Evaluating Applications of a Telemedicine Taxonomy on the Classification of Research

by

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ABSTRACT

By offering increased access to medical care, telemedicine offers significant opportunity for the process of development under Amartya Sen's definition, that development is freedom, including freedom from illness, early death, and preventable disease. It advances development by freeing people from these burdens. However, like many emerging technologies, organizing information and understanding the field faces significant challenges. This paper applies Bashshur's three-dimensional model of telemedicine to the classification of telemedicine literature found in databases to assess the value of the model as a tool for classification. By standardizing language and creating a repository of research done to date in a centralized location, the field can better understand how it is progressing and where work still needs to be done. This paper aims to see if Bashshur's model serves well for this task.

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CHAPTER 1

INTRODUCTION

For about two years, I served as a Peace Corps Volunteer in Western Panama. I lived with the the indigenous Ngäbe-Bugle Tribe, with no electricity, phone, or internet connection. During my service, I worked with The Floating Doctors, a non-profit medical organization, dedicated to providing free, quality healthcare to remote villages. I traveled throughout the region with the doctors, translating from the indigenous Ngäbe language to Spanish and English in about 30 communities they visited every one to two months. Though better than nothing, The Floating Doctors could only offer limited medical care because there were no means of communicating with the villagers and offering advice or care in-between visits in the case of ailments or emergencies.

From this experience, I began investigating the connection between medical care and telecommunications technology. I found that this problem of inaccessible healthcare appeared throughout the developing world. Currently, there are approximately four billion people without internet access and two billion without phone access (McKinsey & Company, 2014). At the same time, medical phone apps and video calling services have proliferated. For those with telecommunications services, resources for improved help continue to grow.

According to Dr. Amartya Sen, development is freedom (Sen, 1999). When people have freedom from violence, the freedom to educate themselves, the freedom to express themselves, etc., we can say that development is occurring. In this vein then, the freedom to receive medical care, the freedom of health, meaning freedom from preventable disease, premature death, and treatable illness, is a critical component of development. By improving the health of people, they can spend more of their time and energy on improving their lives and living out pursuits stemming from their aspirations, rather than just merely trying to survive. The key to this is improved healthcare. If people cannot access even basic medical services when in need, development is surely stymied.

One major barrier to providing medical care is a lack of infrastructural development and physical proximity to health services for the three and a half billion people who live in rural areas (Grammatis, 2014). However, this barrier has started to become less of an impediment as telecommunications technologies begin to penetrate these rural areas. Eric Schmidt, Google Executive Chairman, has predicted that the entire planet will have internet access by 2020 (Schmidt, 2013). This trend makes a relatively new type of medical care delivery more relevant by the day: telemedicine.

Telemedicine actually encompasses a number of technologies, from digital x-rays to over the phone consultations to video conferencing to remote surgery. Telemedicine is simply the use of telecommunications technology for the delivery of medical care or services. It offers the promise of granting access to medical care via video calls, emails, access to medical information, and remote diagnosis and care for these rural people in the near future. For the first time, the vast majority of the planet could be within the reach of medical care. This will change the course of development for many nations, as Amartya Sen would surely agree. Telemedicine delivers freedom by making it easier for people to access medical care. Rather than spending many hours or days traveling to a healthcare center, people can receive medical advice and consultation more locally, freeing up their time and increasing the ease of receiving care.

However, this emerging technology, like all emerging technologies, faces significant challenges before it can realize the potential it offers. Understanding the field as it grows poses one major hurdle. If we look at the development of technologies like email and cellular phones, we see that accurate information and understanding of the technologies in the developing country context drags behind the possibilities that it offers. For example, transnational corporations have a failure rate of 71% in adapting Western information-communication technologies (ICTs) to developing nations (Center on Transnational Corporations, 2010). This suggests a lack of adequate information or research around best practices for the implementation of emerging technologies in developing countries.

For academics and professionals, finding relevant and high-quality research about an emerging technology as the field develops in order to make best decisions poses significant challenges. Information is scattered across many places and significant gaps in the research exist. This holds true for telemedicine as well. It is difficult to find the latest information efficiently, leading to inefficient implementation of projects, repetitive research, and, ultimately, less development.

A better method is needed. This paper aims to test a taxonomy of telemedicine, developed by Dr. Bashshur, as a tool for the organization of existing telemedicine research so that these barriers to development can be overcome and the potential of telemedicine can be more fully realized.

Purpose Of This Study

The purpose of this study is to see if Bashshur's taxonomy can make it easier to classify and access telemedicine research for academics and professionals. Telemedicine can significantly improve access to medical care and the quality of medical care that people receive. However, to make this a reality, quality research must be conducted and easily accessed to learn from it. A vast array of academic literature about telemedicine exists. However, this literature remains largely unorganized. As such, it makes it very difficult to see overarching trends or themes within the literature for other academics and professionals to make better decisions. A framework is needed. The purpose of this study is to examine how Bashshur's three-dimensional taxonomy of telemedicine model serves as this framework. Bashshur's model will be used to sort a set of telemedicine research into the categories he created in order to decipher trends in telemedicine over time, place, and application and to more rapidly access and learn from specific subsets of research. Very little work has been done outside of Bashshur's taxonomy to create standardized language and organization within the field. The field is in disarray, with little clarity and structure (Bashshur, 2011). Previously, there has been little effort made to create a taxonomy. The only other available telemedicine taxonomy offers over 60 categories and additional subcategories (Tulu, 2007). This makes it difficult to realistically use. Bashshur's taxonomy offers the most organized and coherent taxonomy of telemedicine and thus serves as the best option for classifying academic literature. The hope is that Bashshur's model can be used to accurately classify telemedicine literature, allowing people to draw better insights, more quickly, from the literature that exists. This study will see if that is the case and discover where it does and does not work well. To date, many researchers have noted that telemedicine has fallen fall short of realizing the full potential it offers for improved care in both developed and developing nations. The hope is that a system of taxonomy and classification will improve the efficiency and efficacy of researchers and professionals in the spread and optimal use of telemedicine technology. By better understanding how this field has developed, the potential to improve outcomes and medical care for people throughout the world becomes more realistic. Because the stakes of development and the potential of telemedicine are so great, any tool to better understand how this process occurs offers a lot of value.

Problem Statement

Emerging technologies offer great potential for development as well as great challenges. While new technologies can increase access to basic human services, increase efficiency, and alleviate poverty, they also lack sufficient research and shared best practices to be applied as effectively as possible in the development context. The same holds true for telemedicine. While telemedicine can potentially deliver access to healthcare services to a much larger population, these projects fail to meet their objectives over 63% of the time (Rothland, 2012). One cause of these repeated failures stems from the difficulty of learning about the research that has been conducted. Multiple databases, with differing inclusion criteria present telemedicine research in fragmented segments. Within the research, terms are not used uniformly and even contradict one another at times. Especially within the realm of ICT technology, where advances occur rapidly, telemedicine's applications continue to change. This leads to confusion. It is also difficult to know where gaps in the research exist. The lack of a structured, centralized repository with clear criteria makes understanding, utilizing, and improving upon the telemedicine research that has been conducted very difficult.

With these barriers in place, it is essential that a clear view into the research that has been conducted and the outcomes of that research can be understood by those working or looking to enter into this critical field. At present, this is nearly impossible because it is unclear how one could easily access and review all of the available information. A fragmented look at the data increases the likelihood of repetition, misunderstanding, and inefficiency.

