forced to use the public sector facilities (Lerberghe, 1997).

Economy and healthcare go hand in hand; one cannot be improved without influencing the other. The Organization for Economic Co-Operation and Development (OECD), a 14-member convention of countries working together to address key factors of the global economy since 1960, has argued that healthcare and economic performance are not only interlinked but this relationship is an essential priority for well-functioning societies (Frenk, 2004). OECD states

that "poverty, mainly through infant malnourishment and mortality, adversely affects life expectancy," and that national income, through insurance coverage and public spending, directly affects health system improvement (Frenk, 2004).

Namibia's Unequal Healthcare: Cons Karamata, a researcher at Namibia's Social Security Commission, stated that the greatest challenge that Namibian healthcare faces is "the stark inequality in the provision of health services" (2014). Although the Namibian government has prioritized improving the country's health since its independence in 1990, the healthcare system continues to face many challenges (MICT, 2015). As stated in the World Health Organization's *Namibia Analytical Summary of Health Status and Trends of 2010*, some of the major challenges Namibia's public health sector faces include high burden of communicable diseases, high maternal mortality ratio, child malnutrition, and severe institutional capacity gaps. Inequalities in income and in access to medical resources, contribute to Namibia's current health status (Zere, 2007).

Approximately 85% of the Namibian population has no access to private healthcare (Karamata, 2014). The separation of private and public healthcare directly reflects the economic state in Namibia. Although Namibia is classified as a middle-income country, its gini index, a statistical dispersion measure that represents a nation's income distribution, was 70.7 in 2003. This is the highest recorded gini index in the world (Zere, 2007). No country displays a more distinct income gap between the rich and the poor than Namibia.

This gap results not only in limited access to private health facilities, but also in restricted access to medical services. As of 2010, Namibian public healthcare facilities consisted of 265 clinics, 44 health centers, 30 district hospitals, 3 intermediate hospitals, and 1 national referral hospital (WHO, 2010a). Despite this high number of healthcare facilities, access to healthcare still proves to be a concern for a large number of Namibians because of remote location and long distances between clinics (WHO, 2010a). These long distances pose an even larger problem to Namibians seeking healthcare because the public health sector relies so heavily on the national referral system (shown in Figure 3). If patients cannot be diagnosed or treated at the first point of care they are sent up the tiers, to either a secondary or tertiary facility, for more advanced care.
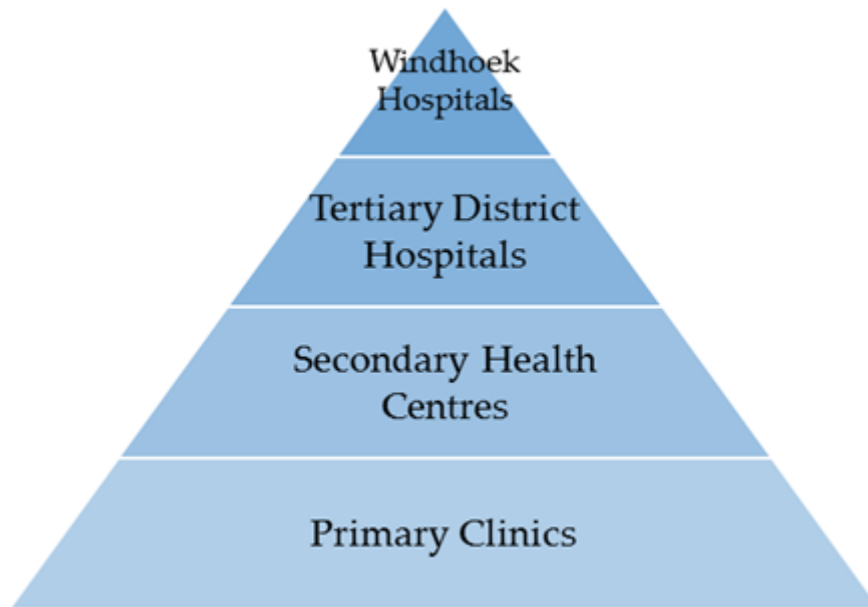
Figure 3 Namibian Public Healthcare Referral System

In 2007, PharmAccess partnered with the Agricultural Employers Association in Namibia to conduct a national study which found that the average travel distance to healthcare facilities was 64 km to a clinic, 99 km to a doctor, and 107 km to a hospital (Bosch, 2011). Due to limitations in transportation, most Namibians would rather risk waiting out their illness than making an arduous trip to a far clinic in forty degree Celsius heat (Bosh, 2011). Although this study was performed only in rural areas of Namibia, the rural population constitutes two-thirds of the Namibian population (Namibia Demographics Profile, 2014).

Those who do have access to healthcare face a stark resource-limited reality. Namibia's public health sector suffers from a deficiency in three critical areas: doctors, nurses and diagnostic technology. The majority of practicing Namibian doctors choose to work in the private sector instead of the public, leaving the public clinics and hospitals understaffed (Isaacs, 2008). According to the MHSS, in 2008, of the approximately 1,500 registered doctors in Namibia, only 261 worked in the public health sector (Isaacs, 2008). Furthermore, the majority of the doctors who choose to work in the public sector are foreigners. In 2008, the Health Ministry confirmed that non-native practitioners ran 32 of Namibia's 34 state hospitals (Issacs, 2008).

Similarly, Namibia lacks nurses. This impacts rural clinics more than state hospitals. In 2013, the only clinic in Otjimuhaka was forced to temporarily shut down because its only registered nurse went on maternity leave. Patients from 38 nearby villages, had to be referred to

the next nearest clinic, roughly 64 km away or the Opuwo District Hospital, almost 138 km away (Iileka, 2013). Nurse staffing proves to be a problem in other regions of Namibia as well. More than 45% of nursing positions need to be filled in the Kunene, Karas and Hardap regions, as well as the vacant 10% to 30% of positions in the remaining regions of Namibia (Iileka, 2013).

Namibia lacks medical devices. Table 1 shows the disparity in medical device availability in the private and public sectors of Namibia. When comparing the number of medical devices in Namibia's public health sector with another country of similar population size, such as Latvia, one can see how greatly Namibia is undersupplied. Whereas Latvia's public healthcare system has a density of 6.7 magnetic resonance imagers per 1,000,000 inhabitants, Namibia does not even have one (Latvia Country Data, 2010).

Table 1 Availability of Medical Imaging Technology in Namibia (World Health Organization, 2010b)

Medical devices	Public sector	Private sector	Total	Density per 1,000,000 population
Magnetic Resonance Imaging	0	2	2	0.9212
Computerized Tomography Scanner	1	7	8	3.6847
Positron Emission Tomography Scanner	0	0	0	0
Nuclear medicine	1	1	2	0.9212
Mammograph	2	3	5	22.643
Linear accelerator	0	0	0	0
Telecobalt unit (Cobalt-60)	1	0	1	0.4606

Without improvements to the country's healthcare system, Namibia's people will continue to suffer from inadequate medical care. Estimated at 2.2 million, Namibia's population is continuously growing and expected to increase up to 2.9 million by 2030 (Sakaria, 2014). With this steadily growing population that suffers from preventable and treatable health problems, a change towards the provision of adequate healthcare is necessary or else, the "highly efficient and advanced private health sector," and the "overstretched and inadequate public healthcare system," will continue to create unequal healthcare in Namibia (Karamata, 2014).

2.2 POCUS Technology: A Champion of Resource-Limited Healthcare

Point-of-care ultrasound (POCUS) offers a potential solution to improve medical care in Namibia and presents a way to lessen the dichotomy between private and public sector healthcare. The World Health Organization has estimated that 60% of the world's population has no access to radiography and 50% has no access to ultrasound (Spencer & Adler, 2008). Radiography and ultrasonography, either in combination or independently, would meet two thirds of all imaging needs in developing countries (WHO, 2009). Imaging presents practitioners with the ability to see inside the body while performing diagnostic and/or invasive procedures and improves success while decreasing complications (Nicolaou et al, 2007). Innovations in the medical field have created an ultrasound that seems ideal for resource-limited environments (Moore and Copel 2011; Sajed, 2010; Spencer & Adler, 2008). POCUS technology, due to its mobility, range of application, and affordability, poses a viable solution to this medical imaging need (Sajed, 2010; Spencer & Adler, 2008). This section will introduce POCUS technology and its many aspects and applications as well as investigate what is required for successful introduction of the technology into resource-limited healthcare systems.

What is it, and what can it do?: Point-of-care ultrasound is defined as ultrasonography that is brought to the patient and performed by the provider in real-time (Moore and Copel, 2011). It is a rapid, accurate, inexpensive and non-invasive imaging technology that comes without radiation risk (Abu-Zidan, 2012). POCUS can be used in both stable and unstable patients, and in western medicine is implemented parallel to physical examination, resuscitation, and stabilization (Abu-Zidan, 2012).

While radiology typically provides still images of internal structures, ultrasound can provide a dynamic view that allows the practitioner to better guide diagnosis and procedure (for more information on ultrasound see Appendix I) (Moore and Copel, 2011). Like regular ultrasonography, POCUS can be applied to many medical specialties. However, the four main applications in modern medicine are emergency medicine, infectious disease, maternal care, and cardiology. A sample of tasks in various medical specialties that point-of-care ultrasound can be used for are listed in Table 9 in Appendix I (for more primary application information on POCUS technology see Appendix II).

Point-of-care ultrasound is a small and transportable technology (Figure 4). The physician brings it directly to the patient, allowing POCUS to be used effectively in bedside care and emergency medicine. Fikiri Abu-Zidan, an expert on ultrasonography, has stated that in emergency medicine "point-of-care ultrasound became an extension of the clinical examination answering urgent important questions" (2012).

Figure 4 A type of point-of-care ultrasound device (A Womanless World, 2014).

Point-of-care ultrasound appears to be an ideal solution to the medical imaging needs of resource-limited environments. Several case studies have been performed in developing countries examining the introduction of POCUS technology; benefits include transportability, range of clinical use, improvements in the quality of care provided and durability in harsh resource-limited environments. These benefits are demonstrated by a one-day study in Ghana conducted by Spencer and Adler (2008), a more extensive study of long-term impact in Rwanda by Henwood et al. (2014), and the use of POCUS in emergency medicine worldwide (Sajed, 2010). A summary of the benefits and applicable case studies can be found in Table 2.

Table 2 Summaries and Benefits of Applicable Cases

Benefits	Cases	
Easy to Transport	Australia Ghana Guatemala	(Sajed, 2010) (Spencer & Adler 2008) (Dean et al, 2007)
Range of Clinical Use	Ghana Guatemala Rwanda	(Spencer & Adler, 2008) (Dean et al., 2007) (Henwood et all, 2014)
Improvements in Quality of Care	Ghana Rwanda	(Spencer & Adler, 2008) (Henwood et all, 2014
Durability in Harsh Environments	Australia Ghana Military Settings	(Sajed, 2010) (Spencer & Adler, 2008) (Sajed, 2010)

The versatility of POCUS is key in emergency settings; with just one simple handheld device, medical professionals can perform a variety of extended examinations on the spot (Sajed, 2010). In natural disasters, POCUS has played key roles in the triage and diagnosis of patients in the field (Sajed, 2010). Anthony Dean, an emergency medical practitioner, and his colleagues brought point-of-care ultrasound to Guatemala. They described the variety of procedures that POCUS was used for; ninety-nine patients received 137 ultrasound exams: 58 pelvic, 73 abdominal, 5 orthopedic, 4 cardiac, 3 pleura and lung, 3 soft tissue, and 1 focused assessment by sonography in trauma (FAST) (Dean et al, 2007). In other emergencies, such as the 2007 cyclone in Australia, Sajed reported the need to transport patients to emergency care required rapid diagnostic capabilities and when the only CT scanner was brought down by the cyclone, POCUS was key in determining the severity of patient illness.

The strength of point-of-care ultrasound in resource-limited environments does not lie solely in its provision of effective real-time diagnosis, but also in its ability to replace more advanced imaging technology in appropriate situations (Moore and Copel, 2011). The images produced by POCUS technology save time, money and resources because they allow practitioners to diagnose patients and eliminate the need for further imaging action. "Given the relatively low cost systems, their mobility, and minimal maintenance," Jacqueline K. Spencer, M.D., M.P.H. states, "they are viewed as the most economical, practical solutions for imaging in developing countries or places where access to care is limited (2008)."

The potential value of POCUS technology in resource-limited environments is demonstrated by the improvement in medical care when it is in use. In a study in Ghana conducted by Jacqueline K. Spencer MD, the most important finding was that the patient outcomes were altered by the intervention of ultrasonography. Of the 67 examinations performed in a single day, 81% of the patients had abnormal findings, and 41% of the ultrasound examinations influenced the decision regarding treatment for the patient (Spencer & Adler, 2008). Even for a single day's use, the technology was used in three different facilities, and the clinical value of POCUS technology was noticeable. The POCUS unit imaged the breadth of medical conditions under extreme heat and humidity conditions, while withstanding frequent electrical failures, further demonstrating the durability and range of use of the technology.

POCUS technology has also been successfully implemented in Rwanda, again with improvement in quality of healthcare provided. In contrast to the 1-day study in Ghana, Henwood et al. studied the impact of the point-of-care ultrasound medical care over a period of six-months (2014). In this study seventeen local physicians (at eleven regional hospitals) underwent a training course and post-course ultrasounds were tracked through a cloud-based storage system. Henwood reports that in the six-months: 1,158 ultrasounds were performed and 84% of cases resulted in a change of management, 30% were admitted, 28% were transferred to a higher level of care, and 23% procedures were performed. Overall, the healthcare received by each patient was improved with the application of point-of-care ultrasound.

The ability to thoroughly assess a patient's medical condition in resource-limited environments by physical examination is restricted by the availability of reliable, accessible diagnostic imaging tools (Spencer & Adler, 2008). POCUS technology, due to its mobility, range of application, and affordability, poses as a viable solution to this medical imaging need. It appears to be the true champion of resource-limited healthcare.

The Importance of Customized Training and Medical Education: Research shows that ultrasound results depend directly on the operator's training and experience (Abu-Zidan, 2012). The practitioner operating the technology needs to learn how to use the equipment and read the images for diagnosis. While applying POCUS technology in Ghana, Spencer and Adler (2008) found:

The challenges to effectively instituting this form of imaging will depend on proper training to ensure appropriate referral of patients who will clearly benefit from such imaging, adequately trained medical personnel to operate the equipment, interpret the images, and provide maintenance, and exploration of collaborative efforts with outside organizations or institutions that can assist with these training needs and financial requirements.

In a 2013 study of POCUS technology in the Emergency Medical system of Columbia, Henwood et al. discovered a high level of interest among EM residents, but a staggering lack of experience: only half had used the ultrasound machine during their training. This lack of exposure proved to be a significant barrier when attempting to introduce POCUS technology because few practitioners knew how to use it. The disparity of ultrasound knowledge in Columbia highlights the lack of standardized training curriculum for POCUS technology (Henwood et al., 2013): a worldwide problem.

No standardized method exists to ensure that practitioners develop the necessary skills for effective POCUS use. Nevertheless, research shows that successful programs share three commonalities. First, studies in medical schools demonstrate that when learning how to evaluate the image produced on the screen during ultrasonography, video clips are more effective than still ultrasound images (Cartier III et al., 2104). Second, teaching students in smaller groups is more effective than large class sizes (Cartier III et al., 2014). Third, students learning how to use POCUS technology prefer to have hands-on scanning experience rather than a large group didactic session where the technique is discussed (Cartier III et al., 2014).

In response to the lack of a universal training method for POCUS in 2014, the International Federation for Emergency Medicine (IFEM) developed Point-of-Care Ultrasound Curriculum Guidelines (IFEM, 2014). These guidelines not only provide a structure for education programs to build on, but a series of suggestions to create successful programs for each setting, and examples of curricula in developed countries.

The IFEM guidelines' strength is that they are customizable to the medical situation in each country. Many POCUS curricula are tailored to the regions they cover. This specification reflects not only the difference in emergency medicine between nations, but in the different POCUS applications to the local disease burdens, the variation in accessible equipment, and the local practitioners' ability to train and retain area-specialized skills. "An inflexible global curriculum," the IFEM states, "is not appropriate because one size does not fit all." Their model prevents both learning unnecessary applications and inexperience in local applications (IFEM,

2014). Figure 5 shows a graphic breakdown of the IFEM curriculum structure and specific details are discussed in Appendix III.
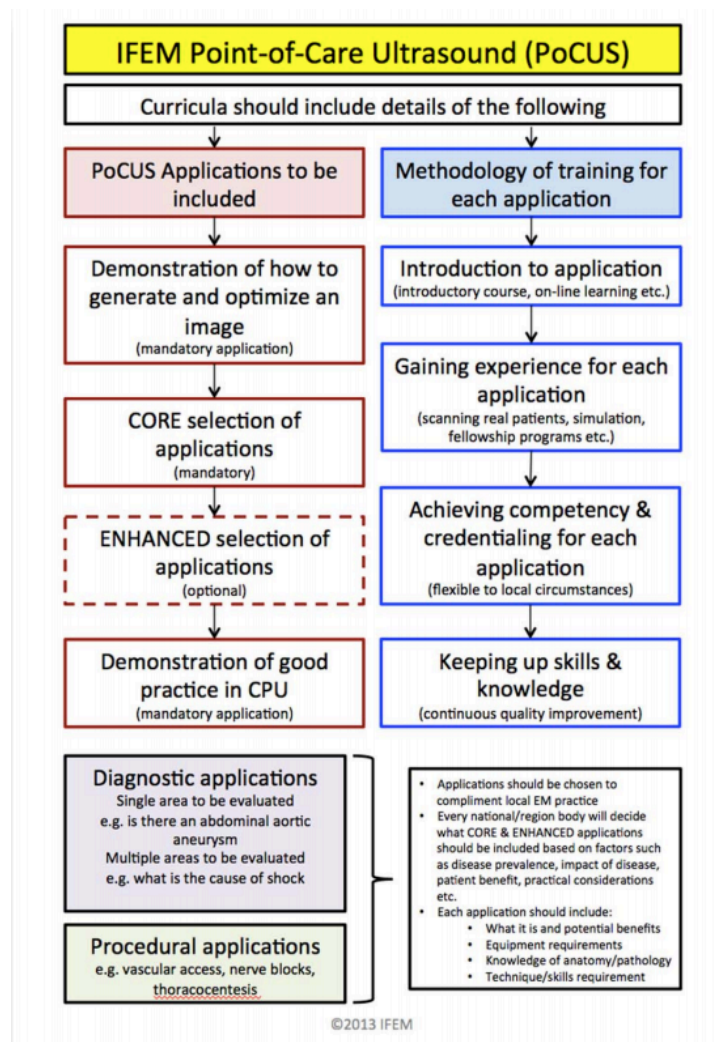
Figure 5 International Federation for Emergency Medicine curriculum guidelines for point-of-care ultrasound (IFEM, 2014).

