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Health in Your Hand: Assessment of Clinicians' Readiness to Adopt Mhealth into Rural Patient Care

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HEALTH IN YOUR HAND: ASSESSMENT OF CLINICIANS' READINESS TO ADOPT MHEALTH INTO RURAL PATIENT CARE

by

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ABSTRACT

HEALTH IN YOUR HAND: ASSESSMENT OF CLINICIANS' READINESS TO ADOPT MHEALTH INTO RURAL PATIENT CARE

by

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Introduction: Technology is as much rural as it is urban, but mobile health (mHealth) could have a unique impact on health and quality of life for rural populations. The adoption of mobile technologies has soared in recent decades leading to new possibilities for mHealth use. This project considers the impact of these technologies on rural populations. Specifically, it is focused on assessing the barriers of physicians and healthcare organizations to adopt mHealth into their care plans. Gaps in knowledge exist in assessing organizational readiness for mHealth adoption, the use of patient-reported data, and the impact on rural healthcare. This project seeks to address those gaps.

Methods: Utilizing semi-structured, open-ended interviews as the primary instrument of inquiry, clinicians' current practices, motivators, and barriers to the use of mHealth technologies were identified. Thematic analysis revealed code-category linkages that identify the complex nature of a rural healthcare organization's current climate from a physician perspective. A thematic map was developed to visualize the flow from category to code. Those linkages were then utilized to construct a refined mHealth readiness model.

Results: Thirteen Wisconsin-based clinicians from the Marshfield Clinic Health System participated in interviews and consults. The interviews uncovered current practices, with 53.8% of participants reporting that they do encourage the use of mHealth apps or wearable devices with patients. Perceived barriers to adoption were categorized into three primary pillars – personal (clinician), patient, and organizational. Organizational was the most prominent category, with codes such as time, uniformity, and policy/direction.

Conclusion: Clinicians, particularly physicians have tight schedules with very limited time for continuing education, research, or exploration into new technologies. Limited clinician time can lead to a lack of familiarity with new and emerging technologies. Clinicians are interested and motivated to learn more, but also need assistance with screening and quality reviews. Organizationally-led directives and suggestions, such as a menu of technologies, would be used.

There are some risks that would need to be mitigated, but if organizations were prepared to manage mHealth it is very likely that physicians could improve the quality of care for their patients. However, many organizations including Marshfield Clinic are not yet prepared to prescribe or prohibit the use of mHealth technologies. Healthcare institutions should consider investing in mHealth analysis, tool development, and the promotion/recommendation of sanctioned tools for clinicians to use with patients.

To my loving wife Stacey, and our four children, Lilyanna, Dylan, Logan, and Mason

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LIST OF ABBREIVIATIONS

App = Application
EHR = Electronic Health Record
EMR = Electronic Medical Record
HIPAA = Health Insurance Portability and Accountability Act
HIT = Health Information Technology
HITECH = Health Information Technology for Economic and Clinical Care
IDC = International Data Corporation
ITU = International Telecommunication Union
MCHS = Marshfield Clinic Health System
mHealth = Mobile health
ONC = Office of the National Coordinator for Health Information Technology
PHI = Protected Health Information
WAMS = Wearable activity monitors

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PURPOSE

Technology is as much rural as it is urban, but mobile health (mHealth) could have a unique impact on health and quality of life for rural populations. This project considers the impact of mHealth technologies on rural populations. Specifically, it is focused on assessing the readiness of clinicians and healthcare organizations to adopt mHealth into their care plans.

Gaps in knowledge exist in assessing organizational readiness for mHealth adoption, the use of patient-reported data, and the impact on rural healthcare.

The following research questions will be answered:

1. Are clinicians using mHealth apps with rural patients in clinical practice?
2. Does the conceptual model for mHealth Readiness work as an evaluative tool for assessing a healthcare organization's readiness to adopt mHealth?

In order to answer these two questions, the Student Principal Investigator (PI) interviewed clinicians in Central and North Central Wisconsin to gather information on experiences, preferences, ambitions, barriers and reservations about the adoption of these technologies and their use with rural patients.

I. INTRODUCTION

Overview

In recent decades many healthcare providers have shifted from disease-centered care to patient-centered care, with a primary driver being quality of care.[1] Historically, medical decisions were made with limited or no patient involvement. Conversations between physicians and the care team were behind closed doors and later communicated to the patient as a set of directives, rather than a conversation with patient input and a group decision. Patient-centered care includes input and inclusiveness, and can include those that are neither provider or patient, such as family.[1] While a patient-centered care model can have the effect of improving patient experience through aesthetic and other customer-service oriented enhancements, confusion in definitions and strategic application can lead to perceived superficial efforts and no real impact in care.[1] New furniture, soft music, and same-day access are improvements, but without a conversation with the care team about next steps, short or long term, patients are still not centered in the model. With a proactive care team, patient-driven technology may be able to improve care.

Out of an unprecedented adoption of mobile communication technologies and the progressive advancement of their application to personal and population health management, a new field of science, research and healthcare has emerged – the study of mHealth, a new field of patient-driven technology-based care. The World Health Organization (WHO) defines mHealth as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices".[2] The mHealth Alliance's definition focuses on opportunity and access by stating "mHealth stands for mobile-based or mobile-enhanced solutions that deliver health. The ubiquity of mobile devices in

the developed or developing world presents the opportunity to improve health outcomes through the delivery of innovative medical and health services with information and communication technologies to the farthest reaches of the globe."[3] Both of these definitions imply an organizationally-driven or practice-driven approach to healthcare. Also, the definitions suggest that the process is merely enhanced by the use of these new technologies. Meanwhile, neither definition specifically uses the term "patient" or "patient-centered". Patient-centeredness includes the patient in the care process, as well as utilization of the patient's abilities, technologies, and preferences in terms of care, communication, and general health management.

Applications (apps) are software programs. This paper will use the terms "applications" and "apps" interchangeably throughout. Mobile applications are software developed specifically for a mobile device, such as a smartphone or tablet. Native apps are software programs developed to be installed directly onto a device, typically downloaded through an app store. When referring to mobile apps, this paper will not include web applications or websites that are optimized using responsive design to function on a mobile device as if they were a native device application. However, mHealth includes software accessible through websites and native applications. In summary, web apps and websites optimized for mobile devices are not called mobile apps, but they can fall under mHealth.

mHealth also includes wearable activity monitors (WAMs). More than 400 WAMs are on the market and being used by consumers across a wide range industries and occupations.[4] WAMs include a multitude of devices that are worn in on various body parts or clothing, such as the

wrist or pocket. Some companies that are currently offering devices include: Apple, Fitbit, Under Armour, Garmin, Jawbone, Pebble Time, LG, and Misfit.[4]

The treatment of many chronic conditions takes place primarily outside the purview and physical environment of a doctor's office. Though clinicians will often require patients to recall detailed information about their symptoms and condition, the appointments may be spread apart and recollection of specific situations can be challenging.[5] Innovative mHealth applications provide the opportunity to enhance and improve the data collection and reporting process. This would make self-reporting easier for the patient and quite possibly more accurate and complete as well.

Some clinicians and organizations may argue that they should not base clinical decisions on patient-reported data. This project sought to uncover barriers and also motivators for those that are already doing so. The opportunity exists for patient-driven health management and is readily available through a flood of consumer software. As of July 2015, there were five primary players in the app store market – Google Play (1,600,000 apps), Apple App Store (1,500,000 apps), Amazon Appstore (400,000 apps), Windows Phone Store (340,000 apps), and Blackberry World (130,000 apps).[6] See Figure 1 for a visual representation of the each store's 2015 app offerings. The number of applications in publicly available app stores has grown exponentially in recent years, especially for Apple (see Figure 2), specifically, the growth of the health and health-and-fitness related applications, which has grown to more than 165,000.[7,9]

Not only are the number of applications increasing steadily, so are the number of downloads. App stores have seen a steady increase from 2009 to 2015, with projections from Statista

jumping to 268,692,000,000 downloads in 2017 (see Figure 3).[10] More than 165,000 mHealth apps available for download on iTunes and Google Play.[9] These two app stores are the two largest in terms of all apps available,[6] as well as mHealth apps. iTunes is a publicly available app store where Apple device users can access software applications and directly install them onto their own personal device. Some applications are free while others charge a fee for the installation. Google Play is very similar, though the apps available in that store are for Android users. Although the public has access to an increasingly large number of applications, there appears to be limited traction among healthcare organizations and clinicians to actively prescribe or engage patients with mHealth technologies much less adopt and integrate patient-reported data into existing electronic medical record (EMR) systems. So, despite the public's easy access to hundreds of thousands of mHealth apps they are not widely implemented by health care providers.

Figure 1 - Number of apps available in leading app stores as of July 2015[6]

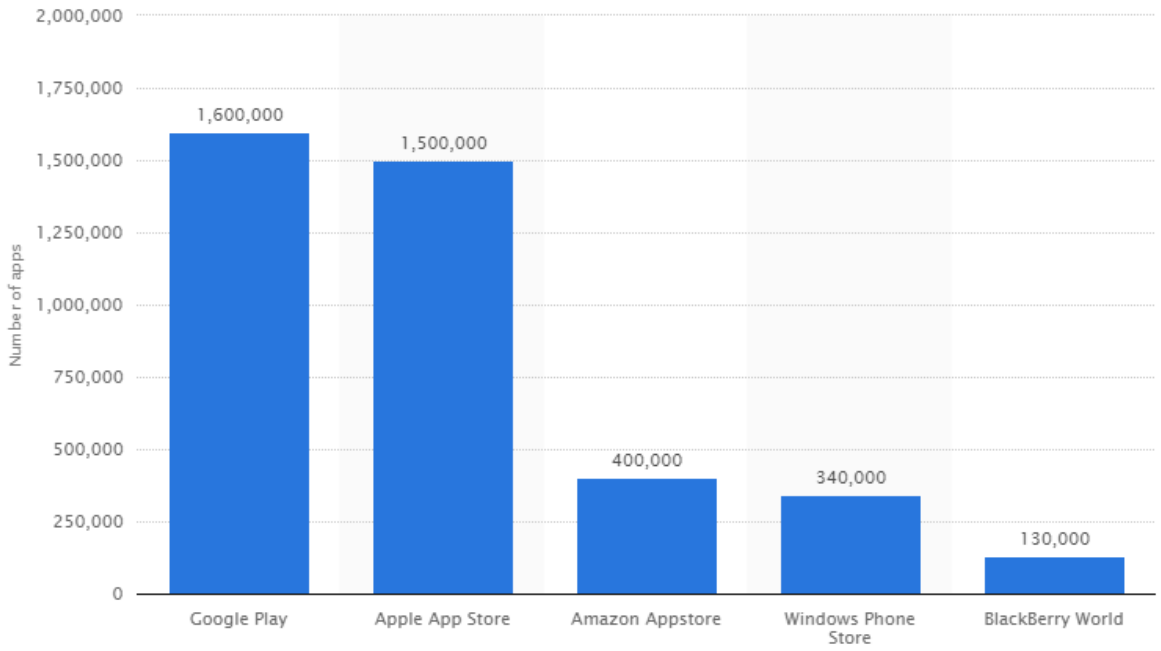


Figure 2 - Number of available apps in the Apple Store from July 2008 to June 2015[7]

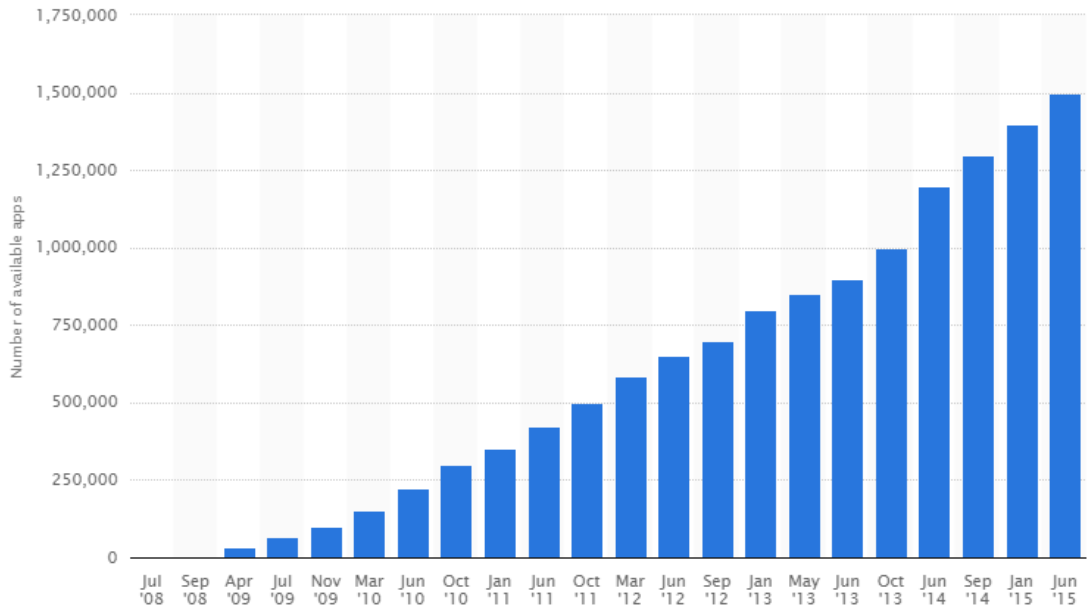
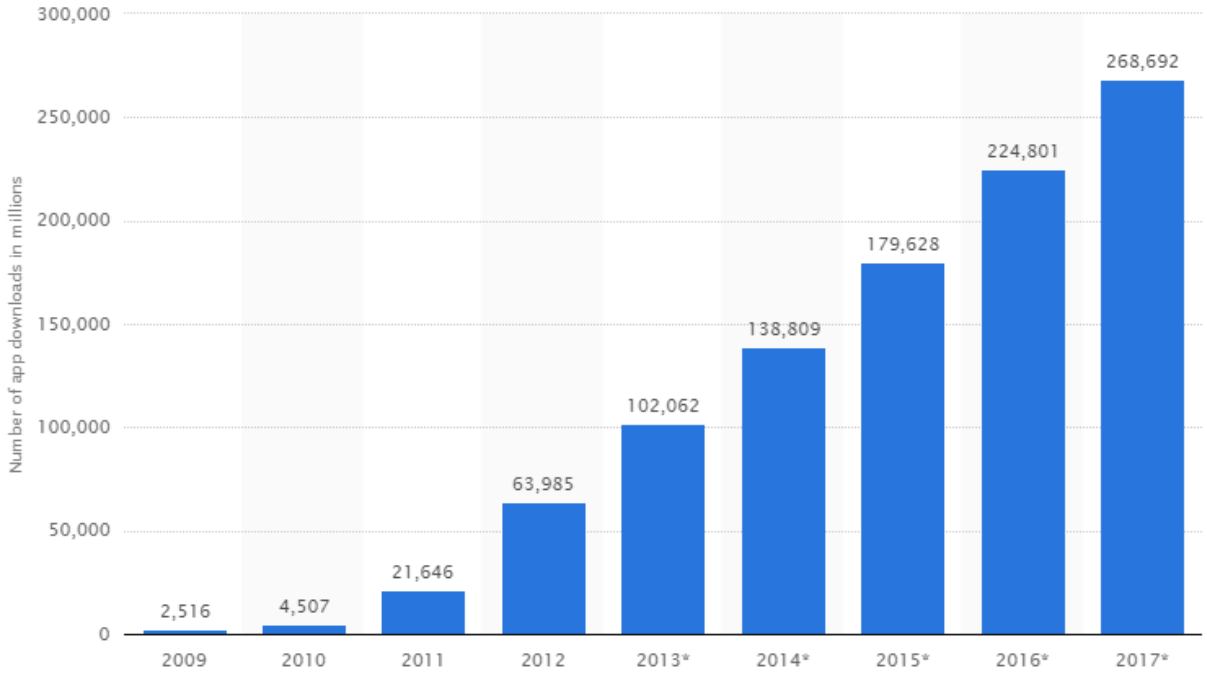


Figure 3 - Number of mobile app downloads worldwide from 2009 to 2017 (in millions)[10]



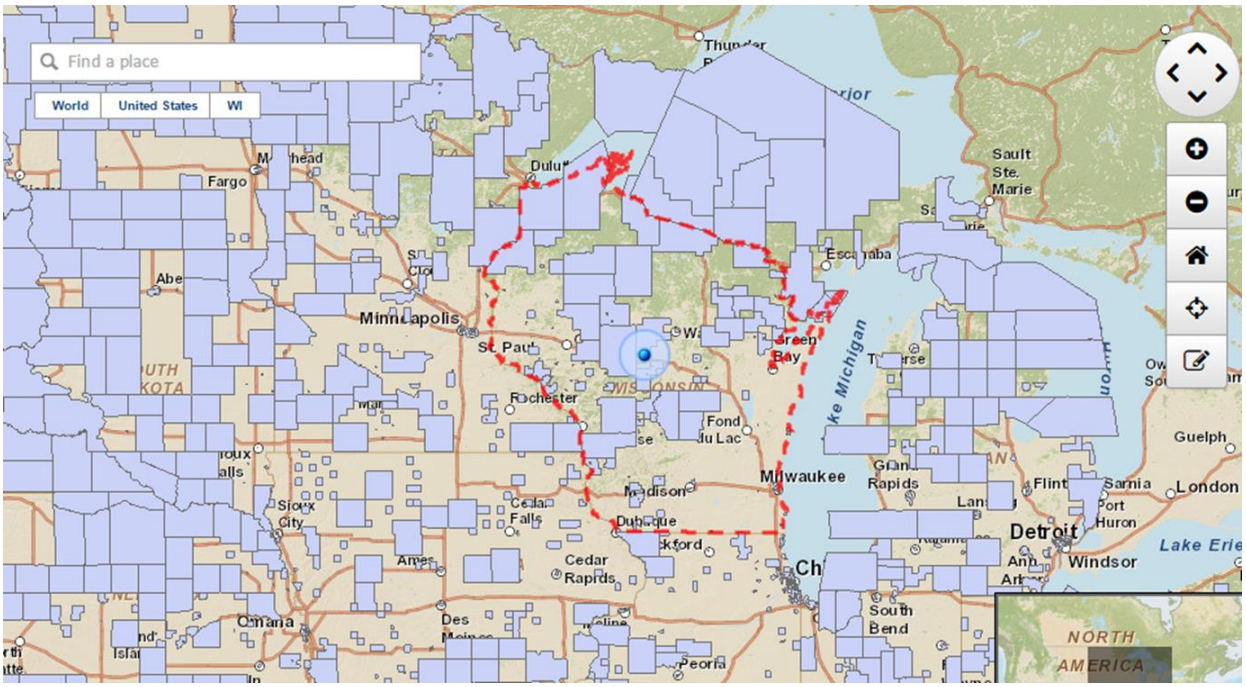
Mobile technologies are not often restricted by geographic boundaries or distance, traffic conditions, or weather. Based on these factors alone, rural populations may have more to gain through the use of these technologies. Beyond rural, the application of these technologies may also be critical to other populations such as parents with two jobs that have a difficult time taking vacation for appointments. The next section will discuss challenges in rural health and highlight internet access and cell coverage progress, which is allowing rural populations to connect with their healthcare providers.

Rural Health

As opposed to urban, rural healthcare focuses on patients in remote settings. Rural populations are often geographically dispersed and faced with limited access to specialized health providers (see Figure 4). The US Census Bureau, does not explicitly define “rural”, rather, it defines

Urbanized Areas (UAs) as areas of 50,000 or more people. It further defines Urban Clusters (UCs) as at least 2,500, and less than 50,000 people, while labeling everything else Rural.[11] Based on these definitions and the underserved locations detailed on Figure 4, it is evident that much of Wisconsin, including Central and Northern Wisconsin, and the Upper Peninsula of Michigan are located in rural areas whose populations have limited access to healthcare services.

Figure 4 - Medically Underserved areas in WI[12]



As the focus shifts to a more local view of Wisconsin, more data becomes available. The Wisconsin Office of Rural Health breaks down a number of different maps and data views of rurality including an overlay of rural as shown in Figure 5. As of 2000, more than 250,000 people live more than 15 miles from a hospital.[13] This data shows how many people live outside that radius from a hospital, but it does not address the number of people that live more than 15 miles from a hospital at which they can receive in-network care coverage according to their insurance carrier. That number may be much higher.