Telemedicine technically allows for the remote application of medical services. Distant countries and regions have started to form thicker connectivity via telemedicine. However, again, structural realities continue to favor the advantaged in this regard over the disadvantaged. The agreements forged for the sharing of medical services both by region and internationally occur within the framework of the "healthcare system" (Wicklund, 2014). The global healthcare system consists of institutions and medical networks that do not provide care to disenfranchised and fringe groups within society, the people that need it most. It is a cruel paradox that with the potential to do such good and to reach these people for the first time, the benefits of telemedicine have largely gone to those already well-within the healthcare system. However, without a clear view into this trend for the layman trying to access research, it is unlikely anything will change.

With telemedicine on the rise and opportunity to increase impact becoming more realistic, it also becomes more complicated and difficult to understand and organize telemedical information by the day. The challenge of bringing structure to a system that already has a significant presence will only get harder. Taxonomy in telemedicine offers a means for both standardizing communication and structuring the historic work done in this field (Tulu, 2007).

The law poses one of the most significant barriers to the widespread distribution of telemedical benefits. No international framework exists for physicians to deliver telemedicine to jurisdictions and countries outside of their own, protecting privacy and confidentiality via data transfer, authenticating health professionals, and how to handle liability (World Health Organization, 2009). Here again, we find that the institutions that govern society disconnect healthcare from individuals by placing bureaucratic barriers in the way. There are many potential factors contributing to this, but a lack of organization is fundamental to resolving any others. If people could see information more easily, these systemic injustices would be harder to uphold. But, how can people come to agree and understand one another if some baseline of common nomenclature does not exist to begin with? How are marginalized people, structurally excluded from society, going to receive care via telemedicine, a technology increasingly governed by these same disorganized structures? As Albert Einstein said, “we can’t solve problems by using the same kind of thinking we used when we created them.”

The irony is that, once utilized, telemedicine has been shown to have snowballing effects for the quality of care delivered in both developed and developing countries, including follow-up care, and tertiary care advice. People in developing areas seek out care earlier and adhere better to prescribed treatments. The technology also benefits medical professionals in rural areas, giving them access to specialist opinion and information, reducing the need to transfer patients, eliminating the expense, time, and stress of travel, and increasing practitioner retention in rural areas (World Health Organization, 2009).

In addition, other barriers, like ICT literacy, infrastructure, and linguistic and cultural differences, means that telemedicine primarily reaches people in industrialized countries, not developing countries, especially on a direct level (World Health Organization, 2009). These barriers will be present in the application of any technology to the developing world. How then are we to overcome them in order to fully realize the potential that technology has to transform the developing world? At present, it is impossible to answer these questions because it is impossible to understand with confidence what attempts have been made to solve this problem on a wide scale. Access to the information needed for better decision-making, in the use of telemedicine both in developed and developing countries is a prerequisite to good decision-making. Bashshur's taxonomy offers a potential tool for improving access to existing telemedicine research for academics and professionals in the field of telemedicine.

Significance Of The Problem

Over one billion people have no physical access to medical care in any form (Lane, 2012). Many more surely live with insufficient and low-quality care. This negatively impacts the opportunity and potential for people to live free, developed lives. At the same time, a lot of work is being done about using telemedicine to fill this gap. However, information on the research being conducted and the ability to learn from it is poorly organized and understood.

This research hopes to see how Bashshur's taxonomy functions as a means of organizing telemedicine information so that a more data-driven approach to research in the field can flourish. In doing so, one can better understand how telemedicine actually gets utilized in the world and make more informed decisions on where to continue research and how to best implement telemedical interventions. Ultimately, this can lead to better implementations in the field using telemedicine for development. With the life-changing potential of this technology it seems highly important for information on research in the field to be easily accessed and learned from. By learning more about actual practices, academics and professionals can better see trends and find where the potential of telemedicine is not being realized for development. Because of the relatively new growth of the field on a global scale, a cohesive and ordered organization or collective has not formed to catalogue and identify trends and tendencies. Additionally, it is difficult to find information from the digitally unconnected, because, by definition, they have no ability to communicate on a global scale.

This research believes that telemedicine has the potential to change who receives health care and how they receive it. Clearly, if the physical barriers between medical practitioners in one location and patients in another location can be eliminated so that care can be delivered, new opportunities for receiving care become possible for people who previously did not have healthcare access. Emerging technology as a whole has a long legacy of potentially benefitting the poor and disadvantaged without actually doing so. There are some instances where technology has improved the lives and opportunities of the disadvantaged though, for example, ARVs for AIDS treatment (WHO, 2003) and internet access for strengthening the economy (The World Bank, 2013). If we can better understand where this is occurring, why, and in what context, then technology that will benefit the disadvantaged can be designed and employed with greater intention. A taxonomy makes this possibility a reality by providing the tools to organize information consistently and coherently and to access that information efficiently. Under Sen's definition of development, if researchers and telemedicine professionals have the freedom to access information more easily, then development can progress. In this case, that freedom gives researchers and telemedicine professionals the time and knowledge needed to push their field forward successfully.

It is critical that disadvantaged people receive the potential benefits of telemedicine. Identifying if they are, where they are, and where there are divergences from optimal conditions lays the groundwork for better realizing this potential. Assisting researchers and practitioners in the field with an organized view of the work is a critical step forward.

Limitations

This study draws data about telemedicine utilization available on the internet. It is not necessarily the case that all instances of telemedicine utilization appear digitally. In fact, it is likely that there is a negative correlation between the remoteness of a telemedicine utilization and its appearance on the internet since institutional utilizers have a higher likelihood of producing and publishing literature about their work. As a result, there may be a disproportionate representation of institutional telemedical utilizations available online. Additionally, often telemedicine practicioning in rural locations within developing countries is, formally, illegal for most physicians to execute. Due to the potential consequences for a physician's career for participating in these rural telemedical acts, there may be a lower likelihood of any public disclosure of this activity. This, again, may result in a disproportionate representation of institutional and inter-institutional utilizations available online.

CHAPTER 2

LITERATURE REVIEW

The summary of available literature on the spread, uses, and effects of telemedicine globally presents a technologically-driven system that has the potential to fill gaps in the delivery of healthcare. However, there is room in the literature to explore how telemedicine has actually spread, been used, and caused change on a large-scale. There are countless articles on the rise of the internet and globalization from a conceptual vantage point. Though contention remains as to what globalization actually entails, it is widely agreed that some process that the term "globalization" represents has started, and continues, to progress.

Literature on the application of emerging technologies to developing countries and the relationship between health and development, in general, is easy to find, though a specific focus on telemedicine is not. This information points to large-scale errors in the application of emerging technologies. Clearly, improved healthcare is a critical focus of development as well.

There are many anecdotes about the utilization of telemedicine for delivery of health care to disadvantaged peoples in developing countries. There are entire papers dedicated to single projects. This does not point to the widespread use of telemedicine in rural settings. That a single project merits an entire article in multiple instances suggests that these projects are unique. Much of telemedicine happens between institutional hospitals, certainly a boon, but not the access-enabling application that many prognosticated.

The lack of academic research around a high-level view of the spread, uses, and effects of telemedicine in reality presents a starting-point from which to evaluate the methodologies and systematic growth of telemedicine worldwide. The question can be posed: Is telemedicine really changing anything?

Emerging Technologies in Developing Countries

While emerging technologies often have the potential to impact the lives of the poor positively, this potential is not often realized. The institutional support and infrastructure to make these technologies function well is often lacking in developing countries (Gunasekaran, 2007). Without an educated population, electricity, and political organization, implementing widescale change poses major challenges that speak to systemic issues. It is easy to mistake the technology as having failed, but it is just that they are not always appropriate for the developing nation context.