The increasing penetration of POCUS into various medical specialties has created an explosion of new applications for the technology. The recent increase of POCUS use, specifically in resource-limited environments cries out for a method of education to ensure proper use of the technology. The IFEM Point-of-Care Ultrasound Curriculum Guidelines provide the flexible anatomy for a successful education strategy on POCUS technology that could easily be adapted to resource-limited environments. The locally customizable approach offered by the IFEM offers a comprehensive and efficient education program by tailoring trainee knowledge to their unique community's particular medical requirements.

2.3 A Sub-Saharan Context for Implementing Medical Technology

Just as variations in medical need across Namibia must be accounted for when developing a training program, diverse cultural perspectives must be considered when constructing an implementation strategy. A foreign agency will not succeed in its endeavors if it ignores the views of the local people. This section will explore the sociocultural implications of introducing medical technology like POCUS.

Research has shown that attempting to implement technology without an understanding of the sociocultural, economic, and political factors at play will almost always fail (Muller-Rockstroh, 2012). Understanding community need, what the local people are willing to do and providing a way for them to solve the problem themselves is vital to the introduction of new technology. Science and technology can provide the tools for a society to meet its needs but alone do not present a solution.

Similarly, in the medical field, Muller-Rockstroh (2012) demonstrates the impact society and culture have on the implementation of technology. Namely, she states, "…that medical technology can be and do quite different things in different contexts." For example, amidst a politically and religiously charged debate on abortion, ultrasound in North America developed into 'baby's first picture' to reinforce the rights of a fetus as a person, separate from its mother (Caspar, 1998). In Greece, ultrasound was introduced at the same time that television became widely used and consequently is appreciated as just another moving picture (Mitchell and Georges, 2000). Brazilians, who use family ties as a fundamental principle behind all social organization, adopted 3D ultrasound as a method to prove kinship (Chazan, 2007). Vietnam's biochemical war history embeds ultrasound in a fear of malformations (Gammeltoft, 2007) and in Botswana where women associate darkness with death and electricity with pain, the actual scanning procedure is endured in fear (Tautz, 1995). Most drastically, India and China have turned ultrasound into a sex selection device that allows termination of female fetuses due to a culture that not only condones this practice but renders it economically practical; sons provide for their families while daughters require the family pay a dowry to a future husband (Heesterbeek, 2000).

Namibia is a multi-ethnic country with a wide variety of sociocultural beliefs and norms. The population is composed of thirteen ethnic groups: Herero, Damara, Nama, San, Rehoboth Basters, Coloureds (mixed descent), Whites (20% German, 20% English, 60% Afrikaans), Caprivian, Kavongo, Topnaars, Tswanas, Himba and Owambo (Namibia People/Tribes, 2014). Each ethnic group has a unique culture; various languages, traditions, and lifestyles can be seen across the country. For example, the Nama, San and Damara speak similar 'click' languages while the Basters and the majority of Coloured people speak Afrikaans. Most ethnic groups were traditionally livestock/crop farmers or fishermen while the Damara, Nama and San led nomadic hunter-gatherer lifestyles. While 90% of the country practices Christianity, some indigenous religious customs are followed today. One notable custom among the Herero and Himba is the ritual fire, which represents life, fertility, prosperity and the happiness of ancestors.

These differences in culture impact the implementation of new medical technology. Language barriers can interfere with the training process. Pastoral societies developed remote communities separated by vast farmlands; thus, villages and their respective clinics are commonly a hundred kilometers apart. Religion often impacts what is considered ethical use of new technology.

Cultural diversity results in varying responses to medical care, especially for infectious disease. In some tribes, customs and community pressures hinder people suffering from AIDS, mental illness, or tuberculosis (TB) from seeking medical treatment or keeping up with any prescribed drug regimen. In the case of infectious diseases like TB, this stigma arises from the misunderstanding that because an infected person has the power to spread the disease, they are somehow linked to witchcraft and sorcery (Rubel & Garro, 1992). Beyond this distorted understanding of disease, people who know how infection is spread often shun diagnosed TB patients in fear of catching it themselves (South African Review of Sociology, 2007). These social stigmas regarding disease translate to a fear of medical intervention – ostracism does not occur until after diagnosis, thus it is better to not get diagnosed. Considering the capacity of POCUS to easily diagnose TB, especially in advanced stages, these stigmas might dramatically impact the implementation of portable ultrasound.

Caution should be taken not to disturb the workplace dynamic when implementing new technology by training one group instead of another. In Namibia, a strict hierarchy of medical staff exists among the doctors and nurses. Due to increased training, doctors are ranked higher

than the highest ranked nurses (Nurses & Doctors, 2015). This stratification of positions allows for smooth operations at Namibian public healthcare facilities and is heavily based on levels of training. Training a medical professional instead of their superior could create tension and disrupt the process of diagnosis and treatment (Greene, 2015).

Improving healthcare in developing countries quickly becomes a multi-faceted problem; economic, social and political factors all come into play. Medical technology is adopted by society to fit specific needs and motivations of the people. Communities with culture, history, and biases cannot be expected to incorporate new technology without a culturally relevant implementation strategy. A careful consideration of the cultural factors and a culturally relevant training program are just as important to the implementation of POCUS as the quantitative analysis of the health facilities' resources.

3. Methodology

This project aimed to assist the Polytechnic of Namibia, School of Health and Applied Sciences and the University of Namibia School of Medicine in assessing the need, feasibility and social impacts of implementing POCUS technology in the Namibian public healthcare system. An exploratory analysis of the sources of variability between public healthcare facilities in Namibia was conducted. We evaluated resources, funding, infrastructure, and personnel of public healthcare facilities in order to:

1. Assess the potential need for and benefits of POCUS technology in Namibian public healthcare facilities.
2. Assess the logistic and economic feasibility of implementing POCUS technology in Namibian public healthcare facilities.
3. Assess the cultural dimensions of implementing POCUS technology in Namibian public healthcare facilities.

3.1 Assess the potential need for and benefits of POCUS technology in Namibian public healthcare facilities.

Desired Knowledge/Rationale: To assess the need for improved medical imaging technology throughout Namibia, we set out to learn about current diagnostic standards in the public health sector. In order to evaluate the quality of care and need for diagnostic technology at each facility we identified several factors that influence the quality of care provided. These factors addressed the following research questions:

- What resources are present at each facility and in what condition?
- What diagnostic tools does the facility have?
- What types of disease are most prominent at each facility?

Methods: We assessed the need for and benefits of POCUS technology at Namibian public healthcare facilities in a series of two steps. First, we used technical background research to draft a list of factors that could potentially influence the care provided by each facility. This list was then analyzed with our sponsor to determine key factors relevant to a needs assessment of Namibian public healthcare facilities. The data pertaining to the criteria was organized in a Data Collection Sheet (Appendix IV).

Second, the Data Collection Sheet was filled out during interviews with medical staff at thirty-nine individual healthcare facilities. Visited facilities are shown in Figure 6. Interviews were conducted in a professional, friendly manner, avoiding offensive language and phrasing questions in an appropriate, sensitive and unbiased way. Verbal consent was acquired for the collection of data and the inclusion of medical staff responses in the report.
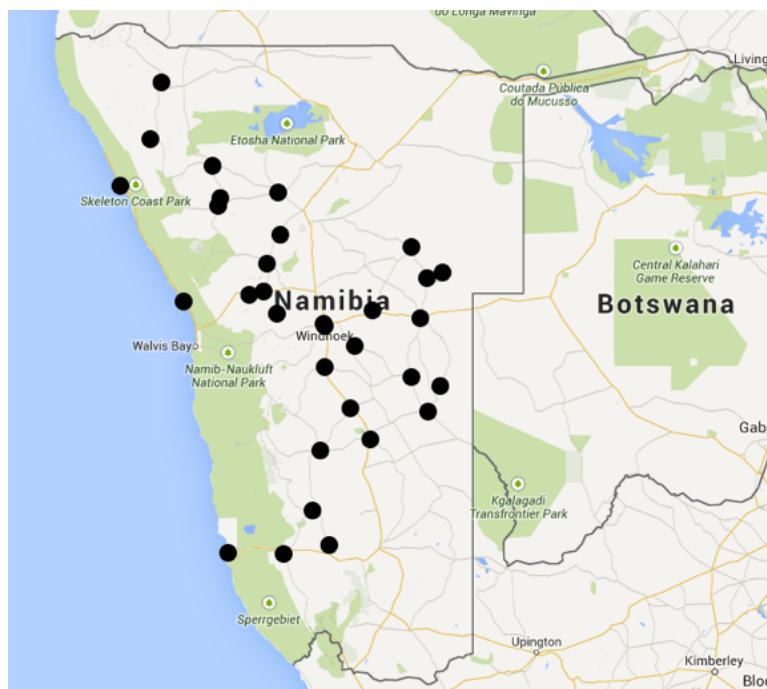
Figure 6 Map of Namibia depicting the locations of facilities visited.

Analysis: Using data collected from each facility, the information was put into a database and analyzed by grouping responses together in categories. Facilities that lacked imaging technology, had high caseloads of TB, maternal care and trauma and were geographically distant from a

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referral center were identified as "in need of POCUS technology." Disease burden, was quantified using numerical assignment as follows:

- Antenatal care = 5
- Deliveries = 5
- Trauma = 4
- TB = 3
- Gastrointestinal/Diarrhea = 3
- Pneumonia = 3
- HIV = 2
- Chronic disease (hypertension, arthritis) = 1
- Upper respiratory tract infection = 1

This numerical assignment was determined by how medical imaging technology is used for the treatment or diagnosis of each disease/care. Diseases/types of care in which medical imaging technology is used more frequently were given higher numerical values. Disease burden at each facility was quantified by taking the sum of all of the numerical assignments for present diseases/types of care.

Justification: With the current lack of documentation within the MHSS, the only feasible way to gather this information was physically visiting healthcare facilities and reaching out to medical professionals. Archival research was not used because there was no available inventory of medical equipment. Visiting the facilities allowed us to get information directly from the source while better understanding how public healthcare works in this part of the world. We not only documented the need for improvement, we witnessed it.

Limitations: There were three primary limitations to our data gathering methods: contacting facilities, willingness to disclose information, and physical constraints. First, lack of documentation, understaffing and remoteness made finding and contacting facilities difficult. The MHSS currently does not have an updated or accurate list of health facilities in Namibia. While we did attempt to find a majority of these facilities by visiting villages/towns and inquiring about their location, we were simply unable to visit every facility or village/town

because we could not predict which village/towns would have facilities. Of those that we were able to find and contact, some were unable to meet with us. Due to understaffing, they did not have enough time to meet with us and tend to their patients.

Second, some medical practitioners were not willing to disclose information due to the risk that it poses to their employment. Thus, the information provided might have been biased and in some instances omitted which could have skewed data analysis.

Finally, time and geographical constraints limited the number of facilities we could physically visit to collect data. The regions in the northwest, as well as some in the southwest were not visited. This may have skewed data analysis.

3.2 Assess the logistic and economic feasibility of implementing POCUS technology in Namibian public healthcare facilities.

Desired Knowledge/Rationale: In order to evaluate and compare facilities, we created a standardized list of factors relevant to the implementation of POCUS technology to use for data collection at each facility. We identified the resources required for use, the cost of the devices themselves, and how the implementation of POCUS would affect the patient's copay. Economic impact and logistics are important to any implementation project; if POCUS implementation was not logistically feasible at a certain facility, a device could not be placed there, no matter the need or possible benefit.

Methods: We used two methods to determine the cost of the individual devices and how the devices will affect the patient's copay. The first was background research. As POCUS is a new device with a heightened popularity, general technical information required for its use was readily available in medical literature. Furthermore, device-specific requirements and the cost of each device were obtained from manufacturer websites. To predict how the implementation of POCUS technology would affect the patient's copay, we researched the Namibian public healthcare system, its policies and medical insurance programs in Namibia. To gain further knowledge of the impact on copay, we conducted informal interviews with nurses at clinics. At each facility we visited, time permitting, we asked the nurses/doctors about the charges for care, and how extending the physical exam with POCUS technology would affect that charge.

The second method we used was consultation of medical experts. We met with three experts who had experience both with POCUS technology and with the Namibian healthcare system: Professor Ernest R. Greene Ph.D., visiting research associate of the Polytechnic of Namibia; Dr. Christian Hunter M.D. Ph.D, Head of Internal Medicine and Physiology Departments at the University of Namibia School of Medicine; and Dr. Günar Günther M.D., Head of Pulmonology at Katutura State Hospital. In meetings with each expert we asked about information closest to their respective knowledge base and expertise. Consults on these specific subjects can be found in Table 3.

Table 3 Information acquired from experts

Expert	Information Acquired
Professor Ernest R. Greene	Required resources, cost, co-pay
Dr. Christian Hunter	Required resources, cost
Dr. Günar Günther	Required resources, co-pay

Analysis: Findings from the background research and expert consultations were compiled into a list of criteria required for the use of POCUS. These criteria were then used to compare data collected from the facilities to a list of appropriate public health regions with the most need. The need of the regions was further stratified by weighted resource and logistic requirements. The stratifications and requirements can be found in decreasing order in the list below.

1. Access to electricity, water, and pharmacy,
2. Access to ultrasound (number and condition)
3. Access to x-ray (number and condition)
4. Average referral distance (in kilometers)
5. Average disease burden
6. Number of doctors

To determine the economic feasibility of implementing POCUS devices at each facility, the cost of the device was compared to current patient copay.

Justification: A majority of the information regarding POCUS technology gathered from background research could have been collected in the field, or through product testing, but the time constraints of this project limited us to consulting existing information. Discussions with experts in Windhoek provided a more focused look at how POCUS could be used in Namibia and the realities of patient copays. These two approaches enabled us to look at the global picture of POCUS technology and a more detailed look into the specifics of Namibian healthcare in a short amount of time.

Limitations: It is possible that we did not address the requirements of specific POCUS devices in our generalized criteria for use. It is also possible that the experts we interviewed expressed biased views. While we do not believe bias was an issue, we are aware of the possibility that it may have affected our results.

3.3 Assess the cultural dimensions of implementing POCUS in Namibian public healthcare facilities.

Desired Knowledge/Rationale: The Namibian population is made up of a variety of peoples consisting of different tribes and immigrants with varying customs and different sociocultural norms. In order to consider their reaction to the introduction of new medical technology it was important that we first understand the cultural views and history of the Namibian people. It was also important that we understand the structure or the social rankings within the medical community to ensure that the introduction of POCUS technology does not disrupt the workplace dynamic.

The reaction of the people cannot be discounted when introducing a new technology. The implementation of POCUS could bring changes to the healthcare system that have social implications: changes to medical staff training, early TB diagnoses and improved antenatal care. We investigated these factors when determining the reaction of the people to new medical imaging technology.

Methods: We conducted informal interviews with medical professionals at selected facilities and randomly selected residents of Namibia in order to:

- Gauge the acceptance towards POCUS technology
- Understand cultural views on: abortion, TB, and medical staff training.

Informal interviews at selected facilities were based on time availability. If the professional was not serving patients and was willing to speak to us for ten or fifteen minutes, we would ask to have a conversation with them. Fifteen residents were selected on an availability basis. If we were to stop in a town, at a gas station or a campsite we would ask the local people we came in contact with about their views.

To further understand cultural views on the topics listed above, we conducted a survey (questions found in Appendix VI) with Public Health students at the Polytechnic of Namibia. Information pertaining to possible social impacts that POCUS technology or training on POCUS technology could have in healthcare facilities was gathered through interviews performed with:

- Professor Ernest R. Greene Ph.D., visiting research associate of The Polytechnic of Namibia
- Dr. Christian Hunter M.D. Ph.D, Head of Internal Medicine and Physiology Departments at UNAMSOM.

Justification: Our method of gathering information on sociocultural norms allowed us to consider a wide range of perspectives in a short amount of time. Interviews with doctors, nurses and professors with medical knowledge informed us about the possible ramifications that implementing POCUS in public healthcare facilities might have. Background research and interviews with the local people gave us a broad look into the cultural diversity of Namibia. Discussions with faculty and students at the universities demonstrated how the population of Namibia views disease and medical technology. This information allowed us to identify possible social impacts of implementing medical imaging technology in the Namibian public health sector.

