THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF RISK MANAGEMENT

Advancing Value-Based Healthcare Through Remote Patient Monitoring

KRISTEN CHOMOS
SPRING 2023

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Actuarial Science
with honors in Actuarial Science

Reviewed and approved* by the following:

Nan Zhu
Associate Professor of Risk Management
Thesis Supervisor

Amanda Hammell
Professor of Practice and Faculty-In-Charge of the Actuarial Science Program
Honors Adviser

* Electronic approvals are on file.

ABSTRACT

The United States (U.S.) spends a significant percentage of GDP on healthcare, but the large amount of spending does not generate high-quality outcomes compared to other developed countries. Opportunity exists for the U.S. to improve the effectiveness of the healthcare system. A more effective and efficient system would lead to better outcomes with reduced spending. Value-based healthcare provides a framework for achieving these long-term goals. This emerging concept measures value as the improvement in health outcomes per the cost of making the improvement. Successful implementation of value-based healthcare leads to better outcomes, lower costs, and subsequently, reduced health and financial risk. Value-based healthcare has been implemented by providing coverage for preventative services and pharmaceuticals. In theory, providing these types of healthcare for patients now will improve their long-term health outcomes and reduce their overall healthcare costs in the long run.

Since the onset of the COVID-19 pandemic, remote patient monitoring (RPM) has increasingly played an integral role in transforming healthcare delivery. The rapid transformation to a digital world served as a catalyst for the utilization of RPM technologies. RPM also seeks to improve health outcomes while reducing costs. The shared goals between value-based healthcare and RPM create an opportunity to expand the scope of value-based healthcare through RPM technologies, specifically pertaining to chronic disease management.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF EQUATIONS

ACKNOWLEDGEMENTS

I would like to thank Amanda Hammell and Nan Zhu for their support throughout the thesis writing process. Amanda helped me narrow in on a thesis topic and prepared me with the necessary resources for this paper. Nan provided the opportunity to work closely with him to navigate my selected topic and learn from his expertise.

I appreciate the entire Actuarial Science program for challenging me as a student and as a young professional throughout my Penn State experience. I was fortunate to take Actuarial Science and Risk Management courses with Nan Zhu, Steven Putterman, Amin Hassan Zadeh, David Cather, and Lisa Posey. The curriculum allowed me to learn holistically and develop quantitative and qualitative understandings of the insurance industry.

I greatly value my experiences in the Sapphire Leadership Academic Program, as a complement to the Schreyer Honors College, for helping me grow as a leader inside and outside of the classroom.

Thank you to my peers in the Actuarial Science program for being great classmates and class partners. It has been rewarding learning together and from each other, and I am thankful for the friendships that we formed throughout the past four years.

Chapter 1

Introduction and Literature Review

Overview of United States (U.S.) Healthcare System

The U.S. healthcare system functions on various elements, including insurance, providers, and legislation. This system intends to bring together the public and private sectors to advance the goal of providing high-quality care to the American population in an efficient and cost-effective manner.

The U.S does not operate on a universal health coverage plan for the entire population, and increasing accessibility remains a key focus area for the healthcare industry. Despite not providing universal coverage, in 2018, 92 percent of the population had healthcare coverage (Tikkanen et al., 2020). Most insured Americans receive health coverage through employer-sponsored plans which emerged in the 1920s. A subset of Americans receive coverage through government-sponsored plans: Medicare, Medicaid, and the Children's Health Insurance Program (CHIP). Medicare and Medicaid were introduced in 1965, and CHIP was formed in 1997. These public insurance programs evolved, and continue to evolve, over time to improve accessibility. U.S. spending on these public insurance programs is comparable to public spending in other developed countries (Tikkanen & Abrams, 2020).

People aged 65 and older receive coverage through Medicare which includes four parts: A, B, C, and D (Tikkanen et al., 2020). The original components, Parts A and B, provide hospital insurance and medical insurance, respectively. In 1973, Part C emerged which allows people to elect traditional Medicare or Medicare Advantage; the latter provides the option to enroll in a managed care organization or private health maintenance organization. In 2003, Part D expanded coverage to prescription drugs.

Medicaid provides coverage for low-income, blind, and disabled Americans on an annual basis (Tikkanen et al., 2020). The program is administered on the state level, so the eligibility requirements vary by state. In 2020, Medicaid provided coverage to 17.9 percent of Americans, and the majority received care through managed care organizations. In 1997, CHIP was established at the state level to provide coverage for children whose families are uninsured. By 2020, this program covered 9.6 million children.

The Affordable Care Act (ACA), passed in 2010, serves as a key piece of legislation for U.S. healthcare. This legislation increased the government's role in healthcare and implemented the concept of "shared responsibility among government, employers, and individuals for ensuring that all Americans have access to affordable and good-quality health insurance" (Tikkanen et al., 2020, p. 212). The ACA connects the role of the public and private sectors to deliver on a national healthcare approach and increase accessibility. From 2010 to 2018, the percentage of uninsured adults decreased from 20 percent to 12 percent due to the passage of the ACA (Tikkanen et al., 2020).

On the other side, private health insurance provides coverage for 67 percent of Americans (Tikkanen et al., 2020). Employer-sponsored plans account for most of this coverage, but individuals can also purchase individual plans. Employers work with private health insurance companies to provide healthcare benefits to employees. Private spending encompasses private health insurance premiums. The private health insurance sector spends $4,092 per capita; this amount of spending is five times the second-highest private spender (Tikkanen & Abrams, 2020). A professor in the Bloomberg School's Department of Health Policy and Management, Gerard F. Anderson, PhD, reports, "'The U.S. remains the most expensive because of the prices the U.S. pays for health services'" (*U.S. health care spending*, 2019, para. 6). Anderson's study

also finds “a widening of the gap between what public insurers and private insurers pay for the same [healthcare] services” (*U.S. health care spending*, 2019, para. 8). The increasing private health insurance costs drive up healthcare spending per capita in the U.S.

Several mediums exist to provide healthcare in the U.S., including primary care, outpatient specialist care, after-hours care, hospitals, mental health care, and long-term care (Tikkanen et al., 2020). Primary care “encompasses specialists in family medicine, general practice, internal medicine, pediatrics, and according to some, geriatrics” (Tikkanen et al., 2020, p. 217). These physicians provide care for more routine needs. Outpatient specialists focus on a specific niche. They typically work in specialized practices, but they also assist in hospitals. As of 2019, 45 percent of primary care physicians provided after-hours care, and there are walk-in, urgent care centers available for after-hours care or one-time needs. Hospitals play an integral role in healthcare outcomes for the U.S. population. According to the American Hospital Association (2023) in 2022, there were 6,093 hospitals in the U.S., and they experienced an annual total of 33,356,853 admissions. Hospital systems (e.g., UPMC hospitals) account for 68 percent of total hospitals, and independent hospitals account for the remaining 32 percent. Most mental health care takes place in an outpatient setting, but in-patient facilities exist as well. Long-term care includes services such as hospice, nursing homes, transportation, and more.