An excellent example of the potential and differences of emerging technologies in developing countries is the spread of cellular phones throughout Africa over the past ten years. Cell phone penetration in Africa has increased by over 4,000% over the past ten years (Malapile, 2013). At the same time, electricity has not reached many of the places that cell phone service does. This means that though many own cell-phones, they are used in different ways than in developed nations. They are typically kept off and only powered on when needed for a call. Additionally, calls are usually made for essential needs, not for casual chit-chat. This means that subscribers pay much less per month than they do in developed nations, making it impossible to cover certain regions if one expects to make a profit.

It also tends to be the case that errors are made because of inadequate availability of information on emerging technologies. As the field emerges, information lags behind the current state of the technology (Ragossnig, 2015). Examples of this include the proliferation of email, text messaging, and Skpe. Data on the value of these technologies did not arrive for years after they were widely used. People had to figure it out for themselves, based mostly on intuition. As such, it is difficult to make informed decisions and find best practices for using these technologies in new contexts. Inefficiencies and unmet potential occur as a result.

The internet is probably the best example of what was once an emerging technology with poorly understood implications. Now, it has been shown that a 10% increase in internet penetration increases GDP by 1.4% (The World Bank, 2013). At first though, few understood the implications of worldwide connectivity. Only until the internet reached high enough adoption levels did the potential for it to improve and change our lives and effect development by improving the freedom of information did the internet's promise become clear.

Development and Healthcare

Healthcare in developing countries poses significant challenges. It is the major focus on large non-profits, like the Bill and Melinda Gates Foundation, and a consistent source of frustration for many governments. One major challenge in delivering successful care in the developing country context is the lack of data available on rural populations, making evidence-based public health decisions much more difficult. (Pearson, 2010). As a result, traditional practices and systems remain in place, even when new options become available. Decisions are relegated to little more than guesses.

At the same time, great strides are being made in the improvement of medical care. Child mortality rates and deaths from preventable diseases continue to decrease and major viruses have been eradicated. Some of this progress can be directly attributed to the emergence of new technologies and medical solutions reaching developing nations (WHO, 2007). What we see is that technology has the power to improve healthcare in developing countries, but systemically applying it is difficult. How can one know what works and to scale those solutions effectively?

Just like any emerging technology, the technology of healthcare needs to be adapted and understood within the context in which it is introduced. Finding a fit between a context's needs and the healthcare model delivered, appropriate healthcare, makes the difference in life and death outcomes (Patel, 2008). We can find telemedicine situated within this discussion. How can this group of technologies for delivering care be best adapted to the needs of the people receiving care? Is there a bias towards certain population groups or types of interventions? We can only begin to answer these questions with a cohesive view into the data.

What is Taxonomy?

Taxonomy, the formal study and theory of classification, arose as a byproduct of the enlightenment (Herbinson, 2011). Leading thinkers of the day began created methods of organizing information into various scientific fields, naming plants, animals, rocks, anything, in great numbers. By creating these naming systems, it became possible to discuss, compare, and contrast systems, organisms, and ideas with greater ease. It many ways, taxonomies were seen as a means of man asserting his dominion over the natural world.

Early on, plant and animal taxonomies were of special importance (Robinson, 2001). By studying plants and animals, people believed they could garner greater insights into the nature of the universe. It is also a necessary prerequisite for creating beneficial medicine, studies, or science involved with these animals.

However, though taxonomy seems like an inert and plain field of study, it is wrought with controversy. For example, delineating between where one species ends and another begins has led to many disputes amongst biologists (Dayrat, 2005). From the get-go, taxonomy has created argument due to the inherent strength and weakness with it – artificial groupings. These types of artificial groupings are essential to producing meaning, but also do not perfectly align with the reality of the natural universe. Much of nature exists on a continuum, not in clear groupings. We see overlap amongst species' characteristics and even their ability to produce offspring together. When people argue about the nature of categories, they are arguing with the nature of reality itself. The power of naming things, the fundamental building block to rational investigation and discussion, though seemingly uncontroversial, contains a lot of importance. It is the essence of what knowledge is built upon.

However, it is widely understood that taxonomies, though often seen as the starting point of scientific structure, are not fundamental, but a human construction. Other modes of sorting, demographic surveys, hierarchies, ideal-types, etc., possess equal validity in terms of their "constructedness" (Ashgate, 2011).

In essence, understanding taxonomy and debates over naming raise interesting ontological issues at the nexus between abstraction and practical application (Anderson, 2005). Though much can be made of what the best means of constructing meaning is, at some point, ideas must be named to function at all. In the realm of the biological, this is one challenge, but in the realm of social sciences, the focus of this paper, this challenge becomes even more acute. Rather than classifying concrete, physical things, ideas and language is being classified. This offers a second degree of construction that makes the whole enterprise inherently more unstable.

What is Telemedicine?

Dr. Bird, who coined the term "telemedicine," understood it as "delivery of care without the usual patient-physician confrontation." This definition is not adequately defined though. Because of the political, social, and moral implications of telemedicine, a broad and agreed upon definition has not really solidified (Bashshur, 2011). A better understanding of the term can emerge from breaking telemedicine down into its component parts, functionality, application, and technology. Functionality denotes the component parts of the medical care process - prevention, diagnosis, treatment, follow-up, and rehabilitation. Functionality can be understood as telemedical in nature when a telecommunications linkage mediates some part of the medical care process. Applications include processes of care across medical specialties, sub-specializations based on disease entities, sites of care, and treatment modalities. Telemedicine occurs in application when a telecommunications facilitates this process. Finally, technology encompasses the components of synchronicity, network design, and connectivity. When these features are created for medical ends, they can be classified as telemedicine (Bashshur, 2011).

What isn't Telemedicine?

To define the scope of this study, it is important to delineate what may seem like telemedicine, but is in reality something else. A term commonly interchanged with "telemedicine," is "telehealth." Best understood, "Telemedicine" is to "Telehealth" what "Medicine" is to "Public Health." Telehealth's domain encompasses that of public health, with a telecommunications function, application, or technology mediating the process. This includes epidemiology, health behavior and health education, health services management, environmental and industrial health, and biostatistics (Bennet, 1978).

Another commonly associated term with "telemedicine," is "e-health." E-health, like the prefix "E-" used in many internet-related processes, denotes some vague relation to the internet and health. This word has been loosely defined, but can be understood to contain electronic health records, health information, clinical decision support systems, and physician order entry (Rizo, 2005).

Finally, the term "m-health" seems to pertain to "telemedicine" as well. M-health appears in the literature in 2003 in response to the expansion of mobile technology for facilitating medical care. M-health can be understood as being comprised of the components of clinical support, health worker support, remote data collection, and a helpline (Istepanian, 2004).

History of Telemedicine

The prefix "tele-" was first used in a medical context in 1905 by a Dr. Einthoven, a Dutch physician and inventor, in reference to a "telecardiogram" In 1950, the term "telognosis" was documented by an inventor, Cooley, in reference to the transmission of radiographs. The first documented use of the term "telemedicine" occurred in 1967 by a Dr. Bird (Bashshur, 2011).