Limitations: The diversity among the Namibian people made it difficult to examine the cultural views of the entire population. Geographic and time constraints did not allow us to interview more members of rural communities.

3.4 Summary

We assessed the potential need for POCUS in Namibian public healthcare facilities through technical background research and data collection during interviews with medical staff at thirty-nine clinics. Data on available resources were compiled and organized into a database. The logistic and economic feasibility of POCUS implementation at the facilities was assessed using background research and consultation with experts in the field. This investigation resulted in a list of regions for the implementation of POCUS technology. Social dimensions were assessed from a medical and a cultural perspective and any possible impacts identified.

4. Findings

The Namibian public healthcare system is in need of better diagnostic technology. Our research shows that although the addition of point-of-care ultrasound (POCUS) devices would be feasible in almost every facility, the need for a POCUS device varies due to differences in referral distances, disease burden and caseload. In addition, we identified several possible social impacts POCUS technology could create. Although these social impacts cannot be proven and will often be situational, it is important to explore the possible changes that POCUS implementation in the Namibian public health sector could create.

4.1 Despite a high infectious disease burden, specifically in TB and HIV/AIDS, and a high demand for antenatal and trauma care, Namibian public healthcare facilities lack basic diagnostic technology, demonstrating a need for imaging devices.

The prevalence of TB and HIV/AIDS in Namibia are among the highest in the world. TB affects six out of every 1,000 people. The adult HIV prevalence rate is 17.8%. Yet, there is a lack of imaging devices in the public healthcare system. Only six facilities of the thirty-nine that we visited had access to ultrasound. These six facilities were district hospitals that serve thousands of people.

Primary clinics in both urban and rural areas do not have medical imaging devices (Appendix IX) even the limited diagnostic resources that some facilities do have are often unused. In Okuryangava Clinic, a secondary referral center, there is one ECG machine; however, "the doctor trained to use it left the clinic and now it stands in the corner collecting dust" (Nurse, 2015). Figure 7 depicts the availability of imaging devices throughout the surveyed Namibian public health sector. Figures 8 and 9 depict the distribution of these devices across the country.
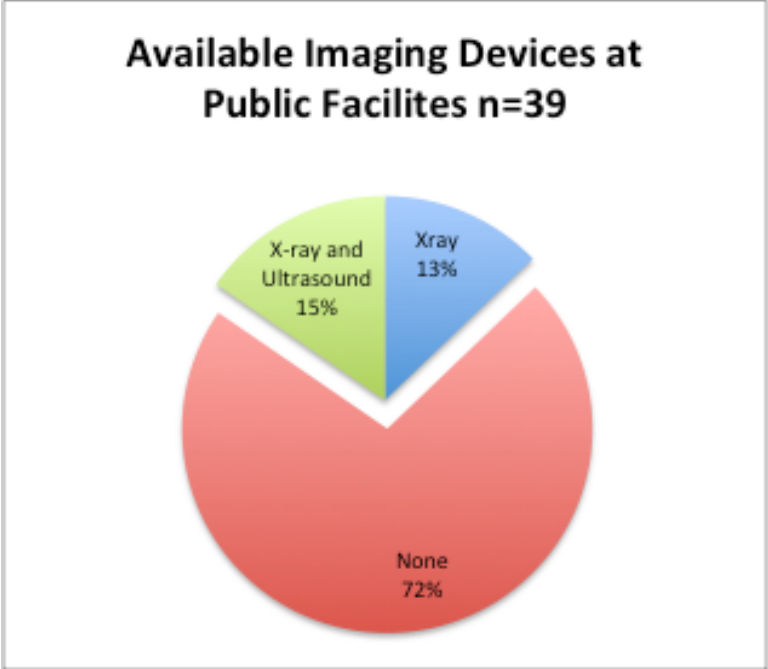
Figure 7 Available imaging devices at surveyed public healthcare facilities. No facility had only ultrasound.
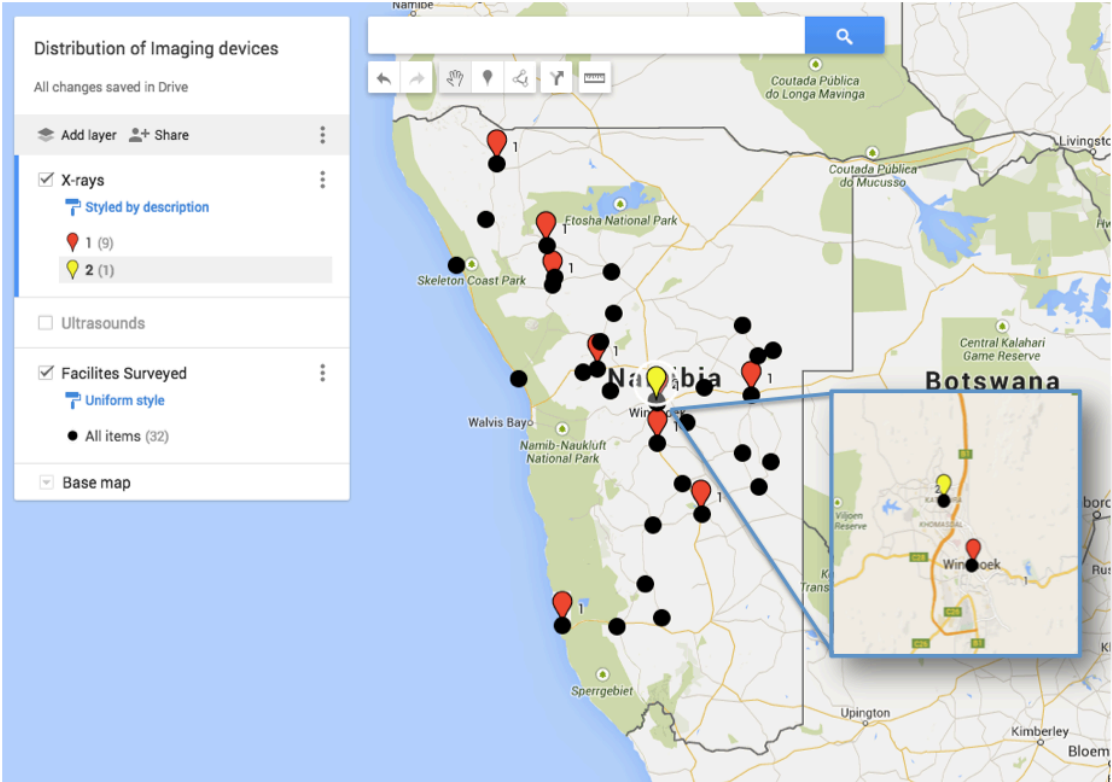
Figure 8 Distribution of X-ray devices in the surveyed public healthcare facilities (n=39).
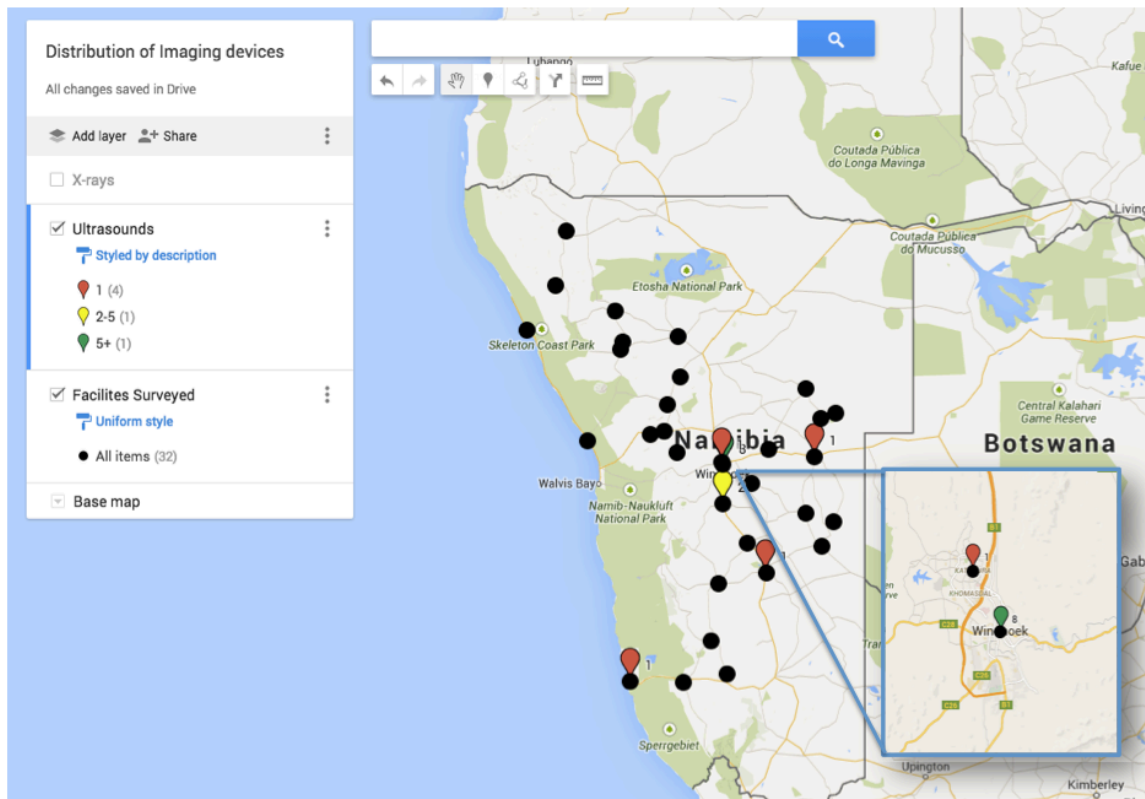
Figure 9 Distribution of ultrasound devices in the surveyed public healthcare facilities (n=39).

Although a few facilities have equipment, it is in poor condition or missing parts. In Katutura State Hospital, a tertiary referral center, a modern portable ventilator could not be used because the power cord was missing. Katutura also had a number of broken ultrasound devices, with only one working machine located in the maternity ward. The one working digital x-ray machine in the hospital was described as "rudimentary" and simply could not meet the demand of patients in the waiting room. Windhoek Central Hospital, on the other hand, has eight ultrasound machines. However, the hospital's administration refuses to give even one machine to Katutura State Hospital in the event that a machine breaks. The nurses and doctors running the public healthcare facilities were unanimous in stating that they could benefit from a POCUS device.

The observed disease burden of Namibia can be classified by eight conditions: TB, HIV, maternal care, chronic diseases (arthritis and hypertension), diarrhea, common colds (and upper respiratory infections), pneumonia and malnourishment. However, the intensity of these conditions in each facility varied depending on location and the types of patients seen. In

Otjimbingwe, the clinic dealt with high caseloads of chronic diseases and pediatric care. High caseloads of infectious disease such as TB and HIV/AIDS were present in all the facilities visited. Many clinics and hospitals, such as Katutura State Clinic and Gobabis State Hospital, had separate wards for TB and specialists who only treated these patients. Alternatively, primary care centers had a single room to isolate TB patients until they could be referred to a secondary or tertiary TB ward to receive medical imaging.

Due to the informality of our interviews with medical staff and time restrictions, obtaining accurate, quantified information on disease burden from all facilities was not feasible. The data collected from the facilities regarding disease burden and imaging devices is organized in Table 4 below. We entered primary clinics with full waiting rooms and asked to speak to the one nurse taking care of patients. This nurse was often nervous about releasing even the most basic data about the facility, never mind sensitive information like disease burden: conversations were frequently cut short.

Table 4 Sample of medical imaging, disease burden and imaging and auxiliary equipment at selected surveyed facilities. Negative responses are highlighted in pink. See Appendix IX for full data set.

Location	Facility Type	Imaging Devices	Aux Equipment	Disease Burden
Kasibib Clinic	primary	1 x-ray	none	
Kalkrand Clinic	primary	0	BP	HIV, TB, diarrhea, colds, maternal care
Mariental Hospital	tertiary	1 x-ray 1 ultrasound	none	TB
St Mary's Hospital	tertiary	1 x-ray 2 ultrasounds	none	TB, HIV, maternal, chronic disease (hypertension) Pediatrics: upper respiratory infections, diarrhea, pneumonia, malnourishment
Katutura Clinic	secondary	1 x-ray	none	
Katutura Regional Hospital	tertiary	1 x-ray	Ventilators, EKG	TB, HIV, trauma, cardiovascular, maternal care
Okuryongava Clinic	secondary	0	EKG "collecting dust"	diarrhea, staph infections, maternal care, TB, HIV
Opuwo Regional Hosptial	tertiary	1 x-ray 1 ultrasound	none	
Gobabis Regional Hospital	secondary	1 x-ray 1 ultrasound	SAT meter and EKG	trauma and maternal care

4.2 All Namibian public healthcare facilities possess the resources required for POCUS operation: power supply, access to coupling agents, access to water and staff.

Resources required for the operation of POCUS technology fall under three main categories: powering the device, operating the device, and sterilizing the device. First, POCUS technology requires access to electricity. Each unit is powered by a rechargeable battery that varies in size and power between make and model. As such, each device requires access to electricity and must be recharged after every 2-4 hours of use (Greene, 2015). POCUS devices can also be charged on a solar cell sheet. Thus, the availability of electricity at each facility can be variable. All surveyed facilities had electricity; however, electrical availability at two out of thirty-nine was variable.

Second, a coupling agent is required for the effective use of the POCUS device. In order for the acoustic waves to effectively pass from the head of the transducer through the skin they cannot cross the air (Lautenschläger, 2008). Ultrasound gel provides optimal contact between the skin and the transducer head without causing reflection or refraction of the wave. Because the gel is water-based, the compound can be easily removed from the skin and equipment by wiping or washing with water. Other media such as oil, hand sanitizer, or lotion can be used if absolutely necessary, but are not ideal and cannot be used if they contain any refractory particles (Lautenschläger, 2008). Namibian public healthcare facilities are equipped with adequately stocked pharmacies, indicating regular access to medical supplies like coupling agents. Pharmacies in public healthcare facilities are stocked based on referral level; primary clinics only have the medication to treat basic illnesses and are expected to refer patients to secondary facilities for more advanced care. If a clinic needs advanced pharmacy items, it can get them from a secondary facility. Thus, all public healthcare facilities have access to coupling agents.

Third, the device has to be sterilized between uses. These sterilization procedures indicate that to properly support the use of the POCUS device a facility must have running water and access to consumables. Sterilization can be accomplished in a number of ways. It is recommended that the transducer still be washed thoroughly every use with a mild soap (Center for Devices and Radiological Health, 2008; Philips, 2010). For less contagious uses, such as obstetrics, practitioners can simply wipe the gel from the transducer and use an alcohol wipe for sterilization (Center for Devices and Radiological Health, 2008). A second method is to use a disposable transducer sheath, or probe cover (a thin plastic bag). This allows the operator to

move quickly between patients, changing the sheath for each patient, and maintaining a clean medical surface (Phillips, 2010). All surveyed Namibian public healthcare facilities had running water; only at three out of thirty-nine surveyed facilities was water unreliable.

Resources that influence the implementation of POCUS technology at the surveyed facilities were limited in availability. The staffing in clinics is uniform; nurses run almost all clinics while regional physicians visit a clinic every one or two months. Primary clinics are generally run by two nurses, health centers by seven nurses, and secondary referral centers by seventeen nurses with a few doctors. From the facilities we visited, all doctors are foreign, mostly from either Zimbabwe or the Democratic Republic of Congo.

Computer access is rare, especially among primary clinics. In the nine facilities out of thirty-seven that did have computers, their condition ranged from out of order to away for program updates to "limited use." We came across only three facilities (Okuryongava Clinic, Rehoboth Health Center and St. Mary's Rehoboth Hospital) using computers for medical record keeping at the time we visited. Table 5 below depicts the distribution of computer availability. The nurses working in primary facilities without computer access simply did not see the need for computers in a medical facility. Instead, they kept patient records on paper files. Ideally, ultrasound images obtained from POCUS technology would be kept in electronic medical records, requiring not only access to computers but also appropriate software and storage space. Because the main niche POCUS technology aims to fill in the Namibian healthcare system is as a tool for dynamic diagnostic triage, storing images is less of a concern.

Table 5 A summary of resources available at surveyed facilities. Sample chosen shows outliers in electricity, water and computer access categories. Negative responses are highlighted in pink. See Appendix IX for full data set.

Location	Facility Type	Electricity	Pharmacy	Water	Computer Access	Doctors	Nurses
Ojimbingwe	primary	Y	Y	off/on	N, nurse has personal laptop	once a month visit	3
Fransfontein		off/on	Y	off/on	N	once a month visit	2
Terrance Bay		off/on	Y	off/on	N	once a month visit	2
Epukiro	primary	Y	Y	Y	Y, out currently to get programs updated	visits every other month	2
Okuryongava	secondary	Y	Y	Y	Y, used for record keeping	2	17
Maltahohe	secondary	Y	Y	Y	Y, but stopped working	0	8
Mariental	tertiary	Y	Y	Y	N	3 (supposed to have 7)	30
St Mary's Rehoboth	tertiary	Y	Y	Y	Y (for ARC and TB registry)	3	50

After examining the resources available to facilities, we developed the following criteria for regional prioritization based on need of POCUS implementation:

- Available imaging; first ultrasound, then x-ray
- Referral distance highest to lowest
- Disease burden highest to lowest
- Number of doctors, lowest to highest

Regions where we found little to no medical imaging technology should be prioritized. The ability to see inside the body drastically improves diagnostic capability and conversely, lack of technology hinders the quality of care (Moore and Copel, 2011). If there is no medical imaging technology in the region, practitioners cannot even refer patients to secondary or tertiary facilities for better diagnostic care. It is likely that they would have to refer to the national level and send patients to Windhoek to receive scans. Referral distance was included as a criterion because larger referral distances create difficulty when a patient seeks medical care or is referred

to receive imaging. Deployment of POCUS devices to areas with larger referral regions would allow for patients to be imaged at their local clinic.