With the different mediums for delivering healthcare, the industry now focuses on integration and coordination for higher quality care. The ACA spearheaded several models to aid in this improvement, including “patient-centered medical home” and “bundled payments” (Tikkanen et al., 2020, p. 219). These models provide an opportunity for continued improvement and development in the healthcare industry.

Given this background on the U.S. healthcare system, key areas of improvement emerge from comparing spending and health outcomes in the U.S. to other highly developed countries. The Commonwealth Fund conducts this analysis using data from the Organization for Economic Cooperation and Development (OECD) to compare the U.S. directly with 10 other countries (Australia, Canada, France, Germany, the Netherlands, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom) and with the 36 high-income countries that make up the OECD average (Tikkanen & Abrams, 2020).

This analysis finds the U.S. spends the most on healthcare but generates the worst outcomes based on different metrics. The U.S. spends more than $10,000 per capita on healthcare, including public, private, and out-of-pocket spending. This amount doubles the amount spent in Australia, France, Canada, New Zealand, and the United Kingdom (Tikkanen & Abrams, 2020). In 2018, public, private, and out-of-pocket spending totaled at $4,993, $4,092, and $1,122 per capita, respectively. From 1980 to 2018, the U.S. consistently spent the highest percentage of GDP on healthcare as shown in Figure 1 (Tikkanen, 2020).

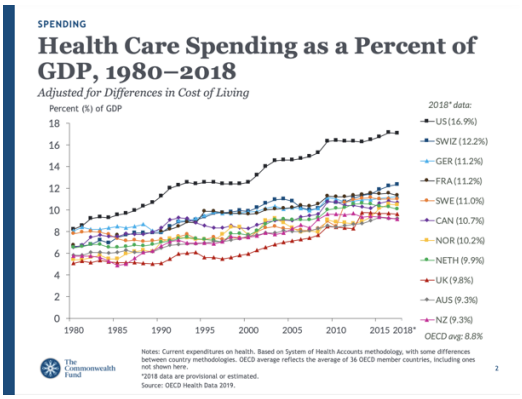

Figure 1: Healthcare Spending

In 2018, the U.S. spent 16.9 percent of GDP on healthcare whereas the OECD average only spent 8.8 percent. As previously noted, the cost of healthcare services and the widening gap

between public and private costs drives up healthcare spending in the U.S. relative to other countries (*U.S. health care spending, 2019*).

Despite the high amount of spending, the U.S. ranks poorly on key health outcomes. This performance is measured based on life expectancy, suicide rate, obesity rate, chronic conditions, diabetes and hypertension, and mortality that could be avoided with effective healthcare. The following series of graphs (Figures 2-7) compares the U.S. with the 10 other countries and OECD average (Tikkanen, 2020).

