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SCHREYER HONORS COLLEGE

THE SCHOOL OF ENGINEERING DESIGN, TECHNOLOGY, AND PROFESSIONAL PROGRAMS

AN ANALYSIS OF ENTREPRENEURIAL HEALTH VENTURES: WHY TELEMEDICINE AND mHEALTH PILOTS FAIL TO SCALE

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ABSTRACT

Telemedicine and “mHealth” recently have become more common in the developing world as channels to overcome medical accessibility problems in rural areas. However, with an increasing number of these ventures, many of them fail to grow beyond a pilot phase into larger, sustainable systems. Even with support from charity organizations, governments, and philanthropists, many telemedicine ventures are not designed with scalability in mind. Therefore, a vast majority of these projects and organizations fail to achieve their full potential of creating and sustaining large mHealth programs to address global health problems. After reviewing 35 entrepreneurial telemedicine and mHealth ventures and 17 additional reports of mHealth and telemedicine and analysis, this thesis documents a variety of challenges that any mHealth or telemedicine venture may face. By using real-world examples, it is hoped that these strategies can be implemented in the design phases of pilot projects to ensure both sustainability and scalability of mHealth operations in the future. Understanding these failure modes and properly implementing them can help organizations develop effective telemedicine and mHealth programs that serve the needs of the billions of this people in this world without access to proper medical resources.

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Chapter 1 Introduction

1.1 Brain Drain Effect

Billions of people around the globe cannot fulfill basic medical needs due to inaccessibility of medical personnel and equipment (Camann, 2008). One of the most significant barriers to healthcare accessibility is the sheer lack of medical resources available. Simply put, there are not enough physicians in many developing countries to serve the entire population. Combined with poor transportation infrastructure, medical accessibility is a severe issue for a significant portion of the world's population. Figure 1 below shows the per capita averages of physicians from 2000–2009.

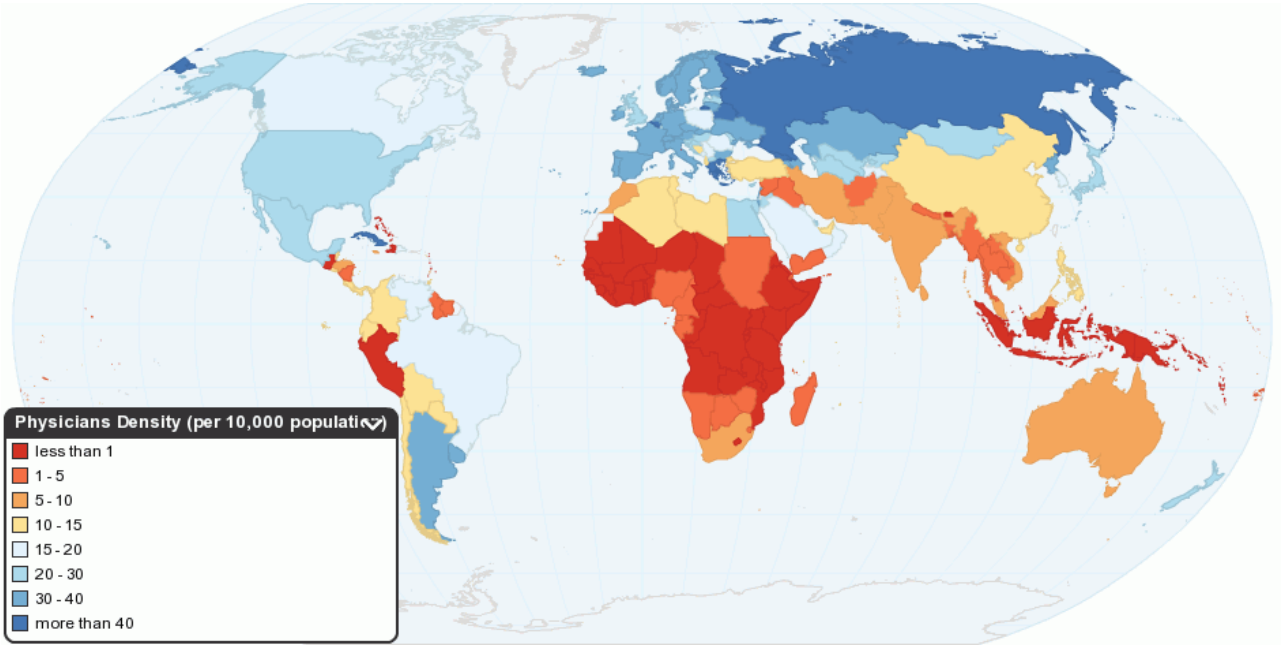

Figure 1-1 Physician Density per 10,000 populations 2000–2009 (Charts Bin, 2009)

From Figure 1-1, it is evident that most of Africa and Southeast Asia suffers from an extreme dearth of medical professionals. One of the most prominent reasons for this disparity is that medical communities in developing nations suffer from a severe migration of medical professionals to more developed nations. This mass migration is a phenomenon known as the "brain drain". Every year,

thousands of doctors and nurses are trained in universities and colleges across the developed world. However, many of these educated professionals take their skills to more developed countries, such as the United States and United Kingdom, in search of a better lifestyle and better pay. In Africa alone, approximately one-fifth of African-born medical physicians currently do not practice on the continent (Clemens & Pettersson, 2008). In an extreme case, Ghana has an estimated 12 physicians per 100,000 population, meaning there is approximately of 3000 physicians for a country of about 24 million (Groenhout, 2012). Therefore, the problem isn't necessarily the amount of medical professionals that are produced in the developing world—the problem is trying to incentivize them enough to stay in their countries to help address some of the most prominent issues for global health.

1.2 Economic Disparity

Not only does the mass migration cause a shortage of medical professionals, but it also represents an economic loss for the country. A report by the United Nations states that each African medical worker who migrants equates to a loss of $184,000 for the entire continent. This means that, not only is the continent losing valuable medical resources, but as these workers are migrating, they leave an economic void behind them.

The inaccessibility to medical resources in developing nations is further exacerbated due to the fact that approximately half of the population in the world lives on less than $2.50 US dollars per day (Poverty Facts and Stats, 2013). Because of such rampant poverty, it is difficult for many people to purchase the already-scarce medical resources that developing nations do have to offer. The income problem is compounded due to the high prices of medicine in many of the world's poorest regions. In a survey done by the World Health Organization of 36 developing countries, it was found that a private sector patient paid anywhere from 9–25 times more for generic medical products compared to international reference prices of more developed nations (Cameron, Ewen, Ross-Degnan, Ball, & Laing,

2008). Even if people have access to basic medical supplies, often they may not be able to afford even basic generic drugs for treating acute and chronic illnesses.

1.3 Community Health Worker Programs

Because of the rampant inaccessibility to medical services, many countries are turning to Community Health Worker (CHW) programs. Countries around the world—such as Kenya, Pakistan, and Brazil—have implemented CHW programs to combat the rising health epidemics (Lehmann & Sanders, 2007). CHW programs allow local communities to elect people to become community health workers, who provide basic medical consultations and administer supplies and diagnostics. All community health workers are volunteers and, so, oftentimes they have other fulltime jobs in addition to their duties as CHWs. However, because CHWs are volunteers, they may not be properly incentivized to perform their duties at the highest level possible. Some CHWs view their new position with zeal; others see it as nuisance because they can't make a livelihood out of it.

Even with the different opinions of these volunteers, CHW programs have proven to be effective for addressing certain health issues, such as infant mortality, fighting HIV/AIDS, and increasing immunization coverage. Many developing countries have seen a rise in the use of certain medications to fight non-communicable diseases. However, CHWs have not been effective at all for addressing other health issues, such as nutritional awareness and the spread of diabetes (Perry & Zulliger, 2012). Furthermore, many of these CHW programs have not been able to effectively scale to national levels. Thus, CHW programs have not become the panacea for addressing the entirety of global health needs. It is the belief of many in the academic community that, in order to increase the effectiveness of CHW programs, there needs to be a proper incentive scheme to ensure the quality of health services that they provide to even the poorest members of their community.

Chapter 2 The Rise of Pilotitis in mHealth and Telemedicine

2.1 Emergence of mHealth and Telemedicine Systems

While governments in the public sector have been developing and refining CHW programs, non-government organizations (NGOs), charities, and academic entities have been promoting mHealth as a solution to global health problems. Over the past decade in the developing world, there has been a very rapid increase in the amount of mHealth to address global health needs for a wide spectrum of health issues. According to the United Nations, mHealth is the use of mobile telecommunications to deliver and administer health services, products, and advice (Vital Wave Consulting, 2009). It has been reported that over 100 mHealth ventures have emerged in Africa alone (PricewaterhouseCoopers, 2012).

With a large number of mHealth organizations emerging in the developing world, it has become necessary to categorize them based on products and services delivered and the method of delivery. Currently, the World Health Organization has broken the categories of mHealth entities into eight separate genres (World Health Organization, 2011). The focus of this research is on mobile telemedicine. Telemedicine is the fourth most frequently reported type of mHealth initiative across the globe. According to the American Telemedicine Association, telemedicine is officially defined as the use of electronic telecommunications to exhange, record, and analyze health data. Devices such as cell and smart phones, laptops, and tablets are all available tools for telemedicine (American Telemedicine Association, 2012). Telemedicine has become a very popular option for delivering healthcare in the developing world because of the widespread availability and knowledge of cell phone usage (Mechael, 2010) (Robertson, Dehart, Heckerman, & Tolle). Telemedicine has become an effective method of bridging the gap between people and medical professionals, but there are still many obstacles that prevent these systems from becoming an effectivesolution to the world's health problems.

2.2 Pilotitis and the Failure to Scale

One of the most significant problems facing many ventures is their inability to grow beyond their pilot stage. Often, telemedicine and mHealth ventures are able to successfully launch a pilot organization, but cannot scale beyond that pilot stage.