The thought of creating a mechanism of exchange of medical services between distant regions has its roots in the early 1900's as well. Prominent physicians decried state boards of accreditation as barriers to the adequate delivery of healthcare and an undue burden on physicians as early as 1901 (The Washington Post, 1901). Internationally, countries have been willing to agree to an exchange of medical services in times of crisis, like Belgium and England in World War I (The Lancet, 1915). In 1945, the issue was also broached between England and France. However, this raised the important question of exchange between unequal powers (Nunan, 1945). Why should a country with a good supply of doctors agree to an exchange and inevitable loss of expertise through the process of diffusion into a less medically developed nation? This question remains pertinent today. It speaks to how medical infrastructure is incentivized and weighed against a moral/ethical duty to act. The first link to physicians and stations in remote areas occurred in the 1920's (Rosen, 1997). The concept of telemedicine is simple – administer care remotely to places it is difficult to reach. The problem comes in who can pay for this care, the legitimization of delivering this care, and the construction of infrastructure in these remote areas, which is just as inconvenient. Only in the 1990's did telemedicine really begin to become a practical reality in any application. This first manifest in centralized, telemedical linkages between hospitals in urban and semi-urban locations (Cochrane Database of Systematic Reviews, 2000).

Globalization and Telemedicine

The meaning of globalization and its relation to medicine holds valuable information. Medical technology, particularly telemedicine, has called into question the meaning of "place," bringing health services to populations that were previously too distant to receive it (Dyb & Halford, 2009). Still, location plays a major role in the quality of care that individuals receive. There is a tension present in the global versus the local. Furthermore, medical technology seems to be restructuring social order to some degree. By extending healthcare to remote areas, these populations are classified and managed differently, in what resembles an *actuarial* model of understanding (Cartwright, 2000). This serves to create groupings of people that receive individualized healthcare and those that receive healthcare tailored to population management and disease control. At the least, two groups are emerging with different health rights. There are obviously powerful forces at play. How these tensions are navigated is not a matter of fate, but of policy and action. Multiple models of globalization can emerge, “unipolar globalization,” based on exclusivity, and “multipolar isolationism,” based on protectionist trade barriers and internal repression, being two undesirable possibilities (Frenk, 2005). Constructing a less sociologically violent and inclusive model seems far more desirable. To build this type of system, an understanding of how and why policy decisions are unfolding in their specific way is of vital importance.

It seems that there is support in the medical community for a more global system, generally. Over 90% of physicians surveyed by St. George University in Grenada said that a global accreditation authority would be beneficial (St. George University, 2013). However, the physicians had much less unanimity with more detailed questions about how to structure such an authority, what standards to apply, or what its ultimate effect would be. There are several approaches to merging disconnected medical systems. Approaches include cross-border exceptions for consultants, mutual recognition, reciprocity, endorsement, limited licensure, national licensure, and registration (Telemedicine Report to Congress, 1997). With each of these methods, there are the elements of inclusivity (who can participate?), agency (how can they participate?), and conditions of association (in what scope can they participate?) that are at the heart of what is being negotiated.

The Common Assumption

One can find a nearly endless supply of academic literature and casual writing that suggests telemedicine revolutionizes healthcare for the better. Theoretically, telemedicine can deliver care to the most distant reaches of the earth. However, little work has been done to examine where new care actually appears. A pre-requisite to receiving telemedicine is internet access. Unfortunately, only 1/3rd of the planet currently has internet access, mostly in developed nations (Internet.org, 2014). This then limits who receives care and still requires the most rural people to travel great lengths to access a health care system that already marginalizes them. Major barriers to delivering internet access to remote locations include low-profits for telecommunications providers, undeveloped transportation infrastructure, and difficulty doing maintenance (McKinsey & Company, 2014). As a result, only people on paved roads, near hospitals already, and with a decent wage have regular access to telemedicine.

Organizing Academia

Academia is an expansive, nebulous complex of institutions, individuals, and ideas. It holds interest for almost every person and organization on earth, for greater opportunity, the discovery of knowledge, and advances in business and technology. With such a complex of interests, it is no surprise that academia lacks sufficient organization. Attempts to govern academia have been around since the beginning of formal education (Ehrenberg, 2004). Hierarchies of power and discipline, from administrator, to educator, to student, created some semblance of order. However, with the expansiveness of the field and the relatively new ability to communicate around the world, though the potential for greater collaboration and discovery exists, much of the organizational infrastructure does not.

Some have theorized that the rise and proliferation of information technology marks the end of the organization of knowledge, that the abundance and coordinating requirements of information have exceeded human capacity (Brown, 1998). However, it seems that there is a way of creating compatible organizational and technological architectures to help further the production of human knowledge.

An obvious place where knowledge and technology intersect is within databases. Databases are another fundamental human construction, not far distant from taxonomies for the classification of information. Again, disagreements agree as to how to best arrange these constructions for the optimal production of human knowledge (Silberschlatz, 2006). What types of searches are possible, what types of literature are included, the inclusions of private business research, compatibility with other databases, and many other topics are points of contention, where humans must decide what is best. This value judgment creates unseen biases within databases that are hard to see and uncover due to the large size and seeming innocuousness of what databases are. In essence, they are gatekeepers.

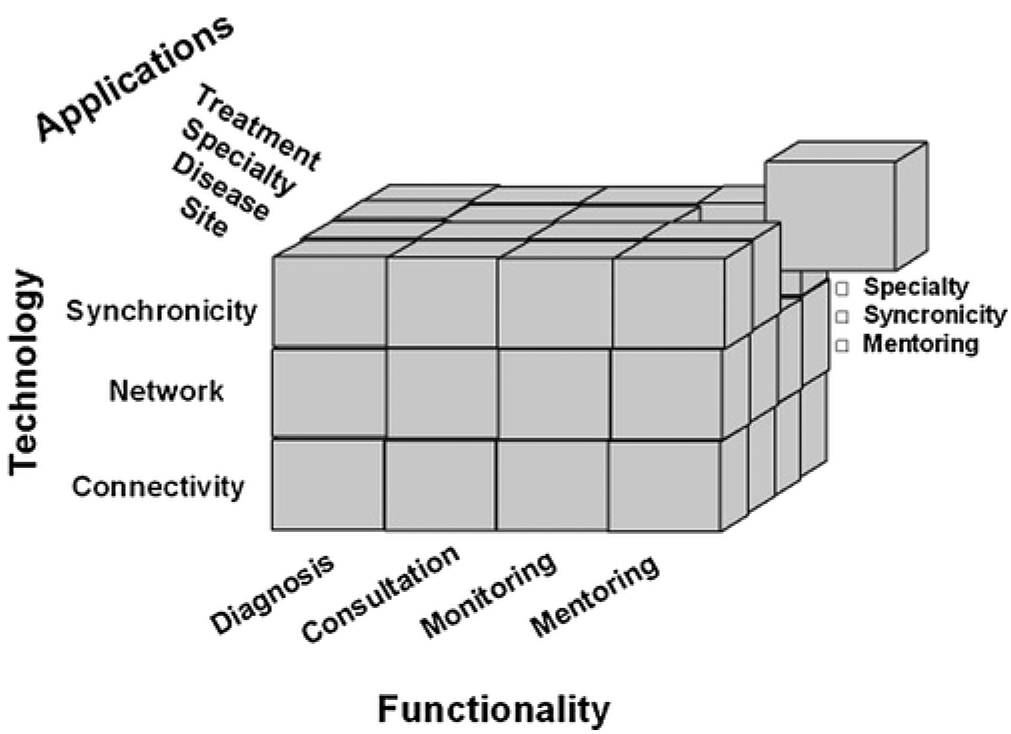
Within telemedicine, there have been two taxonomies created to date. One by Bashshur and one by Tulu. I chose to use Bashshur's taxonomy for this paper because it offered much greater simplicity and clarity than Tulu's. Bashshur's model contains 11 categories for classification while Tulu's contains over 60. With a good deal of subjectivity already in place in the act of classifying using a taxonomy, it seems best to reduce this complexity as much as possible. With over 60 categories, it seems unlikely that literature could be consistently classified.