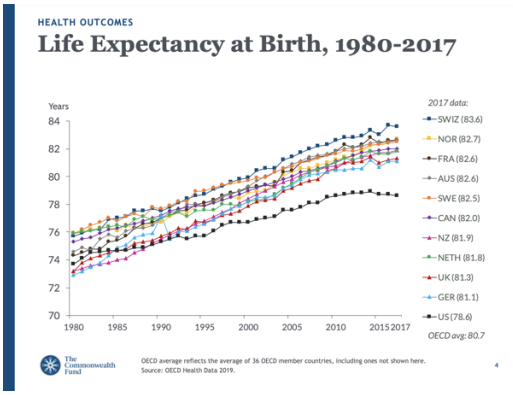

Figure 2: Life Expectancy at Birth

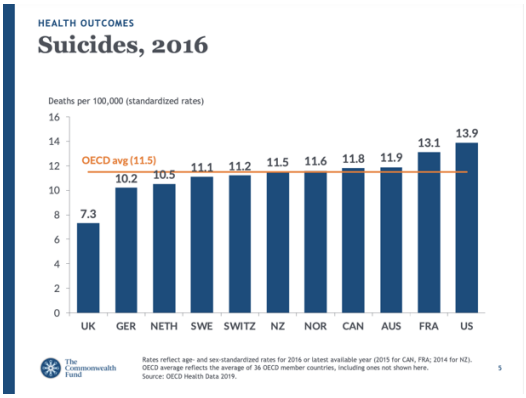

Figure 3: Suicide Rate

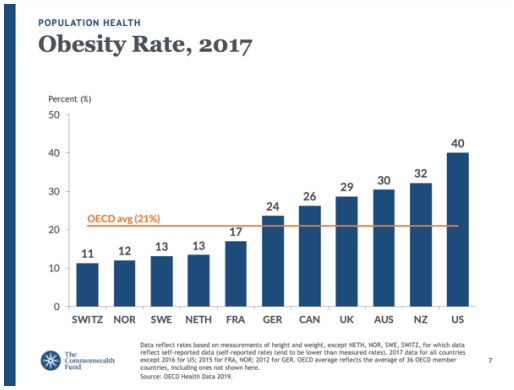

Figure 4: Obesity Rate

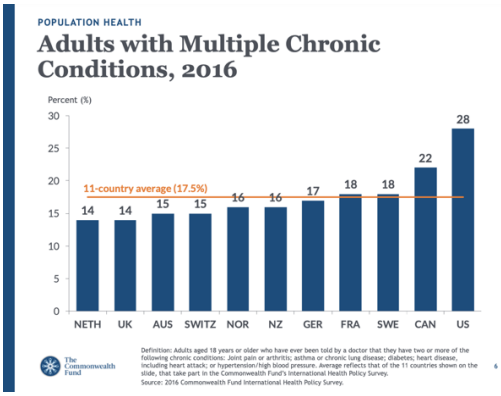

Figure 5: Chronic Conditions

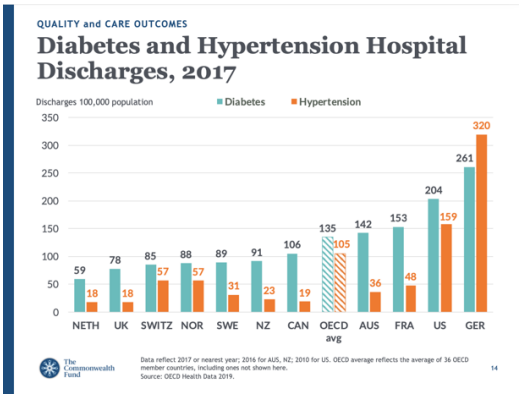

Figure 6: Hospitalizations from Diabetes and Hypertension

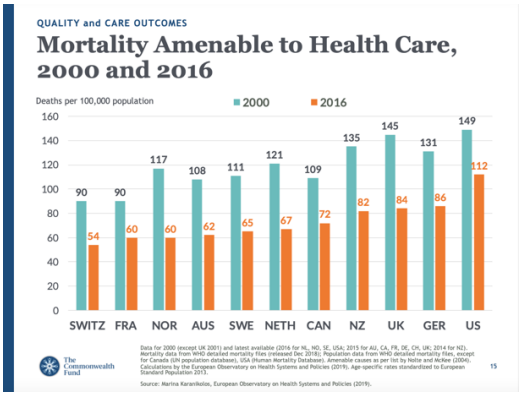

Figure 7: Mortality Amenable to Healthcare

Figures 5, 6, and 7 exploit a critical theme: the prevalence of chronic conditions and the burden of chronic conditions on healthcare outcomes in the U.S. Figure 5 shows the percentage of American adults with more than one chronic condition, including but not limited to, diabetes, heart disease, hypertension. Figure 6 represents the number of hospitalizations incurred due to chronic conditions. The conditions "are considered preventable with access to better primary care" (Tikkanen & Abrams, 2020, para. 20). Figure 7 shows the number of "premature deaths from conditions that are considered preventable with timely access to effective and quality [healthcare];" these conditions include the chronic conditions mentioned previously among others (Tikkanen & Abrams, 2020, para. 21).

This analysis presents the opportunity for the U.S. public and private sectors to improve the effectiveness of healthcare system, specifically regarding chronic disease management. Aetna (2023), a private insurer ranked number 49 on the Fortune 500, notes that the U.S. "spends two to three times more than most developed countries each year, yet achieve worse results" (para. 4). Reducing costs while improving outcomes would signify improved effectiveness in the U.S. healthcare system.

Overview of Value-Based Healthcare

As identified through a review of the U.S. healthcare system, opportunity exists for the U.S. to reduce costs and improve outcomes. An emerging concept, value-based healthcare, seeks to tackle this opportunity through a long-term approach. The "triple aim" presents the goals of value-based care: "improve the [healthcare] experience, improve the health of individuals and populations, and reduce the costs of [healthcare]." Executing these goals requires a "proactive, team-oriented, and data-driven approach" to healthcare (Aetna, 2023, para. 9). This modern, strategic approach provides opportunity to advance U.S. healthcare. Aetna (2023) identifies value-based healthcare as "a critical step in the right direction" (para. 8). This concept continues to gain traction and could potentially play a transformative role in the healthcare industry.

Proactive care plays a key role in this concept: "We're looking to make healthcare proactive instead of reactive, preventing problems before they start" (Cleveland Clinic, 2020, para. 1). Receiving proactive care improves patient outcomes by reducing long-term effects and complications, and this inherently reduces long-run costs. Coordinating care also improves patient outcomes by increasing collaboration between physicians and reduces costs by centralizing care.

Value-based healthcare affects both the patient and provider sides of healthcare. This healthcare delivery model focuses on value rather than quantity as seen in fee-for-service or capitated models. The concept of "value" is measured by comparing "health outcomes against the cost of delivering the outcomes." Value-based healthcare produces key benefits pertaining to "lower healthcare costs, higher patient satisfaction, and reduced risks" (*What is value-based healthcare?*, 2017, para. 2-3). These benefits impact the various stakeholders of U.S. healthcare as shown below in Figure 8 (*What is value-based healthcare?*, 2017).

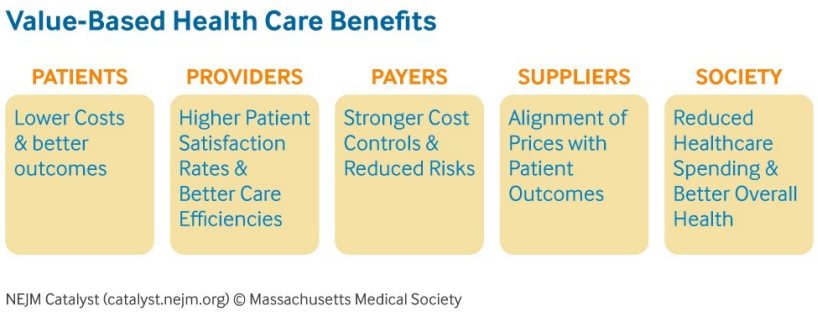

Figure 8: Value-Based Healthcare Benefits

Successful implementation of value-based healthcare benefits patients and society by improving U.S. health outcomes, specifically pertaining to chronic diseases. Chronic diseases include heart disease, diabetes, cancer, obesity, and more. These diseases place a strain on the healthcare system's expenditures and outcomes. Aetna (2023) reports that "six in ten Americans have at least one chronic condition...and four in ten are managing more than one. A staggering 90 percent of [healthcare] dollars spent each year [are] for people with chronic health conditions" (para. 6). Managing these diseases comes at a high cost due to their prominence, long-term nature, and the cost incurred from prescription drugs, doctor's appointments, tests, and procedures (*What is value-based healthcare?*, 2017).

Value-based healthcare strives to improve patient outcomes in the short term and subsequently improve long-term outcomes. This model reduces costs "by organizing teams to care for individuals with similar needs...[to enable] expertise and efficiency" (Teisberg et al., 2020, para. 9). For example, a diabetes patient in a value-based healthcare model can receive treatment from "one integrated team" that can manage all aspects of the disease (e.g., blood sugar, diet, exercise, and mental health) collectively rather than independently to improve outcomes (Cleveland Clinic, 2020, para. 4). Improving outcomes "reduces the compounding complexity and disease progression that drive the need for more care. A patient whose diabetes

does not progress to kidney failure, blindness, and neuropathy is, over time, dramatically less expensive...than a patient whose condition continually worsens" (Teisberg et al., 2020, para. 8).

Further, Aetna (2023) identifies that "multidisciplinary care programs can be an effective way to slow the progression of kidney disease" (para. 15). This finding is supported by an example that coordinates a nurse, dietitian, and social worker to care for all aspects of the patient's chronic kidney disease. This approach intends to prevent long-term health complications by effectively managing short-term health. Improving a patient's outcomes will reduce their demand and overall spending on healthcare throughout their lifetime. This maximizes value by improving long-term health at a lower cost.

Healthier patients lead to a healthier population which will benefit providers, payers, and suppliers as well. Providers will experience decreased chronic disease management which will enable improved efficiency and satisfaction (*What is value-based healthcare?*, 2017). Rather than generating payments from the quantity of care (fee-for-service), providers generate payments from the value of care (fee-for-value). For payers, value-based healthcare provides an effective approach to risk management: A healthier population reduces the overall risk of the population. Payer efficiency increases as well by consolidating payments. Currently, suppliers face pressure due to high cost of prescription drugs and treatments, and the value-based healthcare approach allows suppliers to "align" their prices with the reduced costs from improved health outcomes (*What is value-based healthcare?*, 2017, para. 3).