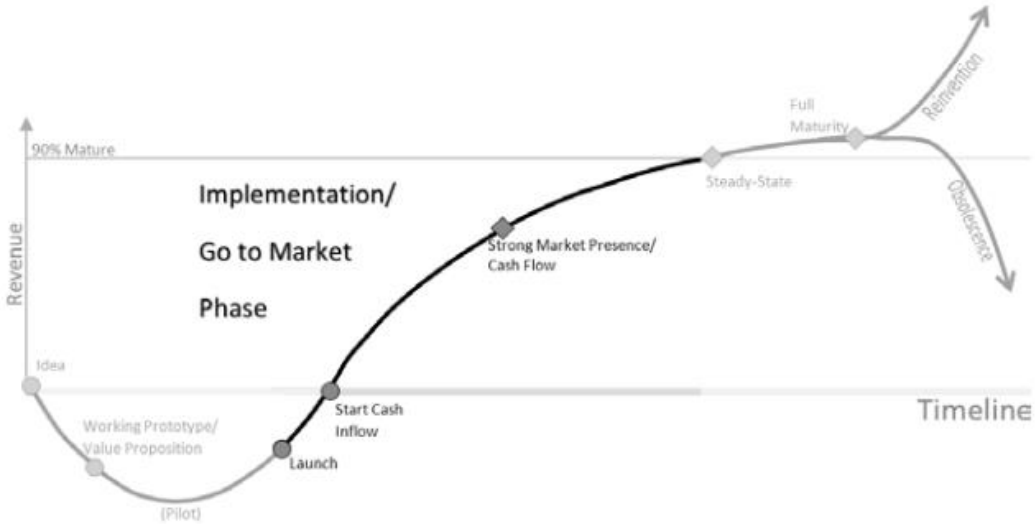

Figure 2-1 Venture Lifecycle (Maley, Perez, & Mehta, 2013)

Figure 2-1 above shows the lifecycle of any venture. The focus of this research is on the stages of a telemedicine venture from its initial idea to where it begins to establish a strong market presence. While there are many problems that may arise during the latter stages of telemedicine and mHealth development, many of the issues determining the scalability and sustainability of these ventures are faced during the early stages of development. The phenomenon of a high number of stagnant mHealth and telemedicine pilots has been deemed as “pilotitis”, or the inability of a venture to grow beyond the pilot phase. Several of the pilot projects examined in this study had no intention of reaching beyond a limited pilot scope. These projects were purely scientific in their nature. Others, however, had goals of reaching a regional, national, or international scope. These organizations failed to do so for a large number of reasons, many of which centered on surviving the first several years of operations and trying to remain financially stable during that time. In Uganda alone, there are over 30 documented mHealth pilots that

have failed to grow to a regional or national level. Figure 3 below shows some of the most prominent mHealth pilots in Uganda as of 2012.

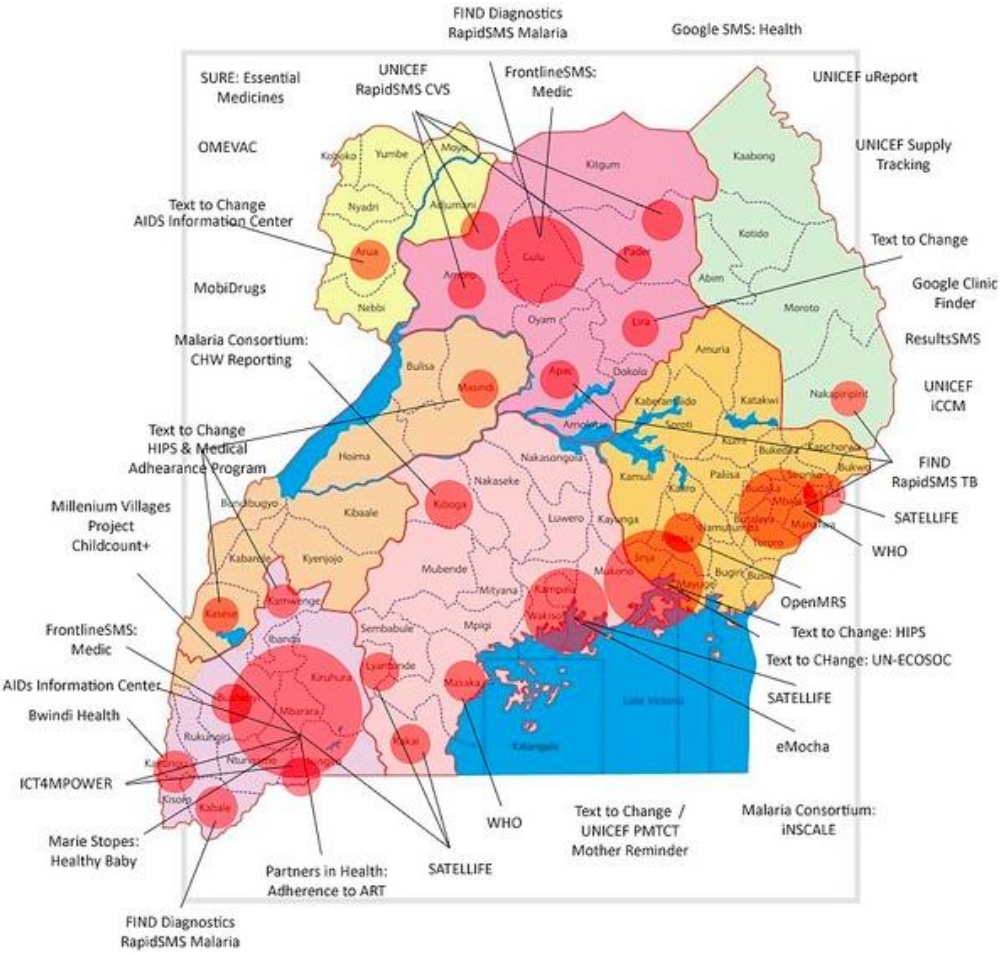

Figure 2-2 mHealth Pilot Prevalence in Uganda 2012 (McCann, 2012)

Uganda is not the only country to receive such international attention for mHealth use. In India, it was reported that over 30 mHealth pilots were started and failed to scale between 2008 and 2009 (Useem, 2012). Further, both Uganda and Rwanda have issued moratoriums on additional telemedicine and mHealth pilots because of the sheer number of pilots already existing in their countries. This constant mHealth and telemedicine venture turnover has given

rise to a new philosophy of designing these ventures from their onset with a regional and national scale already in mind. By doing so, it is hoped that several telemedicine ventures can emerge to serve the needs of millions of people across the developing world, not just pockets of populations where pilot programs exist.

2.3 Telemedicine Pilotitis: An Academic Example

The Humanitarian Engineering and Social Entrepreneurship (HESE) program at The Pennsylvania State University has worked over the past six years to develop a telemedicine system called Mashavu: Networked Health Solutions (commonly known as Mashavu). Mashavu, which means chubby-cheeked in Swahili, is a service venture based in Nyeri, Kenya. Currently, six Mashavu Health Workers (MHWs) offer the Know Your Numbers consultation service, which provides customers with height, weight, blood pressure, and BMI at a nominal cost. While telecommunications is not the focal point of Mashavu, it currently utilizes cell phones as a means of communication. Earlier iterations of Mashavu used cell phones for data collection (Fleishman, Witting, Milnes, Baxter, Moreau, & Mehta, 2010). However, this practice has been replaced with receipt books in order to give customers a tangible product to keep.

Several courses across different programs all address the needs of the Mashavu system. The class EDSGN 452 has an entire section dedicated to the development of an effective business model for Mashavu. These students also have the option of travelling to Kenya in May every year to conduct research and further develop the business model of Mashavu. However, even with dozens of students enrolling in this course every year, there have been many difficulties to address in order to scale the Mashavu system into a large-scale telemedicine venture. Mashavu has not seen significant growth in several years of operation, both financially and in customers served. The goal of this research was to find

a variety of different real-world ventures similar to Mashavu in order to find solutions to the problems that plague its growth.

Chapter 3 Overcoming Pilotitis

3.1 The Need for Sustainable and Scalable Business Models

In order to address the issue of pilotitis, it is believed that ventures need to utilize business models that are more conducive to the resource-constrained environments in which they operate One emerging philosophy to create an effective business model is to ensure stakeholder engagement. An argument can be made that the only feasible way to create sustainable and scalable ventures in the developing world is by incentivizing all stakeholders in a venture to ensure its continued success. Without having proper incentivization for all members of a telemedicine or mHealth venture, there will not be an effective system for sustaining and maintaining the health venture. Therefore, an increasing number of mHealth and telemedicine systems are turning toward CHWs and local entrepreneurs to become the focal point of their operations. By doing so, they engage all stakeholders with incentives to grow the ventures in a sustainable fashion. However, most CHW programs utilize volunteers for their services with no compensation from their governments. Therefore, if mHealth and telemedicine systems want to use CHWs, they must have a proper payment system to ensure CHWs deliver quality services for their telemedicine systems.

Not only do mHealth and telemedicine systems have to have effective incentive programs in their business model, but scaling must be built into the business model as well. Often, mHealth pilots do not adequately take scaling into consideration when creating a business model (Germann, Jabry, Njogu, & Osumba, 2012). When pilots are created, they often do not consider a business model for larger system to serve thousands of potential customers. In order to

effectively do so, business models must be designed in the early stages of creation to deliver services to a greater number of people.

3.2 Failure Modes of mHealth and Telemedicine Ventures

The focus of this research was to find the most prominent issues that plague the development of effective and scalable telemedicine business models. These problems have been dubbed "failure modes". To find failure modes of actual telemedicine and mHealth systems, 35 entrepreneurial telemedicine and mHealth ventures were examined. Furthermore, 17 additional publications and articles were examined from a holistic perspective. A list of these ventures can be found in Appendices A and B. In order to be considered for inclusion in this research, the venture must have met the definition of telemedicine and mHealth, which involves the use of telecommunications and technology to support healthcare and health education. Furthermore, the venture must be located in the developing world. There was a heavy emphasis on Africa, Latin America, and Southeast Asia. Additionally, ventures had to have a focus of using entrepreneurs, CHWs, or other local health workers. By doing so, the research could focus on the failure modes that were applicable to what is believed to be the most promising business model where CHWs are the main focus. Finally, the ventures had to have the objective of providing primary and pre-primary health care. This category includes health education, basic medical diagnostics, and medical supplies to consumers. For each real-world telemedicine and mHealth venture, the business models were framed using Osterwalder's Business Model, shown in Figure 3-1 below (Osterwalder & Pigneur, 2010).

