

Why do Entrepreneurial Health Ventures in the Developing World Fail to Scale?

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Abstract – Telemedicine has become an increasingly common method of improving healthcare access in the developing world. Despite the strong financial, logistical and clinical support from non-governmental organizations (NGOs), government ministries, and private actors alike, the vast majority of telemedicine projects are not designed for, or fail to survive, beyond the initial pilot phase and achieve their full potential. Based on the review of 35 entrepreneurial telemedicine and mHealth ventures, and 17 reports that analyze their operations and challenges, this article provides a narrative review of recurring failure modes, or factors that lead to failure, of such venture pilots. Real-world examples of successful and failed ventures are examined for key take-aways and practical strategies for creating successful commercial telemedicine operations. A better understanding of these failure modes can inform the design of sustainable and scalable telemedicine systems that successfully address the growing healthcare disparities in developing countries.

Keywords – telemedicine; community health workers; failure modes; mHealth; global health; business models

I. INTRODUCTION

Billions of people around the world cannot fulfill basic medical needs due to a lack of accessible medical personnel [1]. Many developing nations have trained volunteers selected by communities and equipped them to become Community Health Workers (CHW) to provide basic medical services. CHW programs have been implemented in countries around the world, from Pakistan to Kenya to Brazil [2]. While they have been effective in addressing health issues such as infant mortality, immunization coverage, and combatting HIV/AIDS, large-scale CHW programs have yet to become the panacea across the entire developing world [3]. Over the last decade, telemedicine and mobile health (mHealth) ventures have emerged to overcome healthcare access challenges. mHealth is defined by the United Nations Foundation as the use of mobile communications to deliver health-related services and products [4]. In the developing world, there has been a rapid increase in the number of mHealth ventures that leverage established CHW programs to access trained employees that are trusted by their communities. Over 350 mHealth projects have emerged in Africa alone [5]. With the rapidly growing number of mHealth organizations, the World Health Organization (WHO) has classified mHealth ventures into eight different categories based on products, services, and delivery methods. Mobile telemedicine is the fourth most frequently reported type of mHealth initiative worldwide [7]. Telemedicine is the use of telecommunications, cell phones, and the internet to store, exchange, and analyze health data [8]. Oftentimes in the developing world, telemedicine is used as a means to easily connect rural patients to medical professionals that could not normally reach. This method of healthcare delivery has become widespread in the developing world due to the ubiquity of cellular devices and improved network coverage [9] [10].

Although the numbers and diversity of mHealth and telemedicine systems being tested is increasing, the fact is that the vast majority of these ventures fail to grow beyond their initial

pilot stage [11]. For example, 23 mHealth organizations in Uganda and more than 30 mHealth pilots in India were unable to scale beyond the pilot phase between 2008 and 2009 [12]. Some of these pilot projects were scientific endeavors with limited project funding with no intent to develop them into financially viable enterprises. At the same time, others were entrepreneurial endeavors that failed due to a plethora of reasons including surviving the initial years needed to stabilize operations and have a positive cash flow. Subsequently, several countries like Uganda and Rwanda issued a moratorium on further telemedicine/mHealth pilots. This phenomenon of an increasing number of stagnant pilots has been termed “pilotitis.” Pilotitis refers to the challenge of telemedicine and eHealth projects failing to expand beyond the initial pilot and ultimately becoming sustainable solutions and organizations. A slightly different perspective on pilotitis emphasizes the need to stop running planned pilot projects and rather focus on implementing projects of meaningful scale.

It can be argued that tangible incentives for all stakeholders engaged in the venture can facilitate the sustainability and scale-up of telemedicine systems. Accordingly, a growing number of ventures are engaging local entrepreneurs and CHWs to operationalize interventions that tackle last mile health care challenges while creating jobs or providing frameworks for income generation and entrepreneurship. This article systematically examines entrepreneurial eHealth and telemedicine projects to determine documented and inferred failure modes that stopped the ventures from growing beyond their initial pilot phase. Entrepreneurs seeking to start and sustain similar telemedicine, eHealth and mHealth projects in the developing world can significantly benefit from understanding these failure modes before designing their systems and business strategies.