Successful implementation of value-based healthcare requires teamwork and coordination. Aetna (2023) expresses that a "robust, team-oriented approach, often led by the patient's primary care doctor" drives the success of value-based healthcare (para. 10). Coordinating care integrates the different realms of healthcare to reduce redundancy and improve

efficiency. Aetna (2023) reports findings from the Institute of Medicine that "unnecessary or repetitive tests [account] for more than 30 percent of all healthcare expenditures. That's more than $910 billion each year" (para. 7). Sharing data through electronic medical records (EMRs) plays an integral role in the ability to coordinate care: "The goal of EMRs is to put crucial patient information at each provider's fingertips, allowing individual providers to see results of tests and procedures performed by other clinicians on the team. This data sharing has the potential to reduce redundant care and associated costs" (*What is value-based healthcare?*, 2017, para. 6). EMRs serve as an asset for improving patient outcomes and reducing costs. EMRs improve patient outcomes by allowing physicians to holistically understand a patient's health, and they reduce costs by eliminating duplicate efforts.

To support the vision and long-term goals of value-based healthcare, Teisberg, Wallace, and O'Hara (2020) provide a strategic framework for implementing this concept. Consistent with other publications, they define value as "the measured improvement in a patient's health outcomes for the cost of achieving that improvement" (para. 1). This definition emphasizes the twofold nature of value-based healthcare: improving outcomes and reducing costs. Their framework, as summarized in Figure 9, identifies five strategic steps to enable a value-based healthcare transformation.

Figure 9: Value-Based Healthcare Framework

First, the authors identify the lack of coordination of healthcare as the "root cause" of expensive healthcare and poor outcomes (Teisberg et al., 2020, para. 13). Other sectors of the economy are structured around consumer needs, but healthcare revolves around providers rather than patients. Hence, specialists work in practice with other physicians in the same specialty rather than organizing into teams that serve various needs. This requires patients to organize their care between doctors; rather, healthcare teams organized around shared needs would improve efficiency and better align care with outcomes and costs.

Second, after establishing an integrated or coordinated team, the team can analyze the common health needs to create a "comprehensive solution" to holistically treat the needs (Teisberg et al., 2020, para. 15). The comprehensive solution focuses on addressing the main condition, common effects from the condition, and any barriers to receiving the care. Third, a team must come together with different providers to deliver on each aspect of the solution. Fourth, to assess the effectiveness of the value-based healthcare approach, the team must measure health outcomes against their service costs. Fifth, after establishing an effective foundation, value-based healthcare teams can expand their partnerships to further their outreach. Collectively, these steps provide a framework for developing value-based healthcare by starting at the core and adding layers.

Overview of Remote Patient Monitoring

Technology plays an integral role in advancing different industries, and the onset of COVID-19 forced the healthcare industry to rapidly integrate the use of technology. As the whole world rapidly relied more on digital capabilities, the healthcare industry accelerated its

digital transformation as well. Telemedicine grew in prominence, and the scope of telemedicine expanded across the healthcare industry.

Within the scope of telemedicine, remote patient monitoring (RPM) technology emerged as a developing trend. Utilizing RPM presents an evolving approach to achieve "improved outcomes and reduced costs." RPM allows physicians "to monitor patient health outside of a traditional clinical setting" (*The technology, devices, and benefits of [RPM]*, 2023, para. 2 & 4). RPM technologies share information between patients and physicians; this allows physicians to monitor patients' health in their daily life rather than only at scheduled appointments, tests, and procedures. Continuous monitoring through RPM technology improves health outcomes and "[generates] savings by preventing more severe and costly health outcomes" (*The technology, devices, and benefits of [RPM]*, 2023, para. 6). Transmitting real-time health data allows physicians to monitor and proactively treat any warning signs that could lead to a severe health episode.

As an emerging trend, research anticipates the use of RPM technologies to continue increasing in coming years. Research forecasts that 60.6 million U.S. patients will use RPM technologies by 2024. As shown below in Figure 10, the greatest percentage increases in RPM users occurred during 2020 and 2021; the timing aligns with the peak of the COVID-19 pandemic (*The technology, devices, and benefits of [RPM]*, 2023). Since the peak of the pandemic, and looking into the future, researchers expect a steady increase in the use of RPM.

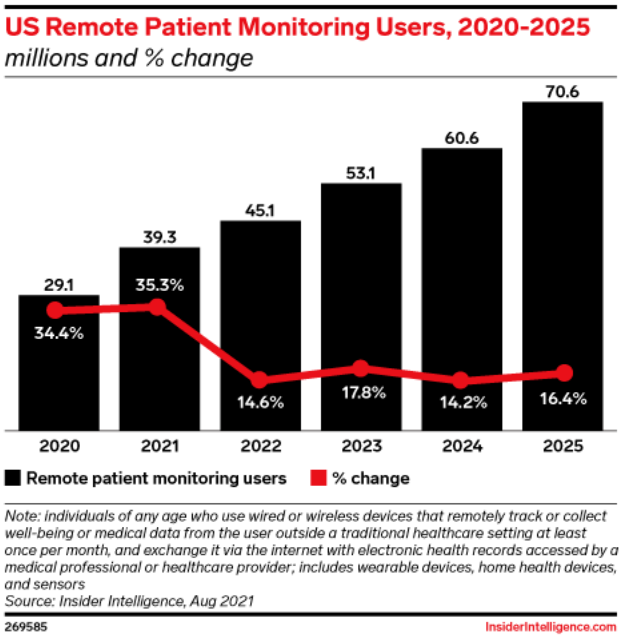

Figure 10: Growth in U.S. RPM Utilization

The RPM technology market offers various devices that help monitor chronic conditions. RPM technology comes in non-implantable and implantable devices. Non-implantable devices include, but are not limited to, the following: continuous glucose monitors, digital blood pressure monitors, electrocardiograms (ECGs), stethoscopes, and wearable activity trackers. These devices help keep patients and physicians informed with relevant data for diabetes, hypertension, heart function, lung function, and holistic health, respectively (*The technology, devices, and benefits of [RPM]*, 2023; Muller, 2023). Specifically, the Eko DUO monitors provide digital ECG and stethoscope readings. Patients utilize the Eko on their own which sends results to the physician, and the DUO provides "an all-in-one cardiac assessment that allows providers to monitor their patient's heart and lung sounds from afar, enabling early detection" (Muller, 2023, para. 11). Popular wearable devices, such as an Apple Watch, track various aspects of an individual's health: exercise, heart rate, ECG readings, sleep, and more.