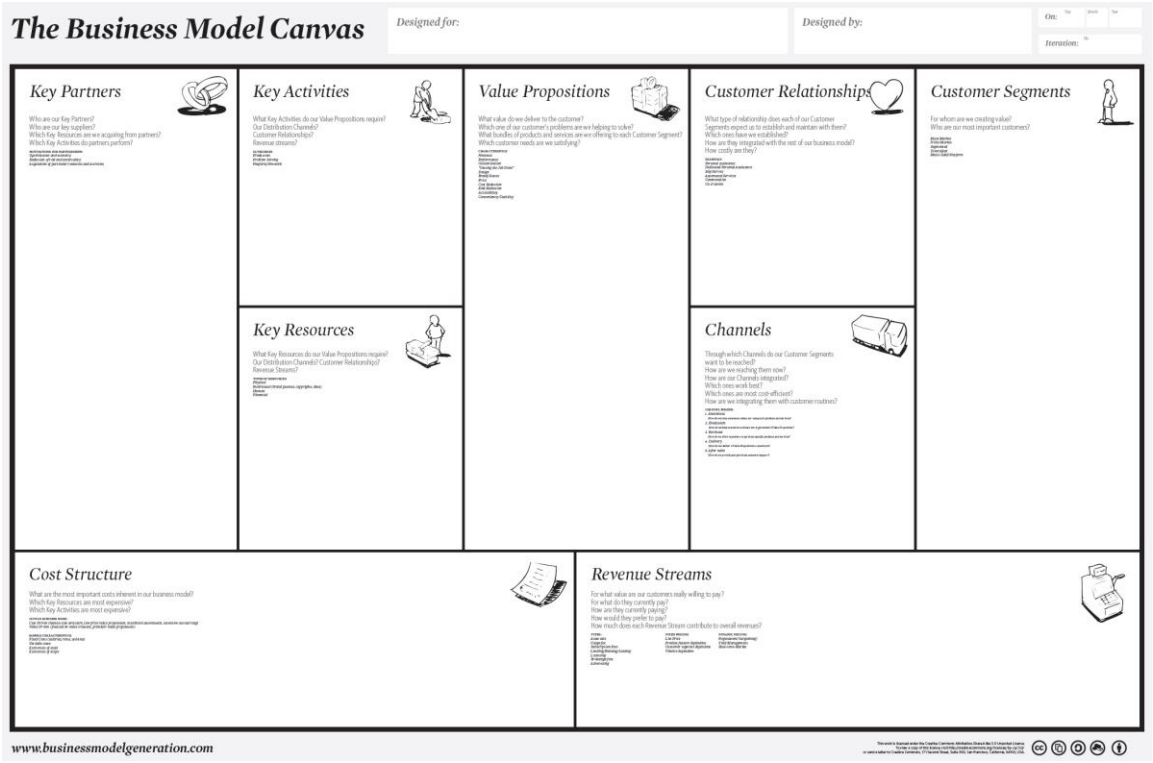

Figure 3-1 Business Model Canvas

By using a standard framework to model each venture, it was easier to understand and conceptualize the business model of the organizations. This allowed for a compilation of failure modes based on these analyses. If any feature of a service, concept, or way of thinking was a hindrance to pilot development, then it was considered to be a failure mode. Further, if any aspect of a telemedicine or mHealth venture had the potential to impede growth, it was also considered to be a failure mode. It should be noted as well that not all ventures examined in this study had the intention of scaling up to a regional, national, or international level. However, these ventures still provide key insights into how these pilots develop from experiments to full-fledged telemedicine ventures.

Based on the research, it was concluded that each of these failure modes is a significant obstacle to the development of telemedicine and mHealth pilots. It is hoped that this research will serve as a guide

to future entrepreneurs to aid them in building sustainable and scalable mHealth models to serve the health needs of the developing world.

Chapter 4 Failure Modes

Recurrent failure modes of telemedicine and mHealth ventures in the developing world are summarized in Table 1. Each failure mode is then described, analyzed, and illustrated with examples in this chapter.

Table 4-1 List of Failure Modes

Financial	Technological	Employee Management	Customer Interactions	Organizational Relationships	Contextual Challenges
1) Access to External Financial Capital 2) Subsidized Service Models 3) Telecommunication Operating Costs	1) Technology Learning Curve for Employees 2) Cell Phone Limitations 3) Internet Capacities and Information Limitations 4) Access to Electricity	1) Employee Use of Telemedicine Funds 2) Finding Medically Knowledgeable Employees 3) Finding Medically Specialized Employees 4) Employee Turnover	1) Developing Trust with Customer Base 2) Community Involvement 3) Customer Accessibility 4) Text Message Marketing	1) Partnerships 2) Reputation of Services	1) Gender Dynamics 2) Stereotyping and Social Stigmas 3) Data Security and Privacy

4.1 Financial Failure Modes

Start-up capital and a sound revenue model play a pivotal role in sustaining a telemedicine system beyond its initial pilot. When telemedicine systems have their origins outside of the country of operation, as is often the case, the operating costs and overheads are even higher. A fundamental challenge to mHealth ventures is that their revenue models are often not defined and validated during the early stages of the venture. This problem is summarized in a statement by Dr. Esther Ogara, the head of e-health for the Ministry of Health in Kenya, "many [mHealth] projects … begin without an idea of who will fund them in the long run." (Useem, 2012). Often, without the continued funding from initial donors, high operating costs cause its eventual downfall.

4.1.1 Access to External Financial Capital

Telemedicine systems need financial investment from outside sources, both at the onset of the venture and during the course of its start-up operations. External capital is especially important in the

early stages of operations when demand is low, the technology is still being tested, and few people are well-versed in using the system. For example, HealthLine, a telemedicine venture in Bangladesh, raised enough money from donors in its design stage to open several fully-operational call centers in Bangladesh. The profits generated by the venture were not sufficient to finance the costs of opening new call centers, so outside sources paid for the call center start-ups (Chen, Chu, & Sheth, 2008). HealthKeepers, an mHealth organization based in Ghana, found that their business model did not allow the operation to both expand and be profitable at the same time. Without external financial support, the venture was doomed to fail because its business model was not conducive to making sustainable profits for its services (Jackson, Jackson, Quinn, & Rodriguez, 2008). Often, the profits generated in a small-scale telemedicine system are not sufficient to scale it, as HealthKeepers found. Without external sources of funding, telemedicine systems will likely be confined to a very small area of operation. These external sources of money can include government grants, NGO aid, and funding from humanitarian organizations. Often, the largest and most successful telemedicine ventures use a variety of government and corporate sponsors who are providing money in exchange for advertising rights, publicity, and public health interests.

4.1.2 Subsidized Service Models

Offering a service free-of-cost can quickly grow the customer base and scale the venture but, eventually, a financially sustainable revenue model needs to be established. Several telemedicine services in the developing world provide free services but are dependent on donations from wealthier nations. These free service models may not be the best solutions for solving health accessibility problems. For example, OpenMRS is a free open source medical record system that relies completely on external funding for upgrades and scaling (Open MRS, 2013). OpenMRS can continue to run its free service model, but there can be serious consequences if donors choose to stop funding it. Additionally, the venture will only grow as much as the donors are willing to support. Even if the service becomes incredibly popular, the growth of the tool is determined by donors and not by the customers.

Switching from a free service to a paid service can present other kinds of failure modes. When customers in developing countries become accustomed to free health services, they may react negatively when telemedicine systems begin charging for services. The number of non-paying customers cannot be correlated with customers who would be willing and able to pay for services. Telemedicine systems must demonstrate the value of their services to the community that held the initial no-cost pilot to ultimately incorporate costs. The price points must be determined by pilot tests with paying customers rather than relying on conducting surveys or assuming appropriate costs. CycleTel, a telemedicine system based in India, initially offered its services for free. After market tests with customers, the venture eventually found that INR 30 (USD 0.50) was an appropriate price to charge for the service (Georgetown University's Institute for Reproductive Health, 2011). As the telemedicine system grew, managers of CycleTel knew that a fee would have to be implemented eventually in order to cover the costs of running the venture on a larger scale. CycleTel's experience also shows that potential price points need be validated and field-tested in the pilot phase. Currently CycleTel is successfully spreading its business practices across India after implementing a fee for its services.

4.1.3 Telecommunication Operating Costs

Operational expenses, especially those for telecommunications, can increase exponentially as the user base grows. While sending a single text message is often inexpensive, a text message sent to 10,000 users can be costly. The price of sending texts can become very high due to poor cellular reception in many parts of the developing world. With poor cell phone infrastructure, cell carriers charge extra for roaming, and these costs can quickly add up with a high volume of text messaging (World Health Organization, 2011). Telemedicine systems need to find ways of circumventing such costs that get multiplied quickly. For example, Project Masiluleke conducts their AIDS awareness campaigns using the free "Please Call Me" service that is widely available in South Africa (Project Masiluleke). The Please Call Me platform allows customers to send free text messages that request the recipient to call back the number that sent the text message. This example shows how telemedicine systems can use preexisting

telecommunications platforms, such as the Please Call Me service, to deliver affordable health information.

Another tool available to telemedicine systems is social media. Websites, such as Facebook and Twitter, have become increasingly popular in the developing world. In Africa, Facebook is now the most popular website. Further, a majority of visits to Facebook on the African continent come from mobile devices, not computers or laptops (Casey & Davies, 2012). Telemedicine systems could tap into these social media websites to not only have a free medium of communication, but also increase awareness of their venture. Without an effective way of transmitting information, the variable cost of telecommunication becomes a significant operational expense as the telemedicine venture expands. Failures can often occur when the cost of communicating with customers becomes too expensive for the organization. As the cost of communication rises, this price increase is passed to the customer, which in turn can cause a significant drop in demand. Telemedicine systems can use existing telecommunications platforms, social media, or older technologies as a more effective and financially viable option than going with the most technologically-advanced products or creating their own web service.