Furthermore if POCUS is deployed to each region, we need to make sure that it will be useful in the treatment of local ailments. The priority of disease burden, quantified by a sum of prevalent diseases/care requirements with POCUS application in each region (described in Method 3.1), was used to ensure that the POCUS devices would be deployed efficiently.

Lastly, the number of doctors observed at each facility was used to prioritize the stratified information. Because an intern and a POCUS device are deployed to a region together, it is logical to place the intern in a facility that is understaffed.

4.3 The revenue generated from patient copays at public healthcare facilities cannot offset the cost of a POCUS device.

Citizens of Namibia receive public healthcare coverage and pay a flat rate copay when they seek medical care. This copay varies depending on the type of care sought and the severity of illness, but always remains under N$10.00. This fee covers all care provided. Charges are distributed in the following manner: Tertiary care N$10, average clinic visit N$2-4, HIV/AIDS and TB is free (a detailed breakdown can be found in Appendix VIII).

In the Namibian public healthcare system, care is provided before asking for payment. Unfortunately, due to the impoverished nature of many citizens who are serviced by the public healthcare system, this method of collecting payment often results in no payment at all. The patient simply does not have the money. Medical staff, especially in rural clinics, report that they do not expect patients to be able to pay for their visits. As such, medical care is frequently provided for free.

The price of each new POCUS model is listed on many manufacturer websites and ranges from $7,000 to $22,000 international dollars. A price comparison of available devices can be found in Appendix X. However, these listed prices do not align with the prices quoted to public facilities. Major manufacturing companies such as GE often offer later model POCUS devices to public facilities for $2,000 to $7,000 international dollars. It is likely that the MHSS would receive similar quotes.

4.4 The possible economic impact of POCUS implementation in Namibia's public healthcare system is complex and difficult to predict due to confounding factors such as referral rates, diagnostic rates and patient's preference to attend facilities equipped with imaging technology.

The economic impact of the implementation of POCUS technology falls into three categories: cost to the patient, cost to the public healthcare system, and patient and practitioner time.

Cost to the patient: Due to the nature of Namibian public health coverage and flat rate copays, there will be no difference between charges for care with and without a POCUS device. The MHSS mandates that all patients who are treated with the same type of medical care are charged the same amount, despite variation in resources used for treatment. For example, in Epukiro Pos-3, patients seeking obstetric care are charged the same amount whether or not they receive a CTG (electronic fetal monitoring). We do not expect this practice to change with the introduction of a new diagnostic resource.

Similarly, experts in the Namibian public healthcare system do not expect the copays to rise with the implementation of POCUS (Nurses, 2015). As POCUS technology should be included in the 2017 MHSS budget, the devices will be a ministry-funded resource and will fall under the same mandate as other resources in the clinics.

Cost to the public healthcare system: The implementation of POCUS devices could affect the cost of care in positive and negative ways depending upon the patient influx and diagnostic rate. The impact on cost of care can be organized into three main categories: diagnosis, referrals, and caseload. The commonality that exists at the core of all of these impacts is the increase in diagnostic capability and accuracy. Cost decreases involve a decrease in false positive diagnoses and a reduced referral rate. Cost increases involve a decrease in false negatives, an increase in referral rates, and an increase in caseload.

Diagnosis: An anonymous doctor at a tertiary referral center revealed that due to a lack of medical imaging technology he and his colleagues were often forced to make "educated guesses" to diagnose their patients. This method often results in false positive diagnoses, and the admittance of patients who do not need treatment.

Conversely, a patient with a false negative diagnosis may come back to receive care later, and in worse condition (Greene, 2015). The progression of the patient's illness may require

extensive care and more resource usage. This situation, preventable by proper diagnosis, may cost the public healthcare system more money. The introduction of diagnostic medical imaging technology would reduce the rate of false diagnoses (Moore and Copel, 2011), and would therefore reduce the ineffective use of resources on patients that did not need them, and provide timely treatment to those who need it.

Referrals: Improved diagnostic capabilities would also impact the rate of referrals from primary clinics to secondary centers and beyond, potentially resulting in more referrals. While the rate of false positives should be reduced as diagnosis becomes more accurate, false negatives should also decline (Moore and Copel, 2011). If more patients are diagnosed with sickness because practitioners can properly detect it, the referral rate might increase. Increased referral rate corresponds to an increase in cost to the public health sector.

However, unnecessary referrals could be avoided due to more accurate diagnosis (Moore and Copel, 2011) and the ability to perform antenatal scans on site. As the public healthcare system often has to cover ambulance and transportation fees because the patient cannot, fewer referrals will save the MHSS money. For example at a clinic in Aus, each referral results in charges for 244 km of ambulance travel, the driver of the ambulance, the nurse that travels with the ambulance, and overnight lodging for the nurse, driver, and patient (Nurse, 2015). In circumstances of antenatal care when an ultrasound is needed, the patient has to be referred to a secondary center or a regional hospital. If the clinic had a POCUS device all antenatal scans could be performed on site, saving thousands of dollars in referral for obstetric care (Nurse, 2015).

Caseload: The last possible negative impact on the cost to the public sector follows a trend we have observed in rural clinics that have only monthly doctor visits. On the day the doctors visit the clinics the caseload doubles. In Otjimbingwe the clinic sees an average of 30 patients per day; when the doctor visits, the clinic serves 80 patients. Nurses tell us that this is a result of the patients seeking "the most advanced medical care possible."

If POCUS is introduced to clinics the quality of the care provided will most likely improve (Moore and Copel, 2011; Spencer & Adler, 2008). If patient reaction mimics that of when the doctor visits, than practitioners could see an increase in the average number of patients per day at their facilities, and/or a redistribution of the caseload in general. In a survey of twenty-four public health students at the Polytechnic of Namibia, over 80% favored private care over

public care, even if they had to pay N$100 for their private visit and the public visit was free. However, a startling 91% said that they would go to a public clinic if it had medical imaging technology. The treatment of more patients requires more resources and will increase medical spending by public facilities.

While these increases in patient load, increase cost to the public health sector, the purpose of these facilities is to diagnose and treat the population. A negative impact with respect to cost does not mean a negative impact to healthcare. In fact, increasing appropriate spending is directly related to better medical care (UCAtlas, 2015).

Patient and practitioner time: The increased diagnostic rate of POCUS technology will allow practitioners to service patients more quickly. Instead of performing several physical examinations, questioning the patient about their symptoms and ruling out a series of other ailments, the practitioner can quickly examine, question the patient and then scan the affected area. In a 60 second scan they can gain the appropriate knowledge to aid in a definitive diagnosis and provide the appropriate treatment (Moore and Copel, 2011). The speed of diagnosis will allow for nurses to see more patients per day, and in hospital settings will save hours of patient and doctor time by bypassing the referral and transport to the imaging department.

Many public clinics, especially those in urban areas like Robert Mugabe Clinic and Hakahana Clinic, cannot serve all of their patients and have to turn them away (Amaambo, 2006). There is more demand for care than hours in the day. It is unlikely that clinics will ever run out of patients but more likely that they will be able to treat the people that they turn away. This has two possible impacts: a change in revenue as a result of the increase in patients seen per day and a reduction of patient waiting time allowing for an increased speed of medical treatment.

Revenue: Admittedly, an increase in revenue is not likely. As many patients do not actually pay the copay, it is unlikely that the any payments made by patients would have a significant impact on the total revenue of public healthcare facilities. Additionally, as patients are charged a copay, the public healthcare system covers much of the cost of their care, and does not actually make any money on the care that they provide to patients. Similar to the economies of developed nations, Namibia's "out-of-pocket" spending is 6% of the total health expenditure of the country (WHO, 2012). This low out-of-pocket cost is supplemented by 68% of total health expenditure accounted for by the public health sector, and therefore the MHSS (the other 26% is accounted for by private care and third party funding) (WHO, 2012). Over half the public health

expenditure, or over a third of the Namibia's Total Health Expenditure, is dedicated to patient care (WHO, 2012). If the number of patients seen per day increases the cost to the MHSS will also increase.

Waiting time: From the perspective of the patient, the increase in patient throughput and reduction in wait time may have a positive impact. Many patients who attend public health clinics either have to wait in line for hours or are turned away because the clinic is over capacity. Public health students at the Polytechnic of Namibia report waiting an average of three hours at the clinic to receive healthcare. "Sometimes," a student told us, "if your leg is fractured [they] will send you home and tell you to come back on Monday."

For some this means that it may take them days to receive care for their ailments, especially if they must walk to a village to receive care from a rural clinic, or are referred to a secondary or tertiary facility. The average distance from one facility to its referral center is 150 km, which is approximately 30 hours walking or 4 hours driving. Figure 10 depicts the referral distances, and Figure 11 the referral times.
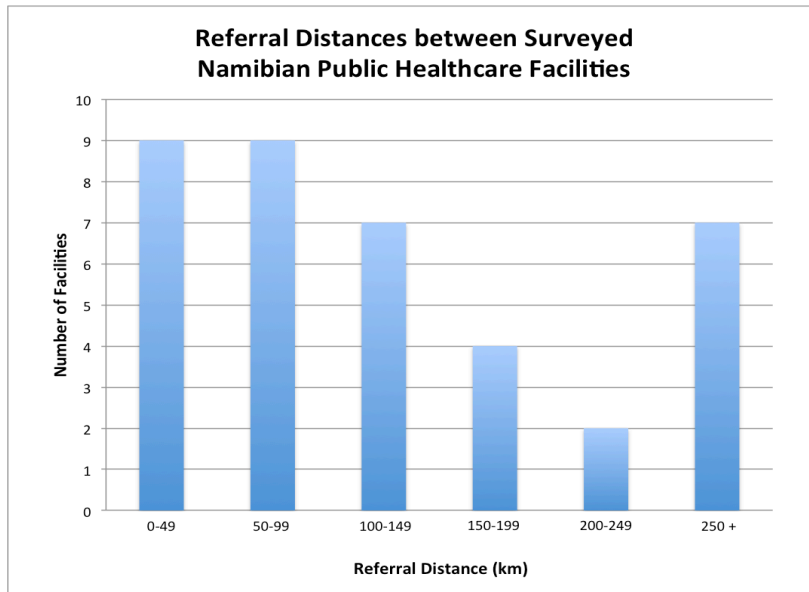
Figure 10 Distance between surveyed facilities to referral centers (n=38[1])
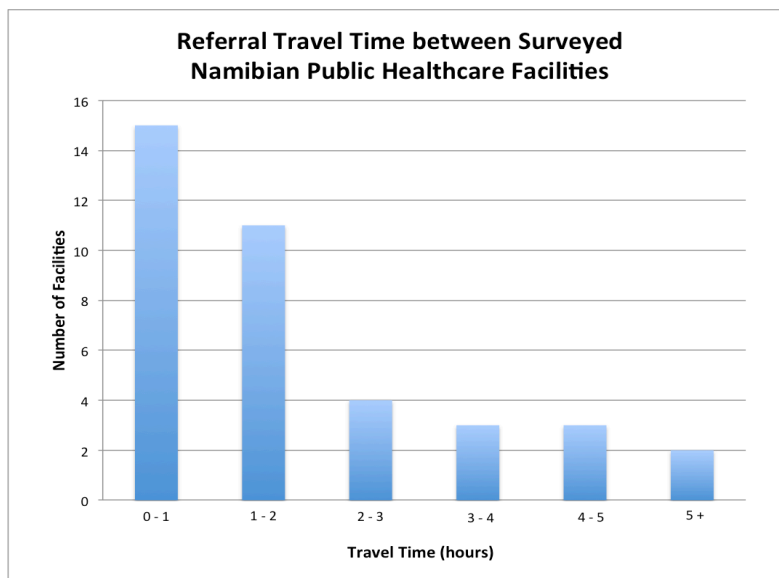
Figure 11 Travel time (driving) between surveyed facilities to referral centers (n=38[2])

With improved triage, only patients who would need to be sent to tertiary care would make the trip. This would save time from avoidable referrals for both medical staff and patients sent out unnecessarily. It can be argued that if these individuals are ill, and have to spend days or weeks being ill, they cannot perform in an appropriate manner conducive to their livelihood. As

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[1,2] n=38 because Windhoek Central Hospital was discarded from the data set due to the fact that it does not refer patients

such, long wait times at clinics may be damaging to economic standing of patients, because they are unwell for a longer period of time. The introduction of POCUS technology, and the increased patient throughput that may result, could help alleviate this problem.

4.5 The implementation of POCUS technology as a diagnostic tool in public healthcare facilities could result in changes in workplace dynamics among medical staff based on differences in training and new work roles/responsibilities.

POCUS implementation could cause positive and/or negative changes in medical staff dynamics in the healthcare facilities between POCUS trained and untrained staff. This would apply to cases where:

1) Less qualified staff were trained rather than higher qualified staff
2) Higher qualified staff were trained rather than less qualified staff.

If less medically educated staff, such as nurses, were trained they could become more important in diagnosing patients, specifically patients who need imaging technology. Higher educated medical staff, such as doctors, who were untrained, could respond to this by either appreciating or undermining the trained staff's new role. Our survey of Public Health students at the Polytechnic of Namibia demonstrated a large majority of students (76% n=24) felt that being trained in a technology that their superior was not, would change their relationship. Whether positive or negative, workplace dynamic changes that take place will be situational and can be a mix of both (Greene, 2015).

Because POCUS implementation requires training, a staff member may have to leave their facility for a period of time to receive it, and would, at the time of the training, cause negative changes in workplace dynamic. In the current system nurses do not receive training after they have completed their education and are assigned a post. As such there is no system, or precedent, to substitute for a nurse that is away on training. With a staff member away from the facility, more pressure would be put on the other staff member(s) to keep the facility operating. This would be debilitating to the facility because nearly all are understaffed (Iileka, 2013; Nurse, 2015). As in the case reported by Iileka in 2013 where a nurse went on maternity leave, when a clinic closes, even for a short period of time, the patients have to travel elsewhere. With Namibia's additional disparity of health facilities and vast geographic distribution, patients have to travel vast distances to receive healthcare (Bosh, 2011). Although the return of the trained

staff member would result in positive changes to the healthcare facility because of the technology, the workplace dynamic between the now trained medical staff member and the rest of the untrained medical staff member(s) could be affected. Again, however, this change would be situational.

4.6 Namibians would rather be seen by a doctor than by nurse and are excited by the prospect of Namibian-trained doctors entering the public healthcare system.

Namibian's preference for doctors is evidenced by the high rates of demand on the days the doctor visits the clinics, and by a recent survey of Public Health students at the Polytechnic of Namibia in which 80% of students stated they would prefer to be seen by a doctor. "It would make a difference when treated by a doctor," a student said, "because they have more knowledge about medical stuffs."

In the Namibian public healthcare sector there are few, if any, native Namibian doctors. In our survey of almost forty Namibian public healthcare facilities we did not encounter a single Namibian doctor. However, we did encounter unbridled enthusiasm for the upcoming graduating class at UNAMSOM, consisting of forty medical students trained over six months with hands-on POCUS curriculum. Nurses and patients alike were joyous in receiving the news that they may soon be working with doctors from their own country.

4.7 The implementation of POCUS technology as a diagnostic tool in public healthcare facilities might create two social shifts: the first, on social stigmas associated with TB thought improved diagnostic capability and the second, on attitudes towards abortion through better antenatal care.

Tuberculosis: According to research, the social stigma against TB causes almost as much harm to the patient as the disease does. The highly infectious nature of the disease causes people to fear catching it. As soon as a patient is diagnosed with late stage TB, they are taken to a TB ward to be isolated for the duration of treatment. The patient's family and friends will rarely visit them (Gunther, 2015). An increase in the number of patients who are diagnosed with late stage TB could be a consequence of POCUS implementation. While diagnosis would be beneficial in stopping the spread of the disease, it would impact the patients who are isolated from their families.

Patients afflicted by late stage TB need to be isolated and treated aggressively. These patients must remain in the ward while patients suffering from less severe symptoms are free to come and go between treatments. Misdiagnosing the severity of the disease could cause patients to be unnecessarily isolated. POCUS devices would have a positive impact by leading to fewer false positive diagnoses specifically of late stage TB as well as increase the number of early diagnoses. With more cases where TB patients are not quarantined away from family and friends, the stigma relating medical care and ostracism could be weakened.

Abortion: Striking responses to the introduction of ultrasound in other countries also call for consideration of how the implementation of POCUS technology in Namibia's public healthcare system could change cultural views on abortion (Muller-Rockstroh, 2012). In the U.S., supporters of the pro-life argument adopted ultrasound images as "baby's first picture," advocating for rights of the fetus even when they countered the mother's. In China and India, due to social pressures including population restrictions and sexism, ultrasound allowed for the identification of gender before birth causing a shift from female infanticide to feticide.