RPM technologies can also come in implantable devices. These small devices automatically track and share data using Bluetooth capabilities. For example, Dexcom and Verily created an "implantable diabetes sensor that transmits health data to monitoring devices or smartphones via Bluetooth" (*The technology, devices, and benefits of [RPM]*, 2023, para. 13). To monitor lung and cardiovascular health, patients and physicians can utilize implantable devices such as pacemakers and cardioverter defibrillators (Mohebali & Kittleson, 2021). Specifically, implantable devices, such as the CardioMEMS and HeartPod, can measure cardiac pressures. The CardioMEMS consists of a lead-less, battery-less pressure sensor to monitor pressure in the pulmonary artery (Abbott, 2023). Abbott produces this device as part of its heart failure management and monitoring options; these options help users to live longer and improve their quality of life. This is one of several implantable devices that Abbott produces to proactively manage heart failure and slow irregular heartbeat.

Some other top companies that compete in the RPM technology segment include Medtronic, Philips Healthcare, ResMed, and Sensonics, Research expects the growing RPM industry "to be worth over $1.7 billion by 2027, up nearly 128 percent from the opportunity the market currently represents" (*The technology, devices, and benefits of [RPM]*, 2023, para. 5). The anticipated growth represents the prominent role that RPM technologies will play in delivering healthcare into the future. This growth signals the opportunity to further integrate RPM technologies within other areas of growth in the healthcare industry.

RPM improves health outcomes for patients and providers. For example, the University of Pittsburgh Medical Center (UPMC) reported that RPM equipment "reduced the risk of hospital readmissions by 76 percent and held patient satisfaction scores over 90 percent" (*The technology, devices, and benefits of [RPM]*, 2023, para. 10). This reduction in hospital

readmissions decreases hospital visit costs and signifies improved patient outcomes, aligning with the goals of RPM technology. As previously discussed, patients with chronic conditions are key beneficiaries of RPM technology, and many companies sell devices to monitor chronic conditions.

Chapter 2

Intersection of Value-Based Healthcare and RPM

Value-based healthcare and RPM technology both advance two key goals: improving patient outcomes and reducing healthcare costs. The shared goals present an intersection between these two emerging healthcare trends. The intersection provides an opportunity to advance the concept of value-based healthcare using RPM technology. Value-based healthcare promotes a strategic concept and framework for transforming the industry that requires a "proactive, team-oriented, and data-driven approach" to healthcare (Aetna, 2023, para. 9). RPM technology serves as a tangible asset to help drive this transformation.

The ability for RPM technology to routinely transmit data from patients to physicians allows physicians to proactively monitor health conditions. The routine monitoring increases the ability for physicians to prevent significant health outcomes by treating patients proactively rather than reactively. Subsequently, patients experience improved health outcomes if proactive treatment prevents them from incurring a major negative health episode. Patients and other key stakeholders experience reduced costs by minimizing costly, emergency events.

Within the concept of value-based healthcare, a team-oriented approach maximizes value by improving outcomes holistically and reducing redundant costs. EMRs are integral to successful multidisciplinary teams, and RPM technology provides another source of shared data among teams. The continuously increasing use of RPM technology and development of these devices provides a reliable source of information.

As previously mentioned in Chapter 1, data plays a crucial role in the success of value-based healthcare. The Chief Digital Health Officer at CVS Health, Firdaus Bhathena, supports that "by leveraging data and analytics, we can improve the overall healthcare experience,

improve health, and reduce medical costs" (Aetna, 2023, para. 21). This use of data and analytics aligns with the goals of values-based healthcare. Data provides critical information about patients, and data sharing through [EMRs] maximizes the effectiveness of analysis and collaboration. Furthermore, utilizing technologies "can help extend care coordination beyond the clinic" (Aetna, 2023, para. 23). Patients who wear an Apple Watch, or another form of health-tracking device, can continuously collect health data for personal tracking and can share this data with physicians as well. These devices, along with other wearable and implantable devices, classify as RPM technology.

Opportunity exists at the intersection of value-based healthcare and RPM technology. Both concepts present emerging trends in the healthcare industry. The industry experienced rapid changes in recent years, specifically regarding telehealth and healthcare delivery. These changes advanced the healthcare industry and showcased the potential for further advancement; this strategic advancement will lead to reduced costs in the long run.

Transitioning to value-based healthcare can trigger "short-term financial hits before longer-term costs decline" (*What is value-based healthcare?*, 2017, para. 11). In the *Harvard Business Review*, Kaiser and Lee explore the short-term and long-term financial impact of transitioning to value-based healthcare in real business cases. For example, surgeons at the Mayo Clinic integrated pathologists into their process for lumpectomies, a surgical procedure to treat breast cancer. Through this coordination, surgeons and pathologists "determine [during the surgery] whether all the cancer has been removed" (Kaiser & Lee, 2015, para. 4). This adds approximately 20 minutes to the procedure, but it capitalizes on the opportunity to remove all the cancer within one procedure. As a result, 96 percent of patients do not need to repeat the lumpectomy procedure. In a five-year study of this approach, the reoperation rate within 30 days

was 3.6 percent at the Mayo Clinic and 13.2 percent nationally. Kaiser and Lee (2015) summarize the results: “Mayo’s costs for surgery are higher in the short term, and it earns less revenue from follow-up operations. But it reduces overall medical costs, and the patient gets peace of mind more quickly” (para. 4). This achieves the goals of improving patient outcomes and reducing costs in the long run.

Collectively, the cases explored in the *Harvard Business Review* conceptualize the short-term and long-term financial impacts of value-based healthcare. The observed financial impact translates to the idea of advancing value-based healthcare through RPM. In the case of RPM, providers will incur upfront costs from investing in the physical capital needed to implement an RPM-based approach. An Australian study notes that few telehealth programs can “[realize cost reduction] within a budgetary cycle” and not have implementation costs (Snoswell et al., 2020, para. 3). Over time, the cost savings will exceed the upfront costs from the initial investment. Patients and payers could also experience front-loaded costs from the expenses to receive RPM devices. As these devices help physicians effectively manage long-term health, patients and payers will experience reduced costs from improved health outcomes. Improved health outcomes will also lead to an increased quality of life for patients which is invaluable.

Value-based healthcare and RPM technology are ongoing areas of exploration and research. With further research and implementation, the widespread use of RPM technology can help support the shift to a value-based healthcare system holistically rather than existing in silos. Various clinical research studies lead to results that align with the goals of value-based healthcare which will be further explored in Chapter 3.

Chapter 3

Statistical Model and Analysis

RPM in Clinical Practice

The use of RPM is an ongoing clinical research topic; in 2020, 96,888 publications focused on the use of biosensors. This approach to healthcare provides a "data-intensive approach" (Peyroteo et al., 2021, para. 4). Many clinical trials study the application of RPM within the scope of chronic diseases, including heart failure, hypertension, and inflammatory bowel disease.