II. METHODS AND METHODOLOGY

This article is based on the systematic study of 35 entrepreneurial health ventures and 17 publications that analyze telemedicine and mHealth projects with a holistic perspective (See Tables 1A and 2A in the Appendix). Most of these ventures fit the core definition of telemedicine by leveraging telecommunications and electronic information to support health care at a distance. However, it should be noted that several ventures used in this study do not meet the criteria to be strictly considered telemedicine, but are considered to be mHealth, eHealth or entrepreneurial health ventures. While the findings are applied to telemedicine, several other health ventures provided valuable insights that can be applied to telemedicine venture pilots. Further, in order to maintain a sharp focus, a venture had to meet the following criteria to be included in the study:

1. Located in the developing world with a focus on African, Latin American, and Southeast Asian nations. This study did not include other parts of the developing world, such as South America and Eastern Europe. It should be noted that there are a few documented successful telemedicine projects in these parts of the world, including the Initiate-Build-Operate-Transfer project in the Balkans [13]. While projects such as this have been successful, many projects have not experienced similar success in Africa, Latin America, and Southeast Asia.

2. Engage local entrepreneurs or CHWs.
3. Provide primary medical care including health education, basic diagnostics, and medical supplies to customers.

For each project, we followed Chen et. al's approach and described the business model using Osterwalder's Business Model Canvas [14]. This provided a standard framework for understanding the operational and business model of the venture and identifying failure modes. A feature of any entrepreneurial health organization was considered to be a failure mode if it was determined to have a significant impact on the failure, or potential failure, of the venture to grow beyond a pilot phase. Not all of the organizations used in this study failed to scale to a national or international level. In fact, several of the organizations used in this study did not have any intention of scaling beyond a pilot for research purposes. These ventures were still used in the study to examine potential failure modes for those organizations who want to scale beyond a pilot. The major setbacks and challenges each of these ventures faced were considered to be failure modes for this study. The failure modes were subsequently categorized under six interrelated thematic areas.

The primary difficulty in conducting this study was the limited amount of information regarding commercial telemedicine systems in the developing world. Articles about the potential for telemedicine do exist, but many of these reports do not document specific challenges facing the commercialization and long-term viability in the developing world. Due to this lack of information, the research endeavor was broadened to encompass a holistic view of mHealth and entrepreneurial health ventures, not just telemedicine. Some of the challenges that mHealth organizations face do not apply to telemedicine, but the failure modes described in this study are nevertheless applicable to ventures across the spectrum.

III. RESULTS AND DISCUSSION

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 the rest of the article.

Table 1 – List of Failure Modes

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

A. 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." [12]. Often, without the continued funding from initial donors, high operating costs cause its eventual downfall.

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 [15]. 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 [16]. 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.

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 [17]. 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 [18]. 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.

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 [7]. 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 [19]. 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 [20]. 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.

B. Technological Capacities and Constraints

One of the fundamental tenets of telemedicine is the use of information and telecommunications technologies (ICTs) [8]. 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.

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 [21]. 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 [22]. 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.

2. Cell Phone Limitations

The popularity of cellular phones has increased ten times in the past decade, and is continuing to grow rapidly [23]. 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 these 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 [22]. 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 [24]. 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 a 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 [7]. With only a limited amount of characters per text message, telemedicine systems need to shorten and streamline text messages to convey practical and actionable health information and 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 [7]. 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 met 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 community health workers for the interactions.

3. Internet Capacities and Information Limitations

Internet bandwidth, and in particular, international bandwidth, is both scarce and expensive in developing countries [25]. 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 [26]. Sometimes, using international bandwidth can't 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 overcome inadequate internet bandwidth include store-and-forward mechanisms, low-bandwidth solutions, or storing information on easy-to-scan handwritten forms for 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 [27]. 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. 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' relation 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. 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 [28]. 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.