Namibia, a predominantly Christian country, is currently in the midst of a debate to legalize abortion. The current policy on abortion reflects a conservative view. According to The Abortion and Sterilization Act inherited from South Africa in 1975, abortion is only allowed in cases of incest, rape or if two doctors confirm that bringing the baby to term would risk the physical or mental well being of mother or child. On the other side of the argument are growing statistics on a phenomenon known as "baby dumping," documented by UNICEF in 2010 with the discovery that thirteen dead babies are found in the Windhoek sewers every month. Namibian women employ other illicit means to terminate unwanted pregnancy including travelling to South Africa and buying pills online to induce abortion (Namibian Sun, 2014). We conducted a small survey of Public Health students at the Polytechnic of Namibia, and asked if they believed that abortion should be legalized. The results are depicted in Figure 12.
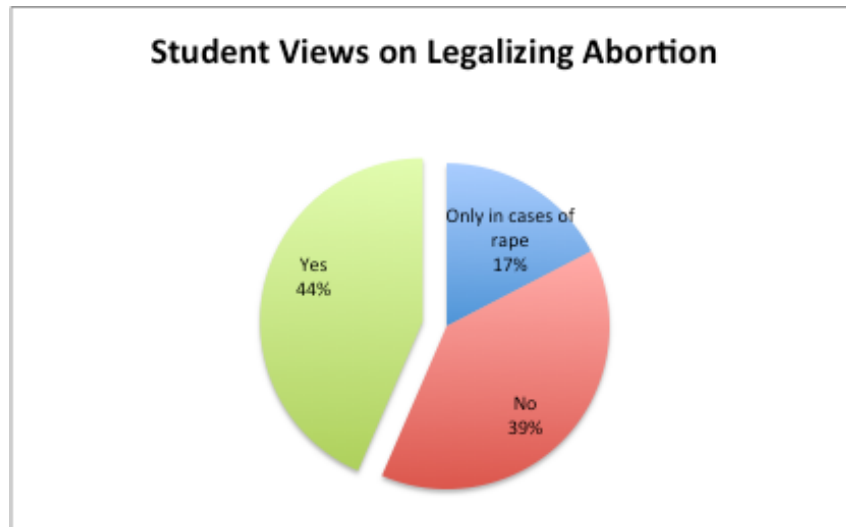
Figure 12 Views on legalizing abortion from survey of Public Health students at The Polytechnic of Namibia (n=23).

The media begs for the government to open discussion on this topic and consider changing to a more liberal policy, but the powerful Christian influence moves the Namibian people against legalization (Planned Parenthood, 2015). This debate is similar to the one in the US, indicating that the widespread implementation of ultrasound technology could possibly have a similar impact in Namibia.

The discussion on gender identification depends heavily on gender roles – if a baby girl can live a life as fulfilled as a boy's, then knowing the gender of the fetus is unlikely to have the dramatic effects it did in China and India. Since its independence, women's equality has been a priority of the Namibian government and large strides have been made in the past 25 years. That being said, traditional gender roles are still the norm, especially in rural communities. Customary law, defined as "traditional common rule or practice that has become an intrinsic part of the accepted and expected conduct in a community," (Business Dictionary Online) is legally considered authoritatively lower than the law of the Constitution but still holds weight in rural villages (Manfred, 2008). This tradition, coupled with a predominantly Christian mindset, determines major aspects of women's rights; female workloads are centered around reproduction and domestic roles, higher education for girls is not a priority, and women owning property is considered a privilege instead of a right (LaBeau, 2009). In our survey of Polytechnic of Namibia Public Health students, three fourths said that women do not have the same opportunities as men.

However, and most importantly, this stereotypical way of life does not appear to reduce the value placed on girls. In an interview with a member of a rural community we discovered that pregnant women of the village frequently visited the closest referral hospital (with an ultrasound) to determine the sex of their child. This trip was made for one purpose: to plan accordingly for the child's future, just like expecting parents in the western world. When asked about gender preference, the interviewee told a story of a couple with three boys who desperately wanted a girl. When the fourth pregnancy turned out to be a boy, the mother stated, "I am done trying, God has made his decision." Similarly, after explaining to the students at the Polytechnic the situation in India and China, the overwhelming reaction was one of disbelief and angered confusion. One student exclaimed, "Why would they do that?" Taking into account that mindset, we find it unlikely that implementation of POCUS technology would begin a national trend of feticide based on gender preference.

5. Conclusions & Recommendations

Based on conclusions from findings in literature reviews, expert consultation, and interviews with people across Namibia, we have formulated these recommendations for the implementation of POCUS technology into the Namibian public healthcare system. This chapter will begin with a conclusion of our findings followed by a list of recommendations, which fall into four sections: pilot study, funding, training and geographic distribution of the POCUS devices.

5.1 Conclusions

5.1.1 Despite a high infectious disease burden, specifically in TB and HIV/AIDS, and a high demand for antenatal and trauma care, Namibian public healthcare facilities lack basic diagnostic technology, demonstrating a need for imaging devices.

The prevalence of TB and HIV/AIDS in Namibia are among the highest in the world. TB affects six out of every 1,000 people. The adult HIV prevalence rate is 17.8%. Yet, there is a lack of imaging devices in the public healthcare system. Only six facilities of the thirty-nine that we visited had access to ultrasound. These six facilities were district hospitals that serve thousands of people.

5.1.2 All Namibian public healthcare facilities possess the resources required for POCUS operation: power supply, access to coupling agents, access to water and staff.

Every facility surveyed had electricity and running water, although sometimes unreliable, as well as a pharmacy, which if restocked periodically will have access to coupling agents. Although staffing was limited at almost every facility, it would be sufficient to effectively use a POCUS device.

5.1.3 The revenue generated from patient copays at public healthcare facilities cannot offset the cost of a POCUS device.

Nurses at primary care facilities expressed the need for an imaging device, but facilities cannot fund them individually. There is little to no income generated from patient payments; these facilities rely on funding from the MHSS. The patient copay is a uniform charge throughout the public healthcare system. It varies by care sought (follow-up, emergency, TB/HIV treatment) but not between facilities, even those with and without medical imaging technology. With the co-pay system, the addition of POCUS at some facilities will not increase the cost of treatment to the patient.

5.1.4 The possible economic impact of POCUS implementation in Namibia's public healthcare system is complex and difficult to predict due to confounding factors such as referral rates, diagnostic rates and patient's preference to attend facilities equipped with imaging technology.

Through expert consultation we found that the impact of POCUS implementation on cost to the patient will not change but cost to the MHSS is unpredictable. Cost to the MHSS could be affected by changes in referral rates, diagnostic rates, and patient's preference to attend a facility that has imaging technology. These changes could result in an increase or decrease in cost, but either way the quality of care available to the patients will be improved.

5.1.5 The implementation of POCUS technology as a diagnostic tool in public healthcare facilities could result in changes in workplace dynamics among medical staff based on differences in training and new work roles/responsibilities.

There is a strict hierarchy between doctors and nurses in the Namibian healthcare system. This hierarchy dictates interpersonal relations not only within the workplace but also in the view of the patients. Most patients would rather be seen by a doctor, as they feel more secure being treated by someone with a higher medical education, further limiting the doctors' time compared to nurses' availability. Training only one group of medical professionals could cause a shift in the dynamic between the two, but this is unpredictable and most likely situational.

5.1.6 Namibians would rather be seen by a doctor than by nurse and are excited by the prospect of Namibian-trained doctors entering the public healthcare system.

Namibians would rather be seen and treated by a doctor than by a nurse. This is evidenced by the high rates of demand on the days the doctor visits the clinics, and by a recent survey of Public Health students at the Polytechnic of Namibia in which 80% of students stated they would prefer to be seen by a doctor.

In the Namibian public health sector there are few, if any, native Namibian doctors. In our survey of almost forty Namibian public healthcare facilities we did not encounter a single Namibian doctor. However, we did encounter unbridled enthusiasm for the upcoming graduating class at UNAMSOM. Nurses and patients alike were joyous in receiving the news that they may soon be working with doctors from their own country.

5.1.7 The implementation of POCUS technology as a diagnostic tool in public healthcare facilities might create two social shifts: the first, on social stigmas associated with TB thought improved diagnostic capability and the second, on attitudes towards abortion through better antenatal care.

Namibia is heavily influenced by conservative religion and the abortion debate is not a comfortable topic for many people. After conversations with our sponsors and a survey of Public Health students at the Polytechnic of Namibia, there does not appear to be evidence to suggest possible changes in attitude or behaviors regarding abortion due to widespread implementation of medical imaging technology. Abortion is an issue, but not because of gender preference. The impact of POCUS technology on the stigma against TB is not as clear. Imaging technology makes diagnosing the stage of TB easier. It is possible that more people will be diagnosed with late stage TB, which requires isolation and carries the connotation of a death sentence. Alternatively, patients that are diagnosed in earlier stages of TB are not forced into quarantine and have a greater chance of being cured. This could lessen the stigma against TB as a highly infectious disease that ostracizes someone from society with no hope of recovery

5.2 Recommendations

5.2.1 We recommend that a one-year pilot study of POCUS technology be conducted by equipping each 2015 UNAMSOM graduate while they complete their internship in the public health sector.

Further studies are required to determine the effects that implementing POCUS technology will have on the Namibian public healthcare system. If data from this recommended pilot study shows an overall positive impact to the public healthcare system, a case can be made for further distribution.

Distribution to UNAMSOM graduates has a number of benefits that fall under four categories: training, cultural variables, people rather than facilities, and geographic distribution.

Training: A suitable training program for staff is integral in the implementation of medical technology (Spencer & Adler, 2008; Henwood et al, 2013; IFEM, 2014), and the UNAMSOM interns are already trained. This helps to alleviate problems that could arise in attempts to teach current medical staff how to use POCUS technology, such as leaving rural clinics unmanned and social tension between staff with varying levels of training and background.

Cultural Variables: We discovered through conversations with professors at both sponsoring institutions that the majority of UNAMSOM students are from the regions in which these public healthcare facilities operate. Therefore, they are aware of local customs and could be more culturally considerate than an outsider. Many impacts of POCUS implementation are surrounded by social stigma, such as TB and abortion. Use of the technology could result in cultural shifts that UNAMSOM students may be more skilled at handling because of their intrapersonal knowledge of cultural trends and stigmas.

Additionally, the Namibian people would rather be seen and treated by a doctor than by a nurse, even more so a Namibian doctor. We believe that this enthusiasm can translate into acceptance of the interns and the technology that they carry with them.

People rather than facilities: From our investigation into the public healthcare system, we determined two trends: first, doctors are based in regional hospitals but travel every month to the clinics in their district; second, what little technology the public sector has access to frequently

goes unused because the person trained to use it has left. Due to these discoveries, we do not recommend giving POCUS devices to specific facilities, but instead to specific practitioners.

We suggest equipping UNAMSOM interns with their own POCUS device and stationing them at District Hospitals. As part of their duties, they will shadow travelling doctors in their visits around the region at which point they will bring POCUS technology to the clinics. Eventually the interns will make these trips alone and the doctors can spend more time at the hospital. The interns should be held responsible for the devices. This sense of ownership will assure that the device is not misused or damaged by individuals that do not know how to operate it properly. In return for the POCUS device, it is the UNAMSOM intern's responsibility to train the doctors and nurses in the region where they are stationed to use the technology.

Geographic Distribution: An effective pilot study requires a representative distribution of data. In this case that data requires an effective regional distribution of the POCUS devices that will show the nationwide impact of POCUS on public healthcare. For their internships, the UNAMSOM interns must go where the University decides to place them in the public sector. This ensures that the data produced by the pilot study will be effective and representative of POCUS impact.

5.2.2 We recommend that funding for POCUS devices in the pilot study come from the MHSS.

The Namibian public health sector is under MHSS jurisdiction. The revenue generated from patient copays at public health facilities cannot offset the cost of a POCUS device because many patients do not pay for their care since they cannot afford it. These findings have led us to the conclusion that the MHSS must fund the POCUS devices if they are to be implemented in the public healthcare system. This method would not only assure that the devices were funded in accordance to governmental processes and regulations, but also create confidence in the MHSS in their ability and commitment to improve Namibia's public healthcare (Haufiku, 2015).

According to Dr. Günar Günther of Katutura State Hospital, "The [implementation of technology] needs to be from the bottom up, not top down." He believes this is the best method for improving point-of-care service to patients. The nurses and doctors that run the public healthcare facilities we visited were unanimous in stating that they could benefit from a POCUS device. From our survey with Public Health students at the Polytechnic of Namibia, we learned

that not only are the nurses and doctors in the public sector asking for improved diagnostic technology, but the communities it would be used in see the need for new technology as well. The Namibian people are asking, the government needs to respond.

5.2.3 We recommend that two UNAMSOM interns, and therefore two POCUS devices, be located in each of Namibia's fourteen regions. Additional distribution of devices and interns can be based on the data we gathered on regional need for medical imaging and staff.

The UNAMSOM graduating class of 2015 will be composed of forty interns. The fourteen regions of Namibia can therefore each receive at least two POCUS devices. Additional distribution of devices and interns can be based on the data organized in Table 6. This serves to ensure that the data produced by the pilot study will be effective and demonstrate the impact of POCUS technology nationwide. We recommend criteria for regional ranking be used in the following manner:

- Available imaging; first ultrasound, then x-ray
- Referral distance highest to lowest
- Disease burden highest to lowest
- Number of doctors, lowest to highest

The following is an example of how the criteria could be used to analyze our data. In this case, regions depicted in:

White, will receive two additional interns with POCUS devices
Light blue, will receive one additional intern with a POCUS device

Table 6 Example of regional ranking for additional distribution of POCUS devices

Region	Reported facilities	Facili-ties visited	Average Patients per day	Average number of doctors[3]	Average Referral Distance	X-ray	Ultraso und	Average disease burden
Omaheke	22	7	38	0.6	445	0	0	16
Erongo	17	5	25	0.03	125	1	0	15
Otjozondupa	21	1	7	0.03	50	0	0	11
Karas	14	3	220	1.4	88	1	1	14
Kuenene	26	7	23	1.7	480	3	1	15
Hardap	14	7	105	0.7	175	2	3	15

The total number of POCUS devices and resulting interns distributed to each region can be found in Table 7.

Table 7 Example of recommended regional distribution of POCUS devices/interns

Region	Total POCUS devices
Erongo	4
Omaheke	4
Otjozondjupa	4
Hardap	3
Karas	3
Kunene	3
Zambezi	3
Kavango East	2
Kavango West	2
Khomas	2
Ohangwena	2
Omusati	2
Oshana	2
Oshikoto	2

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[3] Calculated by the numbers of doctors present and the amount of time a doctor was at the facility ie. If one doctor only came once a month they were counted at 1/30 of a doctor.

5.2.4 We recommend that POCUS training be expanded to consider possible social implications, such as stigmas associated with TB and abortion.

Research, expert consultation, and student surveys demonstrated that POCUS implementation may create two social shifts: the first, on social stigmas associated with TB through improved diagnostic capability, and the second, on attitudes towards abortion through better antenatal care. However, neither is addressed by the curriculum for POCUS training at UNAMSOM, and is only covered by each student's personal experiences. The medical students that are trained on POCUS devices should be aware of the social issues they will most likely need to address in order to properly counsel their patients.

6. Where Society Meets Technology in Global Research Design

In completing our project, we have learned not only about POCUS technology and the Namibian healthcare system, but also about project design, development, and execution. What proved to be the biggest unknown at the onset of our project, and still remains a variable in its success, is the Namibian people and their culture. Executing a technology-based project in a foreign country has taught us to consider variables that we did not know existed.

6.1 Research and Personal Interactions: The Whole Picture.

The importance of considering the viewpoints of the local people cannot be stressed enough, but the reality is that without exposure to these people it is nearly impossible to predict their reactions. Before arriving in Namibia, we spent two months gathering data and discussing our project. We thought we understood what to expect. We were wrong.

Although we researched Namibia's cultures, it was impossible to understand the cultural context in which we would be working without personal exposure to the people. Historical articles on the indigenous people did not provide sufficient context; society's perspective on medicine became apparent only in talking to people face-to-face and visiting healthcare facilities across the country. Attempts to understand our project's possible implications showed how drastically different reactions to similar projects were around the world. Although we drew parallels from past projects, the only way we could be confident that we were being socially sensitive was to learn about the culture of Namibia from the Namibian people.

6.2 Consideration of stakeholders and viewpoints requires adaptation.

Projects abroad have a steep learning curve upon first arriving. The first proposed solution might not be the right one for the people involved. Observations made in country showed that our initial plan of action was infeasible. Opinions from different perspectives (medical professionals, professors at universities and patients at public facilities) proved that there is never a universal solution. Only by considering all of these perspectives were we able to

propose feasible recommendations that would minimize potential negative consequences. After two months of project work in country, the end goal of the project remained the same but the recommendations on how to reach this goal changed significantly. The opinions of multiple stakeholders as well as the Namibian culture were taken into account in creating our recommendations.

A project that expects the unexpected must be willing to change at a moment's notice. This is especially true in a multi-stage project. POCUS implementation will occur in phases, and we have no control over what happens when we leave. Considering the next phase of this project shaped our recommendations alongside stakeholders' perspectives. The people that will continue the project are important to consider because if the basis of our recommendations is not clear, they might not follow our plan for the future. Our recommendations cannot be things we think will work, they have to be founded in evidence and logic understandable to people coming from different backgrounds.

6.3 A proposed program's success depends on the local people's support.

"There is a desperate need. But you cannot only bring in the machines, people need to be trained and see the need for it." -- Dr. Günar Günther

Long-term success of introducing a technology hinges on three variables: the need, the technology, and the training. A researcher understanding a need does not mean that local people do. A lack, as defined by an outsider, may be a normal part of life for local people. In Oashana, Namibia the women refuse antenatal care (Andima, 2015). Most have never been to a hospital. They believe that the only safe way to deliver a baby is at home. Arranging a means of transportation for these women to the regional hospital would be a waste of resources because the women simply would not go. If the people do not recognize the need then there is no convincing them to change their way of life.