CHAPTER 3

METHODOLOGY

Bashshur's relatively simple and well-defined model seems to offer the best existing taxonomy of telemedicine for dealing with large quantities of academic literature because it is the most clear. To assess the efficacy of Bashshur's three-dimensional model of telemedicine taxonomy as a tool for the classification of telemedical research, the model will be used to sort through two databases' results of telemedicine literature.

Fig. 1: Bashshur's Three-Dimensional Model of Telemedicine



Using this model, this study will look to locate how the telemedical ecosystem is structured and view of how it is evolving. Within the Applications group, there exists four categories that literature can be grouped into. Treatment literature, focused on the act of actively resolving an illness, Specialty, focused on an application within a specific medical field, Disease, focused on a specific illness, and Site, focused on the location that telemedicine is conducted. Within the Technology group, there are three categories. These include, Synchronicity, focused on real-time communications across multiple physical locations, Network, focused on sharing knowledge and advice amongst people across different locations, not in real-time, and Connectivity, focused on sharing specific medical information across different locations. The final category is Functionality, which includes four categories. These categories are Diagnosis, focused on identifying a specific illness, Consultation, focused on a doctor interacting with a patient, Monitoring, focused on regularly collecting information on the health of a patient, and Mentoring, focused on a medical professional providing advice and guidance to another medical professional.

This model can be used for comparison to economic, educational, and sociological measures the world over. We can use this model by classifying telemedicine applications within its three dimensional matrix. Each piece of research will be placed into a subcategory within each category, functionality, technology, and application. This will produce a "location" in which that research resides. After processing all of the research generated through a query of multiple databases listed below, we will have a representation of where (meaning what classifications) telemedical applications are playing out in practice.

Study

This study will employ a systematic review of data as processed in published literature to assess the implementation and outcomes of telemedicine, the world over. The review will seek out and analyze the content of literature regarding instances of telemedicine implementation, classifying them according to Bashshur's three-dimensional model of telemedicine across the three broad categories he has defined, application, technology, and functionality. This methodology is an adaptation of The World Health Organization's review of telemedical applications in developing countries, instead adapting it to compare and contrast telemedicine across the entire planet. Since research serves as a strong proxy for the newest and most advance uses of telemedical technology being implemented, understanding current research can point us towards how the field continues to develop.

Inclusion Criteria

The literature review will include clinical studies, feasibility studies, and review articles that meet the following criteria. In essence, any research that had a primary focus on telemedicine and could meaningfully fall within the categories of Bashshur's taxonomy from the year 2014 were included. In total, 815 unique pieces of research were included and classified as part of this thesis:

1) Participants: The review includes health-care practicioners from any discipline using telemedicine and patients receiving care via telemedicine.
2) Interventions: The review includes any instance of the application of telemedicine as defined by Bashshur's three-dimensional model of telemedicine.
3) Outcomes: Studies were included if they looked at patient outcomes, research and evaluation processes, or the education of health-care providers.
4) Publication Date: Literature eligible for inclusions had to have a publication date of January 1st 2014 to December 31st 2014.
5) Language: Only studies in English were included.

Exclusion Criteria

The review excluded studies that examined technical specifications of information and communications technologies used for telemedicine or studies where the primary application of the telemedicine was for administration rather than education or patient care. Additionally, studies that are otherwise deemed unsound or incomprehensible for means of classification will be excluded from the sorting process as well. In essence, anything that did not show a primary focus on medical care and telemedicine as excluded from the classification process. Research that did not fit into the parameters of Bashshur's categories did not get included, since, by definition of the taxonomy, these instances are not clear examples of telemedicine. In total, 54 unique pieces of research were excluded from classification. These pieces were excluded for a variety of reasons, but most only briefly referenced telemedicine and did not focus on it within the research.

Literature Search Strategy

The literature review will draw from the following databases: Medical Literature Analysis and Retrieval System Online (MEDLINE) and The Latin American and Caribbean Health Sciences (LILACS).

The databases will be searched for the term “telemedicine,” “tele-medicine,” and “tele medicine.” This search will look throughout the entire body of literature, not just the title of the literature. This is an effort to ensure that telemedical research, whether or not the individual researcher has classified it as such within the title, arise through the search of the database.

Selection and Processing of Studies

The studies retrieved from this database search will be appraised to identify those that fall within the inclusion criteria. Once this search is complete, I will include the number of studies returned from the search and the number that were actually included in the review here. Each of these studies will then be classified, placing it within Bashshur’s three-dimensional model and in the developing or developed world category. After this classification process, the data will be examined to see what trends and tendencies arise, drawing themes about the global direction and application of telemedicine. Part of this process is inherently subjective. As such, after the sorting of studies is complete, they will be reviewed within the categories that they were placed in to determine consistency and alignment. In a more expansive study, this information could be sorted by multiple people and differences compared in order to view how sorting varies amongst different individuals.

CHAPTER 4

RESULTS

Below are three charts showing the distribution of telemedicine research literature across the Medical Literature Analysis and Retrieval System Database and the Latin American and Caribbean Health Database. Though other databases were initially searched, the searches returned either zero or very few results. These charts break down each literature piece categorized into 1 of the 48 possibility categories across the three different domains of classification mentioned above.

Figure 2: Medical Literature Analysis and Retrieval System Results

		Treatment	Specialty	Disease	Site
Diagnosis	Synchronicity	3	13	1	6
	Network	9	8	0	3
	Connectivity	22	33	0	5
Consultation	Synchronicity	37	14	0	8
	Network	3	0	0	9
	Connectivity	55	3	0	4
Monitoring	Synchronicity	2	6	4	0
	Network	5	0	7	0
	Connectivity	3	31	2	0
Mentoring	Synchronicity	12	0	3	0
	Network	43	12	9	0
	Connectivity	41	0	12	0

Figure 3: Latin American and Caribbean Health Database Results

		Treatment	Specialty	Disease	Site
Diagnosis	Synchronicity	5	17	1	12
	Network	13	18	1	7
	Connectivity	12	20	0	10
Consultation	Synchronicity	55	3	0	5
	Network	8	3	0	1
	Connectivity	23	8	0	2

Monitoring	Synchronicity Network Connectivity	0	9	1	0
		7	0	4	0
		2	21	9	0
Mentoring	Synchronicity Network Connectivity	20	0	0	0
		30	10	4	0
		21	2	22	0

Figure 4: Combined Database Totals

		Treatment	Specialty	Disease	Site
Diagnosis	Synchronicity Network Connectivity	8	30	2	18
		22	26	1	10
		34	53	0	15
Consultation	Synchronicity Network Connectivity	92	17	0	13
		11	3	0	10
		78	11	0	6
Monitoring	Synchronicity Network Connectivity	2	15	5	0
		12	0	12	0
		5	52	11	0
Mentoring	Synchronicity Network Connectivity	32	0	3	0
		73	22	13	0
		62	2	34	0

Data Analysis

The three tables show the resulting distribution of classified telemedicine literature divided into results from the Medical Literature Analysis and Retrieval System Online Database, the Latin American and Caribbean Health Database, and a table with their combined totals. By profiling two different databases, it is possible to demonstrate how the classification system based upon Bashshur's taxonomy can be used to look at literature across different databases and raise questions based upon the results. The classification of 815 separate pieces of literature done as part of the work for this thesis provides a sufficient foundation to test and consider using Bashshur's taxonomy in a wider application. This is not meant to be a comprehensive process, but, instead, an exploratory one. As a whole, being used simply as a tool for classifying telemedicine, Bashshur's taxonomy functions well. However, as the discussion below will mention, the process of classification and standardization possesses a good deal of complexity that Bashshur's taxonomy cannot resolve alone.