4.2 Technological Failure Modes

One of the fundamental tenets of telemedicine is the use of information and telecommunications technologies (ICTs) (American Telemedicine Association, 2012). Because of the increasing access to cell phones, many health ventures have attempted to use these mobile devices as the main method of data collection and communication. In spite of the rapid growth and accessibility of telecommunication technologies, developing countries still have many technological hurdles to bridge. Telemedicine systems should ensure they have a thorough understanding of the capabilities and limitations of the enabling technology infrastructure in the area of operation.

4.2.1 Technology Learning Curve for Employees

Technological literacy of health employees in the developing world, including community health workers, may not be sufficient to operate some telemedicine systems. Consequently, telemedicine systems that rely heavily on technological solutions may be unable to scale if their employees are unable to effectively use the tools given to them. To address this failure mode, CommCare, an mHealth venture in Tanzania, developed a training manual entirely in Kiswahili, the official language of Tanzania. Additionally, they offered several training sessions for community health workers in their pilot phase. The venture also hired specialized trainers to shadow CHWs in the early stages of technology implementation and facilitate the proper use of technology (Bridges.org, 2003). CommCare realized that training cannot be standardized across all communities. Instead, training is most effective when implemented with context-specific preferences like language and gender. In another example, MOTECH, a mobile health system for pregnant mothers in rural Ghana, found it difficult to teach their employees how to use Short Messaging Service (SMS) to effectively communicate with customers (Grameen Foundation, 2012). The telemedicine system must temper its use of advanced technology with the abilities and preferences of its users. Further, employees often need effective training to learn how to use some of the technological devices that telemedicine systems implement.

4.2.2 Cell Phone Limitations

The popularity of cellular phones for personal use in the developing world has increased tenfold in the past decade, and is continuing to grow rapidly (Day, 2011). The majority of phones in use in developing nations are simple handsets with limited computing power, memory, text message length, and language capabilities. Most importantly, for telemedicine, most of these cell phones in the developing world still rely on a basic keyboard interface for text messaging. Telemedicine systems face a significant hurdle to expansion because of the capability limitations of cell phones. MOTECH, a mobile health system in Ghana, attempted to store health information on employees' individual cell phones. However, the limited memory capacities of the phones prevented the venture from successfully implementing this

form of data storage (Grameen Foundation, 2012). Although successful in the long run, MOTECH was forced to substantially change their business model and data storage method. This failure mode can be avoided by estimating the amount of data needed per phone and ensuring that available cell phones have that memory capacity. Local data storage, including cell phones, also has the risk of losing information due to accidental clicking, phone theft, or data overwrites. Store-and-forward mechanisms that send data to a central server as soon as the user reaches an area with adequate cell service are an effective approach to counter this problem. Additionally, most people in the developing world access the internet from their phones (Fidelman, 2012). If telemedicine systems want to create an application for their service, then they should be programmed for flip phones and other basic cell phones.

Restrictions on the number of characters in an SMS (short message service, or text message) message force the abbreviation of health-related messages. A report by the World Health Organization found that SMS length restrictions are a significant barrier to communicating health information (World Health Organization, 2011). With only a limited number of characters per text message, telemedicine systems need to shorten and streamline text messages to convey practical and actionable health information and to minimize costs. One potential solution for addressing this problem is the use of other telecommunication platforms, such as GPRS (General Packet Radio Service—cellular data) along with free messaging, email, and social media services.

English is the predominant language of most cell carriers, which poses problems for regions with few English speakers (World Health Organization, 2011). In this case, locals have to find translators and risk the loss of nuanced information. Health topics that are taboo, awkward, or stigmatized may not be translated or conveyed effectively. Translating to other languages may not be technically or economically viable when scaling in areas with several local languages. A balance must be found between standardization for scale and localizing the system so that it can be optimally used by each community. One potential solution for overcoming language barriers is using local medical professionals, such as community health workers, for the interactions.

4.2.3 Internet Capacities and Information Limitations

Internet bandwidth and, in particular, international bandwidth, is both scarce and expensive in developing countries (Hassler & Jackson, 2010). International bandwidth is defined as the maximum quantity of data transmission from one country to others (International Telecommunications Union, 2009). For example, a university in Kenya in 2011 pays approximately $200,000 for one 1 gigabit per second per month of international bandwidth, compared to $4000 for the same service in Germany. Further, internet bandwidth is significantly slower in developing nations. In 2011, the international bandwidth available to African countries was approximately one-seventieth of the bandwidth that European nations enjoy (Cottrell, 2013). Sometimes, using international bandwidth cannot be avoided because of poor internet infrastructure in the country of operation. Further, telemedicine often has the objective of reaching areas not typically reached by medical professionals. Therefore, systems will only be scalable if they are able to succeed despite unreliable or unaffordable bandwidth. Some safeguards to overcoming inadequate internet bandwidth include store-and-forward mechanisms, low-bandwidth solutions, or storing information on easy-to-scan handwritten forms when the electronic health systems are not accessible.

Another internet-related failure mode is the storage of information on the web. Computing power capacities of servers can affect the way information is stored. For example, Mwana, an mHealth venture in Zambia, did not anticipate large-scale reach when calculating how much computing power would be necessary for their mHealth servers. The servers eventually failed, creating serious delays for moving the project forward (UNICEF Zambia, 2012). This example illustrates the importance of using modems and servers that have the capability to transmit, store, and analyze large amounts of patient health information. Furthermore, telemedicine ventures could potentially use cloud computing as an alternative for data storage. With cloud computing, however, organizations will have to be cautious of issues concerning security and data privacy. Another failure mode is the development and sustainment of a reliable and secure way to store data. Telemedicine systems could choose to use internet servers in foreign countries

in order to mitigate these concerns; however, several issues may arise. Depending upon the organizations' relationships to government ministries, the health laws of the country, and the involvement of locals in the system design, this alternative may be difficult to implement.

4.2.4 Access to Electricity

Telemedicine systems often utilize handheld electronic devices for everyday use when working with patients or collecting data. Cell phones and other battery-operated devices like automated blood pressure cuffs and blood glucose monitors need to be charged on a regular basis. Living Goods, an mHealth venture based in Uganda, found that the inability of both clients and employees to charge their cell phones limited their customer base. While they were able to buy solar panels for their employees, they could not do the same for their customers (Slaughter, 2012). Telemedicine ventures should ensure that cell phones can be charged in a way that is both convenient and reliable for all stakeholders. The cost of charging a phone should be incorporated into the financial model of the venture. Cell phone charging is often an income generating activity by local entrepreneurs in developing countries; a partnership could be lucrative between these businesses and the venture to ensure timely and reliable charge times.

4.3 Employee Management

Due to the sensitive nature of certain health issues, such as HIV or cancer, employee selection and management is critical for telemedicine in the developing world. Telemedicine ventures need reliable, trustworthy staff to make their operation succeed, especially in the pilot phase of the project.

4.3.1 Employee Use of Telemedicine Funds

When profit reinvestment decisions are left in the hands of local managers who may lack business acumen, there can be a potential for failure. Without proper oversight of business decisions, telemedicine systems can fail in the early stages of a venture. Child Family Wellness Foundation (CFW), a health micro-franchising system in Kenya, found that local businesspeople were taking excess profit for their own benefit rather than reinvesting it in the company. This same venture found that employees were

reporting lower sales in order to reduce the commission owed to CFW (Karugu, 2007). Both of these business setbacks significantly impeded the pilot growth. This venture shows that selecting trustworthy employees is critical, especially in the early stages of venture development. Additionally, systems should be in place to ensure that the profits are being reinvested into the venture itself and not left to the discretion of the local managers. In many cases, misused profits may be due to contrasting assumptions or cultural differences rather than corruption. For example, a manager may take money for travel to attempt to fix an employee's broken phone and not inform the organization. Or, a manager may allow employees to take two weeks off for the December holidays without consulting the organization. Mechanisms, especially training, must be built into the system to ensure transparency, accountability, and open communication channels between managers and the telemedicine organization.

4.3.2 Finding Medically Knowledgeable Employees

Health professionals from developing countries are immigrating to more industrialized nations to find better salaries, benefits, and a higher quality of life. Due to this migration, finding health-knowledgeable employees can be a challenge (Pang, Lansang, & Haines, 2002). While it may be difficult for foreigners to locate potential employees in a particular area, community members often know where to find qualified individuals. HealthKeepers, a healthcare franchising business in Ghana, trained employees, called "finders," dedicated specifically to finding other employees for the system. HealthKeepers essentially created their own recruiters and had a much easier time screening employees for the jobs (Jackson, Jackson, Quinn, & Rodriguez, 2008). Without extensive knowledge of an area, telemedicine ventures will have to rely on local knowledge to find educated and qualified medical personnel.

Several telemedicine ventures have attempted to use CHWs as employees. However, sometimes CHWs may not be the best solution for addressing telemedicine needs. The Child Family Wellness Foundation initially hired CHWs to run medical supply shops and clinics in Kenya. Over time, however, they found that they preferred registered nurses over CHWs to run their clinics because of their legal

ability to sell a broader range of health services, such as check-ups and health examinations (Karugu, 2007). Telemedicine ventures cannot expect that all CHWs or local health workers have the technical training to make medical decisions. CHW training is limited to basic health knowledge, and so more complicated mHealth ventures will require more educated employees at higher costs.

In addition to hiring qualified employees, it is important that the employees are working in geographical areas in which they have experience. Hiring local citizens can help avoid language barriers and bridge tribal and ethnic differences. Furthermore, for certain health issues such as HIV/AIDS, it may be necessary for CHWs to be utilized due to their unique role as a trusted member of the community. They will have access to local knowledge about the community that may not be easily available to outsiders. At the same time, this is a double-edged sword because community members might be reluctant to discuss taboo health issues with CHWs due to the awkwardness or privacy concerns.