Once a need is acknowledged, the people must support a proposed solution. If the local people do not support a recommended technology, there will be no one to maintain it after a project team leaves. We considered this by discussing the use of medical imaging with the medical staff in public healthcare facilities. The nurses that we spoke to unanimously agreed that imaging technology would improve the quality of care that they could provide. Most were not

aware of POCUS technology, but were accustomed to using ultrasound and were willing to be trained. Training is crucial to the local people's ability to maintain implementation of a technology and being trained in ultrasound, even basically, would be enough to benefit from a POCUS device. If we did not make sure that people were motivated to embrace change, and prepared to maintain it, there would be no progress.

6.4 The nature of communication will vary by nation, region, and person.

In Namibia, the best way to learn how to communicate effectively, with anyone from bureaucrats to doctors, was to try. In gathering data, language barriers were just the beginning of our difficulties. Contacting people to set up meetings, as is customary in the U.S., proved to be ineffective in most instances. Our first attempt at gathering data was to ask the Ministry of Health and Social Services. It was futile. There was often no contact information for facilities, so scheduling visits was not an option. The facilities with contact information were unresponsive to calls and emails almost half of the time. Only by visiting facilities and asking to speak with nurses were we able to gather data, demonstrating the most effective form of communication in Namibia: face-to-face conversation.

People of different professions preferred to communicate in different ways. The few administrators at facilities that we contacted prior to visiting were happy to set up an appointment to speak formally. Professors at the universities preferred predetermined questions and had strict limits on available time to be interview. Students were comfortable with open-ended questions, enjoying casual conversation and sharing personal experiences. There was variety even within a profession: some nurses were happy to take a moment to answer our questions while others wanted a letter of permission from the MHSS to answer any questions at all. Caution in approaching an individual was the only way to effectively communicate. People will have a preferred way of communicating; it can most often be found with a polite introduction and a few simple questions.

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Appendix

I. Ultrasonography

Two-dimensional ultrasound is used to visualize a plane that is then shown on a screen (Moore and Copel, 2011). The static and dynamic nature of the image shown on the screen result in static and dynamic guidance for procedures, in addition to the technology's diagnostic ability. Static guidance allows practitioners to identify the object of interest and for the form procedural plans (such as angle and placement of a needle); dynamic guidance allows practitioners to view any procedure in real time (Moore and Copel, 2011). As a result ultrasound can be used in procedures performed by practitioners in many different specialties; examples can be found below in Table 8.

Table 8 Selected Applications of Ultrasound/Point-of-Care Ultrasonography, with respect to Medical Specialty (Moore and Copel, 2011)

Specialty	Ultrasound Applications
Anesthesia	Guidance for vascular access, regional anesthesia, intraoperative movement of fluid status and cardiac function.
Cardiology	Echocardiography, intra-cardiac assessment
Critical Care Medicine	Procedural guidance, pulmonary assessment, focused echocardiography
Dermatology	Assessment of skin lesions and tumors
Emergency Medicine	FAST*, Focused emergency assessment, procedural guidance,
Endocrinology and Endocrine Surgery	Assessment of thyroid and parathyroid, procedural guidance
General Surgery	Ultrasonography of the breast, procedural guidance, inoperative assessment.
Gynecology	Assessment of cervix uterus and adnexa; procedural guidance
Obstetrics and Maternal Fetal Medicine	Assessment of pregnancy, detection of fetal abnormalities, procedural guidance,
Neonatology	Cranial and pulmonary assessments
Nephrology	Vascular access for dialysis
Neurology	Transcranial Doppler, peripheral-nerve evaluation
Ophthalmology	Corneal and retinal assessment
Orthopedic Surgery	Musculoskeletal applications
Otolaryngology	Assessment of thyroid, parathyroid and neck masses; procedural guidance
Pediatrics	Assessment of bladder, procedural guidance
Pulmonary Medicine	Transthoracic pulmonary assessment, endobronchial assessment, procedural guidance
Radiology and Interventional Radiology	Ultrasonography taken to the patent with interpretation at the bedside, procedural guidance
Rheumatology	Motoring of synovitis, procedural guidance
Trauma Surgery	FAST, procedural guidance
Urology	Renal, bladder, and prostate assessment; procedural guidance
Vascular Surgery	Carotid, arterial, and venous assessment; procedural guidance
*FAST denotes focused assessment with sonography for trauma	

II. Primary Applications of POCUS technology

POCUS technology has a large array of applications, but this project will focus on four of the primary applications: Emergency Medicine, Cardiology, Infectious Disease, and Maternal Care. Summaries of each application can be found in the sections that follow.

Emergency Medicine: As mentioned in Section 2.2.2 of the background, and demonstrated in the field after a Natural Disaster in Guatemala (Dean et al, 2007) point-of-care ultrasound has a large positive impact on Emergency Medical care. One particular application, focused assessment with sonography in trauma, or FAST, is extensively used in emergency medicine.

South African hospitals experience the highest trauma volumes in the world (Sippel et al, 2011). A 12-month study conducted by Zoe Smith and colleagues in rural KwaZulu-Natal examined FAST exam use on patients with blunt and penetrating trauma. During the study 72 FAST exams were performed on patients with abdominal or thoracic trauma. Fifteen of those 72 scans were defined as positive indicating the presence of free intra-abdominal or pericardial fluid (signs of internal bleeding). The overall specificity of the scans performed was 100%, with 71.4% sensitivity (Smith et al, 2010). Smith and colleagues found value in the use of POCUS technology in this rural South African hospital. They proposed that this application would extend beyond this one trial and have value in all peripheral hospitals for the assessment of patients sustaining blunt trauma. Smith and colleagues concluded that, "In rural areas with limited resources, FAST scans may assist in the appropriate timely transfer of trauma patients for further imaging or definitive surgical intervention."

FAST doesn't only serve purposes in rural medicine. It also has applications in developed countries with many medical imaging resources. In these countries, POCUS technology, by means of FAST application, is used in pre-hospital care. In December 2002, a one-year multicenter study was conducted examining the abdominal trauma cases of five air rescue centers and one ground ambulance team in southwest Germany (Walcher et al, 2006). A total of 202 patients were included in the study, 28 were found to have free abdominal blood. During these trials FAST had a sensitivity, specificity and accuracy of 93%, 99%, and 99% respectively. In 42 of the 202 patients (21%) pre-hospital care was modified due to the findings of FAST. In contrast to the low accuracy of physical examination and hemodynamic measurement, FAST

proved to be highly reliable. While both FAST application examples occur in different environments, both environments at the time of FAST scan can be classified as resource-limited. Just as POCUS technology can be effectively implemented in the emergency rooms in rural Africa, it can be just as effective in the field of urban Europe.

Just as POCUS technology provides a range of trauma applications, it also allows for a vast array of other emergency dependent applications. In the Odense University Hospital emergency department in Odense, Denmark pediatric patients admitted with respiratory issues were randomly assigned to series of standard diagnostic strategies or diagnostic tests supplemented with point-of-care ultrasound to determine the value of POCUS use (Laursen et al, 2014). Over a period of 15 months, 158 patients in the POCUS group and 157 patients in the control group were analyzed. Four hours after admission to the emergency department 139 patients in the POCUS group vs. 100 in the control group had the correct diagnosis, demonstrating the superiority of pairing POCUS technology with standard diagnostic tests. In any emergency room, anywhere in the world, efficiency and accuracy are key. The POCUS technology offers an extension that provides both elements.

Cardiology: The traditional physical exam, including inspection of jugular venous pulsations and auscultation of the heart tones, interpreted along the framework of medical history, can only detect 60% of possible disease, with variable accuracy (Moore and Copel, 2011). A possible solution to physical examination deficiencies is incorporation of point-of-care ultrasound (POCUS) in the bedside evaluation. In well-trained hands, POCUS is recognized to be "accurate and reproducible for assessment of cardiac structure and function" by the American Society of Echocardiography (Spencer et. al, 2003). The improved sensitivity and accuracy afforded by using POCUS in conjunction with the physical examination has been exhibited across a spectrum of doctors, from medical trainees to experienced cardiologists (Panoulas et. al, 2013) and has been demonstrated to improve cardiac abnormality detection by at least 31.5% (Galderisi et. al, 2010). In outpatient care, POCUS improved the number of diagnoses made from 23.3% to 74.6%, leading to faster clinical decisions and fewer tests (Cardim et. al, 2011). Leveraging ultrasound abilities to detect subclinical cardiovascular disease, including asymptomatic dysfunction, POCUS can provide prompt and cost-effective cardiovascular risk screening in outpatient protocols (Kimura et. al, 2007). Large studies in rural India have combined POCUS

with remote image interpretation to provide cardiac evaluation for thousands of patients (Singh et al, 2013) demonstrating that POCUS's portability and wireless transmission capability provides the potential to improve global access to cardiac assessment.

The effectiveness of POCUS as a tool in cardiovascular medicine depends greatly on the training of those using it. As Wiley (2014) states, "Without adequate training, the sensitivity of POCUS is tempered by suboptimal specificity. Thus, educational protocols should be developed for non-cardiologists to ensure safe and accurate implementation of the technology." POCUS is able to improve bedside evaluation effectiveness, provide information to guide patient care, and increase access to cardiovascular assessment worldwide when utilized by well-trained operators as a physical examination extension. With its outstanding capability and many applications, POCUS has the potential to be as fundamental to cardiovascular medicine as the stethoscope.

Infectious Disease: Another way in which practitioners are utilizing POCUS technology is in the infectious disease diagnosis. An example can be found in the diagnosis of mononucleosis (commonly known as mono). Because the mono symptoms are also expressed in common sickness, it can be difficult to correctly diagnose. A determining symptom that separates mono from other causes of a sore throat is splenomegaly (a swollen spleen). Acute spleen swelling can be difficult to notice, but with the POCUS device there is a significantly higher percentage of correct diagnosis (Farukhi 2014). The addition of the bedside technology allows for advance diagnosis in the emergency room; without the ability to examine the spleen there is a higher risk for misdiagnosis, in this case, POCUS allows practitioners to relay the precautions concerning a swollen spleen to the patient in real time.

POCUS also allows for inexpensive full body scans that allow detection of infection (Lichtenstein 2007). Many infections, both common and rare, have specific physical manifestations that can be observed using bedside ultrasound technology. The sites of these infections include the lung, central veins, and maxillary sinuses, and result in symptoms and disease such as gastrointestinal perforation, and meningitis. POCUS technology's ability to examine these infection sights without the need for an invasive procedure makes it essential in the rapid diagnosis of infection (Lichtenstein 2207). As the leading cause of childhood mortality in developing countries is pulmonary infectious diseases (Via 2012), the ability to correctly

diagnose respiratory symptom causes could save countless lives. POCUS is the most reliable and cost-effective option to date (Via 2012).

Maternal Care: Katherine Stanton, a disciple of public health at Flinders University in Australia once stated that, "Maternal mortality is the health indicator that shows the widest gap between rich and poor, both between and within countries." In Africa, the maternal mortality ratio is 620 per 100,000 live births, an abnormally high ratio compared to: 14 deaths per 100,000 live births in developed countries (Stanton, 2013). In fact, in 2005, half a million women died of complications related to pregnancy, 50% occurring in Africa. Also in 2005, 3.1 million infants died before reaching 28 days, with 99% occurring in middle and low-income countries (Stanton, 2013). Disparities between urban and rural populations result in rural areas suffering, especially in developing countries where many maternal health problems are both preventable and treatable.

Unlike the developed world where the ultrasound is a routine procedure during pregnancy obstetric ultrasound coverage and image quality is poor and the opportunity to identify and manage risks during pregnancy is limited to clinical examination in the developing world (Sippel, 2011).

Ultrasound has shown to be a valuable tool throughout pregnancy. In the first trimester, ectopic pregnancy is a leading cause of mortality in women in low and middle-income countries. It requires early identification and prompt intervention which can be addressed with ultrasound use. Because clinical signs and symptoms are not always reliable, ultrasound use plays a pivotal role in diagnosis (Sippel, 2011).

In Africa, ultrasound use has demonstrated positive results. In Egypt, for example, intrauterine growth retardation (IUGR) is a major contributing factor to perinatal mortality and morbidity. With ultrasound use, however, pregnant mothers at risk for IUGR can be diagnosed earlier and receive proper treatment (Sippel, 2011). Additionally in rural Zambia, a pilot program focused on obstetric ultrasound. Approximately 820 midwives participated in this program that determined whether ultrasound skills could be imparted to nurse midwives (Sippel, 2011). The program also proved to have positive results, 441 ultrasounds were performed over a 6-month training period. These midwives reported "ultrasound helped their practice and changed their management" (Sippel, 2011).

The ultrasound use has proven to be critical for maternal healthcare. Already a common device in the developing world, ultrasound technology is starting to have positive effects in developing countries. Not only does ultrasound have the potential to save mothers and infants in developing countries, but it can also further improve the healthcare system management, as reported by the midwives that took part in the pilot program in Zambia. In rural areas, where the time and distance it takes to receive medical care can be deadly, ultrasound technology has significantly benefited maternal healthcare.

III. A Continuation of POCUS Curriculum Components

Many rural clinics share common needs; as such, their curricula can be divided into two main components: the actual curriculum content, such as the applications that are included, and the training and practice methodology. Certain mandatory subjects must also be covered regardless of the region; such as understanding POCUS machine operation and good governance in POCUS practice. Both are imperative to the successful imaging technology use. These two subjects can be further divided into three smaller categories; the knowledge, skill, and behavior, required to fully understand each. Table 9 displays a general guide to the level of understanding that is expect by the IFEM in each category.

Table 9 A breakdown of the knowledge, skills, and behavior that should be included in the POCUS curriculum with respect to understanding of operation and good governance, as described by the International Federation of Emergency Medicine

Understanding of Operation			Good Governance		
Knowledge	Skill	Behavior	Knowledge	Skill	Behavior
The basic components of an ultrasound system Types of transducer Use of ultrasound controls The effect of frequency on image quality and penetration Safety issues Recognition and explanation of common artifacts	Can operate the machine controls Transducer changing Image manipulation and storage	Safe practice Limitations of own skills Integrates ultrasound findings with clinical assessment	Image recording and storing Reporting Medico-legal aspects Consent The value and role of departmental protocols The resource implications of ultrasound use	Integrate POCUS into departmental clinical governance system	Adheres to rule-in philosophy (namely that a focused ultrasound exam may rule in a pathology but generally will be unable to rule it out).

POCUS application itself can also be divided into two main categories, diagnostic and procedural. Diagnostic applications are those that aid diagnosis by answering clinical questions or aiding in patient evaluation. The IFEM states that these applications "may answer a simple binary [yes or no] question: 'is there free fluid in the pericardial space?' It may answer a series of

questions: 'why is my patient shocked?' The latter may be part of a symptom or syndromic approach to patient care.

On the other hand procedural applications are simply those that aid a procedure. This can involve providing anatomical information prior to the procedure or dynamic guidance during the procedure. For each application it is important to specify key information regarding comprehension: what it is, when to use it, and why and how it benefits procedural practices. The curriculum must include the details concerning the knowledge, skills, and behavior the trainees need to master in order to perform these applications.

The curricula need to fully explain the rationale behind each application; for example, understanding the normal anatomy and physiology of each evaluated region for diagnosis or procedure. Appreciation of the pathology being sought, if applicable, is also important and relevant so abnormal ultrasound findings can be recognized. The technique and skills required to use the technology need to be directly stated and specified as they will not only provide clarity to the trainee but help to decide which criteria should be included in any competency assessments.

Equipment maintenance, saving the images and clips that they have scanned and recording all findings from POCUS studies, as well as respecting the limitations of POCUS technology are all good habits for the trainee to develop. Most importantly, the curricula need to be designed so the trainee can apply the findings of POCUS imagery to clinical practice.

POCUS Data Collection Sheet

Date: _____   Location: _____

Contact Name: _____   Facility: _____

Contact Number: _____

Electricity?   Y   /   N   Water?   Y   /   N

Pharmacy?   Y   /   N   Computer Access? Y   /   N

# of Beds: _____   Avg patients/day: _____

Staffing:

	Number	Names	Comments
Doctors			
Nurses			
Other			

Nearest referral center: _____   Distance: _____

Imaging devices:

_____

_____

_____

Aux Equipment:

_____

_____

_____

NOTES:

TB Ward and patients, Medical record keeping, Disease burden, etc.

V. Form: Informed Consent Agreement

WPI The University of Science and Technology. And Life. ™

Informed Consent Agreement for Participation in a Research Study

Investigators: Brynn Cardozo, Hannah Hill, Bonham Pierce, and Nathalie Zakrzewski

Title of Research Study: "Focus on POCUS: A New Medical Technology in the Namibian Healthcare System"

Sponsor: Polytechnic of Namibia, School of Health and Applied Sciences
University of Namibia, School of Medicine

You are being asked to take part in a research interview. We are asking you to take part because you are a member of the medical staff in a health facility we are evaluating for the implementation of point-of-care ultrasound (POCUS) technology. Please read this form carefully and ask any questions you may have before agreeing to take part in the study.

What the study is about: This project aims to aid the Polytechnic of Namibia, School of Health and Applied Sciences in addressing the limited medical care of the rural Namibian peoples resulting from technological, geographic, and monetary constraints by assisting them in the introduction of POCUS technology.

What we will ask you to do: If you agree to be in this study, we will conduct an interview with you. The interview will include general information about your medical experience, the infrastructure and resources of the facility you work in, the medical needs and sociocultural views of the community, and the financial aspects. The interview will take less than an hour to complete. With your permission, we would also like to tape-record the interview.