Implantable intracardiac devices provide the ability to continuously measure cardiac pressures. In a study conducted in Massachusetts, 21 patients with heart failure utilized the implanted CardioMEMS device to monitor cardiac pressure, specifically, pulmonary artery pressure (Mohebali & Kittleson, 2021). This study resulted in twice as many interactions between clinicians and patients through remote management as well as reduced hospitalizations.

In another study, heart failure patients randomly received standard care or remote care (Mohebali & Kittleson, 2021). The remote care recorded vitals daily and incorporated education and monthly phone calls. Patients in the standard care group endured 24 days of unplanned hospitalizations whereas those in the remote care group faced 18 days in the hospital. Additionally, the standard and remote care groups suffered mortality rates of 11.3 per 100 person-years and 7.9 per 100 person-years, respectively. These results signify improved health outcomes from RPM technologies and reduced costs from fewer hospitalizations.

Implantable cardioverter-defibrillators (ICD) provide another remote care option for heart failure patients. In a study on the effectiveness of this device, 101 patients received standard care

and 99 patients utilized the Medtronic ICD device (Landolina et al., 2012). This study aimed to analyze the difference in "rate of emergency room or urgent in-office visits for heart failure, arrhythmias [irregular heartbeat)], or ICD-related events" (para. 11). The use of the implantable ICD device resulted in fewer hospitalizations and annual healthcare visits than the standard care. Figures 11 and 12 summarize the results which support the goals of value-based healthcare: improved patient outcomes, lower expenses, and reduced risk (Landolina et al., 2012).

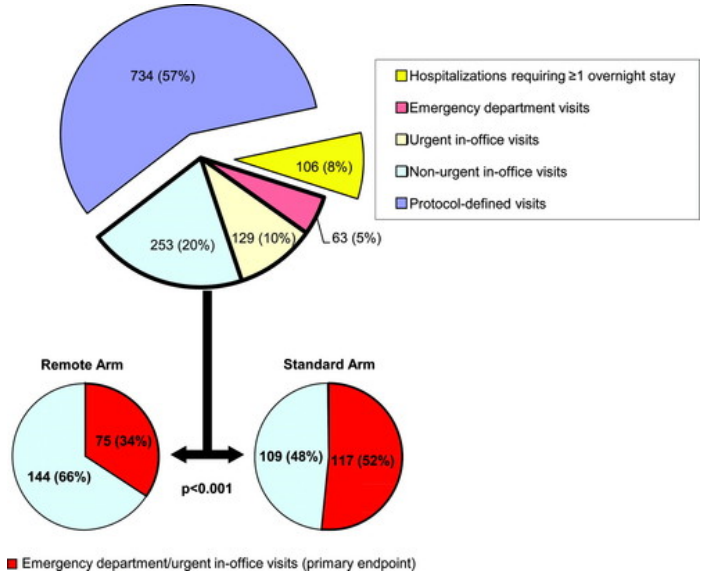

Figure 11: Remote versus Standard Emergency Visits

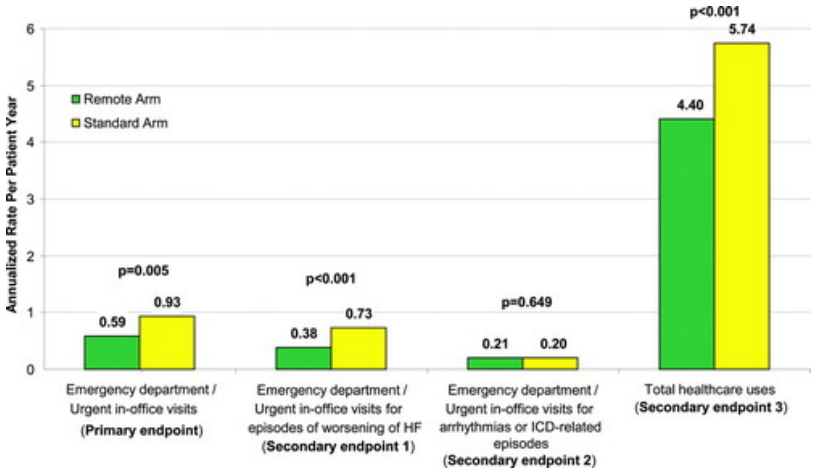

Figure 12: Remote versus Standard Annual Visits

The University of Pittsburgh Medical Center (UPMC) has also explored the implementation of RPM. UPMC studies find that the use of RPM reduces the risk of hospital readmissions by 76 percent while maintaining patient satisfaction scores over 90 percent (*The technology, devices, and benefits of [RPM]*, 2023). Specifically, UPMC & Pitt School of Medicine conducted a study on postpartum hypertension, a complication that impacts health outcomes in the U.S. Dr. Alisse Hauspurg, Associate Professor at the Pitt School of Medicine and a maternal-fetal medicine specialist, states, "'Hypertension complicates 10 to 20 percent of pregnancies in the [U.S.] and is a significant contributor to maternal morbidity and mortality in the postpartum period'" (Siwicki, 2021, para. 6). This study aimed to gain more information about this condition in Black and White women and investigate differences by race.

Since 2018, over 3,000 women participated in the postpartum remote blood pressure monitoring program for six weeks following delivery. This program incorporates the use of an at-home blood pressure device which produced "more than 40,000 blood pressure measurements in the first six weeks postpartum" thus far (Siwicki, 2021, para. 17). Dr. Hauspurg notes this program features "'comprehensive and coordinated approach of clinical operations, [electronic health record] integration, [and] mobile technology'" (Siwicki, 2021, para. 9). These key components of the remote program align with the keys to a successful value-based healthcare approach.

Additionally, UPMC studies RPM technology in the scope of another chronic condition: inflammatory bowel disease (IBD). In 2018, UPMC's Center for High-Value Care received a five-year, $6.3 million grant from the Patient-Centered Outcomes Research Institute (PCORI) (*UPMC Health Plan*, 2018). This grant supports a program that studies 990 IBD patients in three cities to find the most effective patient-centered medical home (PCMH) for managing IBD

(Patient-Centered Outcomes and Research Institute [PCORI], 2018). PCMH refers to a "coordinated approach to patient care" rather than "[existing] in silos" (*What is value-based healthcare?*, 2017, para. 5-6). EMRs play an integral role for the functionality of a PCMH. Specifically, a PCMH provides a coordinated care approach by "[providing] multiple types of care, such as care from a specialist, mental healthcare, and community services" (PCORI, 2018, para. 2).