4.3.3 Finding Medically Specialized Employees

If a telemedicine venture wants to target a very specific health issue, such as optometry or dermatology, there needs to be an adequate amount of those specialized health professionals in the area of operation. NextBillion (VisionSpring), an mHealth system, struggled to hire only optometrists to address vision needs in Africa and Latin America (MANAUS Consulting, 2013). In cases where qualified employees are scarce but demand is high, a referral system may be possible using local health workers, with those in greatest need contacting the medical professionals directly or travelling to a separate facility.

4.3.4 Employee Turnover

Employee turnover particularly hurts early-stage ventures that have invested resources to train employees who then pursue more lucrative opportunities. This challenge is aggravated in developing countries with colonial histories where working for the government and large companies is considered more prestigious than working for a fledgling start-up. Because of the limited amount of resources, including funding for employee salaries, in telemedicine pilots, employees may leave in the early stages the venture. With a high demand and low supply of health professionals in the developing world,

employees have to be properly incentivized even during the pilot stage. VisionSpring found that, because of low wages, the first months of their venture had a very high employee turnover rate (MANAUS Consulting, 2013). Turnover is particularly detrimental for telemedicine ventures that have a lot of training required for specific medical procedures, such as optometry skills or how to use a blood glucometer.

If telemedicine organizations want employees for an extended period of time, they must be properly incentivized to stay beyond the initial pilot. This incentive should be adequate to maintain dedicated individuals but set to the right level to avoid attracting those with purely financial motivations. In some cases, individuals may agree to join the venture with the mindset that the organization is following a traditional aid model, where free goods and services are offered with minimal payback mechanisms. To avoid these misplaced and unrealistic expectations, telemedicine organizations need to communicate the exact daily requirements of employees. Further, as both employees and the community as a whole understand the venture and work expectations better, turnover rate should lessen.

4.4 Customer Interactions

Whether visiting an employee or receiving a text message, each interaction a customer has with the telemedicine system needs to be of high quality. Similar to any other business, telemedicine systems need to ensure that every single customer feels like that the system is trustworthy enough to administer health information.

4.4.1 Developing Trust with Customers

Telemedicine systems need to be able to establish credibility through the interactions they have with their customers. For example, certain ventures have found that sending text messages on a consistent basis (such as once a week on the same day) creates a better relationship with patients (Garai, 2012). JustTested, a telemedicine venture in South Africa, found that trust was created with potential customers by advertising their services with more personal, face-to-face advertising, rather than print media and

word-of-mouth. In fact, over ten times more customers signed up for the service when there were people advertising the service, as compared to other forms of media (African Strategies for Health Project, 2012). However, the costs associated with personal advertising by members of the organization may be too high. If that is the case, the telemedicine system should rely on consistent text messaging to perpetuate trust between the organization and its customers. Other marketing schemes, such as subsidizing the first service, incentives for referrals, or discounts on certain days may also help generate the initial connection between the telemedicine system and the customer. However, trust is not established instantaneously. VillagesReach, an mHealth system in Mozambique, found that trust was only built in communities by providing quality and reliable services over an extended period of time (VillageReach, 2012). Although there is no defined time limit for developing trust, more people will begin to trust the telemedicine system as time passes and the telemedicine venture provides excellent services.

4.4.2 Community Involvement

Effective telemedicine ventures should be able to rally communities to become actively involved in improving their health. By integrating into communities, telemedicine organizations can both increase the customer base and build a better brand name for themselves. BasicNeeds, an international health group that uses CHWs to help mentally ill patients, started an awareness campaign in the community to break down the stigmas of mental illnesses (Raja & Dougherty, 2009). Another example of community involvement comes from MAMA (Mobile Alliance for Maternal Action), a telemedicine system dedicated to giving health information to soon-to-be mothers. Not only did this telemedicine venture give out helpful advice for parenting, but MAMA was also successful in connecting pregnant mothers with each other. The venture found that, over time, more women were joining for both health information and support groups to relate with other pregnant women in their communities (Gagnaire, 2012). By establishing a connection between customers and the surrounding communities, telemedicine systems can better market themselves as both a health service and as a community resource that people can leverage

for a variety of different needs. Telemedicine systems that fail to connect with communities beyond providing health services may find themselves in a state of stagnation.

4.4.3 Customer Accessibility

Even with the use of technology in telemedicine systems, customers should have easy and reliable access to their services. Even if cell phones are the main tool of communication, customers should still have access to employees when problems arise. For example, in a study conducted by Drishtee, people were willing to walk for an hour at most for health services (Lehr, 2008). In addition to geographic accessibility, hours of operation can be a significant factor for telemedicine ventures. Several mHealth ventures found that the evening hours from 6:00 pm to 10:00 pm were some of the most profitable times of the day (Karugu, 2007). Using telecommunication tools effectively, the problem of accessibility can be avoided. HealthLine, a health service in Bangladesh, had its customers call into a 24-hour call center, completely alleviating the accessibility problem by allowing customers to contact the venture at their convenience for a small fee (Chen, Chu, & Sheth, 2008). A call center, while initially simpler to implement, must accompany a business model that allows it to remain profitable at scale or else it will be unable to proceed beyond the pilot phase. Telemedicine systems need to evaluate how the customer will interact with the venture itself. It is important to take into consideration both network and physical availability of a telemedicine system before attempting to implement it in a new community.

Another method to addressing accessibility issues is targeting the telemedicine system toward health workers instead of patients. It can be difficult to reach diverse customer segments in the developing world, and so some ventures have decided to focus their system on health workers. Cell-PREVEN, a telemedicine application in Peru, created a system that allows health officials to diagnose sexually transmitted diseases. By allowing local health workers to interact with customers, Cell-PREVEN could focus their effort on developing their diagnostic system (Curioso, Karras, Campos, Buendía, Holmes, & Kimball, 2005). This telemedicine system shows that it can be profitable to gear their system toward health workers instead of focusing on an application for patients.

4.4.4 Text Message Branding

Since telemedicine systems sometimes use text messaging as a method for communication, consistent messaging that is well-aligned with the brand helps grow the customer base while building trust with them. JustTested, a telemedicine organization based in South Africa, found that attaching a small brand logo at the end of each text message was vital for both creating trust with the customer and growing their reputation. Customers may forget who sent the text even after signing up for the service (African Strategies for Health Project, 2012). JustTested attributed this small detail as one of the main factors for the success of their venture. Without a proper format or brand associated with the messages, telemedicine ventures may find that customers do not trust their text messages. Branding each text message will reinforce with customers that the information being sent through the telemedicine system is reliable and trustworthy.

4.5 Organizational Relationships

Often, telemedicine ventures in the developing world collaborate with a variety of other organizations. Telemedicine systems that effectively leverage these relationships are more likely to succeed in creating a sustainable and scalable venture.

4.5.1 Partnerships

The most successful mHealth and telemedicine systems partner with other companies, non-profits, or governments, both locally and internationally. The health venture Securing Ugandans Right to Essential Medicines (SURE) teamed with Makarere University to conduct their MMS (Multimedia Messaging Service) training workshops. With this partnership, SURE was able to train 113 people in one year, a feat that was only achievable by partnering with Makerere University. Additionally, SURE teamed up with 13 regional pharmacists and eight logistical advisors to help expand its operations. Finally, USAID provided initial capital until SURE could be self-sustaining. While SURE had to conform to USAID's rules and regulations, it was able to eventually become self-sustainable because of these

partnerships (USAID, 2012). Telemedicine systems rarely are self-sustaining in their pilot stage without the help of local and international partnerships. It is important for those leading the telemedicine venture to discuss the equity of work, finances, and time that each partner will contribute. Furthermore, a primary strategic goal, a definition of success, and a plan to scale should be discussed ahead of implementation to ensure that all partners are working with the same vision. This planning conversation can alleviate conflicting assumptions that may impede success later (Mehta & Mehta, 2011).

4.5.2 Reputation of Services

The reputation of mHealth ventures and its employees can have a significant impact on telemedicine systems. If a telemedicine venture fails to present a high-quality, user-friendly service, it can quickly be plagued by negative perceptions. Switchboard is an mHealth system in several African countries that allows rural CHWs to share their patients' information with health officials across the country. However, since information was being collected by local CHWs, it wasn't taken seriously by external doctors (mHealth Alliance and Vital Wave Consulting, 2013). This example illustrates the importance of a telemedicine system's reputation for both customers and other partnerships that the venture may have. It is important for the venture to have an understanding of the relationships between important people and organizations in the community. Further, transparency of actions is vital to prevent rumors and/or fixable issues from leading to larger consequences. This involvement is more important during the pilot phases when the reputation of the services is not well known. A public relations campaign that brings high-ranking officials from the organizations and local opinion leaders together to vouch for the project can enhance its reputation and credibility.

4.6 Contextual Challenges

Each telemedicine system will face unique challenges in each different geographic location based on with which countries, regions, and towns they choose to operate their business.

4.6.1 Gender Dynamics

A customer's gender can have a significant effect on access to the internet. Approximately 33% of all men in the developing world are internet users, as compared to 29% of women, who comprise the majority of the CHW workforce (International Telecommunications Union, 2013). While only a 4% difference, this percentage difference can have huge ramifications when applied to billions of people living in the developing world. Therefore, any telemedicine venture that utilizes the internet as the primary tool of communication must realize that while women may comprise the majority of employees and customers, they may not have the widespread access to internet that men do. Even though most people access the internet from their cell phones, it is important to realize that men have more access to the internet across different devices including cell phones.