Risks and benefits: We do not anticipate any risks to you participating in this study other than possible determination of your identity and backlash against your sociocultural views. We will however make efforts to conceal your identity so that this is not an issue. You will not receive benefits for participating in this study.

Compensation: We will not offer any compensation for your participation in this interview. However, your help in our research project could help the success of pilot studies that could introduce a life-saving medical device into the Namibian healthcare system.

Your answers will be confidential. The records of this study will be kept private. In any sort of report we make public we will not include any information that will make it possible to identify you. Research records will be kept in a locked file; only the researchers will have access to the

records. If we tape-record the interview, we will destroy the tape after it has been transcribed, which we anticipate will be within two months of its taping.

Taking part is voluntary: Taking part in this study is completely voluntary. You may skip any questions that you do not want to answer. If you decide not to take part or to skip some of the questions, there will be no consequence. If you decide to take part, you are free to withdraw at any time.

If you have questions: The researchers conducting this study are a team of students from Worcester Polytechnic Institute and Prof. Greene. Please ask any questions you have now. If you have questions later, you may contact our research team at pocus@wpi.edu. You can reach our sponsor, Prof. Greene at greene_d@nmhu.edu. If you have any questions or concerns regarding your rights as a subject in this study, you may contact the Institutional Review Board (IRB) at irb@wpi.edu or access their website at http://www.wpi.edu/offices/irb.html.

You will be given a copy of this form to keep for your records.

Statement of Consent: I have read the above information, and have received answers to any questions I asked. I consent to take part in the study.

Your Signature _____ Date _____

Your Name (printed) _____

In addition to agreeing to participate, I also consent to having the interview tape-recorded.

Your Signature _____ Date _____

Signature of person obtaining consent _____Date
_____

Printed name of person obtaining consent _____ Date _____

This consent form will be kept by the researcher for at least one year beyond the end of the study.

VI. Student Questionnaire:

→ Hey guys, thanks for having us again… we're going to ask you some questions about the culture in Namibia & how it could possibly have an affect on our project...

→ your identity will be completely confidential, please don't write your names on the paper… if you feel uncomfortable with any of the questions, you don't need to answer them, feel free to leave them blank.

> → if you do feel comfortable giving us other information about demographics, please write at the top of your paper:
> - your gender
> - your ethnic group/tribe
> - where you are from

→ please take this survey seriously and give us your honest thoughts/opinions! Your answers will impact our research.

Written Questions -

1 If you were to have a child, would you want a boy or a girl?

2 Do you think males and females have the same opportunities in Namibia?

3 Would you or your partner ever consider getting an abortion? Would the circumstance/situation

4 Do you think abortion should be legal?

5 Do you know somebody who has been affected by TB ?

6 If you knew someone with TB, would you visit them?

7 Would the stage of their disease affect if you would visit them?

8 have you ever been to a public clinic?

9 how long did you have to wait on average before being seen?

10 were you seen by nurses or doctors?

11 would it make a difference if you were seen by the other?

12 would a clinic having medical imaging technology affect your decision to go there?

13 if both a clinic and a hospital had medical imaging tech would you prefer one over another

14 If you are trained to do something and your boss is not, how do you think it would impact your working relationship?

Discussion: Tell us about your experiences in public clinics.

VII. Meeting Notes- Dr. Günar Günther

Date: 28/03/2015
Location: Katutura Hospital

- "What we are missing here is ultrasound."
- ~700 beds, 1 broken machine, 1 Siemens machine in Gynecology Department, 1 broken Philips machine.
- Radiology department has no ultrasound machine. CT scan is broken.
- Windhoek Central Hospital has 8 working ultrasound machines. Recently, Gunther asked to bring one to Katutura but they were denied because staff at Windhoek Central want to hold on to all of them in case others break.
- Gunther was given a POCUS device on loan and used it for a few weeks. He described it as "perfect and ideal...excellent for screening purposes." In the event that a patient needed a more accurate result, he would send them to use an ECHO machine → this is triage. There was a case where x-ray did not pick up pericardium fluid but a 5 second scan with POCUS did.
- "There is a desperate need. But you cannot only bring in the machines, people need to be trained and see the need for it. Alternatively, being trained on machines you don't have access to is useless."
- Gunther said POCUS was helpful because it is small enough to be carried around during rounds.
- "If you want to improve things, doctors and nurses need to have the power to ask for things. The [acquisition of technology] needs to be from the bottom up not top down."
- In Namibia, basic procedures become complicated because they don't have ultrasound.--> "There is an uttermost need."
- Gunther works directly for the MHSS as a pulmonologist (chest medicine), the first in Namibia. He has 6th year medical students interning with him currently.

Radiology Department:
- Supplied only with a primitive digital X-Ray machine. Noted almost 30 people waiting outside the x-ray room either to be seen or for results back.

Casualties Ward is equivalent to our Emergency Room.
- People are triaged from here into more specific departments. Equipped with multiple procedure rooms, one with a working defibrillator. However, the portable ventilator (relatively new) was missing a power cord and could not be used.
- Staffing and maintenance are seriously lacking. Hospital does not have ultrasound technicians, physicians operate the one working device themselves in the gyno department.
- Patients pay a user fee of N$10 and are put in the system - payment for service is not an issue.

Operating Theater:
- Katutura has recently had specialists come in from South Africa to do major surgery. The Operating Theater is decently equipped, not compared to European equivalents but well enough to get the job done. Generally use intubation scope of 1mm resolution for imaging needs - obviously primitive and not appropriate for many procedures.
- General disease burden: commutative and pleural disease.

ICU:
- 8 beds, not arterial lines because they cannot find the right cables.
- Threshold for taking patients is much different than in the West.
- "It's not like you can't do medicine, you can. It just needs some tender loving care."

TB Ward:
- When Gunther first came here, his most important objective was getting an ultrasound for the TB Ward. General problem with getting machines is cost: frequently double the cost of getting the same device in Europe.
- There was a cat running around the TB ward.
- "Hospitals back home smell sterile, like bleach. Here it smells like french fries, blood and sweat."
- 50 beds in TB ward
- Issues arise because TB patients are not easily transported and the only ultrasound is upstairs. There is no legal framework to control TB patients from leaving.
- Skin test only shows if you have been infected, which estimates say ⅓ of the world population is infected. However, only 10% get the disease.
- Treatment = 2 shots everyday and a handful of pills (even more if patient has HIV/AIDS). It is possible to cure the less resistant strains, cure rate estimated between 40-60% globally.
- There is a huge stigma attached to TB because everyone knows it is contagious.
- It is so rare that physicians are not generally trained to treat it in western schools. "The medical school at UNAM is giving rise to a new generation. These graduates offer hope for change."

VIII. Patient Copay's

- Tertiary Care (primary/regional hospital)   N$10
- Primary and secondary care (local clinics and referral clinics):
  - Common illness (cold, influenza, diarrhea, chronic diseases)
    - Consultation   N$ 4
    - Follow up   N$ 2
  - Maternal/antenatal care
    - Consultation   N$ 3
    - Follow up   N$ 2
    - Emergency   free
  - HIV/Aids and Tuberculosis
    - Screening/testing   free

IX. Data from Surveyed Facilites

Date	Location	Facility	Type	Region	Elect-ricity	Wa-ter	Phar-macy	Computer Access	Avg. patients per day	Doctors	Nurses	Nearest Referral Center	Distance to Referral Center	Imag ing Devi ces	Aux Equipmen t	Disease Burden
Greene	Henties Bay	Henties Bay Clinic	primary	Erongo	Y	Y	Y	N	15-20	once a month visit	2		70km 1.5hr	0		17
Greene	Karibib	Kasibib Clinic	primary	Erongo	Y	Y	Y	N	20-40	once a month visit	4		140Km 2 hr 170km 3.0hr	XR		15
Greene	Omaruru	Omaruru Clinic	primary	Erongo	Y	Y	Y	N	10-20.	once a month visit	2		90km, 1hr	0		13
3/25/15	Ojimbingwe	Ojimbingwe Clinic	primary	Erongo	Y	Y	Y	N	35/nurse, 80/doc	once a month visit	3+2 additional	Hsakos State Hospital	ambulance by	0		
Greene	Usakos	Usakos Clinic	primary	Erongo	Y	Y	Y	N	15-30	once a month visit	2		155km 2.5hr	0		17
Greene	Aranos	Aranos Clinic	primary	Hardap	Y	Y	Y	N	12-20.	once a month visit	2		280km 4.5hr	0		14
4/27/15	Kalkrand	Kalkrand Clinic	primary	Hardap	Y	Y	Y	N	30-40	no doc for 3 years	2	Marienetal District Hospital	78.5km, 1hr	0	BP	11
4/27/15	Maltahoe	Maltahoe Clinic	primary	Hardap	Y	Y	Y	N	40	0	1	Malthoe Health Center	5km 5 min	0		8
4/26/15	Maltahoe	Maltahoe Health Center	secondary	Hardap	Y	Y	Y	Y but stopped working	under renovation	0, call if needed	8	Marienetal District Hospital	112km, 1.6hr	0	Doppler, EKG	25
4/27/15	Mariental	Mariental Clinic	primary	Hardap	Y	Y	Y	Y	30 for screening, more for obstetrics	0	8, +1 for ANC	Marienetal District Hospital	10km,10 min	0	2 Bp Machines, Doppler,	
4/27/15	Mariental	Mariental Hospital	tertiary	Hardap	Y	Y	Y	Y		3 (supposet to have 7)	30	St Marys Hospital Katutura Regional Hospital	268km, 3.5hr	XR + US	Doppler,	17
4/27/15	Rehoboth	Rehoboth Health center	secondary	Hardap	Y	Y	Y	Y(for ARC and TB registry)	80-100	2	13	St Marys Hospital (Rehoboth)	5k, 5 min	0		15
		St Mary's			Y	Y	Y	Y(for ARC and TR	20			Katutral Regional Hospital or Windhoek	87.9 km.	XR+ 2		23

Date	Town	Facility	Level	Region					Patients	Doctor visits	Staff	Hospital	Distance	Doppler, Blood pressure, respirator	
4/25/15	Aus	Aus	primary	Karas	Y	Y	Y	N	17-23	once a month	2	Luderitz District Hospital	122km 1 hr	Doppler, Blood pressure, respirator	11
4/25/15	Bethanien	Bethanien	primary	Karas	Y	Y	Y	N	35	once a month	7	Keetmanshoop District Hospital	138km, 2hr	Cd4	16
4/26/15	Bethanien	Bethanien	primary	Karas	Y	Y	Y	N		once a month	7	Bethanien Clinic	82km, 1hr	0	15
4/25/14	Helmeringhausen	Not permanent	outreach	Karas			n/a			Nurses come once a month					11
4/25/15	Luderitz	Luderitz Hospital	tertiary	Karas	Y	Y	Y	N	20 impatient per day	4	30	Katutura Central Hospital	680km, 9.5hr Windhoek	XR and US	11
Greene	Dorbabis	Dorbabis Clinic	primary	Khomas	Y	Y	Y	N	5-10.	once a month visit	2	Katutura Regional Hospital	80km 2.0hr	0	15
4/1/15	Katutura	Donkerhoek Clinic	primary	Khomas	Y	Y	Y	N	<60	0	5 + 3 students	Katutura Health Center	5min	0	11
3/25/15	Katutura	Hakahana State Clinic	primary	Khomas	Y	Y	Y	Out of order	30/nurse	0	7	Okuryagava Health Center, Katutura Health Center	+/- 5km, 5 min	0	16
4/7/15	Katutura	Katutura Clinic	secondary	Khomas	Y	Y	Y	limited	600	5	17	Katutura Regional Hospital	5k 5min	XR	30
4/7/15	Katutura	Katutura Clinic TB/HIV		Khomas	Y	n/a	n/a	n/a		2	8	Katutura Regional Hospital	5 min drive	Ventilators, EKG etc.	13
Greene	Katutura	Katutura Regional Hospital	Tertiary	Khomas	Y	Y	Y	N	300-450	2	17	Windhoek Central Hospital	5-8km, 10 min	EKG "collecting dust"	20
3/25/15	Katutura	Okuryongava Clinic	secondary	Khomas	Y	Y	Y	Y				Okuryongava Health Center	+/- 5km, 5 min	0	16
3/25/15	Windhoek	Windhoek Central Hospital	Primary	Khomas	Y	Y	Y	Y				Katutura Regional Hospital		XR +8 US	11
Greene	Windhoek Fransfontein	Fransfontein PHC clinic	primary	Kunene	off/on	off/ on	Y	N	6-20.	once a month visit	2		200km 3.5hr	0	15
Greene	Kamanjab	Kamanjeb Health Center	secondary	Kunene	Y	Y	Y	N	20-30.	2	2		250km 4.0hr	XR	15
Greene	Khorixas	Khorixas	primary	Kunene	Y	Y	Y	N	30-40.	once a	4		185km	XR	15

Date	Location	Clinic	Level	Region					ANC/month	Visit frequency	#	Referral Hospital	Distance	Equipment	Total
		Clinic								month visit			3.0hr	US broke / XR and US	15
Greene	Opuwo	Opuwo Regional Hospital	large regional	Kunene	Y	Y	Y	N	40-60	month visit	2		400km 8hr.0	US broke, XR and US	15
Greene	Outjo	Outjo Clinic	primary	Kunene	Y	Y	Y	N	20-30.	once a month visit	2		55km 1.0hr	0	18
Greene	Sesfontein	Sesfontein Clinic	primary	Kunene	Y	Y	Y	N	5-10.	once a month visit	2		120km 2.0hr	0	16
Greene	Terrance Bay2	Terrance Bay2 Clinic	primary	Kunene	Y	off	Y	N	2-10.	once a month visit	2		350km 8.0hr	0	12
Greene	Terrance Bay2	Terrance Bay2 Clinic	primary	Kunene	off/on	/on	Y	N	2-10.	once a month visit	2		270km 8.0hr	0	18
Greene	Aminius	Aminius Clinic	primary	Omaheke	Y	Y	Y	Y, out for program update	10-20.	visits every other month	2		4.5hr	0	15
4/10/15	Epukiro Post 3	Epukiro Clinic	primary	Omaheke	Y	Y	Y	N	80	other month	2	Gobabis Regional Hospital	131, 2hr	CTG	15
4/11/15	Epukiro RC	Epukiro RC Clinic	primary	Omaheke	Y	Y	Y	N		once a month visit	2	Gobabis Regional Hospital	87.5 1.3 hr	0	8
4/11/15	Gobabis	Gobabis Regional Hospital	secondary	Omaheke	Y	Y	Y	N		4	10	Windhoek Central Hospital	204km,2hr drive / 250km	XR + US, SAT meter and EKG	17
Greene	Leonardville	Leonardville Clinic	primary	Omaheke	Y	Y	Y	N	3-6.	once a month visit	2	Gobabis Regional Hospital	250km 4.0hr	0	18
4/10/15	Omitara	Omitara Clinic	primary	Omaheke	Y	Y	Y	N	20/nurse	once a month visit	2	Gobabis Regional Hospital	108km, 1.5 hr driving	0	18
4/10/15	Otjinene	Otjinene Health Center	primary	Omaheke	Y	Y	Y	N	120-160	0	7	Gobabis Regional Hospital	162km, 2.5hr drive	0	15
Greene	Kalkfeld	Kalkfeld Clinic	primary	Otjozondjupa	Y	Y	Y	N	5-10.	once a month visit	2		50km 1.0hr	0	11

X. POCUS Device Specifications

Device											
Make	Siemens	Siemans	GE	GE	GE	Sonosite	Sonosite	Sonosite	Sonosite	Interson Corporation	Medison
Model	Acuson P300	Acuson Freestyle Ultrasound System	VScan (Optional Dual-Probe)	LOGIQ family	Venue 40 Ultrasound	EDGE	M-TURBO	S SERIES	NANOMAXX	U-Blok Turbo	MySono U5
Cost US$		$7,900	$22,000					<$10,000			$26,000
Resources Required		Battery: $160 Battery Charger: $95 Memory Card: $60 — — —	Power Supply Medical License			Electricity to charge battery	Electricity to charge battery	Electricity to charge battery	Electricity to charge battery		
Notes	Laptop sized	wireless transducer; improved needle visualization	4GB Micro-SD memory card; One rechargeable battery; Gel (60g); Pocket sized	laptop sized - generally on carts	iPad tablet sized 10.4" touchscreen display; Anesthesia	8.5 lbs, 12.9X12.4X2.5(in); 5 year warranty; advanced needle imaging; improved tissue algorithms; 8GB internal Flash memory	11.9x10.8x3.1; 6.7 lbs; 8GB internal Flash memory; 5 year memory; 5 year warranty; USB connectivity (2)	15.1x11.6x6.1; 8.5 lbs; 4 GB internal flash memory; 5 year warranty; mountable; three USB ports	14.1x8.2x2.3; 6 lbs; 2GB Internal non-volatile memory; 5 year warranty; mountable and has a stand; two USB ports	Anesthesia; Penetration: 10cm; Built in video camera, wifi, bluetooth; 2.9lbs, 12.5" display; Touch Screen; Life Cycle Costs: Extremely Low; Windows Tablet Based	laptop sized; Built in ECG Function, DICOM and 3D; "Lightweight and Portable"