In the UPMC study, the patients are split into two types of PCMHs: TEAM or TECH (*UPMC Health Plan*, 2018). Care is coordinated between a gastroenterologist, a nurse, and a behavioral health specialist. Patients in the TEAM group receive traditional care, and patients in the TECH group receive care through RPM and telehealth. A one-year pilot study was conducted to focus on the impact of an IBD specialty medical home approach; the success of this study supported the PCORI grant for the five-year study. The pilot study resulted in improved quality of life and reduced need for care; specifically, it resulted in a 30 percent decrease in hospitalizations and a 50 percent decrease in emergency room visits.

Toy Model: Foundation & Assumptions

The PCMH concept aligns with a key goal of value-based healthcare: improving patient outcomes through coordinated care. UPMC's five-year study aims to study the advancement of this goal through a tech-based approach; this parallels the concept of advancing value-based healthcare through RPM. The success of the one-year pilot study provides the foundation for the five-year TEAM versus TECH study.

Therefore, the toy model uses the results of the one-year pilot study as baseline parameter values for frequency. Utilizing these parameters assumes that the use of RPM in the tech-based group will generate similar results to the PCMH pilot study. Therefore, the toy model

benchmarks the decrease in frequency of hospitalizations and emergency department (ED) visits by 30 percent and 50 percent, respectively. The toy model uses these parameters in conjunction with the average cost of IBD-related hospitalizations and emergency room visits to estimate the cost savings from RPM in a value-based healthcare approach.

Toy Model: Hospitalizations

Crohn's disease (CD) and ulcerative colitis (UC) are the two conditions that classify as IBD. Supporting research reports costs separately for these two conditions, so the toy model will utilize the data in aggregate and separated by condition. The Centers for Disease Control & Prevention (CDC, 2022a) report on IBD hospitalizations for Medicare beneficiaries aged 65 and over. For reference, the average hospital stays for CD and UC are 3.9 days and 4.1 days, respectively. Further, another publication reports on hospitalization costs for IBD in the U.S using data from 2003 through 2014 (Xu et al, 2019). This study finds the mean costs per hospital admission for CD and UC in 2014 were $11,345 and $13,412, respectively. The total hospitalization costs for CD and UC in 2014 were estimated at $638.6 million and $450.4 million, respectively (Source 25). By applying the Consumer Price Index (CPI), the toy model estimates total costs for CD and UC in 2022 at $789.4 million and $556.8 million, respectively. Table 1 summarizes these findings and estimations:

Table 1: CD & UC Hospitalization Costs

Year	CD Costs	UC Costs
2014	$638,600,000	$450,400,000
2022	$789,442,599	$556,788,203

As previously stated, the toy model assumes that integrating RPM through a tech-based approach for managing IBD will lead to a 30-percent decrease in the frequency of hospitalizations. The reduction in hospitalizations will generate cost savings, and the model

directly applies the reduced hospitalization factor to calculate reduced costs. After applying the 30-percent decrease, total annual hospitalization costs for CD and UC are estimated to be $552.6 million and $389.8 million, respectively. Figure 13 shows the resulting CD and UC hospitalization costs due to variability in the frequency and cost reduction factor. (Note: The hospitalization costs do not account for the costs of implementing a tech-based approach.)

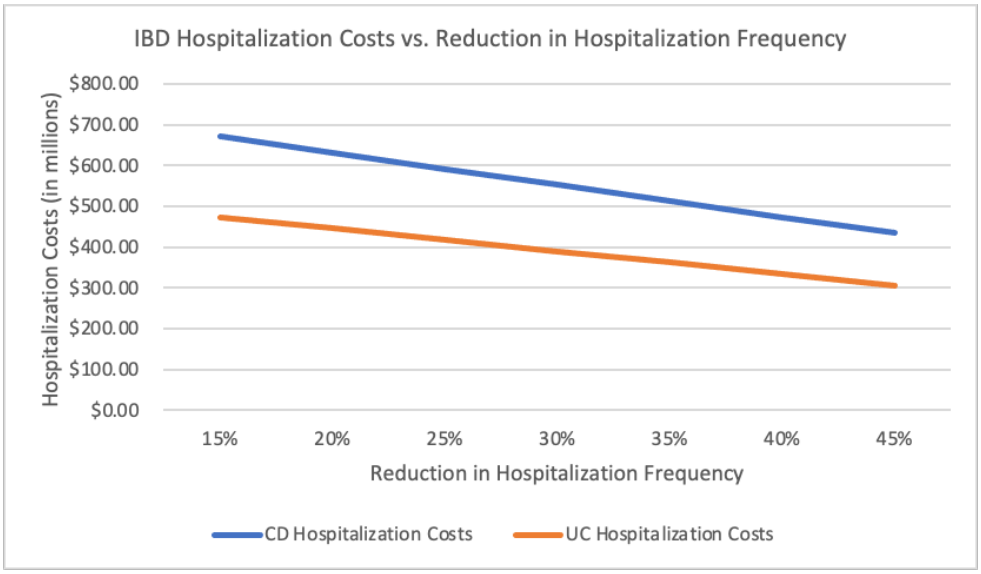

Figure 13: IBD Hospitalization Costs vs. Reduction in Hospitalization Frequency

Toy Model: Emergency Department (ED) Visits

A study from 2016 through 2014 analyzed the ED utilization for IBD in the U.S. This study reports the number of ED visits and the costs of IBD-related, ED visits in 2016 and 2014. To estimate the frequency and cost of IBD-related, ED visits in 2022, I utilized the linear interpolation method. Equation 1 provides the basis for this method:

Equation 1: Linear Interpolation

$$\frac{y - y_0}{x - x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

Table 2 summarizes the findings and estimations on a 2016 cost basis.

Table 2: IBD-ED Visits & Costs (2016 Basis)

Year	Total ED Visits	IBD-ED Visits	Total Cost of IBD-ED Visits (2016 Basis)	Per Visit Mean Cost (2016 Basis)
2006	120,033,750	90,846	$194,773,824	$2,144
CD		63,000	$140,805,000	$2,235
UC		27,846	$53,492,166	$1,921
2014	137,807,901	137,946	$598,961,532	$4,342
CD		93,277	$416,854,913	$4,469
UC		44,669	$181,222,133	$4,057
2022	155,582,052	185,046	$1,003,149,240	$6,540
CD		123,554	$692,904,826	$6,703
UC		61,492	$308,952,100	$6,193

To convert from a 2016 cost basis to a 2022 cost basis, I applied the CPI to the estimated costs for 2022. This method results in the estimations, shown in Table 3, for the number of IBD-related, ED visits and the associated costs.

Table 3: IBD-ED Visits & Costs (2022 Basis)

Year	IBD-ED Visits	Total Cost of IBD-ED Visits (2022 Basis)	Per Visit Mean Cost (2022 Basis)
2022	185,046	$1,223,200,327	$7,975
CD	123,554	$844,900,615	$8,173
UC	61,492	$376,723,916	$7,551

As previously stated, the result of the one-year pilot study provides a benchmark for the reduction in ED visits at 50 percent. By applying this reduction in frequency to costs, the toy model estimates the costs of ED visits for CD and UC at $422.5 million and $188.4 million, respectively. Figure 14 shows the costs of ED visits for CD and UC due to variability in the frequency and cost reduction factor. (Note: The costs of ED visits do not account for the costs of implementing a tech-based approach.)