In addition to internet usage, telemedicine ventures may find gender dynamics to affect their potential employees. In a study by the WHO, 70% of CHWs were women (Lehmann & Sanders, 2007). Since the majority of the CHWs are women and CHWs are often employed for telemedicine operations, projects should plan to combat social stereotypes toward women in local communities. In several South African villages, female health workers were seen as immoral because of their involvement in family planning, interactions with men, and their travel across villages. Their jobs as health workers also threatened the social status of their families (George, 2008). To overcome these barriers, it is important to remain committed and responsive to these enterprising women in public settings. Further, having female health workers dispense medicine and immunizations can help bolster their reputation by showing they have the medical knowledge to be successful health workers.

4.6.2 Stereotyping and Social Stigmas

For certain types of illnesses and diseases, there may be societal stigmas that telemedicine ventures need to combat. BasicNeeds, an mHealth venture based in Africa, faced societal stereotypes as a barrier when trying to treat mental illnesses. To combat these perceptions, BasicNeeds created campaigns

and devoted resources specifically to change community perceptions of people with mental illnesses (Raja & Dougherty, 2009). Telemedicine systems may be unaware of the cultural perceptions placed on a particular disease or illness. Thus, these organizations have to devote resources to not only fight the disease itself, but also try to change cultural views. The hiring process is most vital for these types of ventures, as employees must navigate difficult topics that require great amounts of trust with patients.

There may be social stigmas that prevent people from seeking health. Partners in Health (PIH), an international mHealth organization, found that, in Haiti, women with breast cancer were not seeking treatment because stereotypes within their culture prohibited them from seeking medical help. To combat this issue, PIH offered support group sessions specifically for women with breast cancer (Partners in Health, 2012). This example illustrates that, although cultural barriers can be powerful enough to prevent people from seeking treatment, they can be overcome through community-based approaches. There is strength in numbers, community, and education, but ventures need to be persistent in their efforts since such deep-rooted belief need time to evolve.

4.6.3 Data Security and Privacy

For mHealth and telemedicine ventures collecting customer health data, security and privacy can be compromised, especially as the volume of data increases significantly. Safelife, a telemedicine tool in Uganda, stored health information on PDAs and other mobile devices. By doing so, the responsibility of securing that data was in the hands of the user, not the venture. This created problems because employees could take their devices home containing confidential information and not even know they were doing so. Additionally, current legislation in the developing world may not be conducive to modern data collection and information technology issues (Bridges.org, 2003). Without clear legal guidelines, it may be difficult to define the limits of a patient's privacy of health information, including who can access that information. If a telemedicine system wants to collect and track health information, especially on mobile devices, telemedicine organizations should ensure that the health data is stored in a safe and legal manner.

Even the perception of compromised privacy makes data collection difficult. Mashavu, a mobile telehealth venture where CHWs collect health information from people in marketplaces as well as rural communities, had difficulty convincing people to allow for their data to be entered into a database. This was due to frequent news stories of Kenyan citizens being falsely registered to rival political parties. Although this breach in privacy was unrelated to Mashavu, it rendered data collection impossible.

4.7 Employment Legality

Telemedicine ventures in the developing world may run into problems revolving around the legal status of their entity. The legal obligations of employees for a telemedicine system may deter people from becoming employees. Further, whether or not the telemedicine system is considered a legal business or not can impact people's desires to sign on as employees. HealthKeepers, an mHealth venture in Ghana, faced issues framing themselves as a legal company. People did not want to sign up as employees with HealthKeepers because they did not understand the legal structure of their business model. Additionally, previous ventures similar to HealthKeepers started in Ghana had treated their employees poorly, making it difficult to convince people to join (Jackson, Jackson, Quinn, & Rodriguez, 2008). Organizations need to ensure that they are properly communicating the legal obligations of their employees to ensure that they have a thorough understanding of their responsibilities as employees. Rather than using a series of contracts, one solution for telemedicine systems is to use incentives to ensure that their employees are being responsible and professional (Oliver Wyman, 2008). Furthermore, telemedicine systems should have legal counsel to determine if creating an official, legal entity in the country of operation fulfills the purposes of the venture. It may seem that forming a legal entity is cumbersome for a pilot phase, but it is important to weigh the benefits and drawbacks of creating a legal entity. Issues such as employee protection, mandated holidays, and taxation exist to ensure the social benefit of community members. The venture must weigh these benefits with their own goals and requirements when considering whether being a registered entity is in everyone's best interests.

Chapter 5 Conclusion

Telemedicine and mHealth are increasingly becoming common methods for delivering healthcare solutions across the globe. However, without effective business models to sustain them, many mHealth pilots will be doomed to remain in their pilot stage. By examining real-life telemedicine and mHealth ventures, a compilation of failure modes has been documented. These failure modes include financial, technological, employee management, customer interactions, organizational relationships, and contextual challenges. It is evident that most of the challenges facing these ventures are not medical or technological, but rather, social, economic, and cultural. Simply placing advanced technology in the hands of medical personnel does not solve the issues that affect billions of people worldwide. Business models that are flexible and sustainable are much more suited to combatting the health issues of the 21st century.

By documenting these barriers to pilot growth, it is hoped that future telemedicine ventures can learn from their predecessors. However, there is still further research to be done. The HESE program will continue to examine failure modes and their interactions with some of the most common business models already in place in the developing world. With such a vast number of mHealth and telemedicine ventures arising, certain failure modes impact business models more than others. For example, a diabetes-based telemedicine venture that distributes testing strips will likely face more supply chain issues than a phone-based medical consultation service. Regardless of the business model, however, having a thorough understanding of these failure modes can help telemedicine and mHealth pilots grow into large, sustainable solutions to addressing global health problems.

Appendix A

List of Real-World Telemedicine and mHealth ventures

Venture Number	Name of Venture	Description of Venture
1	FHI360-SATELLIFE	Satellife's provides technological devices to physicians and doctors in the developing world to store and track health information.
2	OpenMRS	Open source project to develop software to support the delivery of health care in developing countries.
3	VILLAGEREACH	VillageReach's model improves access to healthcare by providing a logistics platform to facilitate delivery of medical supplies and by starting and managing social businesses to improve local infrastructure
4	World Health Partners	International nonprofit organization that provides health and reproductive health services in low-income countries by harnessing local market forces to work for the poor.
5	MOTECH	MOTECH is a mobile health system designed specifically for pregnant mothers in rural Ghana. It consists of two applications—one part for the pregnant women, and the other for the nurses and medical workers. Women can register for this system by talking to their local CHWs.
6	eMOCHA	The electronic Mobile Open-source Comprehensive Health Application is a free open-source application, developed by the Johns Hopkins Center for Clinical Global Health Education.
7	FrontLine SMS with CycleTel	The goal of CycleTel is to empower women by providing them with accessible reproductive health information via text message. CycleTel uses a simple fertility awareness-based method of family planning that teaches a woman about basic reproductive information.
8	Janani	A non-profit organization that provides family planning and comprehensive abortion care services in the states of Bihar, Jharkhand and Madhya Pradesh.
9	Securing Ugandans' Rights to Essential Medicines (SURE) Right to Essential Medicines	SURE improves both access and availability of essential medicines and other health supplies. Additionally, the program has a focus of sustaining these supply chains for individuals in rural communities.
10	DKT	DKT provides couples with affordable and safe options for family planning and HIV/AIDS prevention through dynamic social marketing.
11	FrontLine SMS: Medic	The goal of this venture is to connect remote CHWs to centralized clinics. Additionally, this system uses laptops, GSM modems, phones, and a GSM signal, so the internet is not even required

Venture Number	Name of Venture	Description of Venture
12	CommCare	D-tree International work with medical algorithms and mobile applications to improve the standards of care in clinical and community settings they present a mobile phone-based application called CommCare which helps community health workers (CHWs) to provide home-based care and social support to HIV, tuberculosis and other chronic patients.
13	HealthLine	HealthLine Service is a service that is between an individual with a phone and a medical call center. Subscribers to this service can obtain medical advice by simply dialing a 3 digit number. This venture was created through the Grameen foundation and expanded upon by Carnegie Mellon University.
14	Rapid SMS	RapidSMS is a free and open-source framework for dynamic data collection, logistics coordination and communication, leveraging basic short message service (SMS) mobile phone technology.
15	MAMA	Mobile Alliance for Maternal Action (MAMA) was developed to give new and soon-to-be mothers with information about pregnancy and how to raise children via cell phones.
16	SwitchBoard	This is a service that connects CHWs to doctors and other health officials. This way, health workers can transfer information amongst each other.
17	Healthpoint	Provides both sanitary water and consultations with medical professionals to local rural villagers
18	Open mHealth	Open mHealth is non-profit startup-building open software architecture to break down the barriers in mobile health to integration among mHealth solutions and unlock the potential for mHealth.
19	mTrac & U-Report	The primary objective of mTrac is to strengthen disease surveillance and the national medicines monitoring system, and generate community action for improved health system
20	BasicNeeds	This venture works with people suffering from many types of mental and neurological illnesses, in remote rural countryside to urban slums, in Africa and Asia. The work is based on the philosophy of building inclusive communities, where mentally ill people—through development—to realize their own rights.
21	Mwana	With such high rates of HIV, many children are being born with it, unknowingly to their mothers. The survival rate of these children is low, so this is a venture aimed at diagnosing HIV even faster.
22	Riders for Health	Riders for Health provide transportation means for those in the healthcare field so they can treat patients in more remote locations. This venture runs repair shops and vehicles of all sizes to increase accessibility to proper health care.
23	NextBillion (VisionSpring)	Similar to Mashavu, VisionSpring uses a micro-franchise model. VisionSpring gives people, or Vision Entrepreneurs, a kid of materials needed to market and sell eyewear. These salespeople receive training and support from local employees. These entrepreneurs also receive income.