As a leader in rural healthcare, the Marshfield Clinic Health System (MCHS) employs approximately 800 physicians in 86 specialties across more than 50 Wisconsin locations.[14] With recent announcements of purchasing of Ministry St. Joseph's Hospital in Marshfield, Wisconsin and building or acquiring another in Eau Claire, Wisconsin, MCHS continues to grow and expand its reach into these rural populations.[15-20] The organization offers care beyond the geographical boundaries of the state, but its primary service area, as shown in Figure 6, spans across the northern half of Wisconsin. That service area includes a number of frontier counties as well as rural ones. As outlined by the Rural Health Information Hub, the term "frontier" is not universally defined, though is considered to be "the most remote and sparsely populated places among the rural-urban continuum".[21]

Figure 5 - Wisconsin: An overlay of rural [22]

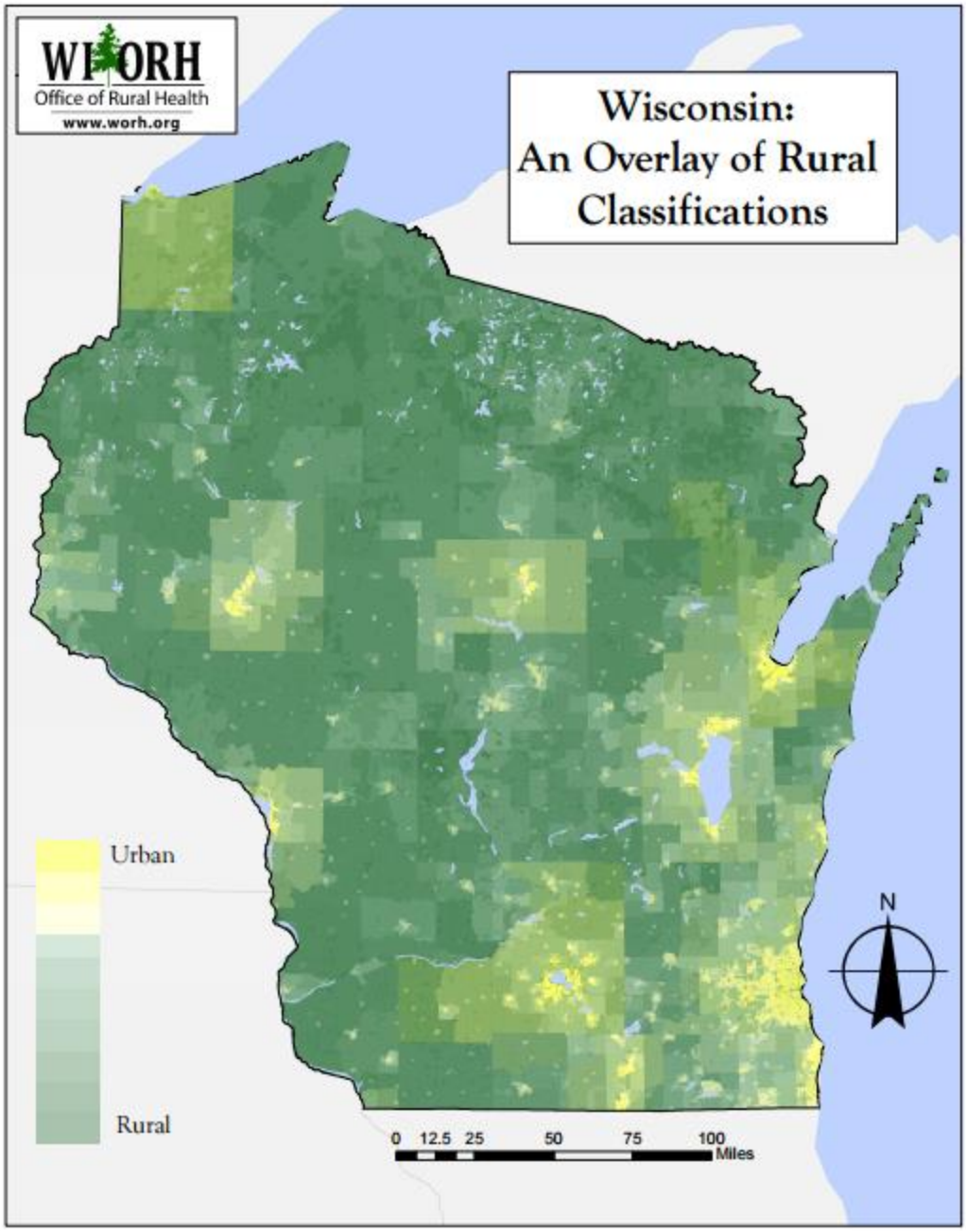


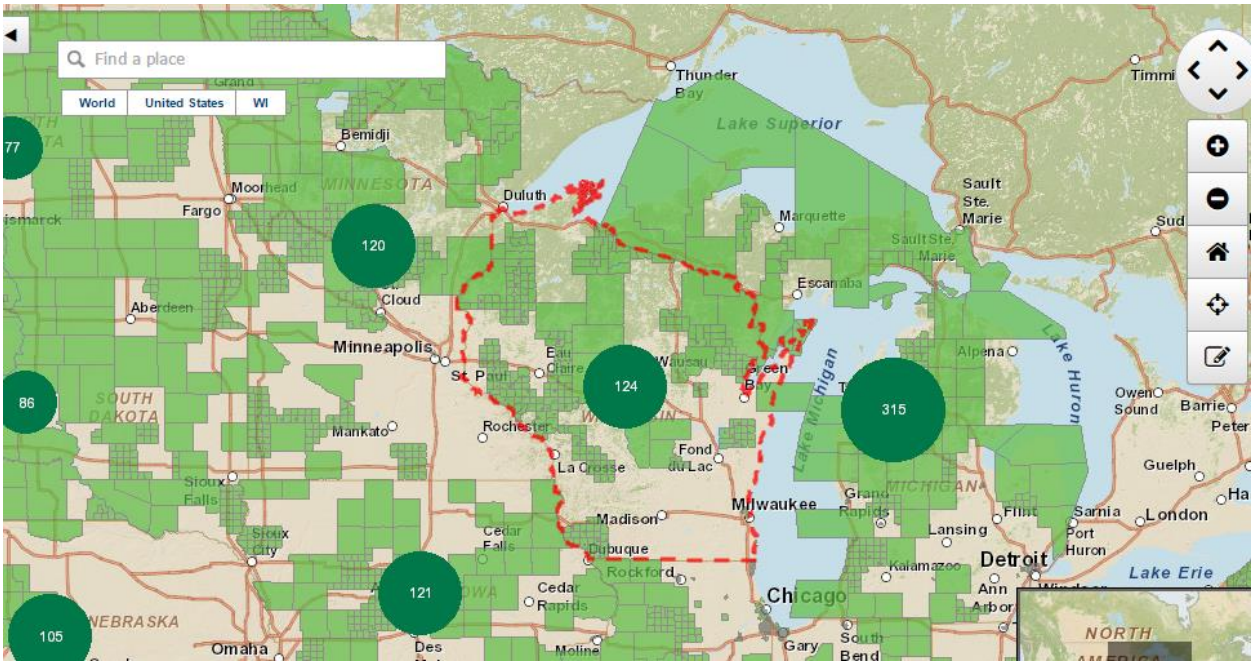
Figure 6 - Marshfield Clinic system of care[23]

Clinician Recruitment and Retention Challenges in Rural Areas

While mobile technologies are becoming more widespread, recruitment and retention of qualified health professionals to remote and rural areas continues to be a challenge.[24,25] There are a significant number of shortages in these professions across the Upper Midwest, as seen in

Figure 7, which illustrates a need for more professionals in those regions. It also highlights a need to seek out and explore alternative methods of health communication, access, and care. One of those alternatives may be the adoption of mHealth.

Figure 7 - Health Professional Shortage Areas, by State[26]



Rural Internet Access and Cell Coverage

There are a number of reasons why broadband access would have limitations in rural, low population density areas, including topographic barriers and vast distance.[27] Internet or mobile-broadband access limitations to be a hurdle across the U.S., particularly in rural areas, though that is no longer likely an inhibiting factor with any significance. According to the International Telecommunication Union (ITU), in 2015 there were more than 7 billion mobile cellular subscriptions, worldwide, which are up from less than one billion in 2010. Internet connectivity

is growing as well, with 3.2 billion people accessing, two billion of those are in developing countries.[28]

In the spring of 2016, Facebook announced further details on its plans to increase broadband internet access through two projects called Terragraph and Project ARIES.[29] Terragraph is designed to deliver high-speed internet access to the world's dense urban areas and is currently being tested in California. The project essentially places hardware on various locations of the city including light poles and buildings.

Facebook is the world's most popular social network, and one of the world's leaders with its messaging service. Project AIRES is still in early development; its primary goal is to extend internet access further into rural areas around the world.[29] Facebook noted in the USA today article that it had studied 20 countries and found that more than 90% of people live 25 miles from a major city. [xx] These projects are also connected with another venture that uses solar powered drones, the size of a Boeing 737 plane, that fly miles above the earth and provides a broadband-level internet access to people within a 50-mile radius below.[29] Google, whose parent company is now Alphabet, is moving forward on a similar project – Project Loon, which utilizes high-altitude balloons to broadcast internet.[29,30]

In a 2015 meeting with members of the Choctaw Nation and other representatives of more than 27 cities, U.S. President Barak Obama was quoted saying "The Internet is not a luxury, it's a necessity. You cannot connect with today's economy without access to the Internet". A program called ConnectHome was established to bolster internet connectivity with another 200,000 low-

income and rural students.[31] Even without President Obama's programs, internet and cell coverage is increasing. 3G mobile-broadband coverage is growing rapidly across the rural areas of the world. The International Telecommunication Union estimates 3G population coverage growth of 45% in 2011 to 69% in 2015, with 29% of the rural population covered, and 89% of urban populations with coverage.[28]

Cell phones are arguably the fastest-spreading technology of all time. They have been adopted across borders and across cultures, and they have deeply penetrated nearly every world industry, including healthcare. Mobile broadband internet showed a penetration of 47%, globally, in 2015, which has increased 12-fold since 2007. These numbers include a proportion of home internet access that increased from 18% in 2005 to 46% in 2015.[28] Though the fixed-broadband rate is growing at a slower pace of only a 7% annual increase and a penetration of 11% by end of 2015, the International Telecommunication Union published a significant gain in the proportion of the global population with 2G or higher mobile-cellular network coverage, which grew from 58% in 2001 to 95% in 2015.[28]

Organizations and marketers across industries have attempted to capitalize on these new communication mediums. Led by Facebook and other mobile-focused development teams, social media has taken a strong foothold among mobile users, with notable opportunities for healthcare to join in through appointment scheduling, reminders, medical record access, mobile sites and mobile applications. Marshfield Clinic reported that its public website has seen a big jump in mobile traffic in the past few years. In November 2011, MarshfieldClinic.org logged less than 10% of its unique visitors from mobile devices. Only two years later the same site had 20% of

visitors accessing through mobile. In November 2015 the share of mobile users had grown to 45%, with projections of 50% for early 2016.[32] This data excludes 7,500+ internally networked Marshfield Clinic laptops and desktops.

Utilizing this connectivity from brick and mortar locations, Marshfield Clinic and many other healthcare institutions have begun organizationally driven programs that facilitate real-time communications between patient and provider across vast distances. Those programs are typically called telehealth or telemedicine. The next section will explore the variations and similarities between these terms and the connection with mHealth.

Telehealth vs. mHealth

Some sources list mHealth as a modality of Telemedicine,[33] while others have spoken of the two as essentially the same thing. In a conversation with Keri Manecke, Telehealth Manager for the Marshfield Clinic Health System, she said "In my opinion, mHealth is a term used to describe mobile technology (such as cell phones, tablets, etc.) used in healthcare. Telehealth can use mobile technology (or mHealth). However, it can also use other technology to bring patients and providers together."[34]

The American Telemedicine Association defines telemedicine as "the use of medical information exchanged from one site to another via electronic communications to improve a patient's clinical health status. Telemedicine includes a growing variety of applications and services using two-way video, email, smart phones, wireless tools and other forms of telecommunications technology."[35] The American Telemedicine Association reports services dating back 40 years,

primarily through telephone at the time.[35] Since that time, technology has advanced significantly, putting pressures on all clinical practices to upgrade information technology systems across their organizations, including Meaningful Use directives to enhance or establish an Electronic Medical Record.[36]

Telehealth programs typically utilize organizational resources to facilitate telehealth visits through organizationally developed, purchased, or leased hardware and software.[37] The systems are in place for physicians to conduct telehealth visits, remotely through communication systems already in place. Patients can sometimes connect through their own devices,[38] but most likely through institution equipment and at a clinic or hospital location. At Marshfield Clinic, for example, the patients would often check into a clinic location as a typical appointment.[24] They are ushered through the rooming process like almost any other appointment, though by a telehealth nurse who is present in the room with the patient.[39] They often use a specifically designated exam room and a telehealth nurse then facilitates the call/exam with a specialist at a different geographic location, using the audio and visual equipment in the room.[39]

Enabling Technologies

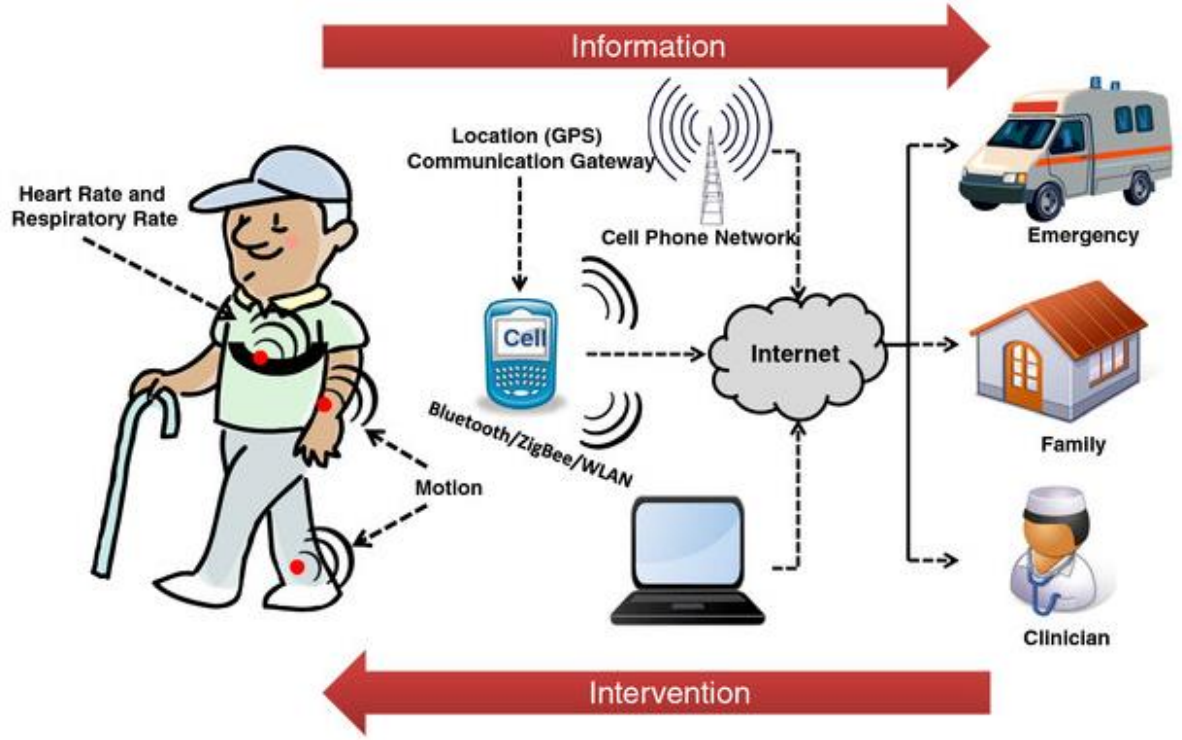
In order to understand the demand, reach, adoption, and potential of mHealth, we also need to explore the existing levels of technology (software and hardware) that are available on the market. This includes the enablers—the hardware that enables new innovative uses, such as the camera phone. This will be a brief synopsis of the variety, though due to the sheer number of products and constant technology innovation, it is certainly not all-inclusive.

The focus of this paper, and the ensuing evaluation, is devices, phones, tablets, and wearable activity monitors. Phones and tables are also the most used devices for downloading, installing, and engaging with mobile app. Apps are software programs that have the ability to leverage the existing on-board hardware technologies of the device. For example, an app can use a camera to take a picture, or a video, or to monitor the blood flow/concentration of your finger to tell you your pulse. Video can be used for real-time chat or for recording and sending a detailed account of a wheezing infant. Apps have been developed for recording and analyzing the rhythmic audio of a sleep apnea patient, or to manipulate the gyroscope and accelerometer of a phone to track your movement, your steps, the distance of your travel, or the disruptive patterns of your sleep. Apps can be developed to connect with other aftermarket hardware as well. Specialized devices exist for pulse tracking, heartrate monitoring, and taking detailed and lighted images of the ear nose and throat, to name a few.

Wearable technologies, including WAMs are considered by some to be a cornerstone of health informatics.[40] WAMs include devices such as the Fitbit, Apple watch, pedometers, and others. A conceptual depiction of a remote monitoring system, developed by Patel, et. al., can be seen in Figure 8.[41] This particular diagram shows WAMS used collaboratively on different areas of the body, tracking heart rate as well as movement. Monitoring systems facilitated through the modalities listed can detect abnormalities, triggering an alert and possible intervention. For example, if the heart rate increases without the motion of the arm/leg, there may be cause for concern. A care team or family member may receive an alert and then attempt to contact the individual to check on his/her status, which may be an emergency or simply that the arm/leg device was not being worn.

The model in Figure 8 is relevant to the discussion because it further illustrates one of the many possibilities of health management. Beyond their original intent, these types of devices and their built-in technologies (e.g. cameras, altimeters, and accelerometers) are the enablers that allow for the development of numerous applications. For example, a phone camera designed to take pictures is now used for taking someone's pulse.

Figure 8 - Illustration of a conceptual remote health monitoring system based on wearable sensors[41]



As a Fitbit user for more than six years, the Student PI has witnessed the technology grow from a pocket device to wrist-warn monitor that can track movement, heart rate, and location through global positioning systems (GPS). The GPS feature is a much more accurate measure of distance traveled and the other sensors provides a more holistic view of health goal progression. Like most technologies, results and feedback are not constant among users and devices.

The variation in WAM devices and quality is wide.[42] Not only variable, and sometimes just unreliable, the data can often be misinterpreted and misused.[42] While some individual devices have shown limited potential, other programs and research have shown impressive results and potential,[41,43-46] including a recent intervention in an ER where physicians used the patient's heart rate data through his Fitbit app to determine a treatment plan.[47] Examples of these programs and research will be further described in the literature review of the following section.

II: BACKGROUND

Healthcare Evolution, Marshfield Clinic

There is no doubt that technologies continue to change the medical landscape, including the way physicians practice medicine and the way patients manage their own health.[48] The first home computers and the start of the information age ignited imaginations and changed knowledge consumption. The smartphone and tablet now allow consumers to take consumption anywhere they want to go. Healthcare, like so many other industries, has witnessed a dynamic shift in consumer behavior. That shift is now just scratching the surface of patient-centeredness.

Marshfield Clinic, celebrating its 100 year anniversary in 2016, was founded by six physicians in 1916 in Marshfield, Wisconsin.[49] In 1924, Marshfield Clinic formed one of its first external partnerships, joining the University of Wisconsin's first preceptor program. For more than 40 years, Marshfield Clinic has administered an electronic health record. The company has developed, tested and implemented an all-encompassing package of electronic clinical out-patient care for the entire care team. Patients also interact through an online portal for viewing medical data, making appointments, paying bills, and securely messaging with a provider and care team.[50,51]

Marshfield Clinic purchased a mainframe computer in the 1960's and used punch cards to feed it diagnoses and procedure data.[52,53] By 1985, the clinic had introduced its first EHR system and had mandated that all physicians use it by 1994.[52] The organization now manages CattailsMD EHR software through a separate clinic-owned company called Marshfield Clinic Information Systems.[53] Its newest EMR software is called MCIS Clinicals™ and will be rolling out to select

clinical specialties in 2016.[54] Although a U.S. leader in electronic medical record development and implementation, Marshfield Clinic is not alone. Many healthcare organizations have shifted or will soon convert to EMR systems[55], but not all have an interactive system for their patients. Patient and clinician use of existing organizationally-provided and approved resources is one thing. However, downloading, installing, adopting, or purchasing commercially available apps for mobile devices that can be used to manage health is something different. This is where a gap may be identified between the innovative clinician and the organizational oversight/guidance and infrastructure.

In part, the mHealth evolution at Marshfield Clinic was kick-started through the entry of a national competition by a research team in the Marshfield Clinic Research Foundation. That team was the first to develop a mobile application for patient use within the health system and the first to compete in a software competition. Like many early innovators in a highly-regulated industry, the team encountered a number of barriers.

Heart Health Mobile™ App Development

This is an unpublished case study that recounts the Heart Health Mobile™ development project. In 2013, the Million Hearts Risk Check Challenge kick-started a cardiovascular disease (CVD) prevention app contest. The contest was sponsored by the federal Office of the National Coordinator for Health Information Technology (ONC) and in partnership with several other governmental bodies, including the Center for Disease Control (CDC) and the Department of Health and Human Services (HSS). In response to the challenge, the Marshfield Clinic Research Foundation's Biomedical and Informatics Research Center developed a Heart Health Mobile™

application. The application is designed to improve awareness of CVD risk and promote risk factor control among regional smartphone users. It deploys a user interface that provides a brief CVD risk assessment that takes into account self-reported behavioral, familial, and biometric risk factors, including blood pressure and lipids. Users are then directed, through on-screen navigation, to nearby community pharmacies, clinics, and other locations where more advanced CVD risk factor screenings can be obtained. Along with social media connections and measurement prompts, basic education materials are provided on key CVD prevention topics such as hypertension, dyslipidemia, weight management, and tobacco cessation.

A multidisciplinary team of 24 members was created to develop the initial app over a 30-day timeframe. This team included a broad cross-section of clinical professionals from medicine, epidemiology, health IT, usability, graphic design, business analytics, and marketing. An Agile project management methodology was used to promote dedicated team resources, adaptive planning, and iterative development with a self-organizing, cross-functional team.

The iOS app was developed, tested, and launched within the 30-day timeframe, then selected as one of five finalists. Additional modifications were developed over the following two months allowing for judges' feedback and testing. A gamified version of the app was the primary addition as well as an HTML 5, web-app version allowing users to access the application through their browser on virtually any device.

In February 2013, the Office of the National Coordinator of Health IT announced that Heart Health Mobile™ was the winner of the competition and the recipient of $105,000. The app was

developed in six different languages, and epidemiologic data, unique users, geo-segmentation, risk factor profile, and customer loyalty, among other data points, are still actively collected. The final product is available at www.hearthealthmobile.com.