XI. Binary Student Survey Responses

Student #	Gender	Ethnicity	1	2	3	4	5	6	7	8	9	10	11	12	13
1	M	Oshivambo /Caprivian	Boy	N	N	Incest/ Rape cases only	Y	Y but not regularly	Y	N	72 hrs	First Nurse, then maybe Doctor	Doctor	Y	Wouldn't matter
2	F	Vambo	Girl	N	Y	Y	Y	Y	Y	Y	2-4 hrs	Nurse	Doctor	Y	Hospital
3	F	Oshivambo	Boy	N	N	N	N	Maybe but it is risky	Unsure	Y	2.5 hrs	Nurse	Doctor	Y	Wouldn't matter
4	F	Vambo	Boy	N	N	N	Y	N	N	Y	.5 hrs	Nurse	Doctor	Y	
5	F	Oshivambo	Doesn't matter	N	N	N, even if raped	Y	Y	Y	Y	1.5 hrs	Nurse	Doctor	Y	Wouldn't matter
6	F	Mixed	Boy	Y	Y	Y	Y	Y	N	Y	2 hrs	Nurse	Doctor	Y	Wouldn't matter
7	F	Oshivambo	Boy	Y	Y	Maybe	Y	Y	Y	Y	.75 hrs	Nurse	Doctor	Y	Hospital
8	M	Oshivambo	Boy	Y	Y	N	N	N	N		Depends	Both	Doctor	Y	
9	F	Oshivambo	Girl	Y	Y	Y	Y	Y	N	Y	3 hrs	Both	Doctor	Y	
10	M	Ndonga	Doesn't matter	N		Y	Unsure	Y	Depends	Y	.5 hours / 1 hr minimum	Nurse	Doctor	n/a	Wouldn't matter
11	F	Wambo	Girl	N	Y	N	N	Y	N	Y	20-30 min	Nurse	Doctor	Y	Wouldn't matter
12	F	Subia	Girl	N	N	Rape cases	Y	Y	Y	Y		Nurse	Doesn't matter	Y	Wouldn't matter
13	F	Wambo	Boy	N	Y	Y	Y	N	Y	Y	4 hrs	Doctor	Doesn't matter	Y	Wouldn't matter
14	M	Wambo	Girl	N	N	N	Y	Y	Y	Y	3 hrs		Doctor	N	Wouldn't matter
15	M	Wambo	Boy	N	Y	Y	Y	Y	N	Y	2 hrs min		Doctor	Y	Wouldn't matter
16	M	Oshivambo	Boy	Y	N	N	N	Y	N	Y	7 hrs	Nurse	Doctor	Y	Wouldn't matter
17	M		Boy	Y	Suicid	Y	N	N	N	Y	6 hrs	Nurse	Doesn't matter	N	Hospital

			e	I don't have a say						matter		
18	M	Nyembia	Girl	N	Y	Y	Y	Y	2 hrs	Nurse	Doctor	Y	Clinic
19	M	Mafwe	Boy	N	Y	Y	Y	5 hrs	Doctor	Doesn't matter	Y	Clinic
20	F	Kwanyama	Boy	N	Rape cases	Y	Y	IDK	IDK	Depends	Nurse	Doctor	Y	Wouldn't matter
21	M	Oshiwambo	Doesn't matter	Y	N	N	Y	Y	2 hrs	Nurse	Doctor	Y	Wouldn't matter
22	F	Subia	Boy	N	N	Y	Y	Y	30 min	Nurse	Doctor	Y	Wouldn't matter
23	F	Mixed	Boy	N	N	Rape cases	Y	N		Doctor	Y	Wouldn't matter

XII. Public Health Student Detail Responses

Date: 15/04/2015
Location: Polytechnic of Namibia
14 Survey Questions

1. If you were to have a child, would you want a boy or a girl?

1: "Boy, I think boys are more understanding and I require muscle power."
2: "A girl, because ladies are more responsible and tend to be caring. If I were to have more, she'll be a good caring big sister."
3: "Boy - I preffer a son. They carry the family name."
4: "I would love to have a baby boy because I have no brother and I have 4 sisters."
5: "It does not matter, as long as it's a child that I can raise."
6: "A boy because we are only 3 sisters and a boy in the family will be a joy"
7: "Boy, world needs more men"
8: "Boy, why? Because I am a boy!"
9: "1st child - Girl, I don't know why"
10: "Both, they are all part of me."
11: "A girl because girls are smarter than boys."
12: "Girl, because girls are adorable and easy to control, more understanding."
13: "First a boy, I don't know why."
14: "Girl, because girls are less prone to sexual linkage diseases."
15: "Boy, girls tend to be problematic. High cases of school drop out and teenage pregnancies"
16: "Boy because male can survive in harsh condition the females"
17: "First child → boy because boys are not taken away from home in times of marriage."
18: "A girl, just don't know why"
19: "I would like to have a boy, simply because I would like to see someone that's my product grow up and share experiences with him that I never got to share with my father."
20: "A boy."
21: "I would want to have a ~~boy girl~~ both or any. Don't really have a particular reason."
22: "Boy, to pass on good morals and principles."
23: "Boy - to protect younger siblings."

2. Do you think males and females have the same opportunities in Namibia?

1: "No there are more opportunities for ladies considering they have higher numbers"
2: "Males are considered as strong and good leaders, so definitely not females are not equally treated and considered."
3: "No, they don't have equal opportunities."
4: "No, man has more opportunities because,"
5: "No"
6: "Yes, I do think we are 50/50"
7: "No"
8: "Yes, because all people are free to do any job that they want, they can do all jobs."
9: "Yes"
10: "No, due to corruption."
11: "They do not have equal opportunity"
12: "No, mostly man get good opportunities or are considered more."
13: "No because females are acceptected [expected] to do more house hold tasks because of the tradition and they aren't offered more opportunities."
14: "No, men have more opportunities than women."
15: "It's more less a 40 to 60 percent in favor of men"
16: "Yes! They all have the same right"
17: "Yes, all male and female get fair opportunity to be who they would like to be."
18: "No, they don't."
19: ---
20: "No it's not equal."
21: "Yes, I think for the past years it has changed, and opportunities are equally available for both genders."
22: "No, opportunities are not equal in Namibia."
23: "No, women are still seen as the weaker gender (mentally and emotionally)"

3. Would you or your partner ever consider getting an abortion?

1: I would not consider abortion as I think every person have a right to life and they want to do with it."

2: "I'll go for abortion because by now I am not ready to become a mother and I'm busy with my studies and having a baby at my age it's gonna give me some tough times."

3: "No, I wouldn't want an abortion, because abortion means taking away an innocent life which is a crime. I just have to pay for my actions."

4: "If I were to fall pregnant, I wouldn't have an abortion because it might put my health at risk and who knows if I will abort the president to be?"

5: "Abortion is not an option, because it's against our culture and beliefs. A child is a blessing and you shouldn't take that little life away. (Catholic)"

6: "Yes and it would be illegal."

7: "Yes, a baby will hinder my school and financial life"

8: "NO, because it is against God intention. (Want to inherit the kingdom of God)"

9: "At my age, yes. I would consider an abortion."

10: "Am single."

11: "Abortion since some people fell pregnant unplanned."

12: "No, abortion is a crime and a sin. I would keep the baby."

13: "Yes, it costs too much to take care of a baby."

14: "No, provided that abortion is illegal, unless there is a prove concerning the health."

15: "It would like an abortion to be done but it's not legal here so I guess it's going to be a baby"

16: "I will not let her get abortion"

17: "I will commit suicide."

18: "I do not have the overall say on the pregnancy."

19: "I would be scared to tell my parent's that my girlfriend is pregnant but I would never opt for an abortion."

20: "I will keep my pregnancy until I give birth to my baby."

21: "No, Hell no, I would not want my girlfriend to get an abortion if she gets…"

22: "Of course not, abortion is not my solution, in fact not the right thing to do."

23: "No, won't feel morally correct. Emotionally it will always haunt me."

4. Do you think abortion should be legal?

1: "I absolutely disagree as its not morally right but I would allow if on the basis of sexual harassment, rape"

2: "Abortion should be legalised because in some cases ladies become pregnant accidentally or they're sometimes raped. Legalizing abortion could save some poor kids lifes if they were to be born unwantedly."

3: "No, it should not be legalized, because that will encourage people to be more promiscuous. Abortion is a crime."

4: "Abortion should not be legalised because it is not fair to the fetus because…"

5: "No, abortion shouldn't be legalised, in reference to any circumstance (e.g. a gal is raped or problems faced with the pregnancy)"

6: "Yes, it should be"

7: "Maybe"

8: "NO, because it is inhuman, it is against God intention and…"

9: "Yes"

10: "Yes, for our development rate."

11: "No, it should not be legal, since people will keep on falling pregnant know that abortion is there to do it better. The bible is saying we must not kill."

12: "No only for cases of rape because if it is legalised it will give kids freedom to practise unsafe sex knowing that there will no consequences."

13: "Yes."

14: "Yes, because this will result in abortion all over the country."

15: "YES! SI! Abortions should be legal"

16: "Yes! Abortion should be illegal because it's life of someone that is killed"

17: "Yes, abortion should be legal cos of some reasons I won't say."

18: "Yes!"

19: "Yes, abortion should be legalised but under the condition that the person receives counselling. I think it should be legalized because people feel and view things differently and pregnancy affects people differently and I think someone in a stable state of mind wouldn't opt for it, unless there are serious reasons why they have to get one."

20: "Yes but only in the case of raping because the pregnancy happened unwanted and from an unwanted partner too."

21: "No! Abortion should not be legal. It is against religion morals."

22: "Of course not, abortion should be illegal."

23: "Yes, but certain conditions, should be set to it."

24:

5. Do you know somebody who has been affected by TB?

1: "I have seen a few"
2: "I know one."
3: "Yes"
4: "Yes"
5: "Yes"
6: "Yes, quite a few"
7: "Yes"
8: "NO"
9: "Yes"
10: "I can't remember"
11: "No."
12: "Yes"
13: "Yes."
14: "Yes."
15: "Yes, but they're fine now"
16: "No"
17: "You."
18: "Yes!"
19: ---
20: "My dad had TB when he was young."
21: "No"
22: "Yes."
23: "Yes"

6. If you knew someone with TB, would you visit him or her?

1: "I would go and visit them but not regularly"
2: "Definitely yes because they need some good caretakers or let me just say some caring people by their sides."
3: "Maybe, but it is risky as I might contract it."
4: "No, because TB is highly contagious"
5: "Yes"
6: "Yes, but I would want to be provided with a mask"
7: "Yes but only if I wear a protective mask"
8: "no one"
9: "Yes, for a short period. But with a mask over my face."
10: "Yes"
11: "Yes, because them with a TB does not mean they should be isolated."
12: "If they are my relative yes and if I don't know them maybe."
13: "No"
14: "Yes, I will absolutely visit them."
15: "I would visit them. I have done it before"
16: "Yes! but in a protective way"
17: "No."
18: "No, it is very contagious."
19: ---
20: "I have no problem with visiting a TB patient as long as I will be on the safe side. Meaning if there is safety."
21: "Ja, I would."
22: "Yes."
23: "No, I wouldn't"

7. Would the stage of their disease affect if you would visit them?

1: "Yes"

2: "Yes it will, by visiting them they might and hopefully become better because they'll have to take their medication regularly and will help them to live better lives."

3: "I'm really not certain."

4: "No"

5: "Yes"

6: "No"

7: "Yes"

8: "I have never seen a person with TB"

9: "No"

10: "It depend"

11: "The person will feel better."

12: "It was in its early stages so it was not so contagious."

13: "Yes"

14: "Yes, provided that if you are protected e.g. wearing a mask"

15: "It would not really make a big difference on their condition, but it builds their moral"

16: "No"

17: "n/a"

18: ---

19: ---

20: "I have no idea"

21: "Yes"

22: "Yes, at a stage where the disease is severe, they would be no visits."

23: "Yes, if it would be depended."

8. Have you ever been to a public clinic?

1: "NO"
2: "I had been to several ones."
3: "Yes"
4: "Yes"
5: "Yes, I have been to a public clinic"
6: "Yes"
7: "Yes"
8: ---
9: "Yes"
10: "Yes"
11: "Yes"
12: "Yes"
13: "I have"
14: "Yes."
15: "I have been to clinic before"
16: "Yes! I was once there"
17: "NO"
18: "Yes"
19: "Yes"
20: "I have no idea."
21: "Yes"
22: "Yes."
23: "Have not been to a clinic."

9. How long did you have to wait on average before being seen?

1: "Not yet, but I know…"
2: "It takes too long, the nurses and doctors are too few for too many patients. Approximately 2-4 hours."
3: "A few hours (2h30mins)"
4: "I was seen after 30 minutes"
5: "an hour and 30 minutes waiting"
6: "At the most 2 hours."
7: "45 minutes"
8: "Belong to the number of people at the place"
9: "3 hours"
10: "Something like half an hour, but sometimes it depend how serious is your illness"
11: "I wait for 1 hour or beyond."
12: "Just some minutes (about 20-30 minutes)
13: "4 hours"
14: "3 hours"
15: "2 hours minimum"
16: "7 hours because the queue was too long"
17: "six hours"
18: "about two hours."
19: "It was very long, I would say approx 5 hours."
20: "It depends on the amount of people that I will find there."
21: "for about 2 hours"
22: "About 30 minutes"
23: n/a

10. Were you seen by nurses or doctors?

1: "Nurse usually"
2: "In some cases a nurse and some a doctor, but firstly a nurse has to get to you."
3: "nurse"
4: "I was seen by a nurse"
5: "Nurse"
6: "nurse"
7: "Nurse"
8: "Sometimes by nurses and sometimes by doctors."
9: "Both"
10: "Nurse"
11: "nurse"
12: "By a nurse"
13: "Nurses"
14: "Doctor, because doctors have more knowledge than nurses."
15: "Doctor"
16: "Nurse"
17: "security guard"
18: "Nurse"
19: "A doctor"
20: "Mostly by a nurse."
21: "A nurse obviously, then if your condition is bad…"
22: "Nurse."
23:
24:

11. Would it make a difference if you were seen by the other?

1: "Preferably yes I trust the doctor much more."

2: "It would make a difference when treated by a doctor because they have more knowledge about medical stuffs."

3: "Yes, I would feel secured being treated by a doctor."

4: "It would be different if I was attended by a doctor because the nurse just sent me to a state hospital"

5: "Yes, nurses this days are not well qualified and they cannot help me 110%"

6: "I would prefer a dr."

7: "Yes. Doctor more experienced"

8: "Doctor"

9: "Not really"

10: "Service varies and treatment."

11: "Yes it will make a difference if I attended by a doctor."

12: "No if they know what they are doing its all good with me."

13: "No, because we have less experienced doctors."

14: "No"

15: "It's more comfortable when you see a doctor rather than a nurse"

16: "No difference will be made"

17: "I won't make no difference."

18: "Yes, it would make a difference."

19: "It really doesn't matter as long as I get quality medical care."

20: "It is better to be attended by a doctor than by a nurse because doctors are more than nurses."

21: "Yes it would, you just kind of feel secured in a doctor's hands."

22: "By a doctor it would make a difference."

23: "Yes, I would feel more at ease with a doctor."

12. Would a clinic having medical imaging technology affect your decision to go there?

1: "Yes as often as possible, if I'm sick"
2: "Yes I would"
3: "Yes"
4: "Every time I'm sick even if it is not a serious sickness"
5: "Yes"
6: "I would go"
7: "Yes."
8: "Never, because…"
9: ---
10: "n/a"
11: "Yes"
12: "More"
13: "Yes, I would go because they have better faciliites."
14: "More"
15: "I would prefer to go there"
16: "Yes"
17: "NO"
18: "Yes, I would love to go there more often."
19: "More frequently."
20: "Yes"
21: "Of course yes"
22: "Yes."
23: "Yes would rather than go to the clinic."
24:

13. If both a clinic and a hospital had medical imaging tech would you prefer one over another?

1: "Not really"
2: "A hospital will do, because at a hospital there're more people (nurse and doctors) medical practitioners to attend to you."
3: "Wouldn't really matter"
4: ---
5: "No, it wouldn't matter which one I go to, but hospitals are usually full, so clinic can possible."
6: "It would not matter"
7: "Hospital"
8: "Medical technology"
9: "Yes, I would go to the one with medical imaging"
10: "Any, so long they can handle my illness"
11: "Any of them which is closer to my place."
12: "No it wouldn't matter, I would go to any based on which one has less patients in line."
13: "No, it would not matter."
14: "No."
15: "It would not make any difference which one you visit."
16: "Medical Hospital"
17: "Clinic."
18: "Clinic"
19: "Clinic, I hate hospitals, because I hate to see people suffering."
20: "It won't matter, any that I prefer I can go."
21: "No, I would go to any, depending on the distance."
22: "Just anywhere. the clinic or hospital."
23: "It would not really matter. Which ever one is closest as both has the necessary equipment."

14. If you are trained to do something and your boss is not, how do you think it would impact your working relationship?

1: "It will because he will seem offended but it can also aid in efficiency within the workplace if they would cooperate."

2: It would, because he/she will need me to do that certain job and would get to be close and be more good with me."

3: "yes"

4: "The relationship will depend on the individual. It might get strong and at the same time it might get weak if the doctor becomes jealous."

5: "Yes, the relationship would change."

6: "No it would not because we constantly learn from each other"

7: "Definately"

8: "No, because in life no body is perfect"

9: "Yes, it would"

10: "Yes, if the boss is friendly and independent, he will not feel bad about it and the bond between you can grow so strong."

11: "Yes"

12: "It would change the relationship."

13: "No, it would not change anything."

14: "No"

15: "it would not change anything in some cases but in others it would boost your with the boss"

16: "Yes"

17: ---

18: "It would change."

19: ---

20: "Yes it will."

21: "Not really, cause then I am keeping it to my self and he is not aware of it."

22: "Yes, the relationship/dynamic would change."

23: "Yes. The boss may feel inferior, but it can go both sides. The working relationship may become strained or relaxed.