Venture Number	Name of Venture	Description of Venture
24	The HealthStore Foundation	Through micro-franchising, Healthstore has been able to establish a network of small pharmacies and clinics that bring essential medicines to marginalized populations in Kenya.
25	Healthcare Without Harm	The organization focuses on raising awareness to the healthcare sector of the toxic pollution that they inflict on the environment and population worldwide through toxic recycling that is ecofriendly and not simply incinerated.
26	DrishTree	Drishtee develops several 'milkman routes' in a certain area. These routes develop micro-franchises that deliver services in health, finance, and education. It uses a kiosk-based system. This venture emphasizes creating effective rural supply chains.
27	One World Health	Not for profit medical company that develop medicines for pediatric care for diseases that are only found in the worst living conditions of the world (for example diseases such as Black Fever). It is a self-sustaining social enterprise, founded with philanthropy, driven by global health inequity, and sustained by revenues. Initial focus areas are contraception and neglected/orphan diseases.
28	Partners In Health	Their mission is to provide a preferential option for the poor in health care. By establishing long-term relationships with sister organizations based in settings of poverty, Partners In Health strives to achieve two overarching goals: to bring the benefits of modern medical science to those most in need of them and to serve as an antidote to despair.
29	Living Goods	This is a system of developing entrepreneurs who sell education and products to families. micro-entrepreneurs who go door-to-door teaching families how to improve their health and wealth while selling a broad assortment of affordable, life-changing products.
30	Praekelt Foundation	The Praekelt Foundation uses text messages to deliver information about HIV/AIDS in certain parts of Africa
31	Project Masiluleke	Collaboration employing mobile technologies and HIV self-tests to combat the HIV/AIDS and TB epidemics in South Africa
32	HealthKeeper	HealthKeepers is a social franchise business model that creates entrepreneurs out of literate village women. These women are supplied with basic medical supplies and then sell them to people in rural communities.
33	Cell PREVEN	Cell PREVEN is a venture that seeks to combat STD growth by early identification. It uses mobile groups of workers to accomplish this task.
34	Child Family Wellness Foundation (CFW)	CFW offers nurses and CHWs the opportunity to create their own microfranchise by becoming a part of the larger CFW system. They open up their own stationary business to provide drugs and other medical supplies to people in rural communities.

Venture Number	Name of Venture	Description of Venture
35	JustTested	The JustTested program provides information and supported to people who have just been tested for HIV, regardless of the outcome. This service sends HIV-related information via text messages over a three month duration.

Appendix B

Additional Literature Considered

Title of Article	**Synopsis**
Seven Factors for Designing Successful MHealth Ventures	This is an article written on the current state of mhealth ventures and how they can be designed better.
Barriers to MHealth Implementation	This article is a study by the World Health Organization on mHealth projects and the shortcomings associated with these projects
Telemedicine in Western Africa	This venture is a telemedicine system that connects patients in rural parts of Mali to doctors.
Microfranchising at the Base of the Pyramid	A discussion of lessons from DrishTree, VisionSpring, and a few other microfranchise models.
Evidence needs to catch up with enthusiasm for mobile phones & health, aka mHealth	An article discussing the difficulty in evaluating mHealth programs in Africa.
Designing mHealth Programs with Scale in Mind	An article in the Stanford Social Innovation Review about how to design mHealth ventures in the beginning of their stages with scaling in the design phase. This article was written by Merrickk Schaefer, a member of the World Bank.
Building MHealth Ecosystem	An article about mHealth on scaling mHealth initiatives written by Erica Kochi, a leader for UNICEF's Innovation Unit.
Upgrades to basic mobile phones aim for a smart future	This article looks at how the future looks for the developing smartphone industry in Sub-Saharan Africa, meaning that future mhealth solutions may have an easier time integrating into the social norm.
UN mHealth Report (2011)	A report by the United Nations on the state of mHealth ventures across the globe and the potential for mHealth in the future.
Scaling Telehealth Programs: Lessons from Early Adopters	While the article is focused on telemedicine systems in the US, it discusses barriers to telemedicine from a holistic perspective.
Telemedicine: Opportunities and Developments	This report documents barriers when developing telemedicine systems, with an emphasis on cultural differences. It is sometimes difficult for different subcultures to communicate health information with each other.
Evaluating Innovative Health Programs: Lessons for Health Policy	This paper discusses how quality can often be an issue with health ventures. In the Kenyan Drug Distribution Scheme, the overseeing organization had surprise visit and inspections to ensure that the workers were delivering quality products and services.

Bibliography

African Strategies for Health Project. (2012, May 6). *mHealth Compendium.* Retrieved October 29, 2013, from Johns Hopkins Bloomberg School of Public Health: http://www.jhsph.edu/departments/international-health/_documents/USAIDmHealthCompendiumVol2FINAL.pdf

American Telemedicine Association. (2012). *What is Telemedicine?* Retrieved January 4, 2014, from American Telemedicine Association: http://www.americantelemed.org/learn/what-is-telemedicine#.UvZ8mIWylLE

Berg, M. (1999). Patient care information systems and health care work: A sociotechnical approach. *Int J Med Inform*, 86-101.

Bridges.org. (2003, February 28). *Evaluation of the SATELLIFE PDA Project, 2002.* Retrieved November 14, 2013, from Give Well: http://www.givewell.org/files/Cause1-2/AED-SATELLIFE/AED-SATELLIFE%20-%20EIN%2022-3051191-%20CAUSE%201%20ATTACHMENT%20-%20Bridges.org%20Report.pdf

Broderick, A., & Lindeman, D. (2013, January). *The Commonwealth Fund.* Retrieved 3 2013, April, from Scaling Telehealth Programs: : http://www.commonwealthfund.org/~/media/Files/Publications/Case%20Study/2013/Jan/1654_Broderick_telehealth_adoption_synthesis.pdf

Camann, M. (2008). *Global Persepctives on Mental Health.* Sudbury: Jones & Bartlett Publishers Inc.

Cameron, A., Ewen, M., Ross-Degnan, D., Ball, D., & Laing, R. (2008, December 1). *Medicine prices, availability, and affordability in 36 developing and middle-income countries: a*

secondary analysis. Retrieved January 2, 2014, from World Health Organization: http://www.who.int/medicines/technical_briefing/tbs/lancetmedprices.pdf

Casey, M., & Davies, M. (2012). *Social Media in Africa.* Retrieved November 19, 2013, from Deloitte: http://www.deloitte.com/assets/Dcom-SouthAfrica/Local%20Assets/Documents/TMT_Social_Media.pdf

Charts Bin. (2009). *Global Distribution of Physicians per 10,000 population.* Retrieved January 6, 2014, from ChartsBin: http://chartsbin.com/view/gcu

Chen, R., Chu, E., & Sheth, R. (2008, December 10). *Final Report - Healthline.* Retrieved November 14, 2013, from CMU Contributed Webserver: http://www.contrib.andrew.cmu.edu/~rchen1/BizComSite/Documents/Final%20Report.pdf

Clemens, M., & Pettersson, G. (2008). New data on African health professionals abroad. *Human Resources for Health*.

Cottrell, R. L. (2013, January 29). *How Bad Is Africa's Internet?* Retrieved January 11, 2014, from IEEE Spectrum: http://spectrum.ieee.org/telecom/internet/how-bad-is-africas-internet

Curioso, W. H., Karras, B. T., Campos, P. E., Buendía, C., Holmes, K. K., & Kimball, A. M. (2005). Design and Implementation of Cell-PREVEN: A Real-Time Surveillance System for Adverse Events Using Cell Phones in Peru. *American Medical Informatics Association.*

Day, G. (2011, November 25). *Universal Telecom.* Retrieved November 11, 2013, from Institute of Electrical and Electronics Engineers: http://sites.ieee.org/gday/2011/11/25/universal-telecom/

Fidelman, M. (2012, August 09). *Forbes.* Retrieved September 2, 2013, from http://www.forbes.com/sites/markfidelman/2012/10/09/why-we-must-mobilize-developing-nations/2/

Fleishman, A., Witting, J., Milnes, J., Baxter, A., Moreau, J., & Mehta, K. (2010, Spring). Validation Process for a Social Entrepreneurial Telemedicine Venture in East Africa. *International Journal for Service Learning in Engineering, 5*(1), 1-24.

Gagnaire, K. (2012, April 11). *MAMA Bangladesh - Connecting Health Information and Services to Mothers Through Mobiles.* Retrieved November 4, 2013, from USAID: http://blog.usaid.gov/2012/04/mama-bangladesh-connecting-health-information-and-health-services-to-mothers/

Garai, A. (2012, December). *Seven Factors for Designing Successful mHealth Projects.* Retrieved November 2, 2013, from http://www.slideshare.net/innovadorslab/seven-factors-for-designing-successful-mhealth-projects

Geissbuhler, A., Ly, O., Lovis, C., & L'Haire, J.-F. (2003). Telemedicine in Western Africa: lessons learned from a pilot project in Mali, perspectives and recommendations. *National Center for Biotechnology Information,* (pp. 249-253). Geneva.

George, A. (2008). Nurses, community health workers, and home. *Global Public Health: An International Journal for Research, Policy and Practice, 3*(1), 75-89.

Georgetown University's Institute for Reproductive Health. (2011, October). *Case Study: FrontlineSMS and Georgetown University's Institute for Reproductive Health.* Retrieved November 14, 2013, from Frontline SMS: http://www.frontlinesms.com/wp-content/uploads/2011/10/FrontlineSMS_IRH_CycleTel_2011.pdf

Germann, S., Jabry, A., Njogu, J., & Osumba, R. (2012). The illness of pilotitis in mHealth – Kenya KimMNCHip brokering partnerships for national scale up early lessons. *Geneva Health Forum.*

Grameen Foundation. (2012, September). *Mobile Technology for Community Health in Ghana.* Retrieved November 14, 2013, from Grameen Foundation: http://www.grameenfoundation.org/sites/grameenfoundation.org/files/MOTECH-Lessons-Learned-Sept-2012.pdf

Groenhout, R. (2012). The "brain drain" problem: Migrating medical professionals and global health care. *International Journal of Feminist Approaches to Bioethics, 5*(1), 1-24.

Hassler, B., & Jackson, A. M. (2010, April - June). Bridging the Bandwidth Gap: Open Educational Resources and the Digital Divide. *IEEE Transactions on Learning Technologies, 3*(2), 110-115.