The app met the criteria of the ONC and its partners for the competition and for the national rollout of the Million Hearts Campaign. However, the organizational barriers in place at the Marshfield Clinic prevented additional timely and strategic actions from taking place that would have made an impact on the research and a potential impact on the business. The two primary opportunities that were missed were

1) the app did not store Protected Health Information (PHI)
2) the app did not include Marshfield Clinic locations/addresses

Thus, the app lacked comparative data to evaluate a crucial component of the app and the entire program—whether it was making an impact on health (specifically the users' weight, blood pressure, and cholesterol numbers). Furthermore, the largest and most concentrated group of users/downloads came from the Marshfield Clinic service area, in part as a result of increased media exposure and television interviews. However, Marshfield Clinic locations were not showing up in the app as users were presented with screening locations in their area to have their blood pressure or cholesterol checked.

The team's evaluation of the lessons learned uncovered a number of barriers to further successes. This case illuminates a number of elements critical to the basis of this research project including

organizational readiness. The following section expands on the Heart Health Mobile™ lessons by explaining other examples of mHealth adoption and research in the literature.

mHealth research and integration into clinical practice and patient outcomes

The use of mHealth and mobile devices to monitor, track, send, receive, consume, or otherwise engage in one's own health continues to be a topic of technology, clinical care, legal, and policy debate. Some mHealth studies are inconclusive, many are in progress, and many have shown positive results.

With limited technological sophistication, mHealth programs can have significant impact, reaching a vast number of patients across vast geographic boundaries. For example,

- One study of infant weight management in Kenya has shown that the use of mobile phones is an effective way of gathering and communicating timely infant weights at the community level.[56]
- An open-source data management platform, used by the United Nations Children's Emergency Fund (UNICEF) and others, was implemented to monitor more than 11,000 pregnancies across Rwanda.[57] The study showed an increase of 27% in the number of facility-based child deliveries after an introduction of a system that includes Short Message Service (SMS) text alerts directed to community health workers in emergency situations.[57]
- An intervention which studied women registered for primary healthcare facilities in Zanzibar, saw improvements in attendance of those who received educational SMS

communications and mobile phone cash vouchers, versus those who did not receive the messages.[58] It should also be noted that these studies appeared to have had a high impact on *rural* patient populations.

- WAMS were shown to increase physical activity in older adults, with potential for all ages.[59]

More sophisticated technological mHealth solutions may include Clinical Decision Support (CDS) tools. CDS tools provide additional support and assistance to the clinician, either remotely or at the point of care. Some studies show limited positive effects and suggest further research is needed.[60] For example, improvements have been shown in decreasing medication errors and harm with some CDS tools.[60] Other research has shown that health workers who were tasked with administering an integrated management of childhood illness using personal digital assistants (PDAs) as their clinical decision support tools were found to be more confident in their personal ability to deliver care and also with an improved level of protocol adherence.[57,61]

Healthcare providers' opinions are often relied upon by researchers and marketers alike. MedData Point is a market research program powered by MedData Group that collects and analyzes data from the Medical Product Guide community to provide healthcare marketers with insights into trends, technologies, and perceptions among physicians and across a variety of specialties and practice sizes.[62] In a 2015 survey of physicians, MedData Point found that improved quality and continuity of care is the number one reason for physician adoption of mHealth applications.[63] Time efficiency and improved communication with patients were the second and third reasons for adoption.[63]

Not surprisingly, the adoption of devices that house mHealth applications is also on the rise in healthcare settings. In a survey administered by HIMSS Analytics, more than half of U.S. hospitals reported the use of smartphones and/or tablets at their facilities. Sixty-nine percent claimed to use apps to access clinical information while only 33% believe they can access most or all of the clinical systems that they need through smartphones or tablets.[64] A third of those clinicians also indicated that the use of these devices would build efficiencies in patient care and also limit or eliminated redundancy.[64]

Healthcare organizations' use of mobile technologies varies even more than their use of EHRs. In one survey, 43% reported using mobile technology to send secure text messages internally, while 32% using mHealth to send secure text messages back and forth with individual patients.[65] These adoptions and research studies are of interest to a number of stakeholders including the U.S. Food and Drug Administration (FDA), which was seeking comments regarding mHealth clinical trials in mid-2015.[66] At that time, the FDA was interested in learning more about the new opportunities for studying devices and medical products, as well as the barriers and other challenges that might affect clinical trials using these types of mHealth devices.[66] The FDA was also interested in looking more closely at research that utilizes data collected from different devices, known as the Bring Your Own Device (BYOD) method.[66]

mHealth devices and technologies, including WAMs, have been used to track, report, communicate, engage, and otherwise facilitate the delivery or management of healthcare. There are many examples of research in the literature including depression,[67] smoking cessation,[67] cardiovascular care,[68-71] physical activity, obesity, or fitness,[72-77] diabetes,[78] pregnancy

prevention,[79] pregnancy management,[80-81] and nutrition education.[82-83] These examples and others are a testament to the traction mHealth technologies can have with its users, urban or rural, and are steps towards populations of patients beginning to take ownership in their own health.

Mobile apps designed for clinical workflow tasks are also increasingly used in healthcare. Photographs have been important communication and documentation elements in patient care for many years, but the technological advancements in digital image capture and transfer have recently accelerated. Mobile apps, such as CliniCam, have been created to help facilitate the secure data transfer of an iOS based device (iPhone or iPad), allowing clinicians to capture photographs and send them to the patient's record in the EHR, stored as Portable Document Format (PDFs).[84] The researchers leveraged the existing organization's service-oriented infrastructure to facilitate the transmission of the image files while the user is on the secure WiFi network.[84]

mHealth technology studies have shown improved patient outcomes. Yet while there have been successes, there are still some major concerns with the use of this technology to manage protected health information and to provide clinical decision support. Two important areas of concern for clinicians and healthcare organizations as they consider mHealth in patient care are the quality and security of mHealth technology.

Assessing App Quality and Security

Depending on its intended purpose, an application's use could result in dire consequences if there is an error/bug in the system and the output is misleading or just plain incorrect. For example, if an cardiovascular health screening application were to present a low risk score of having a heart attack or stroke to someone who, in actuality, has a very high risk score (potential to have a heart attack or stroke) that person is less likely to seek medical care or consult a physician. A very small error in the system or in the data entered by the user could lead to much more severe consequences. While it is still not clear what the physician's liability would be in a case where an application provided incorrect information to a user, there is no doubt of the disastrous outcome for the patient.[85]

An additional complexity encountered by the Heart Health Mobile™ project and many others was the assessment and determination of whether or not the mHealth application is a "medical device". Definitions and policies are complex, but one of the key factors is the organization of origin. If developed by a covered entity, the application is likely to fall under more rigorous review by the FDA.[86] The FDA guidance on medical devices and mobile applications was revisited in 2015 and has since clarified a number of requirements and exemptions to their review. This included a published list of "mobile apps for which the FDA will exercise enforcement discretion".[87] Certain types of apps are not considered medical devices; the costs and benefits of this policy remain to be determined.

Researchers from the United Kingdom created and tested an 18-item checklist to help clinicians in evaluating mHealth apps.[88] The researchers expect clinicians will be able to utilize this

checklist as a guide and feel more confident about using medical apps for themselves and their patients.[88] This was the only quality assessment-like checklist located in the literature regarding mHealth application review for physicians. A flurry of other organizations and researchers have attempted to address and decipher the complexities of quality control of mHealth, including security,[89-92] privacy,[92-93] laws and regulations,[94] and EHR integration architectures.[95]

Clinician use and preferences of mHealth in clinical practice

Despite some security concerns with mHealth applications, clinician use of mHealth has continued to increase.[96] Forty-six percent of healthcare professionals say that they will introduce mHealth apps into their practice within the next five years.[96] In the same survey of 500 health professionals, 86% believe that health apps will increase their own personal knowledge of their patients' conditions, and 96% of users of mHealth apps reported that these apps improve their quality of life.[96] Empowering patients to take ownership and responsibility for their own care is often a pillar of a patient-centered model of care. This has impact potential from mHealth technologies. Seventy-two percent of surveyed healthcare professionals indicated that they believe health apps will encourage their patients to take more responsibility in managing their own health.[96]

There are studies in the literature focusing on rural populations, potentially more than what has been done with urban populations, though that has not been verified. A study of healthcare providers in rural areas of northern India found that there was a high adoption rate. [97] They concluded that healthcare delivery in Himachal Pradesh is suboptimal and challenging for a

number of reasons, though the providers were highly technology literate and are already using mobile services and technologies in the region.[97]

Other literature reviewed included a study in Tanzania where researchers had successes with community members recording and communicating infant birth weights via mobile phone to healthcare providers.[98] Additionally, a group of Australian researchers conducted a qualitative study of pregnant of postpartum women and health professionals that included obstetricians, general practitioners, midwives, dietitians, physiotherapists, and community pharmacists.[99] Their findings showed a uniform embrace of mHealth communication and interventions amongst the women who were interviewed. However, a variation in attitudes was found with the health professionals, who were also quicker to identify potential risks and barriers to its adoption.[99] Many clinicians, including those with rural populations have a tendency to be cautious.

Meanwhile, consumer/patient adoption rates of smartphones, tablets, WAMs, and other internet-connected devices continues to rise and shows limited barriers to the adoption of mHealth technologies.[100] Limited scientific research has been done to assess clinician views, motivations, and barriers in regards to adoption of these technologies into clinical practice with rural patients.

A Framework for Community Readiness

In a rural community of Bangladesh, Khatun, et al surveyed 4,915 randomly selected household members aged 18 years and older.[99] The research team found only 5% of participants had internet connectivity, only 50% were aware of SMS, and only 37% generally reading them. Literacy was the primary barrier. Twenty-one percent needed to charge their phones at someone

else's home, since there was no electricity in their own homes. Despite these barriers, the majority (73%) showed an interest in using mHealth technology in the future.

The team developed a framework for assessing community readiness for mHealth. That development, further described below, led to some interesting findings that have helped guide future studies, including this paper. The framework identified three high level areas of readiness that will be described in greater detail as this paper expands on those three dimensions and refines a model to fit healthcare organizational readiness.

Previous literature is encouraging, but it should be noted that many of these studies were single interventions, often focused in isolated communities. There is currently a gap in knowledge and an absence in the literature around clinicians' unofficial use of these types of technologies with rural patients. It may be because clinicians that are doing so are acting in silos with limited or no organizational direction or approval processes.

Researcher Experience

Lessons learned from the Heart Health Mobile™ project provided a foundation of experience from the development team perspective. The Student PI served as the project manager and primary decision maker, dedicated 95-100% during the three-month timeframe of development. Responsibilities included review of contest requirements, communication hub for many organizations and stakeholders, tester, content developer, marketer (co-wrote a marketing and business plan with the Director of Applied Sciences), and the primary decision maker on design, functionality, and content in the application. Working daily with the programmer, and several

times per week with the graphic designer, the position of project manager does not accurately depict the role within this project. It should also be noted that the programmer also spent many additional hours outside of the work hours in the office coding and testing the application on evenings and weekends.

This project included moving an iOS-based mHealth application, with accompanied web app, from conception through development, testing, and through many barriers of a large healthcare organization. The application was launched in a production-ready state and made available for download in a public app store, the Apple Store. This experience identified barriers and opportunities for organizational efficiencies. It also highlighted an interest from the patient population through the number of downloads that were seen in a short period of time. It also uncovered an interest from clinicians with whom the team worked closely during its development, including the chair of Cardiology.

Beyond the Heart Health Mobile™ project, the Student PI had worked on several other research projects while employed at the Biomedical Informatics Research Center, part of the Marshfield Clinic Research Foundation. One of those projects was an early assessment of clinician use of tools that collect or communicate patient-reported data. The team talked with physicians about their use of mHealth, particularly within the specialties of sleep medicine and behavioral health. The team learned that several clinicians were using tools at that time, but in no formal or organized fashion. At the time, the researcher was interested in how one might develop a software system flexible enough to collect various patient-reported data through a survey-like tool.

Another project was writing a grant proposal, which was unfortunately not funded. The team met with Oncology care team members and patients to collect feasibility data. The proposal called for the development of a software application that would meet the needs of cancer rehabilitation patients. This was essentially a mobile app that patients could use to track mood, pain levels, and general adherence to the rehab program. It would also provide guidance on exercises and related health education content. Thought the project was not funded, it was a valuable exercise in the needs analysis of a unique population of motivated and willing mHealth adopters.

Exposure to clinical workflows, processes, and care management is typically acquired through working or volunteer positions in that field. For the Student PI, the past 18 months have yielded experiences in healthcare that most will never have as a patient and parent. This included the pregnancy and birth of identical triplets and their subsequent 2-month hospitalization primarily in the pediatric intensive care unit (PICU).[101-102] This experience has built new knowledge as a patient, a parent, and a user of many different technologies. Interactions with clinicians included many specialties and organizations such as the Marshfield Clinic, Ministry Hospital, UW-Health, and the Marathon County Birth-to-Three program. The Birth-to-Three program provides ongoing physical, occupational, and speech therapy for two of the boys who sustained lasting effects from the brain injury caused by Human Parechovirus Type 3.[103]

During the boys' hospitalizations, physicians noted that the organization had not likely ever tested a patient for more things that the boys were tested for during their search for answers. The case essentially stumped the medical community and networks of physicians were contacted in

hopes of finding a diagnosis. A Facebook Page was also created to provide updates and also to continue the search in hopes that someone who read the story would have seen similar symptoms in newborns. Posts on that Page often reached more than 20,000 viewers.[104]

Experiences define who we are as human beings and influence the decisions we make from that point forward. Holistically, this set experience has supplemented the Student PI's coursework and education in biomedical and health informatics. And in part, these experiences led to the formation of this project's original proposal and research questions.

III: RESEARCH METHODS

Overview

As mentioned in previous chapters, mHeath technologies such as apps are widely available, along with the personal devices needed to run them. Clinicians and researchers have had successes with mHealth in urban and rural settings at various locations around the globe. However, limited organizational adoption has emerged in rural Wisconsin.

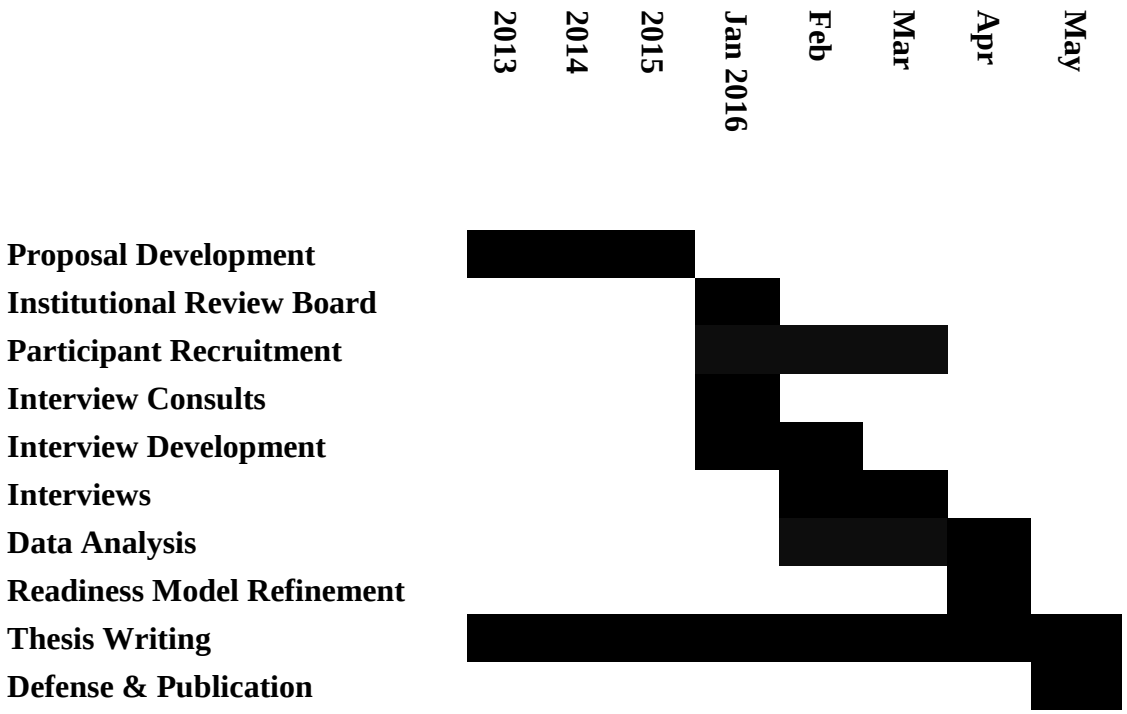
Clinicians who see patients are particularly busy and may be less likely to complete electronic or paper-based surveys. Therefore, this study was done using semi-structured, open-ended interviews. This two-part methodology includes consults and interviews as the primary data collection, and the refinement of an mHealth readiness model utilizing this study's findings.

Institutional Review Board

This study was approved as minimal risk after review by the University of Wisconsin – Milwaukee Institutional Review Board. The protocol has been granted Exempt Status under Category 2 as governed by 45 CFR 46.101(b) (see Appendix A). This study was also reviewed by the Marshfield Clinic Research Foundation's Office of Research and Integrity and approved as minimal risk and Exempt from Further Review (45 CFR 46.101(b)(2)) (see Appendix B).

Timeline

Figure 9 - Timeline



Recruitment of Participants

Interviews and consults were conducted at Marshfield Clinic locations in Wisconsin. Interviews were one-on-one interactions. The clinicians were recruited via phone and email (see Appendix H, Recruitment Email). The sessions were scheduled at the convenience of the clinicians.

Data Collection

Data collection was carried out between February and April of 2016 in Marshfield, Wisconsin. The sessions were recorded using a battery-powered Olympus DM-620 audio recorder. Hand-written notes were also taken. Following the consults and interviews additional notes were taken, notes were reviewed, and the audio recording was reviewed for additional note-taking and thematic analysis.

Theory

Fred Davis's original Technology Acceptance Model predicts acceptance based on the end-user's perceived usefulness and perceived ease of use of the technology for a specific purpose.[105] This model, while it does have its uses, did not have the applicable focus for this project. Since this study was more focused on mHealth as a large set of technologies, rather than a specific app or device another model was selected.

The Diffusion of Innovation theory is one of the oldest social science theories, and was developed by E.M. Rogers in 1962.[106] The theory originated in communications. The concept guided explanations of how ideas may gain in popularity and momentum to spread through a population or social system. This theory informed and guided the project and will be further assessed in its relation to the newly refined conceptual model for mHealth readiness, particularly as a framework for clinician adoption, and also organizational adoption of mHealth technologies.

Interviews

The Student-PI has life and educational experience with mHealth, healthcare, and informatics; this experience guided much of the interview process. The principal method of investigation was open-ended, semi-structured interviews. The interviews were loosely bound around questions that ask the informants to reflect on their participation in mHealth. Open-ended, semi-structured interviews are largely conversation-driven and clinician time was a constraint. Because of these, it was difficult to predict exactly which questions may come up with individual subjects, and at

what point in the flow and under what context. The initial proposal called for 10 interviews, or until data collection reached the point of theme saturation.

Interviews as the primary source of data collection were used for the following reasons:

1. Access to clinicians' time was expected to be a challenge. Likelihood of completing an online or paper survey that provides the level of detailed data would be slim.
2. Interviews provided a richer and deeper set of data.
3. The use of mHealth in this care system is not formalized or structured. There exists a vague policy on cloud computing, not addressing mHealth specifically. So, the topic of mHealth is difficult to administer through surveys for these two additional reasons:
    a. The organization has not promoted or limited mHealth use through policy.
    b. Clinicians have a limited understanding of the term and needed clarification as to what technologies are considered mHealth.
4. Historically, there has not been a lot of consistency between physicians' practices, as they are often granted some autonomy.
5. There was likely going to be unique mHealth preferences based on individual experiences, backgrounds, and patient demographics that could be better captured through an interview format.

Consults

Consult interviews were conducted as a way to refine the interview schedule and questions. Consult recruitment was handled in the same fashion as discussed above for interviews. Three MD clinicians were interviewed as consults for the project. Each represented a different clinical specialty and background. The consult interview schedule was refined after each consult and those details are described in the following sections.

Initial consult interview schedule

The initial design of the semi-structured interview schedule as submitted for the dissertation proposal:

1. What is your clinical specialty?
2. How old are you?
3. Do you own a personal smartphone, tablet or both?
4. Are you familiar with mHealth?
    a. If not (speculative questions)
        i. Examples of mHealth apps
        ii. Do you see advantages to using mHealth with your patients?
        iii. If you could envision the interaction with a patient through mHealth, how would it go?
        iv. What barriers would you face, should you choose to use mHealth with your patients?
    b. If yes (experiential questions)
        i. What kinds of apps?

ii. Why did you choose those?
iii. What platforms? (iOS, Android, etc.)
iv. Does this work better for certain patient groups?
v. Can you describe your interaction with the patient through mHealth?
vi. What challenges do you have with the apps you use?
vii. What **barriers** do you face in using mHealth with your patients?

Consult 1, interview schedule revisions

As the project progressed, additional background and literature reviews were completed and follow-on discussions with the project advisor and committee members led to some adjustments to the first consult interview schedule (see Appendix D). A few questions were revised and others were added prior to the first consult.

Consult 2, interview schedule revisions

Following the initial consult and before starting the second consult, review of the interview audio recording led to adjustments of the interview schedule (see Appendix E) that included question placement, and wording. For example, in order to assess a clinician's starting point in the clinical field, the question revised to: "When did you start clinical practice?" The question needed to be more specific the respondent would not include time as a medical student and resident. It should be noted that this question was further adjusted during interviews to be asked as, "When did you start clinical practice, not including medical school and residency?"

Consult 3, interview schedule revisions

The second consult (see Appendix F) also yielded unique perspectives of the clinical workflows and possibilities for mHealth integration. The interview schedule was again refined based on feedback and flow of the interview. The schedule itself was also further reformatted to make it easier for the interviewer to follow during the interview process. For example, two columns were created one for experiential (clinicians who had experience using mHealth with patients) and one for speculative (clinician with no experience using mHealth with patients).