To begin, one must look at the numbers. These classifications yield some consistent trends across the two databases that merit further consideration. The main points to consider are categories with consistently high numbers of literature, absent numbers of literature, and categories with a large discrepancy between the two databases, relative to the total number of classified pieces of literature. Though we cannot draw final conclusions through the comparison of two databases, the databases provide sufficient content to being to look at the questions, strengths, and weaknesses, that Bashshur's taxonomy can allow a researcher or business professional to begin to examine. Though this paper will look more closely at these basic comparisons, focusing mostly on cross-database comparisons, other comparisons could be easily made. These include looking more closely into relationships with how regions or countries or the economic strength of nations relates to the type of research being done and getting published throughout the world. Additionally, one could use the classification system to look at changes to the distribution of classified literature over time. This would offer insight into how the field of telemedicine has evolved over time. One could even extrapolate trends from historical data to predict the type of research that will be done going forward, perhaps even helping researchers find funding for the research they want to conduct. Additionally, funding sources for these studies could be traced back to look more closely at what kind of financial source is leading to what kind of research. Finally, one could break down the types of research being done and correlate them to different academics to see who specializes in what type of research. Researchers could also more easily find where to fill the voids in the field by quickly seeing what research has already been done. With a fuller view into the general types of research being done, a whole new set of data becomes available that can be compared and juxtaposed in an almost endless number of ways. As the already substantial body of telemedical and associated types of literature continues to burgeon, the importance of this type of systematic classification system will only become more indispensable. At its base, Bashshur's taxonomy is a system of organization. In some ways, though a logical and coherent taxonomy system is necessary, it is the existence and use of any type of taxonomy like this that matters more than the specifics of how that taxonomy defines categories.

The three categories with the greatest amount of literature are consultation-synchronicity-treatment (CST), consultation-connectivity-treatment (CCT), and mentoring-network-treatment (MeNT). Most notably, all three of these categories contain the "treatment" attribute. This means that, at least within these two databases, research focused on treatment occurs most often. The greatest amount of literature, CST, pertained to work done with direct consultations, happening in real time, focused on treatment. Most of this literature looks at variances in outcomes related to doctor-patient interactions that happen via voice or video. This is not a surprising result. Telemedicine allows people to communicate without being in the same physical location. These studies look at the impact remote communications has in relation to in-person interaction. The second most common category, CTT, contains studies looking at different modes of "connectivity," basically variances in how the telemedicine is occurring, be it video, voice, text, a combination with in-person visits, etc. Again, this is a less than surprising result. It seems that academics want to see if the medical outcomes seen from in-person medical evaluations can be reproduced remotely and the best ways to do that remotely. Finally, the third most common type of literature is MNT. This type of literature looks at the efficacy of transferring knowledge and advice remotely via a network approach, meaning discussion boards, online platforms, and websites. This is also a common focus of how one might imagine telemedicine being used, transferring the knowledge of specialists to a wider audience without requiring the limited time of that specialist, on-demand. With all of these commonly occurring categories, the general motivation seems to be comparing standard medical practices to the new treatment modalities that become possible when long-distance communications becomes an option.

On the other side of the spectrum, there were quite a few categories that had no instance of literature occurring. These include monitoring-network-specialty (MoNS), mentoring-synchronicity-speciality (MeSS), diagnosis-connectivity-disease (DCD), consultation-synchronicity-disease (CSD), consultation-network-disease (CND), consultation-connectivity-disease (CCD), monitoring-synchronicity-site (MoSSi), monitoring-network-site (MoNSi), monitoring-connectivity-site (MoCSi), mentoring-synchronicity-site (MeSSi), mentoring-network-site (MenSi), and mentoring-connectivity-site (MeCSi). All instances of site-based monitoring and mentoring studies did not occur. These studies, if they existed, would be examining the variations of monitoring and mentoring depending on different types of locations, like a doctor speaking to another doctor in a hospital as opposed to in his car or in the jungle. It is therefore not that surprising that this type of research has not occurred. It is more surprising that no instances of CSD or MeSS appear. CSD literature would look at some aspect of real-time discussions pertaining to a specific disease. MeSS literature would look at some aspect of mentoring pertaining to a specific specialty. It could be that the most salient feature of telemedicine, being the difference in physical locations causes more research to appear about the technology than any specific specialty or disease. When it comes to real-time discussions and interaction, which is what the synchronicity category encompasses, it seems that trying to find differences in efficacy across diseases and specialties is not of as much interest as the medium through which the discussion and interaction occur.

Finally, it is interesting to look at wider discrepancies between the two databases. Mentoring-connectivity-treatment (MeCT), consultation-connectivity-treatment (CCT), and consultation-synchronicity-specialty (CSS) all presented pretty big variations between the two databases. In the MEDLINE database, MeCT literature represented 9.6% of the total articles that fit the search criteria. In the LILACS, MeCT literature represented only 5.3%. For MEDLINE CCT literature it was 12.8%, as compared to 5.8% for the LILACS database. For CSS literature it was MEDLINE 3.3% and LILACS .8%. How does one account for these variations between the two databases? One can look at the literature that these two databases contain as one mode of investigation. The most significant difference between the MEDLINE and LILACS databases is the territory they cover. MEDLINE aims to be a comprehensive database of biomedical literature while LILACS only aims to cover medical literature in Latin America and the Caribbean. The other apparent difference is that MEDLINE covers only biomedical literature whereas LILACS covers scientific and technical literature. In this way, these differences can be ascribed as a way of comparing the focus of literature in the entire world as compared to just Latin America and the Caribbean as well as differences between biomedical investigations and scientific-technical ones. What we see is that, on a whole, less literature in all three of these categories is arising in the LILACS database. Perhaps because the LILACS database has a broader focus, as compared to must biomedical literature, the distribution of literature is over a moderately broader domain.

A great example of the dynamic found in much of the research is found in the article, "Clinical- and cost-effectiveness of telemedicine in type 2 diabetes mellitus: a systematic review and meta-analysis," by YK Zhai. In this study, researchers compare the outcomes of different interventions, phone calls, emails, and video-conferencing in dealing with the chronic illness of diabetes and then analyze the results. While this research is certainly valuable, it looks at people already receiving care and sees if additional care makes a difference via telemedicine. For those hoping to see the advantages and challenges of telemedicine in the developing world, the abundant research of this type does not help much.

On the flip-side there is some research that looks at telemedicine in the developing world. For example, "Mobile health data collection at primary health care in Ethiopia: a feasible challenge," research by AA Medhanyie, offers promise. In this study from 2014, rural health workers in Ethiopia were equipped with smart phones and asked to collect data on patients. The research goes on to discuss the outcomes and challenges to successful implementation. However, this research is hard to come by and hard to find if you don't know what you are exactly looking for or where to look.

One also wonders if the differences that exist between these databases and similar databases reveal something about the curators of the databases themselves. Some type of criteria must be passed for inclusion into these databases. The reason several other databases were not included in this study that were included in The World Health Organization study that this research draws it's inspiration from, in terms of methodology, is that they contained almost no search results for "telemedicine" literature in 2014. This can be understood also as representing some bias or blind spot with the organizers and sources that create those databases. Especially because telemedicine research straddles the line between the fields of medicine, technology, and human development, it is easy to muddle and confuse the significance, meaning, and state of the research. In a sense, these databases have already done a preliminary round of classification of telemedicine research, designating many papers as irrelevant and not including them within the database at all. Without greater transparency into the way these decisions are made, a lot of unknown variables exist in interpreting the data Bashshur's taxonomy helps to produce.