C. 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.

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 [29]. Both of these business setbacks significantly impeded the pilot growth. This venture shows that selecting trustworthy employees are vital, 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.

2. Finding Medically Knowledgeable Employees

Health professionals from developing countries are emigrating 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 [30]. 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 [16]. 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 (CFW) 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 [29]. 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.

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. [31]. 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. 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 of the venture. With a high demand and low supply of health professionals in the developing world, employees have to be properly incentivized even in the pilot stage. VisionSpring found that because of low wages, the first months of their venture had a very high employee turnover rate [31]. 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 time, they must be properly incentivized to stay beyond the initial pilot. This incentivization should be adequate to maintain dedicated individuals but 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.

D. Customer Interactions

Whether visiting an employee or receiving a text message, each interaction a customer has with the telemedicine system needs to be high quality.

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 [32]. 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 [33]. 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 [34]. 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.

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 [35]. 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 [36]. 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.

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 [37]. 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 6:00pm to 10:00pm were some of the most profitable times of the day [29]. 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 [15]. 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 [38]. 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. 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 [33]. 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 customers that the information being sent through the telemedicine system is reliable and trustworthy.

E. 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.

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 [39]. 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 [40].

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 [41]. This example illustrates the importance of a telemedicine system's reputation for both customers and other partnerships 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 initial 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.

F. Contextual Challenges

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

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 [42]. 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 [2]. 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 [43]. 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.

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 [35]. 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 weren't 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 [44]. 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

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 [21]. Without clear legal guidelines, it may be difficult to define the limits of a patient's privacy to 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.

G. 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 [16]. 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 [45]. 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.

IV. CONCLUSION

This article serves as a guide for both new and existing telemedicine ventures looking to expand beyond their pilot stage into sustainable and scalable telemedicine systems. The failure modes described in this article indicate that most of the problems facing telemedicine systems are not technological or clinical issues. The most significant barriers to telemedicine development in the developing world are social and economic in nature. Any telemedicine system in the developing world needs to ensure that it is effectively leveraging its resources in the country of operation to overcome any cultural barriers that could hinder development. Even with highly sophisticated technology, telemedicine systems will never be able to scale beyond their pilot without thorough knowledge of socio-cultural and business practices. Finding practical and innovative incentive models and accountability mechanisms for all the stakeholders is the holy grail of fighting pilotitis in the developing world.

Further research is underway to understand and articulate the impact of these failure modes on diverse telemedicine operational and revenue models. With a large number of mHealth and

telemedicine systems operating in the developing world, some failure modes impact particular business models more so than others. Systemic issues that influence the viability of telemedicine ventures are also being studied and will be the subject of subsequent manuscripts. For example, supply chain problems can hamper the growth of ventures that provide blood glucose tests, or other services that need constant supplies. As health ventures scale, they may have to rely on a combination of national and regional carriers to deliver products to remote areas [46]. These transportation costs can easily become a failure mode if they are not accurately calculated into the cost of telemedicine system operations. With extensive knowledge of all of these failure modes, telemedicine systems in the developing world will be able to combat pilotitis and grow into sustainable and scalable organizations that address the rising global health challenges.

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None of the authors for this publication have any commercial, financial, or legal associations that would create a conflict of interest for the purposes of this research.

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Appendix:

Table 1A: List of Ventures Examined

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 isn't even required
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 (company webpage)
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 – realise 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 kit of materials needed to market and sell eyewear. These salespeople receive training and support from local employees. These entrepreneurs also receive income.
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	MicroBusiness for Health (MBH) has developed 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.
35	JustTested (from external report)	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.

Table 2A: 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 Merrick 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.
Skoll Foundation World Forum	General webpage with articles about healthcare in the developing world
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.
InSTEDD	An mHealth service similar to OpenMRS.
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.
mHealth - beyond the pilot	An informal collection of mHealth and telemedicine ventures across the globe