Interview schedule

Interviews were framed around questions that asked the informants to reflect on their participation in mHealth with rural patients. As described in the previous section, the interview structure was designed and refined throughout initial interview consults.

The following questions made up the semi-structured interview schedule:

1. What is your clinical specialty?
2. What percentage of your patients would you classify as “rural”
3. And approximately how many patients is that?
4. Do you own a personal smartphone, tablet or both?
5. Do you use health-related apps on your phone or tablet? Which ones. If not, why
6. Do you use other types of technologies, perhaps wearables like the Fitbit, to monitor health?
7. Are you familiar with the term “mHealth”?

8. Do you currently prescribe or encourage the use of mHealth apps with your patients?
    a. Why or why not? What barriers are discouraging you from doing so?

If not (speculative questions)	**If yes (experiential questions)**
Examples of mHealth apps Do you see advantages to using mHealth with your patients? If you could envision the interaction with a patient through mHealth, how would it go? What **barriers** would you face, should you choose to use mHealth with your patients?	What kinds of apps? Why did you choose those? What platforms? (iOS, Android, etc.) Does this work better for certain patient groups? Can you describe your interaction with the patient through mHealth? What challenges do you have with the apps you use? What **barriers** do you face in using mHealth with your patients?

9. Could you envision an mHealth tool that better connects the care team and also loops in the patient/parents?
10. In terms of encouraging mHealth use with patients, can you tell me what you think other clinicians' barriers are across the organization?
11. How old are you?
12. Are you married?
13. Do you have children? Grandchildren?
14. What year did you start clinical practice?
15. Now that we've talked for a while, I want to ask again – what do you think are the top three barriers to clinicians using mHealth technologies with their patients?
16. Can you think of any other questions that would be interesting to you?

Coding: Identifying Themes and Categories

The primary method of analysis was audio coding. Audio coding is the process of listening to the audio transcriptions and taking detailed notes.[108] Based on literature review and the Student PI's experience, codes were identified and also formed the basis of the study – the research questions. Deductive reasoning techniques were utilized to construct theme and category linkages. Deductive coding is the process of coding qualitative data with preexisting codes already in mind.

The existing theme categories, identified by Khatun, et al. in their study of barriers to rural community readiness to adopt mHealth, were used as a starting point. Those categories were technological readiness, motivational readiness, and human resource readiness.[85] These were a natural fit for the evaluation of community readiness, particularly a rural community. The researchers in Khatun's study were also interested in the individuals within that community and had surveyed residents, using door-to-door, in-person data collection methods.

Khatun's categories were modified for this study to: clinician readiness, patient readiness, and organizational readiness. As noted, these three categories were identified through the Student PI's experience as well as through the literature review process, including work done by Khatun, et al.[99] The themes themselves were identified as relationships between the codes and the categories, such as the relationship between the organization and the legal/liability barriers to mHealth adoption which is described in further detail in the results.

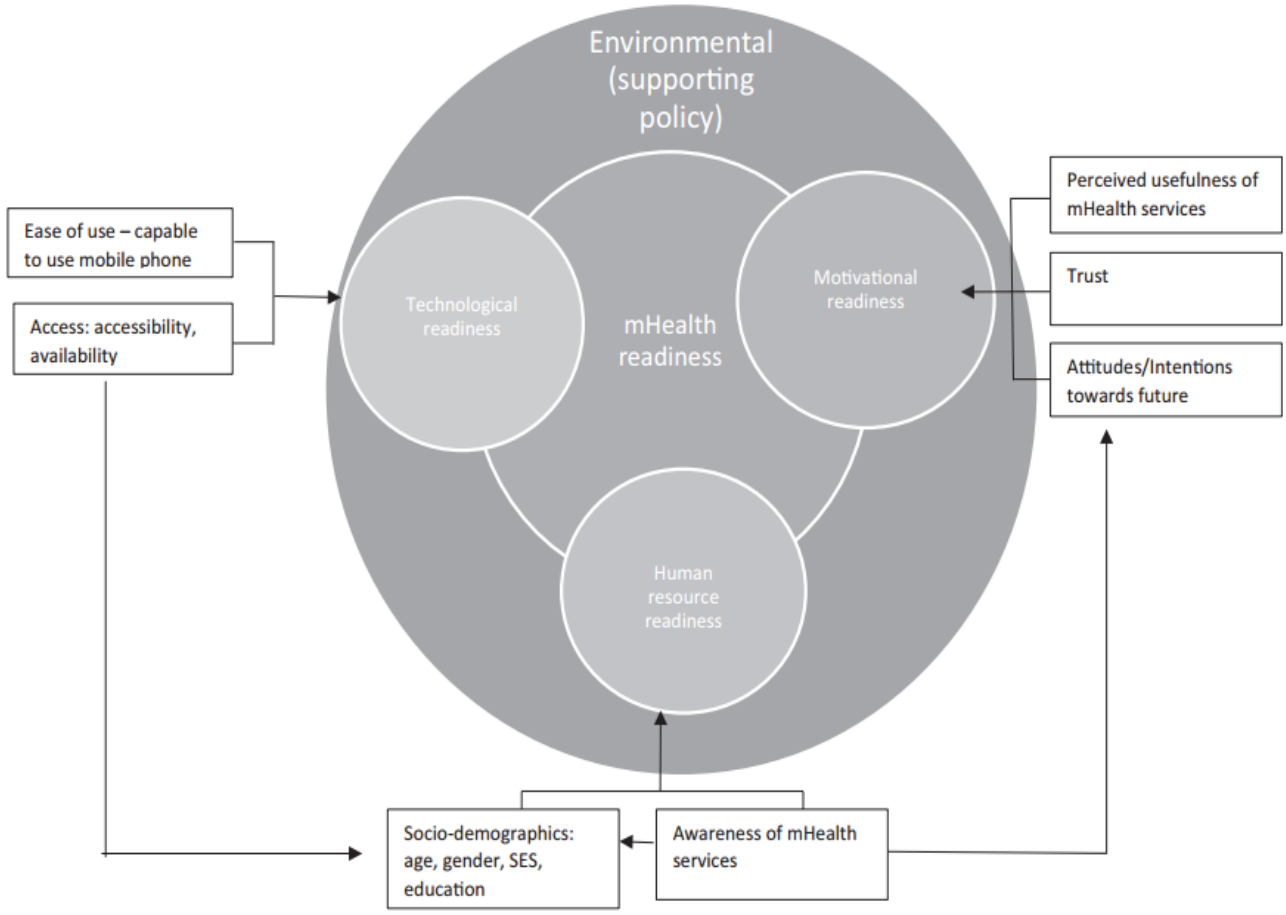
The review of the audio recordings allowed for some inductive reasoning[109] – the possibility that other themes and sub-themes would emerge. This process was used to identify additional themes

throughout in data. The audio recordings were analyzed through manual playback, review, and note-taking. Once the responses were coded, a second review of the audio recordings was completed to refine the codes and confirm any omissions or inclusions. Three categories were used to further define the themes and a thematic map was created to display the findings.

mHealth Readiness Model Refinement

The previous section's description of the work by Khatun, et al. was also utilized here, as the basis for the Readiness Model refinement. Refinement of the model was assessed prior to the interviews and several new categories were identified, as mentioned in the previous section. The original model was created for community readiness based on in-person surveys of residents in a rural community of Bangladesh.[99] The refined model is focused on healthcare organizational readiness with data collected from clinician interviews. Further defined through interview data, refinements were made to the model, including changes to category titles and influencers. Each category was further assessed for thematic linkages to codes. Those linkages, or relationships, are what encompass the core of this study and the recommendations are built into a newly refined model. Refinement is described in detail in the Results section.

Figure 10 - Conceptual model for mHealth readiness, developed by Khatun, et al.[99]



IV: RESULTS

Overview

This section presents the results of the consults, interviews, and mHealth readiness model refinement. Additional conclusions, reflections and recommendations for action and future research are included in the following section.

Consults

The consults served two primary purposes: to refine and build the interview schedule, and as data for the study. By mid-point in the interview all three consult participants had come up with different examples of how clinicians could use mHealth applications or technologies with rural patients that were not currently in practice or part of an offering with the EMR.

Demographics

Three clinicians were interviewed as consults. Each of the consults represented different clinical specialties, though these details are omitted from the results and methods because of being a potential identifier if linked with other data. Due to the small sample size, it may be possible to triangulate the responses.

The clinicians were physically located at the Marshfield center of the Marshfield Clinic. Their patient base was primarily Marshfield and the surrounding communities including Stratford, Auburndale, Pittsville, Spencer, Hewitt, Bakerville, Rozellville, Arpin, Vesper, and others. Generally, their patients lived within a twenty mile radius of the center. It was confirmed during an interview that patients do often travel further depending on the specialty of care needed.

Table 1 displays some demographics of the consult participants. The full clinician interviews, discussed below, will describe additional demographic details. Additional data from the Consults is included in the results below, including a combined analysis of the perceived barriers to mHealth adoption.

Table 1 - Descriptive demographics of consult informants

	Position	Age	Gender	Smart-Phone Owner	Tablet Owner	Child-ren	Grand-children	Patients seen per month	% of patients viewed as rural
1	MD	61	Female	No	Yes	Yes	Yes	Question not asked	
2	MD	62	Male	Yes	Yes	No	No	14-22	100%
3	MD	37	Male	Yes	Yes	Yes	No	200	10-20%

Interview Schedule Refinement

The primary purpose of the consults was interview schedule refinement. During the consults and again as the final questions, the interviewer asked for any additional comments regarding the use of terminologies, the wording, and the general make-up of the interview questions. Feedback regarding individual questions was taken into account and integrated into the interview schedule as described in the Methods section. The semi-structured, open-ended schedule allowed the opportunity to collect unique data from each participant.

Interviews

There was variation between clinicians, partially based on specialty, and partially based on individual adoption of technologies. The interviews uncovered a strong personal interest and passion for the participants' patients. And the conversations exposed uses of the technology that are already in their practice, or that they are considering for future interventions (see Table 2).

There were 12 different clinical specialties represented in the results. For the protection of the study's participants, clinical specialties have been omitted.

Of the clinicians interviewed (including consults), 92.3% were physically located at the Marshfield center, Marshfield, Wisconsin. And 7.6% were located in Eau Claire, Wisconsin, but saw patients remotely through telehealth and in person in Marshfield and Eau Claire. Another ten clinicians were contacted during recruitment, but were not able to participate. As the paper will discuss in the limitations, time is a challenge when attempting to recruit from this particular population.

Demographics

Table 2 - Descriptive demographics of interview participants

	Age	Gender	Smart-Phone Owner	Tablet Owner	Patients seen per month	% of patients viewed as rural	Prescribing/ Encouraging mHealth app / technology	Examples used or plan to use
Consults	61	Female	Yes	Yes	Question not asked		Yes	Fitbit, MyFitness Pal
	62	Male	Yes	Yes	14-22	100%	No	
	37	Male	Yes	Yes	200	10-20%	No; but hopes to	Fitness
Interviews	58	Male	Yes	Yes	200	90%	No	
	37	Male	Yes	Yes	14-22	"Most"	Yes	MyFitness Pal
	47	Female	Yes	Yes	100	95-100%	Yes	FitBit
	43	Male	Yes	Yes	40	100	Yes	MyFitness Pal
	47	Female	Yes	Yes	200	75%	Yes	Omitted
	53	Female	Yes	Yes	40	75%	No; but hopes to	BP
	40	Male	Yes	Yes	10	60%	No; but hopes to	Physical Rehab
	40	Male	Yes	Yes	200	100%	Yes	Apple iWatch, Fitbit
	46	Female	Yes	Yes	48	100%	Yes	Blood sugar, fitness, others omitted
	37	Male	Yes	Yes	200	90%	No; but plans to	Fitness

There were thirteen total participants, with consults and interviews combined. There were 38.4% (5/13) female and 61.5% male. The average age was 46.7, with the oldest being 62 and the

youngest being 37. Clinicians' personal adoption of mobile devices was higher than anticipated. At the time of the interviews, 100% of participants owned tablets, and 92% owned smart phones. And the one clinician who did not own a smartphone was planning on purchasing one within the next few weeks. Additionally, 77% were parents and 30% of those were grandparents. This social/family connection might explain the higher rates of communication device adoption.

Very few participants had an understanding of the term *mHealth* or its scope, with only 23% responding that they were familiar with the term prior to the interview. Though once it was described and examples were given, 100% knew of other cases and gave examples of mobile devices or wearables used for personal health-related activities.

The consults and interviews revealed themes that guided the development of additional questions and refined existing ones. Themes ranged from basic definitions, patient outcomes, time and knowledge, to organizational constraints and barriers. Those themes are further described below.

Coding

As themes emerged they were assigned to categories. The three primary categories were originally planned as themes that were anticipated – personal/clinician barriers, organizational barriers, and patient barriers. The rest of this section breaks down the thematic categories and the themes within each main category.

Table 3 shows the breakdown of the top barriers identified during the interviews and consults combined. The question asked: "Now that we've talked for a while, I want to ask again – what

do you think are the top three barriers to clinicians using mHealth technologies with rural patients?" Several clinicians listed more than three, this table only shows the top three responses tallied (answers 4, 5, etc. were omitted). *Clinician Familiarity* and *Clinician Time* accounted for 38.4% of identified barriers (15/39) to using mHealth applications or technologies with rural patients. Eight out of the next ten were organizationally-based barriers including EMR/Data with 12.8% (5/39) and HIPAA/PHI with 10.2% (4/39) of total responses. Patient connectivity was combined with technology adoption and accounted for 10.2% (4/39) of the total responses, higher than anticipated.

Table 3 – "Top three barriers" to mHealth adoption, identified during interviews and consults (n=13; 39 responses)

BARRIERS	NUMBER OF RESPONSES
Clinician Familiarity	9
Clinician Time	6
EMR/Data	5
HIPAA/PHI	4
Patient Connectivity/Tech	4
Organizational Direction	2
Patient Acceptance	2
Patient Affordability	2
Uniformity of use	2
Hindering patient-provider communication	1
Technology reliance and limited patient face-time	1
Usability of the app/tech	1

Clinician Adoption at Marshfield Clinic

As shown in Table 2, 53.8% (7/13) of participants reported encouraging the use of apps or WAMs with patients. When discussing My Fitness Pal, the clinician was quoted saying:

> "I've had a fair amount of success by cueing people into some things like My Fitness Pal. If I've assessed a patient and they have some readiness to change, I'll do some motivational interviewing around that and get people to buy into it and committed to making a lifestyle change. I'll specifically call out a tool to help

> them. I've had the patient pull it up in the app store and download it in the office and kind of get them started in terms of what you need to do. Both I and my spouse have used that tool in our practices and have had patients that have had tremendous results because of it."

According to the participant, the couple had heard a speaker giving a presentation on this mHealth tool at a continuing medical education (CME) event, and also noted that "it wasn't driving patients to alter drug therapy; it was a way to track, record, and provide feedback. So, it was just a great way to engage patients. My spouse and I started using it, and then started recommending it to patients". Motivated by an initial presentation of possibilities, the couple engaged in their own research, testing out the technology on their own. Soon after, deciding that it would be a great fit for their patients. While, the participant did note limitations and that it is not a one-size-fits-all approach, they described notable successes and a positive outlook on the technology and its use in patient care:

> "Does it help everybody? No. But a much higher percentage of patients had a positive change as a result of using that, than I ever saw had a positive change by me speaking with them and giving them a pamphlet to take home. It gave them something actionable, something that they had to report into. And when they would come back in, they would actually pull it up on their smartphones. We could kind of walk through and I could see they were actually doing it and we were seeing the results, in terms of what their numbers looked like."

This participant compared the data collection to a patient's home blood sugar monitoring, "I don't go through all of those [data], I look at their average or I look at a range and say their blood sugar over the past two weeks ranged from fasting morning sugars of 100 up to 150 and I record things more globally that way." While noting that he/she does put some of the patient-reported data into the EMR, he/she did prefer to have some type of automatic feed. This feedback is discussed in the Data/EMR section below.

Additional examples of clinician adoption identified during the interviews are further explored in the discussion section of the paper. There are other examples of motivated clinicians that are using various mHealth technologies with patients, and also voiced their excitement over the results of those interventions. Several examples are unfortunately omitted from the results due to the possibility of identifying the participants through the clinicians' specialty, and the specificity of the mHealth apps being used with patients. The following section outlines perceived barriers of clinician adoption that were identified during the interviews.

Clinicians' Perceived Barriers Category 1 – Personal (Clinician)

This category was established as a division of themes relating back to the clinician's personal barriers and not necessarily influenced by the organization or the patient. Of the three categories, this one saw the smallest number of responses. Those themes are described in more detail below.

Technology Adoption

Not to be confused with technology adoption of patients or of the organization, this section discusses the technology adoption levels and readiness of the clinician. As the last section discussed, adoption and readiness to use with patients was of interest to a number of participants. Also, the adoption of technologies including smartphones and tablets was very high among respondents (100%). However, participants still noted personal adoption as a perceived barrier for clinicians who see rural patients. Participants also discussed this when asked what they feel are the perceived barriers of *other* clinicians within the organization.

Familiarity with mHealth Options

Even though a majority of the participants reported engagement with mHealth, a general lack of familiarity with mHealth apps and technologies was common. This also was the leader in the "Top three barriers" question, with 23% of all possible answers being "familiarity". Additionally, 66.6% (2/3) of consults also reported this barrier, including one stating that "taking the time to learn about what apps might be useful" to them is a challenge.

Unless they were a personal adopter, mHealth technologies are not something they were actively looking for, including trying to find new tools that might help with their clinical practice. Of those that are not using any mHealth or WAM technologies now (46.1%), familiarity was one of the biggest barriers. One clinician was quoted saying:

> "How do you learn about it? To me that's a barrier. It's a time issue. I'm not going to spend my free time looking for it. And if the clinic doesn't offer it to me I'm probably not going to learn a lot about it. If someone put on a continuing education course on mobile apps that you can use with your patients, I would probably go, but I have never seen one. There's never been one offered here. I'm not sitting around at my desk a lot in my medical practice doing nothing, where I would have time to look these things up."

Clinicians' Perceived Barriers Category 2 – Patient

One clinician who spoke at length about patient barriers was also an adopter of mHealth and frequently promoted the use of several technologies with her patients. The majority of the patient barriers that she identified during the interview were based on experience and not speculation. Those barriers are described in this section, though these barriers were not highlighted across all interviews or specialties. The data is not exclusively described in a way in which the patient barriers are assumptions based on speculation of the clinician, or based on actual attempts to implement mHealth technologies. The results described here are a mix of both.

Affordability

The barrier of patient affordability emerged early on, but was limited. It was mentioned only once in the "Top three barriers" of clinicians, but was discussed during two other interviews as a potential barrier. Affordability does not appear to hold any argument for barriers to adoption. An assumption is that this was likely a more significant barrier five to ten years ago as the smartphone adoption rates were just starting to climb.

Willingness and Adherence

Coded as a Patient Acceptance response to the "Top three barriers" question, the willingness and adherence of patients was discussed with two participants. One of those participants does use mHealth technologies with his/her patients, but he/she also sees a unique patient population not representative of the whole patient population. Though as noted above, the specialty is omitted to protect the identity of the participant, in this case further research with regard to barriers related specifically to the participants' specialty is warranted.

Access and Connectivity

Access and Connectivity was a barrier identified on 10% of the responses to the "Top three barriers" question. It also emerged throughout the interviews. While conversations touched on this topic at some point, it was not always in a way that access and connectivity was viewed as a barrier. For example, one participant talked about access and connectivity as a barrier when they had first started to promote My Fitness Pal with patients. This was in part, because many of the patients still had flip phones at the time and were encouraged to use their home computer to keep track of activity. This had limited success. However, since the increased adoption of smartphones

among that participant's patient population, they have seen this particular theme of Access and Connectivity fade as a barrier. Others also noted that access and connectivity is no longer a hurdle since cell coverage is so well spread across Marshfield Clinic's service area.

Clinicians' Perceived Barriers Category 3 – Organizational

Limited Time and Existing Knowledge

All three consults noted time limitation as a barrier to understanding, locating, evaluating, or implementing mHealth technologies with patients. Time also accounted for 15.3% of the responses to the "Top three barriers" question. Clinicians, particularly physicians, have tight schedules with very limited time for continuing education, research, or exploration into new technologies. One participant was concerned about the potential "time-sink" that an app which facilitates patient-to-physician interaction might impose. When asked what he thought other clinicians' barriers might be, he was quoted saying:

> "Once I've initiated the use of the app, will I be overwhelmed by the amount of information that's provided to me? More than I can handle, and at times disappoint the expectations of my patients because I can't? You know, they're emailing me or texting me, or doing whatever it is that this app is going to do, and I don't have time to respond to all may patients who are using the app. That's another potential barrier I think."

Uniformity

A lack of uniformity across clinicians and departments emerged from the interviews. Uniformity in this context is described as a common and guided practice among different clinicians to use similar mHealth tools. Clinicians who commented on uniformity noted that it should be

considered in any type of organizational model moving forward. Several of the participants noted that they did not have any type of departmental process in place, but would benefit from some type of uniformity or common footing. This concept links closely with the next section that more specifically defines an organizational piece that is missing.