One wonders if the weighting of types of research being done in the field of medicine, with certain types of research far outstripping others, can be correlated to the more general category of telemedicine installations being operated as a whole. If these same tendencies to favor certain types of interventions correlate to how all telemedicine is being conducted, it opens up a lot of questions. This is largely outside of the scope of what this paper aims to cover. However, briefly, one can contemplate that certain types of telemedicine interventions are easier to conceive of and implement than others, but that this ease does not necessarily correlate directly to the efficacy and utility of the interventions being done. Additional research looking at the outcomes of research, rather than just what research is being done, could yield beneficial insight into where telemedicine is best used and applied.

The world of social science research is much more imperfect than hard science or mathematics. As such, there will never be any pure sense of complete knowledge or conclusion that arises from research. However, efforts to create statistics that can serve as a foundation for wider knowledge-generation is essential. Bashshur's taxonomy provides this foundation. Once can imagine other ways of organizing this taxonomy, maybe looking more closely at the medium, population, or intent of various research projects to make different characteristics of the research stand out, but Bashshur's taxonomy is sufficiently detailed and coherent to function. Adding in extra elements for classification could be part of constructing additional meaning and knowledge and would not necessarily need to replace the taxonomy that Bashshur has created.

CHAPTER 5

REVIEW AND DISCUSSION

The process of classifying and representing this data yielded a lot of insights into the strengths and weaknesses of Bashshur's three-dimensional taxonomy of telemedicine model for classifying literature types. There is no doubt that a method for better understanding what research is being done in the field of telemedicine is needed. The implications for improving healthcare and the implications for development are too great. What this classification of data has shown is that the vast majority of telemedical research occurs within institutionalized medical systems, not rural areas. The ability to find research on rural telemedicine is challenging because little of it exists and there is no easy way to discover it. Since Aldinger's research states a correlation between medical research and interventions in the field, we can reasonably state that telemedicine is not reaching rural areas, limiting people's freedom to accessing adequate healthcare, avoiding treatable illness and preventable disease. Under Sen's definition, this means that development itself is being limited. People are expending time merely trying to be healthy rather than spending energy improving their lives and making positive progress. Increased interventions in rural telemedicine offer the potential to increase development.

Like many emerging technologies, information on the newest innovations within the field of telemedicine lags behind the current state of events. Bashshur's taxonomy has the potential to improve this situation, but is no panacea. If adopted, Bashshur's taxonomy could improve the sharing of ideas and best practices within the field of telemedicine. However, retroactively applying this standardized language, though not impossible, poses greater challenges. A classification system should ideally be simple and fast when dealing with large aggregates of data. Even better, this system could scan articles for key words and even be automated, making it unnecessary for a human to scan through hundreds of articles for dozens of hours, like this research project required. Inconsistent use of language prevents this at present. Though Bashshur's taxonomy offers one adequate method for classifying telemedicine projects, it still faces these challenges of inconsistency. As a result, culling through large sets of data takes a lot of time, making it impractical for widespread use at present. This is not to say that this can't be corrected. The discussion below will examine what works well given the current state of telemedicine literature and want could be improved.

The idea of universal adoption of a standard is appealing, but also seldom realized without top-down enforcement or support. This is the crux of the structure of academic research in telemedicine, if not of larger academia as a whole. Though the system promotes and believes in the power of ideas and knowledge, there is no unified organizational structure that curates and governs how the process of generating new knowledge occurs. As such, basic discourse in a field, much less across disparate fields, becomes confused, with different groups understanding studies and information with different interpretations. Of course, there are conferences and peer-reviewed journals to combat this chaos to a certain extent, but these solutions are far from anything like a unified and systematic approach to understanding a field. At the same time, it is this chaotic approach that creates a field of research to begin with. One cannot provision how researchers will discuss ideas and information and knowledge that has not yet been created. So, there must be some middle ground.

The closest thing to this type of governing, comprehensive database is likely LexisNexis. There is no more comprehensive and complete database of a wide range of academic literature and no database used for academic research as extensively. If this organization was to place greater and more stringent organization into how research must use language in order to join the database, significant results may occur. This is primarily question of incentivization. What priorities are of high enough priority to motivate researchers to care about abiding by a standard?

To best understand the challenges associated with an adequate classification system for telemedicine literature, one must understand the current state of the literature. Though this particular focus is on telemedical literature, some of the issues discussed are applicable to academic literature as whole. The underlying assumption related to a statistical analysis of the telemedical literature is that this type of classification can yield meaningful insight into the state of the field. There are reasons to think this is not the case. First, as discussed above, when using language, understanding and meaning will necessarily vary between individuals, making the boundaries drawn within studies somewhat interpretable. Additionally, though hard numbers can illuminate certain realities, it is also very possible that it obscures others. Long-term, systemic changes to a field and unexpected technological innovation means that the numbers may not indicate future trends. Just as it is impossible to predict the stock market with 100% accuracy, so too, what lies ahead for a field of research can be perfectly extrapolated based upon past results. That being said, Bashshur's taxonomy does serve as a useful tool for understanding what has happened historically. Though this is not perfect, there is little else once can do when creating knowledge and reviewing the state of a field of research. Whole books could be dedicated to looking at how innovation and change occurs, but the processes involved contain so many variables that it is near impossible to predict innovation. And, again, this exceeds the scope of the research being presented within this paper. However, when momentous change does occur, a tool like Bashshur's taxonomy can be useful in looking back at trends and anomalies to gain insight into what causes the unexpected to occur in an effort to make it less mysterious going forward. The researcher is constantly battling ambiguity. Bashshur's taxonomy offers an extra weapon in this fight.

The telemedicine literature is scattered about in many databases under variant search criteria, uses conflicting terminology to describe projects, and is less than comprehensive. Additionally, that rapid growth and change in this field has led to a burgeoning collection of literature, but with little cohesive vision or communication. As a result, it is difficult to piece all of this data together in one place to produce a comprehensive view of the current state of research in the field. And, as mentioned above, as the field evolves, the meaning of terms and the possibility associated with it, especially in such a technology-laden field like telemedicine evolves beyond past studies. For example, the idea of telemedicine is almost wholly different when being discussed before and after the widespread use of the internet. Entire new possibilities and types of research become possible.

Additionally, there are many concurrent variables present in telemedicine literature. Bashshur breaks this down into three groups function, application, and technology. This research is often comparative in nature, looking at traditional approaches to delivering medical care in comparison to telemedical approaches. This poses more complication. It is necessary to understand how this cross-comparison is being viewed on top of the way the independent telemedicine care and standard care is delivered. As a result, it becomes increasingly difficult to confidently classify literature into standardized groups and to feel that these classifications are not largely arbitrary. No simple method of culling through the literature in a comprehensive way, designating a greater field of variables is available or centralized.

The visualization of this multi-variable data poses challenges as well. It is difficult to drill down and understand the results of the analysis in an intuitive and visual way. Research has shown that visual cues, like variant shapes and colors and sizes are understood and processed much more rapidly than the numeric configurations we find in a typical Excel spreadsheet. Communicating and classifying extensive amounts of telemedicine literature call for a better method for displaying that data. Software like Tableau exists for visualizing data in a similar manner, but this is geared more towards geographic data and the software struggles to integrate multiple data sources without lengthy configuration.