International Telecommunications Union. (2009). *International Telecommunications Union.* Retrieved January 3, 2014, from International Bandwidth: http://www.itu.int/ITU-D/finance/work-cost-tariffs/events/tariff-seminars/Maputo-09/pdf/session2-Abosse-Internat_Bandwidth-en.pdf

International Telecommunications Union. (2013, February). *ICT Facts and Figures 2013.* Retrieved November 6, 2013, from International Telecommunication Union: http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2013-e.pdf

Jackson, A., Jackson, J., Quinn, M., & Rodriguez, Y. (2008, May). *Preventative Health Care at the Village Level in Ghana: A Social Franchising Solution.* Retrieved November 14, 2013, from BYU Marriot School: http://marriottschool.byu.edu/selfreliance/docs/Ghana-Current_Practices_Challenges_and_Opportunities.pdf

Karugu, W. (2007, September). *Child & Family Wellness Shops: A Model of Sustainable Health Care for the Most Vulnerable.* Retrieved October 18, 2013, from Growing Inclusive Markets: http://growinginclusivemarkets.org/media/cases/Kenya_HealthStore_2008.pdf

Kochi, E. (2013, February 20). *Stanford Social Innoation Review.* Retrieved October 12, 2013, from Building the mHealth Ecosystem: http://www.ssireview.org/blog/entry/building_the_mhealth_ecosystem

Lehmann, U., & Sanders, D. (2007). *Community health workers: What do we know about them?* University of the Western Cape, School of Public Health.

Lehr, D. (2008, August). *Microfranchising at the Base of the Pyramid.* Retrieved October 7, 2013, from Oliver Wyman.

Maley, S., Perez, A., & Mehta, K. (2013). OPEN 2013: NCIIA's 17. *National Collegiate Inventors and Innovators Alliance.*

MANAUS Consulting. (2013, March). *Evaluation Report VisionSpring: Eye Care for the Base of the Pyramid.* Retrieved November 12, 2013, from NextBillion: http://www.nextbillion.net/pubs/images/FINAL_VisionSpring_Evaluation.pdf

McCann, D. (2012, February 22). *A Ugandan mHealth Moratorium Is a Good Thing.* Retrieved January 15, 2014, from ICTWorks: http://www.ictworks.org/2012/02/22/ugandan-mhealth-moratorium-good-thing/

Mechael, P. (2010). *Barriers and Gaps Affecting mHealth in Low and Middle Income Countries: Policy White Paper.* Columbia University. Earth Institute.

Mehta, C., & Mehta, K. (2011). A Design-Space and Business-Strategy Exploration Tool for Infrastructure-based Ventures in Developing Communities. *International Journal for Service Learning in Engineering*, 30-57.

mHealth Alliance and Vital Wave Consulting. (2013, February). *Sustainable Financing for Mobile Health (mHealth).* Retrieved November 20, 2013, from mHealth Alliance: http://villagereach.org/vrsite/wp-content/uploads/2013/07/Sustainable-Financing-mHealth.pdf

Murphy, T. (2013, February 18). *Humanosphere.* Retrieved January 5, 2014, from mHealth Works, Now They Have to Prove It: http://www.humanosphere.org/2013/02/mhealth-works-now-they-have-to-prove-it/

Oliver Wyman. (2008, August). *Microfranchising at the Base of the Pyramid.* Retrieved Septemeber 12, 2013, from http://www.oliverwyman.com/media/OW_En_Community_Acumen2008MicrofranchisingWorkingPaper.pdf

Open MRS. (2013). Retrieved November 14, 2013, from http://openmrs.org

Osterwalder, A., & Pigneur, Y. (2010). *Business model generation.* 2010: John Wiley & Sons.

Pang, T., Lansang, M. A., & Haines, A. (2002). Brain drain and health professionals . *British Medical Journal*, 499-500.

Pang, T., Lansang, M., & Haines, A. (2002). Brain Drain and Health Professionals. *BMJ*, 324, 499-500.

Partners in Health. (2012, November 27). *Breast Cancer Groups Help Eliminate Stigma.* Retrieved December 1, 2013, from http://www.pih.org/blog/breast-cancer-support-groups-help-eliminate-stigma

Perry, H., & Zulliger, R. (2012, September). *How Effective Are Community Health Workers?* Retrieved September 25, 2013, from Core Group: http://www.coregroup.org/storage/Program_Learning/Community_Health_Workers/review%20of%20chw%20effectiveness%20for%20mdgs-sept2012.pdf

Piotrowski, J. (2013, March 25). *Sci Dev Net.* Retrieved November 1, 2013, from Upgrades to basic mobile phones aim for a smart future: http://www.scidev.net/global/systems/feature/upgrades-to-basic-mobile-phones-aim-for-a-smart-future-1.html

Poverty Facts and Stats. (2013, January 7). Retrieved January 2, 2014, from Global Issues: http://www.globalissues.org/article/26/poverty-facts-and-stats

PricewaterhouseCoopers. (2012, February). *Touching Lives Through Mobile Health: Assessment of the Global Market Opportunity.* Retrieved 12 2013, September, from PricewaterhouseCoopers: http://www.pwc.in/assets/pdfs/telecom/gsma-pwc_mhealth_report.pdf

Project Masiluleke. (n.d.). Retrieved November 1, 2013, from http://poptech.org/system/uploaded_files/27/original/Project_Masiluleke_Brief.pdf

Raja, S., & Dougherty, C. (2009). *Mental Health and Development Sustaining Impact, Annual Impact Report: 2009.* Retrieved October 7, 2013, from Basic Needs: http://www.basicneeds.org/download/annual_impact_reports/PUB%20-%20BN%20Annual%20Impact%20Report%202009.pdf

Robertson, J., Dehart, D., Heckerman, D., & Tolle, K. (n.d.). *Healthcare Delivery in Developing Countries: Challenges and Potential Solutions.* Retrieved November 13, 2013, from Microsoft Research: http://research.microsoft.com/en-us/collaboration/fourthparadigm/4th_paradigm_book_part2_robertson_heckerman.pdf

Schaefer, M. (2013, February 20). *Stanford Social Innovation Reiew.* Retrieved October 12, 2013, from Designing mHealth Programs with Scale in Mind: http://www.ssireview.org/blog/entry/designing_mhealth_programs_with_scale_in_mind

Slaughter, C. (2012). *Beyond the Hype: Driving Real Impact with Mobile.* Retrieved November 1, 2013, from Living Goods.

Squire, L., Jones, A. M., & Thomas, R. (2010). *Munich Personal RePEc Archive.* Retrieved March 12, 2013, from Evaluating Innovative Health Programs:: http://mpra.ub.uni-muenchen.de/29205/2/MPRA_paper_29205.pdf

UNICEF Zambia. (2012). *Project Mwana: Using Mobile Technology to Improve Early Infant Diagnosis of HIV.* Retrieved November 11, 2013, from UNICEF: http://www.unicef.org/partners/Partnership_profile_2012_Mwana_Zambia_V2_approved.pdf

USAID. (2012, October). *Annual Progress Report (Year 3) October 2011 to September 2012.* Retrieved November 3, 2013, from Securing Ugandans' Right to Essential Medicines: http://sure.ug/?download=Annual%20Y3%20progress%20Report%20-%20for%20distribution.pdf

Useem, A. (2012, December 11). Mobile health initiatives look to service providers for scale. Devex Impact.

VillageReach. (2012, August 21). *VillageReach Mission, Goals and Strategies for Fical Years 2013-2015.* Retrieved October 1, 2013, from http://villagereach.org/vrsite/wp-content/uploads/2013/03/VillageReach-Mission-Goals-Strategies-FY2013-2015.pdf

Vital Wave Consulting. (2009, Februrary). *mHealth for Development: The Opportunity of Mobile Technology for Healthcare in the Developing World.* Retrieved November 14, 2013, from United Nations Foundation: http://www.globalproblems-globalsolutions-files.org/unf_website/assets/publications/technology/mhealth/mHealth_for_Development_full.pdf

What is Telemedicine? (2012). Retrieved January 16, 2013, from American Telemedicine Association: http://www.americantelemed.org/learn/what-is-telemedicine#.Utl697ROmUk

World Health Organization. (2010). *World Health Organization.* Retrieved September 12, 2013, from Telemedicine Opportunities and Developments in Member States: http://www.who.int/goe/publications/goe_telemedicine_2010.pdf

World Health Organization. (2011). *mHealth: New horizons for health through mobile technologies.* Retrieved November 14, 2013, from World Health Organization: http://www.who.int/goe/publications/goe_mhealth_web.pdf

ACADEMIC VITA

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EDUCATION:

The Pennsylvania State University – University Park, PA 08/10 – Present
Schreyer Honors College
B.S. Industrial Engineering, Minor in Economics

RESEARCH EXPERIENCE:

Humanitarian Engineering and Social Entrepreneurship, University Park, PA 01/13 – Present
Concepts of Operations Team Leader

- Further developed the Mashavu Telemedicine System by organizing partnerships with businesses and universities
- Researched different failure modes of telemedicine systems in developing countries
- Worked with Mashavu Health Workers to create a standard training manual for future employee training

WORK EXPERIENCE:

General Electric Healthcare, Westborough, MA 06/13 – 08/13
Process Engineering

- Worked on a team to redesign a part of a product process for "Cellbag" assembly, reducing process time by 40%
- Completed a "5S" project to organize workstations in order to increase efficiency of quality inspections
- Collaborated with engineers to update 120 process procedures

General Electric Transportation, Erie, PA 05/12 – 08/12

- Managed 60 critical parts to simplify the process of conducting a product audit at the plant
- Developed system to track identifying, shipping, receiving, and processing infancy failures for all critical parts at the General Electric facility

AWARDS:

- HESE Change Agent Award (2013)
- Waltemeyer Howard Sr. Scholarship (2013)
- Van Dyke Memorial Scholarship (2013)
- Nelson/Magraw Scholarship in Engineering (2013)
- Alpha Pi Mu (2011 – Present)
- Schreyer Honors College Academic Scholarship (2010 – 2014)
- Dean's List: 7/7 Semesters