Lack of Policy / Direction

The tone of the interviews highlighted a number of different concepts and ideas that were not necessarily identified in the participants' "top three barriers". Lack of Policy/Direction emerged from every interview and consult as a point of discussion. Though when asked the question of "top three barriers" only 23% mentioned this as a top barrier (3/13). If asked, none of the participants were aware of a policy or specific process, either departmental or organizational, in regards to the review or screening of a new mHealth technology that a clinician would like to put into practice with his/her patients. As it stands, those that are currently encouraging patient use of some type of mHealth technology have done so with no authoritative oversight other than their own, or sometimes peer-recommendation and review. That said, of all the technologies that were mentioned, the majority were health and fitness related (e.g. My Fitness Pal, Fitbit), with others that were more specialty-focused (data omitted to protect participant anonymity).

Clinicians also discussed additional challenges of understanding organizational policy and procedures, especially regarding instances where precedence has not already been established. One conversation that followed a question regarding the process for integrating a new mobile technology led to one clinician stating that:

> "I came here and I now understand Dilbert cartoons, because you can't just do it. In fact, in my first year I innocently tried to do a few things and got my hand slapped because I was going outside of channels and I didn't even know channels existed yet and that wasn't mHealth sorts of things, but other things." The participant did note that this was in regards to another type of issue, not mHealth, but still held weight and influenced the subjects' perception of approval processes. And another participant noted that the act of "trying to get all the different people on board, and even knowing who to ask sometimes, is really difficult".

In the absence of a formal written Policy, the Policy section can be further broken down into several sections – 1) information systems security and related policies, 2) legal concerns with liabilities, and 3) app quality and patient safety. Surprisingly, none of these three were discussed by participants in with any significance. Policy was discussed from an organizational direction perspective. Security was discussed, but from a patient data and patient privacy perspective, and legal concerns and liabilities were discussed and will be further noted in the paper below. There were just two mentions of app/WAM quality, which are mentioned later in the paper, and no discussion about patient safety.

HIPAA/PHI

Responses that were combined into this code included: "HIPAA," "Protected Health Information (PHI)," "Privacy, Security," "Confidentiality," and "patient privacy".

Clinicians were outspoken about this as a barrier to how they practice or how they would like to practice medicine, with 10.2% of responses in the "top 3 barriers" question. One clinician noted that "HIPAA turns out to be a barrier, because everyone is so afraid of messing it up" and another clinician referred to the general concept as "HIPAA-phobia" and often a prohibitive

element within the healthcare industry. Another participant referred to HIPAA regulations as "very confusing and difficult to interpret".

Data and the EMR

Almost all of the interviews and consults voiced their desire to integrate patient-reported data into the EMR, with 12.8% of the responses in the "top 3 barriers" question. Clinicians also noted that the current system would not be able to handle it in an efficient way. None of the participants commented in detail on the constraints and technological challenges of mapping patient-reported data to clinical systems or how best to store that data for later retrieval and how it would be used with clinical decision support (CDS). In summary, clinicians are already using that data and would like to have it somehow integrated into the EMR.

When talking with one of the participants about the current Cattails MD and My Marshfield Clinic system that is used at MCHS, the clinician was quoted saying:

> "We have to learn how to leverage tools like that, in concert with some of these apps and other things, to say how can we exchange information out of your Fitbit that helps connect your care team with how you're doing? Are you getting your steps every day? Are you on track with your caloric intake and all of that stuff? So, I think there's some opportunity to marry those through a tool like the Portal."

Another participant who was interested in using that data noted that he/she often will make note of using the My Fitness Pal with the patient, but other than noting it there is no structured or uniform method of capturing such data. And when asked about the process of recording it, the clinician noted that he/she did not transfer detailed data such as weights, steps, and activities "mostly because it's just an onerous task to transcribe those over".

Legal and Liability

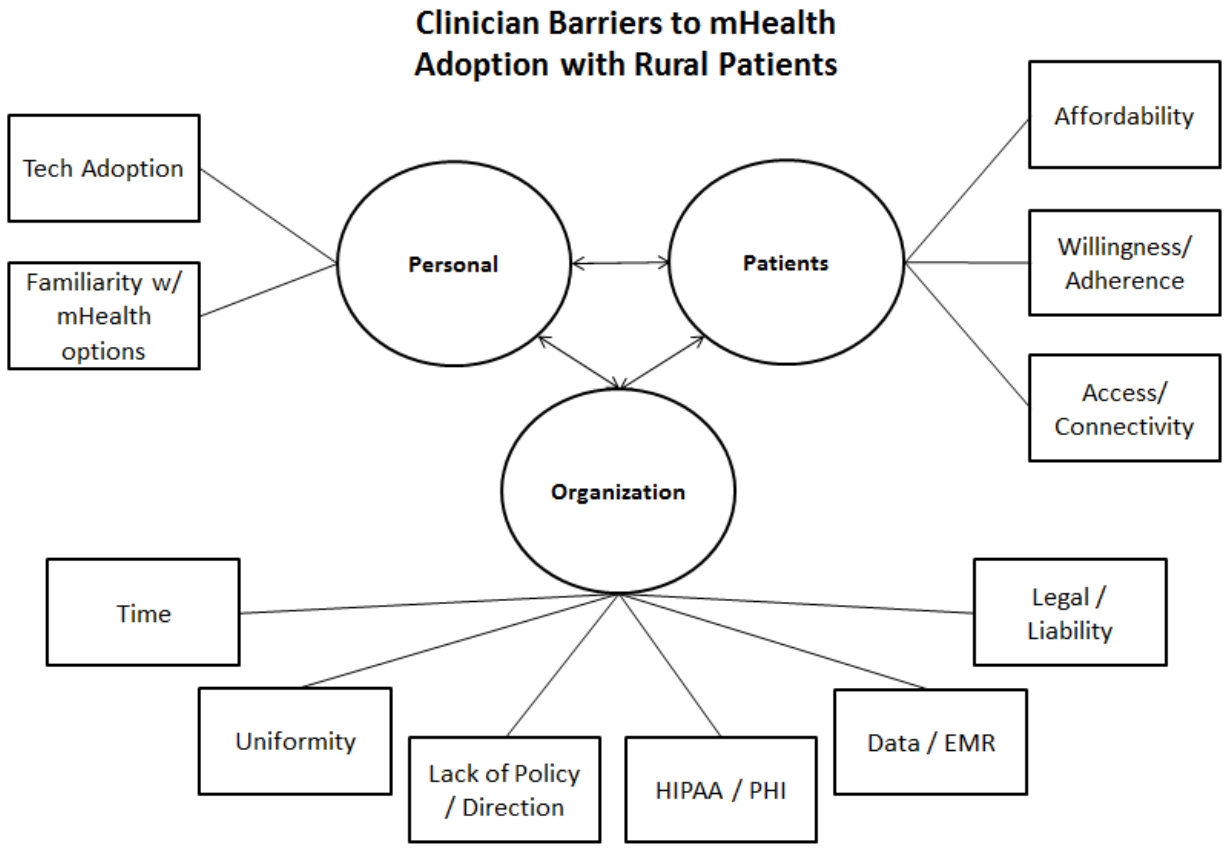
Legal refers to the Legal Department within the organization. As just a code, Legal/Liability holds little meaning and could be easily linked to a clinician barrier – as personal liability or malpractice; that particular linkage was only identified as a barrier during the interviews once. One clinician noted that "some are afraid that by recommending something, if anything ever went wrong, that they would somehow be personally liable." Meanwhile, the linkage between the *organization* and Legal/Liability was more frequent.

All three consults noted specific organizational constraints in regards to using mHealth apps and technologies with patients. Two of the three cited "legal" as one of the barriers in trying to get an organizational decision. One of the consults suggested departmental consensus and recommendations as a way to move new techniques through Legal and into practice.

Thematic Map

Figure 11 displays the coded responses of the top barriers identified throughout the interview process, as well as the thematic placement in identified categories of Personal, Patients, and Organization. Though the diagram does not display a weighted view of the responses, it does lay out the categorical branching that was somewhat anticipated at the conception of the project. This structural design was predicted based on prior experience and literature review. As mentioned above, many of the codes fell under organizational, while there were still responses leading toward patients and the clinician as barriers in the adoption model.

Figure 11 - Thematic map of clinician-identified barriers



mHealth Readiness Model Refinement

The original model of mHealth readiness based on the work by Khatun, et. al,[99] was described earlier and shown in Figure 10. As the refinement process began, three pillars and primary dimensions of readiness were formed – technological, motivational, and clinician. Technological is primarily the technical ability for the clinician and his/her patients to be able to connect and engage with an mHealth app. Both would need to have a device (e.g. smartphone or tablet), connectivity (home for patients, office/exam room for clinicians) through mobile broadband, and/or connectivity through broadband (e.g. wifi). The project does not seek to assess the connectivity and overall readiness of the patients, just the perceived patient readiness in the opinion of the clinician. "Motivational" refers to the willingness of clinicians to engage with patients in mHealth. Clinician and organizational readiness are the key areas of inquiry for this project, thus the refinement began.

As the interviews unveiled thematic linkages between codes and categories, the framework refinements began to take shape and can be seen in Figure 12. The Technological pillar was eliminated early as the data showed this is a very small barrier, if at all. The motivational barrier was also eliminated from the framework once enough data showed that clinicians who participated in this study were adopters themselves and promoters of mHealth technologies with patients.

It should be noted that this is just a framework and has not yet been tested. It is also valuable to note that the model should be used with the assumption that patients and clinicians are already motivated and that technology is not a barrier to adoption. Since both of those pillars were

eliminated from the original model, they are not to be included in assessments utilizing the new model.

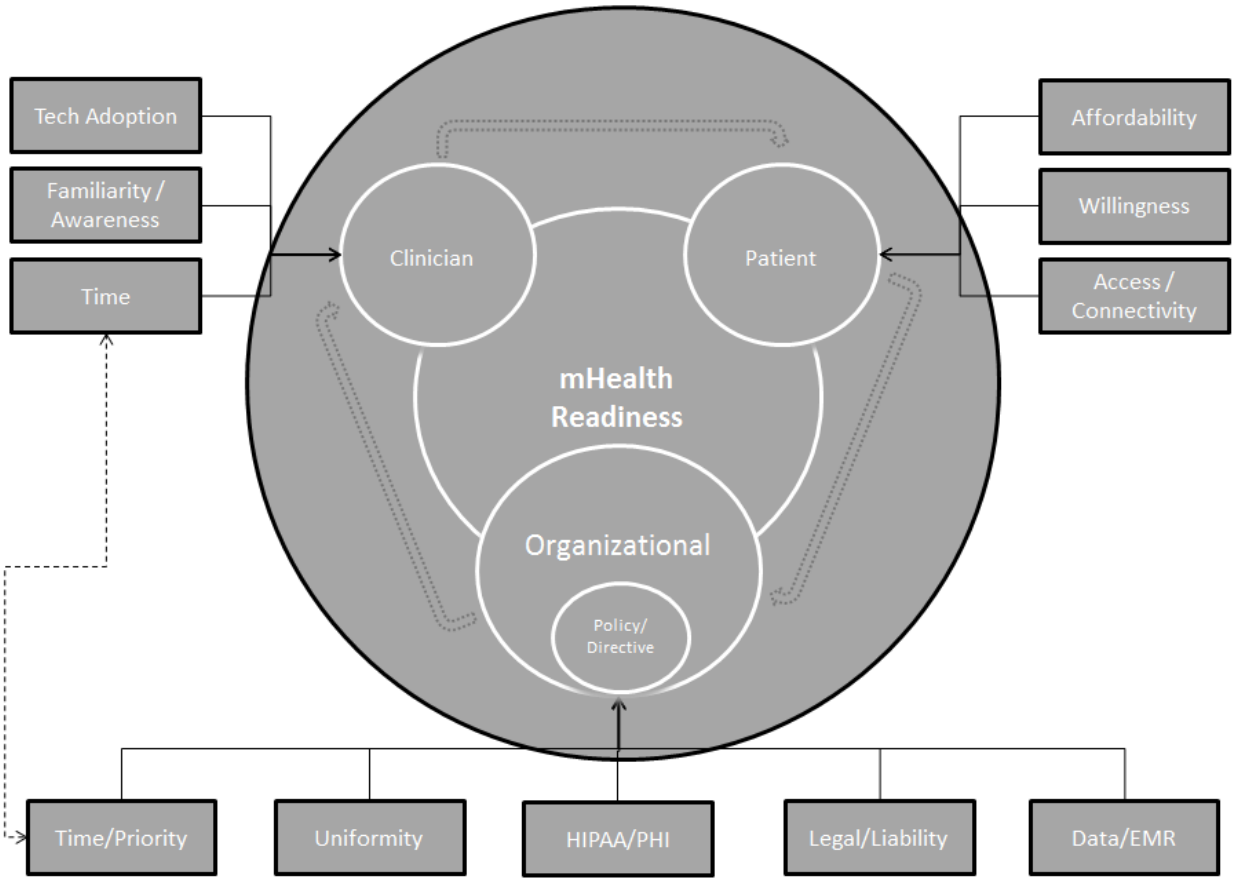
The coded barriers form a basis of decision making and readiness for each of the three categorical pillars, now labeled as “Clinician”, “Patient”, and “Organizational”. These three primary dimensions have been defined as pinnacle and foundational elements of assessing overall readiness to adopt mHealth in patient care. This framework was developed for MCHS specifically, and for other healthcare organizations generally.

There is an arrow connecting “Time” from the clinician and the organization. This represents a unique barrier that can be placed in either or both of the categories. For example, the clinician’s time was a clear barrier to adoption, but it is not known if that is and organizational barrier because there is not enough time allowed in the schedules for research/education. The other complexity is that time and priority is a potential barrier for the organization itself. Due to the current cultural climate and the competitive expansion into new markets, including the acquisition of a hospital and it’s thousands of staff members, the organizational priority and available administrative time to dedicate to mHealth may be limited.

The double-wide arrows represent an informational flow from organization to clinician to patient and back to the organization in the form of feedback and patient experience. There will be further discussion and recommendations in the discussion section as well.

It should also be noted that the model, while created based on international work, may not be as easily adaptable to international healthcare organizations. It could possibly serve as a framework, but would have to be thoroughly tested since there's so much variation in external variables and the potential for different barriers in each organization, region or country.

Figure 12 - Conceptual model for clinician mHealth readiness



V: DISCUSSION AND CONCLUSIONS

Overview

This project sought to understand the barriers to adoption, with a strong assumption that some innovative clinicians were already using mHealth tools with rural patients. This assumption was confirmed during the interview process, and in fact we found an even higher rate of adoption than anticipated. The small sample size of our study is not statistically significant, and is likely not representative of the whole MCHS clinician body. Nevertheless, our results strongly suggest that healthcare organizations should consider investing in mHealth analysis, tool development, and the promotion/recommendation of sanctioned tools for clinicians to use with patients.

Organizational mHealth readiness depends on a number of factors, not all of them addressed in this study. However, the readiness of clinicians was identified as well as barriers preventing them from furthering their mHealth practices. A follow-on study could help to identify the perceived relative importance of the barriers identified. For example, it will be useful to discover whether *time* and *familiarity* fall under personal/clinician or under organization. It could be argued that the organization is responsible for the education, training, and communication about new technologies for its physicians and staff. It could, as well be argued that the clinician is responsible for keeping abreast on new opportunities, including mHealth, to improve patient care.

One of the initial consult interviews was with a participant who was very interested in the project and what the Student PI might learn about mHealth adoption. Near the end of the interview the Student PI described more about some of what researchers and clinicians have been using, as

described in the literature. The participant was very interested, saying "you've been holding that back this whole time?" The interview schedule, as described earlier, was semi-structured. Later in the interview process, as in this case, there was often a little more back and forth discussion about what falls within the realm of mHealth and what some clinicians and organizations have had success with, as available in the scientific literature. The clinician also said that "these are things that we should start talking about as a group, immediately. These are inspiring."

The same clinician continued to describe some of the possibilities where mHealth would be useful. The clinician then added that "I think about maybe kids that are in that tween to teenager years that are having challenges to get more active and curb their weight, lose weight, do something like that. I'm inspired; I think I should start something like this. That would be great." The researcher had not planned on discussing mHealth in a way to influence the participant in any way. The tone of any information was neutral, as much as possible, so as to not persuade or motivate the participant to consider mHealth technologies. Limitations, challenges, and barriers were discussed as well as some of the interventions in the literature. This particular physician's reaction is one example that suggests healthcare organizations should consider investing in mHealth.

Other interviews yielded similar results and further showed that the organization is not yet prepared for innovative clinicians. mHealth as a tool for improving patient outcomes is already being embraced by some, and others may be very interested in its potential. One clinician's perceived value was described as the time between visits, which is otherwise unmonitored and

loosely reported with unknown accuracy during the next appointment. That clinician was quoted saying:

> "Where I see the real value, is in between visits. So, I may only see a patient with diabetes every 6 months or see a patient with high cholesterol once a year. So, you might cue them in to My Fitness Pal and talk about lifestyle modifications. But do I bring them back in two months specifically to say, are you using your app? No. If there's no clinical reason to bring them back and it's just preventative care, you might not see that person for a year. But if that was then connected and you have the ability to make that link you could actually have some tracking of patients' *in-between* time and provide some positive reinforcements. So let's say the patient starts using a tool like My Fitness Pal and they hit a ten pound weight loss. Well, that would be great if that could somehow trigger onto my worklist so that our practice could do an outbound communication to that person as a "thumbs up" you hit the ten pound weight loss! That's awesome! Let us know how we can help. Let people know that you're involved in their care and you're recognizing and applauding them for their efforts and helping to fuel the fire."

While there are some risks that would need to be managed and mitigated, if organizations were prepared to manage mHealth it is very likely that clinicians could improve the quality of care for their patients. At least, our preliminary results suggest that many physicians may see such benefits of mHealth technologies. However, many organizations, including MCHS, are not yet prepared to prescribe or prohibit the use of mHealth technologies. That said, there are some recommendations that come from this study, particularly the formation and promotion of a Resource Menu. Those details are further described in the unexpected outcomes section below.

Diffusion of Innovations

The Diffusion of Innovations Theory has emerged as a commonly applied theory in helping to understand the rate at which innovations are adopted by different populations and in different settings. The theory consists of five basic characteristics of innovations that influence the rate of adoption: relative advantage, compatibility, complexity, trialability, and observability.[106] These

characteristics, described below may each have unique application to clinicians' perceived barriers to adopting mHealth technologies with rural patients.

Relative advantage

Rogers explains the relative advantage as "the degree to which an innovation is perceived as being better than the idea it supersedes".[106] For many clinicians in both large and small health systems, an electronic health record is already in place. Documentation of histories, medications management, etc. is all under one system that is accessible via laptop/tablet at the point of care – in the exam room. While this technology exists and is used by 100% of physicians in the MCHS, it does not offer functionality that allows patients to record and track their own data, like they would with My Fitness Pal. Thus, the question of whether or not the new technology would be an advantage over existing remains unanswered. According to the data collected for this study, there are clinicians who believe that mHealth does complement existing systems. However, there are also clinicians who do not believe so. The question might be whether or not the clinician knows something is better, or if they would take the time to find out.

Compatibility

Rogers explains that compatibility is "the degree to which an innovation is perceived as consistent with existing values, past experiences and needs of potential adopters".[106] An initial implementation of an electronic medical record can be extremely challenging for an organization, regardless of size. With upgrades to a new version of an EMR, such as MCIS Clinicals, clinicians are asked to engage with new technologies and often fundamental changes to their workflows. EMR upgrades are much different than adopting and encouraging the use of

patient-used technology and embracing patient-reported data. That use of patient-reported data is a shift in practice and is currently outside the realm of the MCHS EMR. That disconnect might be key in hindering rates of adoption.

Complexity

Throughout his work, Rogers refers to complexity as "the degree to which an innovation is perceived as relatively difficult to understand and use".[106] Like the other characteristics of the model, complexity is subjective. What is complicated for some is simplistic to others, especially in terms of technology and software. Individual backgrounds, education, and personal adoption of similar technologies are likely influencers within this characteristic of complexity. This also points at the fact that these technologies have been refined by other groups, and matches those groups' needs. So, it can be complex to use a simple technology.

Trialability

Examining the next characteristic, Rogers defines trialability as the "degree to which an innovation may be experimented with on a limited basis".[106] The trialability of many mHealth technologies is relatively available. As compared to the trialability of a new EMR, which would likely be difficult to attain a test account for, preloaded with test patients. Many applications within mHealth are available for clinicians to use themselves. Many of the technologies sited by clinicians in this study (e.g. My Fitness Pal and Fitbit) are readily available through a number of retail outlets. In fact, one of the participants specifically stated that he has his spouse had tested My Fitness Pal on their own prior to encouraging it with patients – trialing the innovation on a limited basis.

Observability

Finally, Rogers' fifth characteristic of the diffusion of innovation theory is described as "the degree to which the results of an innovation are visible to others"[106] The results of mHealth utilization, personally, or with patients can be measured easily, depending on the tool that is selected of course. For example, participants in this study commented on the successes that were had with the use of My Fitness Pal. One clinician stated: "a much higher percentage of patients had a positive change as a result of using that, than I ever saw had a positive change by me speaking with them and giving them a pamphlet to take home". This is a testament to their own work, and also a clear statement that should garner some additional investigation by other clinicians and healthcare organizations. If clinicians are able to observe results of improved patient health from the use of off-the-shelf mHealth tools, this deserves further study.

It should be noted that these characteristics and the underlying theory were not used to guide the interview question formation for this study. Thus, the interviews didn't specifically inquire about the applicability of each characteristic in regards to the participants' experience or speculation around their personal adoption or the perceived barriers of other clinicians' adoptions.

All of these individual characteristics from Roger's innovation diffusion theory are overshadowed by a barrier which was identified throughout this project – the clinicians' lack of time to dedicate to learning and exploring new technologies. Additionally, a lack of familiarity was commonly identified barrier. The time limitations, coupled with an already lagging familiarity of effective and available mHealth tools means something significant – without

organizational direction, information, education, and persuasion, many clinicians are not likely to adopt an innovation such as mHealth into their practice. Clinicians may be familiar with the concept of mHealth; 100% of the participants in this study were. However, if they are not aware of a specific tool that would be of value, the characteristics described above and their evaluative function, have no applicability.