Likely the most challenging feature of the multi-variable telemedicine data set though comes in the act of classification itself. When working with natural language as opposed to numeric data, the process of classifying draws hard boundaries in a constructed and artificial manner. Much of the data has some degree of overlap between multiple category groupings that cannot be adequately conveyed via standard classifications. Since it is often this grey area of research that presents the most interesting and significant and challenging research being done in the field, some method of better conveying this complexity would also benefit academics and professionals culling through and examining this data. It is very likely that another person looking at the same set of research articles that were classified as part of this paper would lead to at least some degree of variance from the numbers represented in this paper. Studies overlap into more than one category, application, and technology.

Variant languages pose a major challenge to successful categorization of information as well. Though Bashshur's taxonomy may suffice in some regards within English language research being conducted, this is far from the entirety of all telemedicine research. Though a taxonomy may succeed in organizing one language, differences in interpretation, meaning, and culture will still create confusions amongst different languages. Is it even possible to process knowledge the same way in different languages? This comes back to a fundamental question posed by the Whorfian hypothesis, does language shape how we experience reality? How can we confirm that two groups understand information in the same way? Perhaps this calls for too great a standard. Is it sufficient that information is mutually intelligible, if not precisely communicated? In this regard, fundamental questions and challenges in meaning make Bashshur's taxonomy limited. Must we create an independent taxonomy for every language that research is conducted in? This seems unrealistic and counterproductive. Instead, like much of what this thesis concludes, perfect cannot be the enemy of progress, limiting all efforts because a completely precise cannot be devised.

In some ways, the disarray of telemedical literature is not unlike what we what we see in international relations. Internationally, many actors – nations, regional contingents, independent rulers, policy-makers, etc. - communicate and have a general awareness of others' ideas and goals, but their actions do not have any type of centralized, governing body to best coordinate how each actor's actions coalesce with the greater whole. The legacies of individual histories, cultural biases, variant resources, and disparate goals leads to misunderstandings, ignorance, and, sometimes, violent conflict. Though I don't foresee much violent conflict arising between various telemedical researchers, the challenge we see in creating any type of global, governing body with strong authority, is not dissimilar to the challenges preventing a more governed field of telemedicine or of academia as a whole. With no one coordinating the energy of all these actors, much energy, time, and opportunity gets squandered.

Bashshur's taxonomy offers a reliable means of standardizing language across groups, but standardization requires the authority to enforce and manage information. If no group works to regulate standards, then the likelihood of those standards having a rigorous application that achieves the objectives they are meant to, becomes slim at best. Though Bashshur's taxonomy can serve as this standard for common terms within the field of telemedicine, it does nothing to solve this larger problem of making anyone use the taxonomy. Adding a taxonomy, a new system, into the field, requires time and belief from telemedical researchers. Though one can hope that the merits of some system will somehow lead to their adoption, in practice, it seems that some greater governance is required for true change.

Though Bashshur's taxonomy has lent beneficial insights into the state of the telemedicine research, the process of classifying social science research is quite laborious, with or without a clear taxonomy like the one Bashshur has developed. The time commitment involved with classifying just over 800 articles was intense. One wonders if alternative methods that reduce this time commitment might exist. Automated computer classification, self-classification by researchers, and classification by publishing journals all seem like ways of reducing the uncertainty, biases, and time commitment associated with any one individual conducting this process. In some ways, the classification biases that arise from individuals using the taxonomy speaks more to a characterization of that individual than the research being done. The ways in which we understand research and categorize them reveal a lot about the person categorizing. Experimenting with different individuals classifying the same information to see how they vary could also yield interesting information. By creating a standard like Bashshur's taxonomy, the ability to look into how people produce and process knowledge also becomes easier to examine.

Conclusion

Little telemedical research, by proportion, happens in the rural setting in developing countries. The interesting question is, why? Does this mean that less actual telemedicine is occurring in these places or just less research? My personal experience is that both less research and less actual telemedicine is occurring in rural locations. Having lived in an area of Panama without access to healthcare, it seems that the infrastructural barriers that prevented care there are prevalent throughout many developing countries. In addition, there tends to be a correlation between the amount of medical research being conducted and the frequency of interventions done for that type of intervention (Aldinger, 2009). The more research being conducted on a topic, typically, the more of that type of care is actually occurring. From this correlation, it is reasonable to assume that, because research on rural telemedicine interventions are lagging behind other types of research, that the practice of these interventions is also lagging behind.

Why? There are multiple stories we can tell about this phenomenon. On one level, it could be that it is simply more difficult to reach rural areas and so less work gets done there. We could also say there are structural inequalities, with the urban and educated receiving more resources and care than those in great need in rural areas. It is also possible that telemedicine just isn't well-suited to these rural areas. If development is freedom, then development is being hindered in rural areas by a lack of access to healthcare. It seems highly unlikely that there is some conscious intent to deprive the rural poor from healthcare. More of the problem, I suspect is just a lack of information. The problem is that, without access to organized information about these inequalities, it becomes very difficult to know which of these narratives is the most relevant. How can proper decisions be made and a situation understood, without easy access to information?

By using Bashshur's taxonomy, we at least have the groundwork to confirm this trend and a tool to collect and sort whatever information does exist. If widely adopted, this could potentially rectify some of the challenges that finding information on the research that has been done does pose. The challenge comes in asking how to get people to actually care about this issue and use a unified method in sorting the research that exists.

Finding effective methods of classifying telemedical research and academic literature holds significant opportunity for the spread and understanding of telemedicine as well as other academic fields that lack well-organized sources of information. By classifying data in the way this project did, new insights into how research has evolved over time, where the focus of research has been, where gaps remain, regional difference in research, and a plethora of other possibilities easily emerge. The primary challenges to this task include data collection, inconsistencies and discrepancies of language, data presentation and visualization, and a legacy of confused materials. Bashshur's taxonomy offers resolving all four of these issues, if a leading organization applied the taxonomy and took measures to display that data easily. This can be said for the creation of logical taxonomies and their applications for almost any field of academic research. The confusion comes in the grey, human area of human values and opinion. Many researchers would argue over where one field even begins or ends, much less how to sort the research of the field. Nevertheless, some kind of greater standard and unbiased organizing body to curate and moderate discourse within a field would benefit those involved. It seems that no silver bullet exists when it comes to the organizing of information because no matter how diligently constructed of a taxonomy exists, the structures will always remain human constructions, proxies for reality.

As the possibility of automatically sorting, storing and visualizing mass quantities of data flourishes with the invention of "big data" databases like Hadoop and MongoDB, intelligence tools like SAS and SPSS, and visualization tools like Tableau and QlikView, the possibility of bringing some order to unruly quantities of unstructured, uncategorized information sets has become realistic. Still, technology cannot resolve human barriers and their legacy, like sorting old, confused literature, agreeing on standards, and deciding the parameters of data to be included. Technology, at present, can only help facilitate acting on decisions made by humans. The challenge of reforming a system, *in media res,* requires a great deal of authority and organizational leadership. Though a taxonomy can aid that organization dramatically and increase their authority over the long-term, the taxonomy itself cannot create it. Like most applications of technology, the power and significance of Bashshur's taxonomy of telemedicine ultimately depends on how humans use it. Technology creates potential. Humans create reality.

To do so, people must have the right information available to them. Right now, telemedicine academics and professionals do not. Though seemingly banal, the way we collect information informs the way we make decisions and ultimately leads to outcomes that inform how development plays out. It is difficult to see the connection between academic databases and development work, but it does exist. The information we are exposed to informs the decisions we make. For emerging technologies in the development context, on a number of levels, access to adequate information is particularly challenging. Bashshur's taxonomy offers one method of beginning to improve this.

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