Meanwhile, those that have been made aware, either by their own initiative, by patients, or by the organization, will likely undergo a similar series of evaluations as described above. Each of the five characteristics of the theory may play a part in clinicians' willingness, readiness, and rate of adoption of mHealth. These may very well play an integral role in assessing where a healthcare organizational would fall on the diffusion of innovation scale.

Unexpected Outcomes

The project yielded a number of unexpected outcomes from the interviews. These outcomes suggest potential future projects as well as immediately practical actions to take based on recommendations from the participants in the present study. Other outcomes are also discussed in the pages below.

mHealth Resource Menu

Participants showed a desire for guidance and instruction, especially with regard to recommendations on what to use with patients, what others are having success with, and what has positively affected patient outcomes. Several participants noted that a seminar, webinar, or presentation on mHealth apps would be helpful and would attend. Participants were interested in

a "menu" that offers the organization's recommended mobile applications or technologies. One of the participant's responses included:

> "I would love to have some sort of databank of vetted apps that we could recommend for our patients, without each and every one of us just playing around and trying to figure it out for ourselves. To say that, if you're going to motivate patients for weight loss, here are some good apps that have been looked at by the organization, are as free of bias as you can be, and safe. I know there has been some discussion, and once in a while I hear bits and pieces, but I don't' think there's anything formal in place."

After several of the subjects requested this type of document during interviews, it was added to the schedule as a question for others. Of those that were asked if they would be interested in seeing such a list, all of the participants said they would. One was quoted saying:

> "I think having some of that stuff sanctioned and clarified for our providers who are generally mystified by all of this, because most of them only know what they've taken initiative to learn on their own. And as an organization, I think we can do a lot better job of steerage and helping people to go through those thousands of different options and say here's what we consider to be the cream of the crop. And give providers, and maybe even patients, a library of things that they could go to that might be helpful for them."

While application and technology quality never arose as a solidified theme, some clinicians hinted to it in ways such as this participant's comment: "I don't think we want to promote an app that is a 30-day grapefruit diet. So who's going to vet all that stuff when the world of apps is just exploding, I think it's a real issue for us." A quality review of mHealth technologies certainly needs to be a part of any type of formal vetting and recommendation process.

Stimulated Clinician Adoption

One of the participants reported no use of mHealth with patients, but was a personal user, including the Apple Watch. During one of the last questions of the interview, the participant

voiced that he was now very interested in learning more about what has been used and is going to be giving much more thought to how to best utilize these with patients. As a physician caring for a specific disease, he had considered himself to not have a strong vested interest in patients' total health. But after the interview he said that he was thinking of how to better incorporate fitness-related technologies into patients' recovery regimens and will continue to investigate.

Internet-based Care Program at Marshfield Clinic

Internet-based Care was a new program at Marshfield Clinic that was discovered during the interview process. The program was amid the pilot testing phase in late spring 2016. This new program was intended for patients to engage with a clinician through a mobile device or through their home or work computer. Reimbursement for this care had been negotiated by one carrier at the start of the pilot – Security Health Plan. The coverage/reimbursement was likely a leading contributor to the general lack of organizational drive to establish a program sooner. An interview participant also commented on the potential this new program will have to reach rural populations as well as urban who now might be able to connect online and not have to take time away from their job to come to a more structured appointment at a clinic location.

The participant also noted that "its device-agnostic, so you can use smartphone, tablet, pc, laptop, it doesn't make any difference. Android and iPhone will work so it really doesn't matter which operating system you're on". The pilot is starting out slowly. Some providers in the pilot are hesitant and need guidance. A bit surprised at the challenge of getting the piloting physicians to embrace the concept, the participant stated that:

> "I thought they would grab this and see all kinds of use for it. But they kind of look at it and say I just am not sure where this fits into my practice, what kind of patients will benefit from this? And so you almost have to lead them through and say well, have you thought about depression follow-up? Have you thought about things that don't require hands-on visits? Is there another way to interact with that patient to deliver care? And when you kind of them to water, some of them will drink. But independently, there seems to be a disconnect between technology and applying to traditional practice. They just aren't making that leap, a lot of them. Independently, they kind of need to be shepherded. But it seems like once they start to use the technology, they start to see more and more role or application for it within their practice. But they don't initially make that crosswalk, it's very interesting."

The program has been in pilot since late 2015, and was noted by the same participant that "we started in November [2015] with the very first pilot providers having visits this way. Our goal is to have 50 visits with a less than 2% failure rate." They plan to finish the pilot by the end of May and then move into a more massive rollout across the system. It was also noted in that same interview that other healthcare organizations are ahead in terms of their use of mHealth technologies and adoption of similar internet-based care models. Those systems noted include: Ministry, which part of Ascension Health, Health Partners, and Mayo Health System.

Participant Feedback

General feedback from clinicians was very positive. Participants seemed to enjoy the conversation and the follow-up discussion after the interview about what the project is about and what other technologies are being used with patients. Several clinicians asked to reconnect and were interested in the findings, with others who wanted to see some type of educational program or presentation about what is recommended and useful in clinical care.

Accuracy and Honesty in the Data

The honesty of participants is often critiqued in qualitative research, questioning the integrity of participant responses, and thus the data. This study was able to eliminate some of that critique through the context that bookended said responses. Participants were honest about experiences that they would have been behooved to lie about. For example, the use of unsanctioned apps and technologies in patient care was described at length by clinicians who knowingly were practicing outside the purview of higher authority, guidance, or direction. Therefore, it seems as though all participants were providing candid responses.

Interviews versus Surveys

While surveys may have allowed for a wider dissemination, geographically, clinicians' time is a significant limitation. The time itself will be discussed later in the limitations sections of the paper. Meanwhile, it is also noteworthy that the clinicians' availability and general willingness to take the time to complete a detailed survey which would be comprehensive enough to answer the questions within this study would have been hurdle. It was assumed that the response rate would not have been high enough. Additionally, the complexity of the questions and the relationships between the questions and the direction that questions needed to flow, either experiential or speculative in nature, would have been challenging to communicate through a succinct survey. Language and definitions would have also been difficult to communicate effectively at the onset of a survey. Many participants often skip through the initial verbiage and overviews of paper-based or web-based surveys. This particular project needed to take some time early in the interview to describe mHealth and to convey what specific technologies are under its umbrella.

Finally, gathering the rich data that interviews are able to provide was necessary for this project. It was determined that a survey would have been too difficult to ask participants to accurately and fully describe themselves and other influencers in a meaningful way. Particularly, it would have been difficult to follow-up on barriers and ask for descriptive examples to better illustrate the unique linkages and relationships between the coded themes and the categories (clinician, patient, organization)

Future Directions

Future research needs to focus on organizational/administrative perceptions, which may include interview with legal teams and decision-making administrative leaders of healthcare organizations. What has been found through this research and a review of the literature is that clinicians are interested in or already using mHealth technologies with patients. Also, patients are interested in or already using mHealth technologies, and some research has shown positive outcomes from mHealth interventions. Meanwhile, organizations have not yet actively embraced or supported its use.

Healthcare organizations may be the furthest removed from the patient experience and the use of mHealth interventions. They should review these studies and the results so that they can make more informed decisions.

If the study were to be repeated, it is recommended to recruit from multiple institutions and a broader geographic reach. Not only would the data be more representative of the population, but also because the researcher would be able to more descriptively report the findings. Specifically,

they could have described more about participants' clinical specialties and the unique technologies and apps that are being used in patient care. This study is limited in that regard, since those identifiers were stricken from the written report. The data is still valuable, but would be more valuable with those additional details.

Limitations

This study had limitations. This section will describe some of those limitations that the Student PI encountered throughout the project. They vary from organizational definitions to recruitment and clinician time.

Sample Size and Time of clinicians

Recruitment was a challenge primarily due to the limited time that physicians have in their workday and personal lives. Clinicians, particularly physicians, have a demanding schedule and are often tasked with seeing as many patients as possible throughout their workday. Even the non-physician staff that were contacted (e.g. physical therapists, clinical psychologists, and nurse practitioners) were either non-responsive or not able to accommodate a forty-five minute to one-hour interview. Those that did agree to participate were often interested in shortening it during the scheduling process. Several interviews were interrupted for a patient-care issue that needed to be addressed, but were reconvened minutes later. The only participants that were not interrupted had dedicated research time as part of their contract, were currently traveling, or were meeting at the end of their workday.

Definitions

The definition and classification of rural is not without complexities. These complexities include the Rural Health Information Hub's "Am I Rural" tool results.[110] Those results show conflicting reports for the Marshfield Clinic's Marshfield address (1000. North Oak Ave, Marshfield, Wisconsin). For Program Eligibility, this address is rural and eligible for the CMS – Rural Health Clinics (RHC) Program and also for the Federal Office of Rural Health Policy (FORHP) – Grant Programs. Meanwhile, in the very next section of that report, the location is defined as: "Considered Urban – located within an Urbanized Area or Urban Cluster." And has a primary description as a Metropolitan area core, in the category range of 10,000 to 49,999 (large urban cluster).

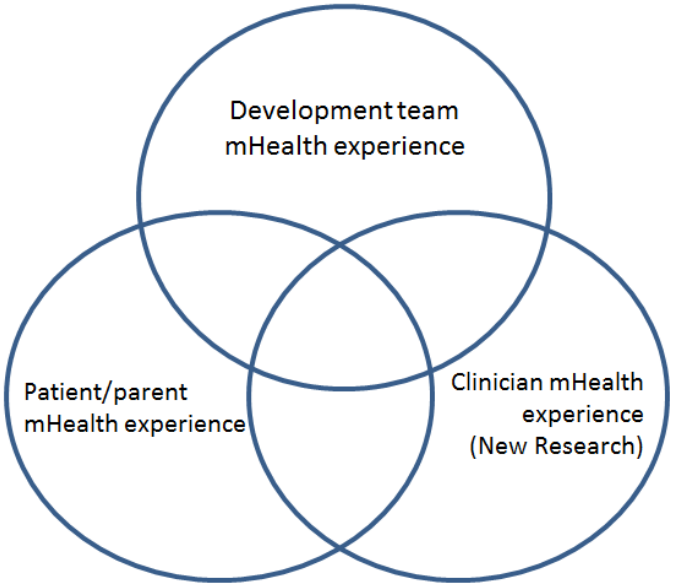
The term rural had different meaning amongst participants. Even within the consults there was variation, with one stating that all of patients seen are rural, while another was quoted as saying "you've got city water with fluoride, that's not rural". Some of the respondents asked before they answered - "do you consider Marshfield as rural?" the interviewer responded with "yes, Marshfield is rural". The respondents that answered 60% or less as rural all asked that same question and changed their answer after hearing the response. Responses that changed are noted in Table 2.

mHealth as a term was also not well understood at the start of the interviews. This was also noted earlier in the paper. The general technology was familiar to the participants; just the term mHealth was not. Once it was described and what fits under the mHealth umbrella, all participants identified having prior knowledge of the concept.

Researcher Bias

The combination of developer and patient/parent experience is now coupled with new research, to better understand the workflows, barriers, and motivations of clinicians who provide care for rural patients (see Figure 13). The personal experience of the Student PI created a basis and led to the research questions. This also created biases, which undeniably plays a role in every researcher's work. Although the interview process was semi-structured, the biases were mitigated as much as possible through structured questions and analysis of that data.

Figure 13 - mHealth experience model



REFERENCES

1. Epstein, R. M., & Street, R. L. (2011). The Values and Value of Patient-Centered Care. The Annals of Family Medicine, 9(2), 100-103.
2. MHealth New horizons for health through mobile technologies. (2011). Retrieved December 05, 2015, from http://www.who.int/goe/publications/goe_mhealth_web.pdf
3. MHealth Alliance FAQs. (2015). Retrieved December 01, 2015, from www.mhealthalliance.org/about/frequently-asked-questions
4. Wearable Technology Database | Vandrico Inc. (n.d.). Retrieved November 5, 2015, from http://vandrico.com/wearables/
5. Domingo-Salvany, A. (2008). The science of real-time data capture: Self-reports in health research. Journal of Epidemiology & Community Health, 62(5), 471-471.
6. Number of apps available in leading app stores 2015 | Statistic. (n.d.). Retrieved December 12, 2015, from http://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/
7. Number of available apps in the Apple Store from July 2008 to June 2015 | Statistic. (n.d.). Retrieved December 12, 2015, from http://www.statista.com/statistics/263795/number-of-available-apps-in-the-apple-app-store/
8. Medscape (n.d.). Retrieved March 6, 2016, from http://www.medscape.com/viewarticle/851226
9. IMS Health Study: Patient Options Expand as Mobile Healthcare Apps Address Wellness and Chronic Disease Treatment Needs. (2015). Retrieved December 5, 2015, from http://www.imshealth.com/en/about-us/news/ims-health-study:-patient-options-expand-as-mobile-healthcare-apps-address-wellness-and-chronic-disease-treatment-needs?_ga=1.47339943.1097519728.145735240
10. Number of mobile app downloads worldwide from 2009 to 2017 | Statistic. (n.d.). Retrieved December 12, 2015, from http://www.statista.com/statistics/266488/forecast-of-mobile-app-downloads/
11. What is Rural? (n.d.). Retrieved December 14, 2015, from https://ric.nal.usda.gov/what-rural#INTRO
12. Medically Underserved Areas. (n.d.). Retrieved December 13, 2015, from http://datawarehouse.hrsa.gov/Tools/MapTool.aspx?tl=MUA
13. Rural Health Resources, Research & Events | Wisconsin Office of Rural Health. (n.d.). Retrieved April 13, 2016, from http://worh.org/WisRuralAreas
14. Marshfield Clinic Health System - Corporate Information. (n.d.). Retrieved April 16, 2016, from https://www.marshfieldclinic.org/health-system
15. Hocking, A. (2016, March 16). Turney discusses assuming ownership of St. Joe's, future of Marshfield Clinic. Retrieved April 16, 2016, from http://www.hubcitytimes.com/2016/03/16/turney-discusses-assuming-ownership-st-joes-future-marshfield-clinic/
16. Marshfield Clinic hospital to open by summer 2018. (n.d.). Retrieved April 16, 2016, from http://www.marshfieldnewsherald.com/story/news/local/2015/04/15/new-hospital-open-marshfield-years/25816395/

17. Boulton, G. (2016, April 15.). Marshfield Clinic plan includes new hospitals, facilities. Retrieved April 16, 2016, from http://www.jsonline.com/business/marshfield-clinic-expansion-plan-includes-new-hospitals-other-facilities-b99482412z1-299991121.html
18. Sandler, M. (2016, March 11). Marshfield Clinic will buy instead of build. Retrieved April 16, 2016, from http://www.modernhealthcare.com/article/20160311/NEWS/160319975
19. Bringe, J. (2015, October 28). Marshfield Clinic announces plans for new Eau Claire hospital. Retrieved April 16, 2016, from http://www.weau.com/home/headlines/Marshfield-Clinic-announces-plans-for-new-Eau-Claire-hospital-300205781.html
20. Boulton, G. (2016, March 11). Marshfield Clinic to buy St. Joseph's Hospital in Marshfield. Retrieved April 16, 2016, from http://www.jsonline.com/business/marshfield-clinic-to-buy-st-josephs-hospital-in-marshfield-b99685938z1-371819541.html
21. Rural Health Information Hub. (n.d.). Retrieved April 13, 2016, from https://www.ruralhealthinfo.org/topics/frontier
22. Wisconsin: An Overlay of Rural Classifications - worh.org. (n.d.). Retrieved April 13, 2016, from http://worh.org/sites/default/files/Map8-RuralClassificationOverlay.pdf
23. Marshfield Clinic System of Care Map. (n.d.). Retrieved April 12, 2016, from https://www.marshfieldclinic.org/imagecatalog/Corporate Health System/Maps/State Map-MarshfieldClinic.pdf
24. Macdowell, M., Glasser, M., Fitts, M., Fratzke, M., & Peters, K. (2009). Perspectives on Rural Health Workforce Issues: Illinois-Arkansas Comparison. The Journal of Rural Health, 25(2), 135-140. doi:10.1111/j.1748-0361.2009.00209.
25. Halaas, G. W., Zink, T., Finstad, D., Bolin, K., & Center, B. (2008). Recruitment and Retention of Rural Physicians: Outcomes From the Rural Physician Associate Program of Minnesota. The Journal of Rural Health, 24(4), 345-352. doi:10.1111/j.1748-0361.2008.00180.
26. Health Professional Shortage Areas. (n.d.). Retrieved December 13, 2015, from http://datawarehouse.hrsa.gov/Tools/MapTool.aspx?tl=MUA
27. Broadband In Rural Areas. (n.d.). Retrieved March 12, 2016, from http://www.broadband.gov/rural_areas.html
28. International Telecommunication Union - ICT Facts & Figures. (2015, May). Retrieved December 02, 2015, from http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf
29. Guynn, J. (2016, April 13). Facebook debuts terrestrial tech to deliver Internet. Retrieved April 14, 2016, from http://www.usatoday.com/story/tech/news/2016/04/13/facebook-f8-internet-connectivity-terragraph-project-aries/82960840/
30. Project Loon. (n.d.). Retrieved April 14, 2016, from https://www.google.com/loon/
31. Obama unveils rural Internet access program, dings constantly connected teens. (n.d.). Retrieved March 12, 2016, from http://www.politico.com/story/2015/07/obama-unveils-rural-internet-access-program-dings-constantly-connected-teens-120195
32. Marshfield Clinic Web Analytics [E-mail interview]. (2015, December 5).
33. What is Telehealth? (n.d.). Retrieved December 11, 2015, from http://cchpca.org/what-is-telehealth

34. Telehealth vs. mHealth [E-mail interview]. (2015, December 11).
35. What is Telemedicine? (n.d.). Retrieved December 5, 2015, from http://www.americantelemed.org/about-telemedicine/what-is-telemedicine
36. Electronic Health Records (EHR) Incentive Programs. (n.d.). Retrieved March 12, 2016, from https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/index.html?redirect=/EHRIncentivePrograms/01_Overview.asp#TopOfPage
37. Field, M. J. (1996). Telemedicine: A guide to assessing telecommunications in health care. Washington, D.C.: National Academy Press.
38. Zairina, E., Abramson, M. J., Mcdonald, C. F., Li, J., Dharmasiri, T., Stewart, K., . . . George, J. (2016). Telehealth to improve asthma control in pregnancy: A randomized controlled trial. Respirology. doi:10.1111/resp.12773
39. Telehealth process at Marshfield Clinic [E-mail interview]. (2015, December 19).
40. Zheng, Y., Ding, X., Poon, C. C., Lo, B. P., Zhang, H., Zhou, X., . . . Zhang, Y. (2014). Unobtrusive Sensing and Wearable Devices for Health Informatics. IEEE Transactions on Biomedical Engineering IEEE Trans. Biomed. Eng., 61(5), 1538-1554.
41. Patel, S., Park, H., Bonato, P., Chan, L., & Rodgers, M. (2012). A review of wearable sensors and systems with application in rehabilitation. Journal of NeuroEngineering and Rehabilitation J NeuroEngineering Rehabil, 9(1), 21.
42. Martin, T., Jovanov, E., & Raskovic, D. (n.d.). Issues in wearable computing for medical monitoring applications: A case study of a wearable ECG monitoring device. Digest of Papers. Fourth International Symposium on Wearable Computers. Retrieved March 12, 2016.
43. Grant, R.W., J.A. Schmittdiel, R.S. Neugebauer, et al., Exercise as a vital sign: a quasiexperimental analysis of a health system intervention to collect patient-reported exercise levels. J Gen Intern Med, 2014. 29(2): p. 341-8.
44. Sallis, R., B. Franklin, L. Joy, et al., Strategies for promoting physical activity in clinical practice. Progress in cardiovascular diseases, 2015. 57(4): p. 375-386
45. Burke, L.E., J. Ma, K.M. Azar, et al., Current Science on Consumer Use of Mobile Health for Cardiovascular Disease Prevention: A Scientific Statement From the American Heart Association. Circulation, 2015. 132(12): p. 1157-213.
46. Cadmus-Bertram, L.A., B.H. Marcus, R.E. Patterson, et al., Randomized Trial of a Fitbit-Based Physical Activity Intervention for Women. Am J Prev Med, 2015. 49(3): p. 414-8.
47. Rudner, J., Mcdougall, C., Sailam, V., Smith, M., & Sacchetti, A. (2016). Interrogation of Patient Smartphone Activity Tracker to Assist Arrhythmia Management. Annals of Emergency Medicine. doi:10.1016/j.annemergmed.2016.02.039
48. Zinner, M. J., & Loughlin, K. R. (2009). The Evolution of Health Care in America. Urologic Clinics of North America, 36(1), 1-10. Retrieved March 12, 2016.
49. The History of Marshfield Clinic - Six Founding Physicians. (n.d.). Retrieved March 12, 2016, from https://www.marshfieldclinic.org/about-us/history
50. My Marshfield Clinic. (n.d.). Retrieved March 12, 2016, from https://ishine.marshfieldclinic.org/
51. Mayer, J., Kitchner, T., Ye, Z., Zhou, Z., He, M., Schrodi, S. J., & Hebbring, S. J. (2014). Use of an Electronic Medical Record to Create the Marshfield Clinic

Twin/Multiple Birth Cohort. Genetic Epidemiology Genet. Epidemiol., 38(8), 692-698. Retrieved March 12, 2016.
52. Lohr, S. (2008, December 26). Healthcare that puts a computer on the team. New York Times. Retrieved March 12, 2016, from Lohr, S. (2008, December 26). Health Care That Puts a Computer on the Team. Retrieved March 12, 2016, from http://www.nytimes.com/2008/12/27/business/27record.html?_r=0
53. Marshfield Clinic Information Systems (MCIS) - About Us. (n.d.). Retrieved March 12, 2016, from https://www.mcis.com/about-us/
54. MCIS Clinicals. (n.d.). Retrieved March 12, 2016, from https://vimeo.com/144119698
55. White, R. E. (2008). Health Information Technology Will Shift the Medical Care Paradigm. J GEN INTERN MED Journal of General Internal Medicine, 23(4), 495-499. Retrieved March 11, 2016.
56. Gisore P, Shipala E, Otieno K, et al. Community based weighing of newborns and use of mobile phones by village elders in rural settings in Kenya. BMC Pregnancy Childbirth. 2012;12:15.
57. Ngabo F, Nguimfack J, Nwaigwe F, et al. Designing and Implementing an Innovative SMS-based alert system (RapidSMS-MCH) to monitor pregnancy and reduce maternal and child deaths in Rwanda. Pan Afr Med J. 2012;13:31.
58. Lund S, Hemed M, Nielsen BB, et al. Mobile phones as a health communication tool to improve skilled attendance at delivery in Zanzibar. BJOG. 2012;119(10):1256-1264.
59. Mercer, K., Li, M., Giangregorio, L., Burns, C., & Grindrod, K. (2016). Behavior Change Techniques Present in Wearable Activity Trackers: A Critical Analysis. JMIR MHealth UHealth JMIR MHealth and UHealth, 4(2). doi:10.2196/mhealth.4461
60. Garg, A. X., Adhikari, N. K., Mcdonald, H., Rosas-Arellano, M. P., Devereaux, P. J., Beyene, J., . . . Haynes, R. B. (2005). Effects of Computerized Clinical Decision Support Systems on Practitioner Performance and Patient Outcomes. Jama, 293(10), 1223. Retrieved March 12, 2016.
61. MitchellM, Hedt-Gauthier BL, Msellemu D, et al. Using electronic technology to improve clinical care—results from a before-after cluster trial to evaluate assessment and classification of sick children according to Integrated Management of Childhood Illness (IMCI) protocol in Tanzania. BMC Med Inform Decis Mak. 2013;13(1):95.
62. Healthcare Leads & Generation. (n.d.). Retrieved March 12, 2016, from http://www.meddatagroup.com/about/
63. Infographic: Physician Adoption and Predictions of Mobile in 2015. (n.d.). Retrieved December 11, 2015, from http://www.meddatagroup.com/2015-physician-use-of-mobile/
64. Essentials Brief: Mobile Devices Study. (2014). Retrieved December 11, 2015, from http://www.himssanalytics.org/research/essentials-brief-mobile-devices-study
65. Mobility in Healthcare: Survey Results. (n.d.). Retrieved March 12, 2016, from http://app.assetdl.com/landingpage/healthcare-survey-2014/
66. FDA seeks comments on mHealth in clinical trials. (2015, November 5). Retrieved March 12, 2016, from http://www.mhealthnews.com/news/fda-seeks-comments-mhealth-clinical-trials
67. Powell, A. C., Torous, J., Chan, S., Raynor, G. S., Shwarts, E., Shanahan, M., & Landman, A. B. (2016). Interrater Reliability of mHealth App Rating Measures:

Analysis of Top Depression and Smoking Cessation Apps. JMIR MHealth UHealth JMIR MHealth and UHealth, 4(1). Retrieved March 12, 2016.
68. Morris, M., & Guilak, F. (2009). Mobile Heart Health: Project Highlight. IEEE Pervasive Comput. IEEE Pervasive Computing, 8(2), 57-61. Retrieved March 12, 2016.
69. Piette, J. D., Striplin, D., Marinec, N., Chen, J., & Aikens, J. E. (2015). A Randomized Trial of Mobile Health Support for Heart Failure Patients and Their Informal Caregivers. Medical Care, 53(8), 692-699. Retrieved March 12, 2016.
70. Weichelt B, VanWormer JJ, Kadolph C, Xu Y, Williams S, Burish D, Barwick M, Moritz B, and Lin S. Heart Health Mobile: An interactive, educational, monitoring and gaming application to improve cardiovascular health. USAID. mHEALTH Compendium Vol. 3. November 2013. Page 12.
71. Marshfield Clinic's Heart Health Mobile app wins HSS competition. (2013). Retrieved March 12, 2016, from http://www.news-medical.net/news/20130215/Marshfield-Clinice28099s-Heart-Health-Mobile-app-wins-HSS-competition.aspx
72. Urrea, B., S. Misra, T.B. Plante, et al., Mobile Health Initiatives to Improve Outcomes in Primary Prevention of Cardiovascular Disease. Curr Treat Options Cardiovasc Med, 2015. 17(12): p. 59.
73. Hebden, L., A. Cook, H.P. van der Ploeg, et al., A mobile health intervention for weight management among young adults: a pilot randomised controlled trial. J Hum Nutr Diet, 2014. 27(4): p. 322-32.
74. Kirwan, M., M.J. Duncan, C. Vandelanotte, et al., Using smartphone technology to monitor physical activity in the 10,000 Steps program: a matched case-control trial. J Med Internet Res, 2012. 14(2): p. e55.
75. Martin, S.S., D.I. Feldman, R.S. Blumenthal, et al., mActive: A Randomized Clinical Trial of an Automated mHealth Intervention for Physical Activity Promotion. J Am Heart Assoc, 2015. 4(11).
76. Glynn, L.G., P.S. Hayes, M. Casey, et al., Effectiveness of a smartphone application to promote physical activity in primary care: the SMART MOVE randomised controlled trial. Br J Gen Pract, 2014. 64(624): p. e384-91.
77. Padhye, N. S., & Wang, J. (2015). Pattern of active and inactive sequences of diabetes self-monitoring in mobile phone and paper diary users. 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC).
78. Pumper, M., Mendoza, J., Arseniev-Koehler, A., Holm, M., Waite, A., & Moreno, M. (2015). Using A Facebook Group As An Adjunct To A Pilot mHealth Physical Activity Intervention: A Mixed Methods Approach [Abstract]. Studies in Health Technology and Informatics, 219, 97-101. Retrieved March 12, 2016.
79. Mangone, E. R., Lebrun, V., & Muessig, K. E. (2016). Mobile Phone Apps for the Prevention of Unintended Pregnancy: A Systematic Review and Content Analysis. JMIR MHealth UHealth JMIR MHealth and UHealth, 4(1).
80. Willcox, J. C., Pligt, P. V., Ball, K., Wilkinson, S. A., Lappas, M., Mccarthy, E. A., & Campbell, K. J. (2015). Views of Women and Health Professionals on mHealth Lifestyle Interventions in Pregnancy: A Qualitative Investigation. JMIR MHealth UHealth JMIR MHealth and UHealth, 3(4).
81. Demment M, Graham M, Olson C. How an online intervention to prevent excessive gestational weight gain is used and by whom: a randomized controlled process evaluation. J Med Internet Res 2014;16(8):e194

82. Hingle, M., & Patrick, H. (2016). There Are Thousands of Apps for That: Navigating Mobile Technology for Nutrition Education and Behavior. Journal of Nutrition Education and Behavior, 48(3).
83. Vandelanotte, C., Müller, A. M., Short, C. E., Hingle, M., Nathan, N., Williams, S. L., . . . Maher, C. A. (2016). Past, Present, and Future of eHealth and mHealth Research to Improve Physical Activity and Dietary Behaviors. Journal of Nutrition Education and Behavior, 48(3).
84. Landman, A., Emani, S., Carlile, N., Rosenthal, D. I., Guelich, S., Semakov, S., . . . Poon, E. G. (2015). A Mobile App for Securely Capturing and Transferring Clinical Images to the Electronic Health Record: Description and Preliminary Usability Study. JMIR MHealth UHealth JMIR MHealth and UHealth, 3(1).
85. Yang, Y.T. and R.D. Silverman, Mobile health applications: the patchwork of legal and liability issues suggests strategies to improve oversight. Health Aff (Millwood), 2014. 33(2): p. 222-7.
86. U.S. Food and Drug Administration. (2015, September 22). Retrieved March 12, 2016, from http://www.fda.gov/MedicalDevices/DigitalHealth/MobileMedicalApplications/default.htm
87. U.S. Food and Drug Administration. (n.d.). Retrieved March 12, 2016, from http://www.fda.gov/MedicalDevices/DigitalHealth/MobileMedicalApplications/ucm368744.htm
88. Wyatt, J. C., Thimbleby, H., Rastall, P., Hoogewerf, J., Wooldridge, D., & Williams, J. (2015). What makes a good clinical app? Introducing the RCP Health Informatics Unit checklist. Clinical Medicine, 15(6), 519-521.
89. Zubaydi, F., Saleh, A., Aloul, F., & Sagahyroon, A. (2015). Security of mobile health (mHealth) systems. 2015 IEEE 15th International Conference on Bioinformatics and Bioengineering (BIBE). Retrieved December 02, 2015.
90. Office of the National Coordinator for Health Information Technology. Guide to Privacy and Security of Electronic Health Information. 2015 [cited 2015 19 October]; Available from: https://www.healthit.gov/providers-professionals/guide-privacy-and-security-electronic-healthinformation.
91. Federal Trade Commission. Complying with the FTC's Health Breach Notification Rule. 2010; Available from: https://www.ftc.gov/tips-advice/businesscenter/guidance/complying-ftcs-health-breach-notification-rule.
92. Arora, S., J. Yttri, and W. Nilse, Privacy and Security in Mobile Health (mHealth) Research. Alcohol Res, 2014. 36(1): p. 143-51.
93. He, D., M. Naveed, C.A. Gunter, et al., Security Concerns in Android mHealth Apps. AMIA Annu Symp Proc, 2014. 2014: p. 645-54
94. mHealth Laws and Regulations. 2014; Available from: http://cchpca.org/mhealth-laws-and-regulations
95. Marceglia, S., P. Fontelo, E. Rossi, et al., A Standards-Based Architecture Proposal for Integrating Patient mHealth Apps to Electronic Health Record Systems. Appl Clin Inform, 2015. 6(3): p. 488-505.
96. Are Mobile Medical Apps Good for Our Health? A New Study by Research Now Reveals That Doctors and Patients Say 'Yes' (n.d.). Retrieved December 06, 2015, from http://business.itbusinessnet.com/article/Are-Mobile-Medical-Apps-Good-for-Our-

Health-A-New-Study-by-Research-Now-Reveals-That-Doctors-and-Patients-Say-Yes--3802697
97. Ganapathy, K., Kanwar, V., Bhatnagar, T., & Uthayakumaran, N. (2016). M-Health: A Critical Analysis of Awareness, Perception, and Attitude of Healthcare Among Providers in Himachal Pradesh, North India. Telemedicine and E-Health.
98. Mitchell, M., Hedt-Gauthier, B. L., Msellemu, D., Nkaka, M., & Lesh, N. (2013). Using electronic technology to improve clinical care – results from a before-after cluster trial to evaluate assessment and classification of sick children according to Integrated Management of Childhood Illness (IMCI) protocol in Tanzania. BMC Med Inform Decis Mak BMC Medical Informatics and Decision Making, 13(1), 95. Retrieved December 02, 2015.
99. Khatun, F., Heywood, A. E., Ray, P. K., Hanifi, S., Bhuiya, A., & Liaw, S. (2015). Determinants of readiness to adopt mHealth in a rural community of Bangladesh. International Journal of Medical Informatics, 84(10), 847-856.
100. Number of mobile app downloads worldwide from 2009 to 2017 | Statistic. (n.d.). Retrieved December 12, 2015, from http://www.statista.com/statistics/266488/forecast-of-mobile-app-downloads/
101. Hocking, A. (2015, March 5). Against all odds. Retrieved April 16, 2016, from http://www.hubcitytimes.com/2015/03/05/against-all-odds/
102. Anderson, H. (2015, July 9). SPECIAL REPORT: Stratford Identical Triplets Survive Rare Virus. Retrieved April 16, 2016, from http://www.wsaw.com/news/headlines/SPECIAL-REPORT-Stratford-Identical-Triplets-Survive-Rare-Virus-298490601.html
103. Weichelt, B. (2015, January). Dylan, Logan & Mason. Retrieved April 16, 2016, from http://www.parechovirus.com/dylanloganmason.html
104. Weichelt, B., & Weichelt, S. (n.d.). Weichelt Triplets. Retrieved April 16, 2016, from http://www.Facebook.com/weichelttriplets
105. Davis, F. D. (1985). A technology acceptance model for empirically testing new end-user information systems: Theory and results.
106. Rogers, E. M. (2003). Diffusion of innovations. New York: Free Press.
107. Miller, R. L. (n.d.). Rogers' Innovation Diffusion Theory (1962, 1995). Information Seeking Behavior and Technology Adoption: Theories and Trends, 261-274. doi:10.4018/978-1-4666-8156-9.ch016
108. Wainwright, M., & Russell, A. (n.d.). Using NVivo Audio-Coding - Social Research Update ... Retrieved April 14, 2016, from http://sru.soc.surrey.ac.uk/SRU60.pdf
109. Thomas, D. R. (2006). A General Inductive Approach for Analyzing Qualitative Evaluation Data. American Journal of Evaluation, 27(2), 237-246. doi:10.1177/1098214005283748
110. Am I Rural? Rural Health Information Hub. (n.d.). Retrieved April 13, 2016, from http://www.ruralhealthinfo.org/am-i-rural

APPENCIES

APPENDIX A

UNIVERSITY of WISCONSIN
UWMILWAUKEE
Department of University Safety & Assurances

Melissa Spadanuda
IRB Manager
Institutional Review Board
Engelmann 270
P. O. Box 413
Milwaukee, WI 53201-0413
(414) 229-3173 *phone*
(414) 229-6729 *fax*

http://www.irb.uwm.edu
spadanud@uwm.edu

New Study - Notice of IRB Exempt Status

Date: February 15, 2016

To: Timothy Patrick, PhD
Dept: Health Sciences

Cc: Bryan Weichelt

IRB#: 16.229
Title: Health in Your Hand: Assessment of Clinicians' Readiness to Adopt mHealth into Rural Patient Care

After review of your research protocol by the University of Wisconsin – Milwaukee Institutional Review Board, your protocol has been granted Exempt Status under Category 2 as governed by 45 CFR 46.101(b).

This protocol has been approved as exempt for three years and IRB approval will expire on February 14, 2019. If you plan to continue any research related activities (e.g., enrollment of subjects, study interventions, data analysis, etc.) past the date of IRB expiration, please respond to the IRB's status request that will be sent by email approximately two weeks before the expiration date. If the study is closed or completed before the IRB expiration date, you may notify the IRB by sending an email to irbinfo@uwm.edu with the study number and the status, so we can keep our study records accurate.

Any proposed changes to the protocol must be reviewed by the IRB before implementation, unless the change is specifically necessary to eliminate apparent immediate hazards to the subjects. The principal investigator is responsible for adhering to the policies and guidelines set forth by the UWM IRB, maintaining proper documentation of study records and promptly reporting to the IRB any adverse events which require reporting. The principal investigator is also responsible for ensuring that all study staff receive appropriate training in the ethical guidelines of conducting human subjects research.

As Principal Investigator, it is also your responsibility to adhere to UWM and UW System Policies, and any applicable state and federal laws governing activities which are independent of IRB review/approval (e.g., FERPA, Radiation Safety, UWM Data Security, UW System policy on Prizes, Awards and Gifts, state gambling laws, etc.). When conducting research at institutions outside of UWM, be sure to obtain permission and/or approval as required by their policies.

Contact the IRB office if you have any further questions. Thank you for your cooperation and best wishes for a successful project

Respectfully,
Melissa C Spadanuda
Melissa C. Spadanuda
IRB Manager

APPENDIX B

Marshfield Clinic
Research Foundation

1000 North Oak Avenue
Marshfield, WI 54449-5790

715-387-5241
1-800-782-8581
Fax 715-389-3131

Office of Research Integrity & Protections

INSTITUTIONAL REVIEW BOARD
FWA # (FWA00000873)

Date: January 20, 2016
PI: Bryan Weichelt
SP Code: WEI40116
Title: Health in Your Hand: Assessment of Clinician's Readiness to Adopt mHealth into Rural Patient Care

On January 19, 2016, your request for IRB exemption of the above referenced project was reviewed. The Office of Research and Integrity (ORIP) has determined that the project is exempt from further IRB review (45 CFR 46.101(b)(2)). ORIP has determined that no Protected Health Information will be used for this project, and therefore HIPAA Privacy Regulations are not applicable.

If you propose to make changes to the exempted research, you must submit a new IRB Exemption Request to ORIP prior to making the change. ORIP will re-evaluate the project to determine whether the proposed changes affect the exemption determination.

Lori Scheller

Lori Scheller, Administrator
Institutional Review Board

APPENDIX C

Initial Consult Interview Schedule

1. What is your clinical specialty?
2. How old are you?
3. Do you own a personal smartphone, tablet or both?
4. Are you familiar with mHealth?
    a. If not (speculative questions)
        i. Examples of mHealth apps
        ii. Do you see advantages to using mHealth with your patients?
        iii. If you could envision the interaction with a patient through mHealth, how would it go?
        iv. What barriers would you face, should you choose to use mHealth with your patients?
    b. If yes (experiential questions)
        i. What kinds of apps?
        ii. Why did you choose those?
        iii. What platforms? (iOS, Android, etc.)
        iv. Does this work better for certain patient groups?
        v. Can you describe your interaction with the patient through mHealth?
        vi. What challenges do you have with the apps you use?
        vii. What **barriers** do you face in using mHealth with your patients?

APPENDIX D

Consult 1, Interview Schedule

1. What is your clinical specialty?
2. Do you own a personal smartphone, tablet or both?
3. Are you familiar with mHealth?
    a. If not (speculative questions)
        i. Examples of mHealth apps
        ii. Do you see advantages to using mHealth with your patients?
        iii. If you could envision the interaction with a patient through mHealth, how would it go?
        iv. What barriers would you face, should you choose to use mHealth with your patients?
    b. If yes (experiential questions)
        i. What kinds of apps?
        ii. Why did you choose those?
        iii. What platforms? (iOS, Android, etc.)
        iv. Does this work better for certain patient groups?
        v. Can you describe your interaction with the patient through mHealth?
        vi. What challenges do you have with the apps you use?
        vii. What barriers do you face in using mHealth with your patients?

1. Do you or could you imagine connecting with patients or parents through mHealth as a tool that's beneficial for you as a clinician and/or for the patient and parents?
2. Could you envision an mHealth tool that better connects the care team and also loops in the patient/parents?
3. Can you talk about your colleagues' use of mHealth and if they do not use it what you think some of their barriers are?
4. Can you think of any other questions that would be interesting to you?
5. Do any of these questions need to be reworded?
6. How old are you?
7. How long have you been seeing patients?

APPENDIX E

Consult 2, Interview Schedule

1. What is your clinical specialty?
2. What percentage of your patients would you classify as "rural"
3. And approximately how many patients is that?
4. Do you own a personal smartphone, tablet or both?
5. Do you use health-related apps on your phone or tablet? Which ones. If not, why
6. Do you use other types of technologies, perhaps wearables like the Fitbit, to monitor health?
7. Are you familiar with the term "mHealth"?

If not (speculative questions)
Examples of mHealth apps
Do you see advantages to using mHealth with your patients?
If you could envision the interaction with a patient through mHealth, how would it go?
What **barriers** would you face, should you choose to use mHealth with your patients?

If yes (experiential questions)
What kinds of apps?
Why did you choose those?
What platforms? (iOS, Android, etc.)
Does this work better for certain patient groups?
Can you describe your interaction with the patient through mHealth?
What challenges do you have with the apps you use?
What **barriers** do you face in using mHealth with your patients?

8. Do you currently prescribe or encourage the use of mHealth apps with your patients?
    a. Why or why not? What barriers are discouraging you from doing so?
9. Could you envision an mHealth tool that better connects the care team and also loops in the patient/parents?
10. In terms of encouraging mHealth use with patients, can you tell me what you think other clinicians' barriers are across the organization?
11. How old are you?
12. Are you married?
13. Do you have children? Grandchildren?
14. What year did you start clinical practice?
15. Now that we've talked for a while, I want to ask again – what do you think are the top three barriers to clinicians using mHealth technologies with their patients?
16. Can you think of any other questions that would be interesting to you?
17. Do any of these questions need to be reworded?

APPENDIX F

Consult 3, Interview Schedule

1. What is your clinical specialty?
2. What percentage of your patients would you classify as "rural"
3. And approximately how many patients is that?
4. Do you own a personal smartphone, tablet or both?
5. Do you use health-related apps on your phone or tablet? Which ones. If not, why
6. Do you use other types of technologies, perhaps wearables like the Fitbit, to monitor health?
7. Are you familiar with the term "mHealth"?
8. Do you currently prescribe or encourage the use of mHealth apps with your patients?
    a. Why or why not? What barriers are discouraging you from doing so?

If not (speculative questions)
Examples of mHealth apps
Do you see advantages to using mHealth with your patients?
If you could envision the interaction with a patient through mHealth, how would it go?
What **barriers** would you face, should you choose to use mHealth with your patients?

If yes (experiential questions)
What kinds of apps?
Why did you choose those?
What platforms? (iOS, Android, etc.)
Does this work better for certain patient groups?
Can you describe your interaction with the patient through mHealth?
What challenges do you have with the apps you use?
What **barriers** do you face in using mHealth with your patients?

9. Could you envision an mHealth tool that better connects the care team and also loops in the patient/parents?
10. In terms of encouraging mHealth use with patients, can you tell me what you think other clinicians' barriers are across the organization?
11. How old are you?
12. Are you married?
13. Do you have children? Grandchildren?
14. What year did you start clinical practice?
15. Now that we've talked for a while, I want to ask again – what do you think are the top three barriers to clinicians using mHealth technologies with their patients?
16. Can you think of any other questions that would be interesting to you?
17. Do any of these questions need to be reworded?

APPENDIX G

Participant Information Sheet

UNIVERSITY OF WISCONSIN - MILWAUKEE
Participant Information Sheet

Title: Health in Your Hand:
Assessment of Clinicians' Readiness to Adopt mHealth into Rural Patient Care

This information sheet explains the research study. Please read it carefully. Your participation in this study is entirely voluntary. Please ask questions about anything you do not understand.

Purpose:

- The overarching purpose of this study is to investigate the opportunities and barriers to clinicians' use of mobile health applications (mHealth) with rural patients. Specifically, the Student PI will interview physicians and nurses in Central and Northcentral Wisconsin to gather experiences, preferences, ambitions, barriers and reservations about the adoption of these technologies.
- The primary aims of the project are 1) to explore the current landscape of mHealth use with rural patients and 2) to refine and assess a conceptual model for mHealth Readiness as a tool for gauging healthcare organizations' readiness to adopt mHealth.

Confidentiality:

- All information collected will be kept securely with access only given to the Student PI and advisers. Specific persons and their titles mentioned in the information will also be kept in confidence. Pseudonyms will be universally applied and all identifiers will be absent from analysis and dissemination. Data subject to analysis will have identifiers stricken as described above. Data will be withdrawn or destroyed at the subject's request and/or at the end of the project.

Participation:

- The participation in this study is entirely voluntary. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you do not want to answer.
- The research will result in public presentations, working papers, and articles. The interview may be audio-recorded and may be quoted in publications and archived, with any identifiers removed. Participants can designate any comments as "off the record" and they will be deleted from the audio recording. You will not be able to retract any comment that is already in print or in press.

For Questions about this Research, Contact:

- Any questions, concerns, or complaints that you may have about this study can be answered by Bryan Weichelt. Mr. Weichelt can be reached at the National Farm

Medicine Center, Marshfield Clinic Research Foundation 1000 N Oak Ave, Marshfield, WI 54449, by email (weichelt@uwm.edu), or via telephone at (715) 506-0960.

- If you have any questions about your rights as a research subject, you may contact the University of Wisconsin – Milwaukee's IRB office at irbinfo@uwm.edu or (414) 229-3173. The IRB is responsible for helping protect rights and welfare of human research subjects. You may contact the IRB office to discuss problems and concerns, to request information or ask questions, and to offer input.

APPENDIX H

Email Recruitment

UNIVERSITY OF WISCONSIN - MILWAUKEE
Recruitment Email

Title: Health in Your Hand:
Assessment of Clinicians' Readiness to Adopt mHealth into Rural Patient Care

Subject: Requesting your expertise for an mHealth research project

Body:

Hi Dr. ____,

I am a PhD Candidate at the University of Wisconsin-Milwaukee in the biomedical and health informatics program and am working on my dissertation project. I also work at the National Farm Medicine Center, which is part of the Marshfield Clinic Research Foundation. I am hoping that I might be able to sit down with you for one hour to ask you about your use of mobile health applications/apps with rural patients.

The overarching purpose of this study is to investigate the opportunities and barriers to clinician use of mobile health applications with rural patients. These applications are commonly called mHealth apps. For more information about the study, please see the attached information sheet.

If you are willing to participate in the study, please let me know by responding to this email and I can work with you to set up a time that accommodates your schedule.

Thank you in advance for your time and consideration. Your participation is greatly appreciated.

Best regards,
Bryan Weichelt

_____

Bryan Weichelt, MS, MBA, PMP
PhD Candidate - Biomedical and Health Informatics
University of Wisconsin - Milwaukee
Cell: (715) 506-0960
weichelt@uwm.edu

Research Project Manager

National Farm Medicine Center (NFMC) | National Children's Center for Rural and Agricultural Health and Safety (NCCRAHS)
Marshfield Clinic Research Foundation | Marshfield Clinic

APPENDIX I

Verbal Consent Script

UNIVERSITY OF WISCONSIN - MILWAUKEE
Informed Consent – Verbal Consent Script

Title: Health in Your Hand:
Assessment of Clinicians' Readiness to Adopt mHealth into Rural Patient Care

Hello. I am Bryan Weichelt. I am a PhD Candidate at the University of Wisconsin-Milwaukee in the biomedical and health informatics program. I also work at the National Farm Medicine Center, which is part of the Marshfield Clinic Research Foundation. I am conducting this research study under the supervision of Dr. Timothy Patrick, my UWM adviser, and Dr. Casper Bendixsen, my on-site adviser.

This consent process explains the research study. Your participation in this study is entirely voluntary. Please ask questions about anything you do not understand.

Purpose:
The overarching purpose of this study is to investigate the opportunities and barriers to clinician use of mobile health applications with rural patients. These applications are commonly called mHealth apps.

Procedures:
If you volunteer to participate in this study, you will be asked to join me for an interview, anticipated to last one hour, in which I will ask you demographic questions and questions regarding mHealth use with rural patients' clinical care.

Potential Benefits and Risks:
There are no anticipated benefits or risks with your participation in this study.

Confidentiality:
All information collected will be kept securely with access only given to me and my academic advisers as needed. Specific names and their titles mentioned in the information will also be kept in confidence.

Participation:
The participation in this study is entirely voluntary. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you do not want to answer. If you consent, de-identified data may also be used in publications or presentations.

Please also be aware that:

1. You can ask to have the audio recorder turned off at any time during the interview, and the recorder will be turned off.
2. You can ask for any or all parts of the audio recording to be taken out of the data set.
3. You acknowledge that you will not be able to retract anything that is already in print or in press.

Do you consent to be part of this study?

CURRICULUM VITAE

Bryan Weichelt, MS, MBA, PMP
National Farm Medicine Center & National Children's Center for Rural and Agricultural Health and Safety
1000 N Oak Ave, Marshfield, WI 54449
Phone: 715-221-7276
weichelt.bryan@mcrf.mfldclin.edu

Academic Degrees:

Candidate	*PhD*	UW-Milwaukee Milwaukee, WI	**Biomedical & Health Informatics**
Dec. 2013	MBA	UW-Whitewater Whitewater, WI	**Business Administration**
Dec. 2011	MS	UW-Stout Menomonie, WI	**Information & Communication Tech**
Dec. 2006	BA	UW-Eau Claire Eau Claire, WI	**Criminal Justice**
Dec. 2006	BA	UW-Stout Menomonie, WI	**Psychology**

Professional Experience:

2015-present ***Project Manager – National Farm Medicine Center, National Children's Center for Rural and Agricultural Health and Safety, Marshfield, WI***

Currently responsible for managing a number of different research projects within the two centers. The position has also provided for some flexibility to expand my own research interests including the two successful grant submissions listed below

2015-present ***Principal Investigator- Enhancing and Evaluating the National Database of Ag Injury and Fatality News Clippings, NCCRAHS, Marshfield, WI***

Wrote and submitted the research application for this $20,000 proposal which aims to enhance the current AgInjuryNews.org platform by incorporating new resources and functionality to improve its use and general reporting of agricultural injuries and deaths by U.S. reporters. We also aim to strengthen organizational partnerships to further build a sustainable model for this dataset.

2015-present ***Principal Investigator- Robotic Milker Systems: A Cross Sectional Study Evaluating Farmer Perceptions of Quality of Life on Robotic and Non-Robotic Dairies, NFMC, Marshfield, WI***

Wrote and submitted the research application for this $18,571 proposal which aims to assess dairy farmer perceived quality of life. It is anticipated that the advantages of implementing robotic milking systems into small dairy operations will improve general quality of life and potentially the total health of the farmer and the family.

2014-present ***Owner, Weichelt Acres and Orchard, Stratford, WI***

Establishing an orchard of several varieties of apple and other fruits, as well as beginning the initial startup phase of maple syrup production

2013-present ***PhD Candidate – University of Wisconsin-Milwaukee, Biomedical and Health Informatics, Milwaukee, WI***

Currently conducting qualitative research through informant interviews with clinicians to identify current practices as well as barriers and motivators to the use of mHealth applications and technologies with rural patients

2012-present ***Co-founder, Director, Stratford Farmers Market, Stratford, WI, Facebook.com/StratfordFarmersMarket***

The mission of the Stratford Farmers Market is to promote fresh, affordable produce in the Stratford area while providing opportunities for central Wisconsin farmers to bring their products to a new market on a regular basis. In the first year of operation the market registered more than 20 different produce vendors from around Central Wisconsin.

1990-present ***General Laborer, Calf Caretaker, Equipment Operator, Weichelt Dairy Farm, Stratford, WI***

Grew up on a small family-operated dairy farm that milked 60-70 Holstein cows

2014-2015 ***Health Communications Manager, National Farm Medicine Center, Marshfield Clinic Research Foundation, Marshfield, WI***

Worked with the Director of the National Farm Medicine Center and the National Children's Center for Rural and Agricultural Health and Safety on communications and outreach projects, as part of the Advanced Knowledge Mobilization and E-Communication project

2012-2014 ***Information Systems Project Manager – Biomedical Informatics Research Center, Marshfield Clinic Research Foundation, Marshfield, WI***

General project management, business workflow analysis, use case development, testing, vendor selection and implementation, IRB application development, publication editing, writing,

presentations internally and at national conferences, SharePoint 2010 trainer for the department

2010-2012 ***Document Control Specialist, Institute for Quality, Innovation, and Patient Safety, Marshfield Clinic, Marshfield, WI***

Usability testing, vendor search and selection, web design, production, and distribution, technical writing and document presentation, software trainer

2010-2012 ***Captain, Battalion Logistics Officer, 1-120th FA, Wisconsin Army National Guard, Wisconsin Rapids, WI***

Responsible for more than $15 million in equipment, supervised all aspects of logistical operations of the battalion throughout drill weekends and annual training, logistics team was responsible for providing ammunition, fuel, food, water, maintenance, and transportation services to the subordinate units

2010 ***Information Technology Intern, City of Marshfield, Marshfield, WI***

Gained experience in helpdesk, web development, server maintenance, and project management

2009-2010 ***First Lieutenant, Platoon Leader, Alpha Btry 1-120th FA, Wisconsin Army National Guard, Camp Cropper, Iraq***

Successfully served as the Compound Duty Officer of a Detainee Guard Force Unit, during mobilization, in support of Operation Iraqi Freedom, oversaw all aspects of detention operations including detainee care, custody, and control, mediator between the detainees and higher command with the aid of a linguist, officer in charge of detainee family visitation for the entire compound, oversaw all detainee movements • Advised on cell assignments, internal security, and mission tracking, additional Platoon Leader duties included: counseling, mentorship, training, planning, education benefits advisor, personnel management, personnel integration, inter-branch/inter-agency liaison with Joint Interrogation and Debriefing Center, Navy, FBI, and MPI (military police investigations)

2008-2009 ***First Lieutenant, Training Officer, Alpha Btry 1-120th FA, Wisconsin Army National Guard, Marshfield, WI***

As a lieutenant, I planned, coordinated, and executed pre-mobilization training for the unit's 125 Soldiers on over 300 Army Warrior Tasks, FORSCOM briefs, and Collective Training Tasks. The unit went to the mobilization center, Ft. Bliss, TX with a 95% completion rate, the highest of 23 units

Honors:

2016 Equity Livestock & Sales Scholarship
2015-16 Donald P. Weber Veterans Memorial Scholarship

2013	Million Hearts Risk Check Challenge™, Office of the National Coordinator for Health Information Technology (U.S. Department of Health and Human Services), Washington, DC www.HeartHealthMobile.com
2012	Leadership Marshfield selection and sponsorship from Marshfield Clinic, Marshfield, WI
2010	Meritorious Service Medal, US Army

Professional Affiliations:

2016-present	National Farmers Union
2016-present	Wisconsin Agritourism Association
2016-present	American Society for Agricultural & Biological Engineers
2015-present	Farmer Veteran Coalition
2015-present	American Public Health Association
2014-present	International Society for Agricultural Health and Safety
2012-present	American Medical Informatics Association
2013-present	American Marketing Association
2012-present	Project Management Institute
2012-present	Project Management Institute – Northeast WI Chapter
2010-present	Stratford Area Chamber of Commerce
2010-present	Veterans of Foreign Wars (VFW) – Life Member

Community Involvement:

Annual	VFW Post 4352 food stand and other fundraisers
Annual	Stratford Area Chamber of Commerce
2010-2014	Stratford Area Recreation Men's Basketball League
2013	Salute a Soldier / Armed Forces Day 5k fundraiser
2011-2013	Village Board Trustee, Village of Stratford
2011	Leadership Marshfield Program

Peer-reviewed Publications:

Zhou Z, He M, Brilliant M, Brautbar A, Miller A, **Weichelt B** and Lin S. Informatics Challenges to Implement Pharmacogenetics to Clinical Practice [abstract]. HMO Research Network Conference; 2013 Apr 16-18; San Francisco, USA. Clinical Medicine & Research. 2013;11(3):147-48. doi:10.3121/cmr.2013.1176.ps3-2.

Accepted Abstracts and Presentations:

Weichelt B., Bendixsen C, and Keifer M (2016, Sep) A Robotic Reality: Milking the most out of Life on a Small Dairy Farm and Prepping for the Next Gen. Podium presentation at World Conference on Injury Prevention and Safety Promotion, Tampere, Finland

Weichelt B., Bendixsen C, and Keifer M (2016, Sep) Farm Mapping to Assist, Protect, and Prepare Emergency Responders (MAPPER). Podium presentation at World Conference on Injury Prevention and Safety Promotion, Tampere, Finland

Weichelt B, Reyes IA, Mahnke A, Verhagen L, Ray W, and Keifer M. (2016, Sep) Algorithmic Approach to Injured Workers: Designed for Dairy and Pork, Applicable Across Industries. Podium presentation at World Conference on Injury Prevention and Safety Promotion, Tampere, Finland

Weichelt B., Bendixsen C, Salzwedel M, and Lee BC (2016, Sep) Tracking the Tragic: Publicly Accessible U.S. Agricultural Injury and Fatality News Clippings Data. Podium presentation at World Conference on Injury Prevention and Safety Promotion, Tampere, Finland

Salzwedel M, **Weichelt B**., and Lee BC (2016, Sep) Next Generation of Work Guidelines for Youth. Podium presentation at World Conference on Injury Prevention and Safety Promotion, Tampere, Finland

Salzwedel M, **Weichelt B**., and Lee BC (2016, Sep) Safety for Youth Involved in Community-Based Agriculture (CBA). Podium presentation at World Conference on Injury Prevention and Safety Promotion, Tampere, Finland

Lee BC, Salzwedel M, **Weichelt B**., (2016, Sep) Using the Socio-Economic Model as a Guide for Agricultural Safety Interventions. Podium presentation at World Conference on Injury Prevention and Safety Promotion, Tampere, Finland

Bendixsen C, Barnes K, **Weichelt, B**, VanWormer, J, Keifer M. (2016, Sep) Battlefield to Farmfield: Risk Perceptions of US Military Veterans Transitioning into Agriculture. Podium presentation at World Conference on Injury Prevention and Safety Promotion, Tampere, Finland

Weichelt B, Bendixsen C, Murphy D, and Keifer M. (2016, July) From Paper and PC, to your Pocket: FARM-HAT Going Mobile. Podium presentation at the Annual International Meeting for the American Society of Agricultural and Biological Engineers, Orlando, FL.

Weichelt B, Bendixsen C, Yoder A, Murphy D, Keifer M. (2016, Jun) Emerging Software Applications in Agricultural Health and Safety. Panel presentation at the International Association of Agricultural Health and Safety, Lexington, Kentucky

Weichelt B, Salzwedel M, Heiberger S, Lee BC. (2016, Jun) Algorithmically Presenting Prevention Briefs on AgInjuryNews.org. Podium presentation at the International Association of Agricultural Health and Safety, Lexington, Kentucky

Weichelt B. (2016, Feb). Child Safety on the Farm: Balancing the Risks and the Benefits. Podium presentation at the Accelerated Genetics Winter Get-away. Wisconsin Dells, WI

Weichelt B, Reyes IA, Ray W, Mahnke A, Verhagen L, Halstead S and Keifer M. (2015, Oct) Nuance to Numbers: Transforming Unstructured Physical Therapist Field Data to Structured Farm Task Data for an Injured/Ill Return to Work Software Application, Poster presentation at UMASH Center Presentation/Conference, St. Paul, MN

Weichelt B, Reyes IA, Ray W, Mahnke A, Verhagen L, Halstead S and Keifer M. (2015, Nov) Nuance to Numbers: Transforming Unstructured Physical Therapist Field Data to Structured Farm Task Data for an Injured/Ill Return to Work Software Application, Poster presentation at APHA conference, Chicago, IL

Mahnke, A, Verhagen L, **Weichelt B**, Reyes IA, Ray W, Halstead S and Keifer M. (2015, Nov) User-Centered Design of an Application to Aid in the Safe Return to Work of Injured Farm Workers, Poster presentation at AMIA conference, San Francisco, CA

Weichelt B, Reyes IA, Mahnke A, Ray W, Verhagen L, Halstead S and Keifer M. (2015, Nov) A Not So Lame Outlook for Injured Farm Workers: Return to Work Software Application Development, Podium presentation at AMIA conference, San Francisco, CA

Weichelt B, Salzwedel M (2015, Sept) It's Harvest Season: Are the Children Safe? Webinar presentation for National Farm Safety and Health Week, AgriSafe Network

Weichelt B, Salzwedel M, Heiberger S, Steinmetz, A, Egle, S, and Lee B C. (2015, June) Developing a Collection of Child Ag Injury News Clippings: Web-based News Clippings Database – NCC2, Podium presentation at ISASH conference, Normal, IL

Weichelt B, Bendixsen C, Salzwedel M, and Lee B C. (2015, June) Community-Based Agriculture: Safety Guidelines for Children, Podium presentation at ISASH conference, Normal, IL

Salzwedel M, Devault J, **Weichelt B**, Bendixsen C, and Lee B C. (2015, June) Utilization of Survey Results to Update Agritourism Safety Materials, Podium presentation at ISASH conference, Normal, IL

Weichelt B, Bendixsen C, Salzwedel M, Lee B (Eds.) (2015). Community-Based Agriculture: Safety Guidelines for Youth Working in Gardens. Marshfield Clinic, Marshfield, WI.

Reyes IA, Mahnke A, **Weichelt B**, Ray W, Keifer M. Facilitating the return-to-work of injured and ill farm workers: An online decoder for clinicians. American Public Health Association 142nd Annual Meeting and Exposition
November 15-19, 2014, New Orleans, LA

Reyes IA, Mahnke A, **Weichelt B**, Ray W, Keifer M. A computer application for clinicians to facilitate the return-to-work of injured agricultural workers. Safety and Health in Agricultural and Rural Populations. October 19-22, 2014, Saskatoon, SK, Canada

Reyes IA, Bellendorf N, Meehan T, Wenger R, Kadolph C, Halstead S, Mahnke A, **Weichelt B**, Ray W, Keifer M. Facilitating Return to Work for Injured and Ill Animal Agriculture Workers. J Agromedicine. 2014 Apr; 19(2):232.

Finamore J, Ray W, Kadolph C, Rastegar-Mojarad M, Ye H, Bohne J, Xu Y, Tachinardi U, Mendonça E, Burish D, Sondelski J, Pfingsten M, Finnegan B, Bartkowiak B, **Weichelt B**, and Lin S., (2014, April) Marshfield Dictionary of Clinical and Translational Science (MD-CTS): An Online Reference for Clinical and Translational Science Terminology, Podium presentation at HMORN conference, Phoenix, AZ

Iris Reyes, MPH; Nancy Bellendorf, OTR; Tami Meehan, PT, DPT, OCS; Ron Wenger, PT, DPT, OCS, MTC; Christopher Kadolph; Shaun Halstead; Andrea Mahnke, MS; **Bryan Weichelt, MS, MBA, PMP**; William Ray; Matthew Keifer, MD, MPH. Facilitating Return to Work for Injured and Ill Animal Agriculture Workers Poster, North American Agricultural Safety Summit September 25, 2013, Minneapolis, MN.

Zhou Z, He M, Brilliant M, Brautbar A, Miller A, **Weichelt B** and Lin S. Informatics Challenges to Implement Pharmacogenetics to Clinical Practice [abstract]. HMO Research Network Conference; 2013 Apr 16-18; San Francisco, USA. Clinical Medicine and Research. 2013;11(3):147-48. doi:10.3121/cmr.2013.1176.ps3-2.

Weichelt B, VanWormer JJ, Kadolph C, Xu Y, Williams S, Burish D, Barwick M, Moritz B, and Lin S. Heart Health Mobile: An interactive, educational, monitoring and gaming application to improve cardiovascular health. USAID. mHEALTH Compendium Vol. 3. November 2013. Page 12.

Weichelt B, Kadolph, C., VanWormer, JJ., Lin S. (2013, November) Heart health in your pocket: Lessons learned from the development of a smartphone app, Podium presentation at HIMSS conference, Milwaukee, WI

Weichelt B, VanWormer J.J., Xu Y., Barwick M., Lin S., (2013, May) Heart Health Mobile, Demo at Bio International conference, Chicago, IL

VanWormer, JJ., Xu, Y., **Weichelt, B**., Williams, S., Burish, D., Barwick, M., Moritz, B., & Lin, S. (2013, April). Heart health in your pocket: Lessons learned from the development of a smartphone app. Poster presentation at the annual HMO Research Network Conference, San Francisco, CA.

Current Research Interests

Applying communications technologies to the current agricultural health and safety landscape, including assessing effectiveness of new tools and mHealth's potential to engage rural farm populations