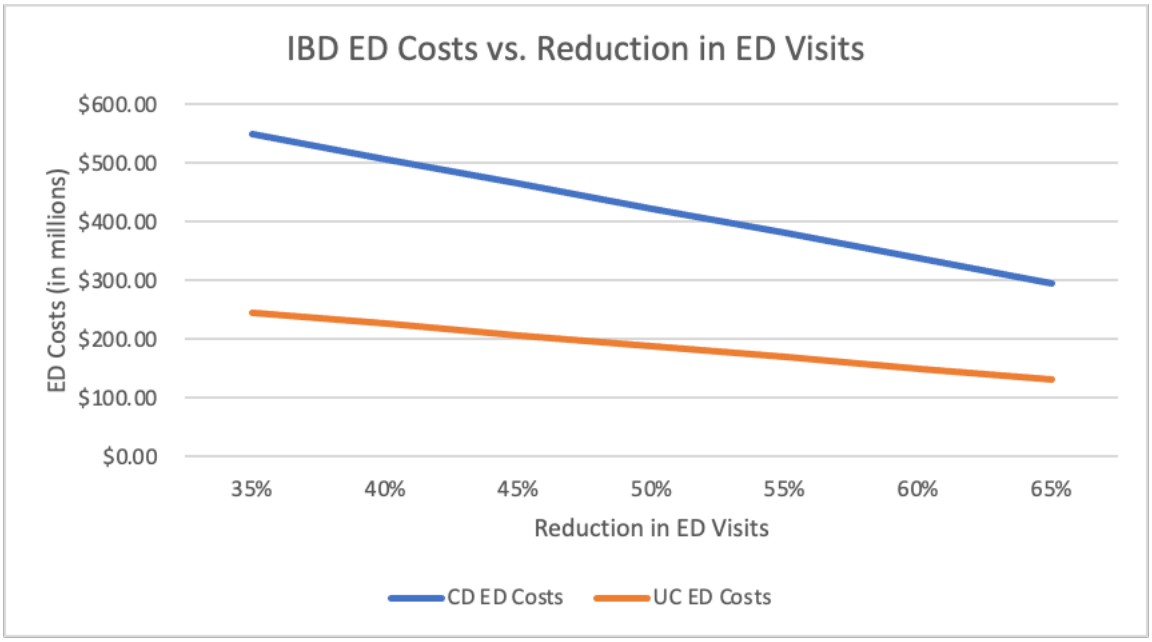

Figure 14: IBD ED Costs vs. Reduction in ED Visits

Application to Value-Based Healthcare

Value can be quantified as the ratio between the cost of resulting health outcomes and the cost of delivering the outcomes. In the UPMC study, the cost savings from reduced hospitalizations and ED visits represent the cost of health outcomes, and the difference in cost between the TECH and TEAM approaches represent the cost of delivering the outcomes. Equation 2 summarizes this ratio:

Equation 2: Value of TECH

$$\frac{Cost\ Savings}{Cost\ of\ TECH - Cost\ of\ TEAM}$$

As explained in Chapter 2, negative short-term financial impacts will likely result from transitioning to value-based healthcare, specifically through the TECH approach in this case. Therefore, this ratio must be analyzed in the long run to quantify the true value of a tech-based approach to value-based healthcare. If the value of this ratio is greater than one in the long run, the TECH approach adds value as the long-run cost savings from improved health outcomes (i.e., reduced hospitalizations and ED visits) exceed the marginal cost of implementing the TECH approach. If the TECH approach proves less expensive and improves outcomes in the long run, then this approach improves the cost efficiency on both sides: savings from improved health outcomes and a cost-efficient healthcare delivery method.

The information about the UPMC study does not specify costs for the TEAM and TECH approaches. However, a 2020 study examines the ability of telehealth to reduce healthcare costs through a synthesis of existing literature (Snoswell, 2020). This study pooled 17 individual studies on the cost-minimization effect of telehealth. Of these 17 individual studies, nine of them reported cost savings from telehealth, six of them reported cost savings "after a workload threshold was achieved," and two of them reported increased costs from telehealth (Snoswell,

2020, para. 15). The workload threshold refers to a break-even point in which cost savings exceed the initial investment. The study reports that the payback period could occur immediately or up to nine years after the initial investment. This directly supports the idea that implementing RPM requires front-loaded costs that will be recovered through cost savings over time through coordinated care and improved outcomes.

The individual studies identify various reasons for lower costs. Since the toy model in this chapter focuses on reduced hospitalizations and ED visits, I will leverage the individual studies that utilized RPM and generated similar outcomes to benchmark the initial investment for RPM. A 2008 Belgium study focused on using RPM to manage high-risk pregnancies and reduce the length of hospitalizations. On a 2019 cost basis, the RPM required an initial investment of $15,409.17 and resulted in cost savings of $233,958 per patient (Snoswell, 2020, Table 2). Additionally, a 2006 Canadian study focused on RPM for chronic obstructive pulmonary disorder (COPD) to reduce hospitalizations and at-home nurse visits. On a 2019 cost basis, the RPM required an initial investment of $24,609.38 and generated cost savings of approximately $13,713 annually per patient (Snoswell, 2020, Table 2). As the costs of these initial investments are recovered over time through cost savings, the ratio explained above will result in a value greater than one, signifying added value from the TECH approach. Eventually, the marginal costs for the TEAM approach will outweigh the TECH approach. In this case, the TECH approach adds value by reducing costs on both the patient and provider sides.

The U.S. healthcare system must adopt telehealth, and specifically RPM, more broadly to improve the cost metrics of the U.S. healthcare system since “telehealth is likely to benefit from economies of scale” (Snoswell, 2020, para. 18). In this case, economies of scale models a decrease in the long-run average costs of telehealth as the quantity of telehealth increases.

Leveraging the value-based healthcare framework can support the broader implementation of telehealth.

This toy model supports the ability for RPM to advance value-based healthcare and shows the potential at the intersection of these healthcare trends. As seen in this model by leveraging existing research, the use of technology in healthcare leads to improved health outcomes and reduced costs. The widespread implementation of this approach, beyond managing IBD, could help the U.S. reduce the amount of GDP spent on healthcare and improve metrics regarding chronic conditions and health outcomes. Improving these metrics would signify improvements in the U.S. healthcare system and align the U.S. with the effectiveness of healthcare in other developed nations.

Chapter 4

Ethical Considerations

All players in the healthcare industry must understand and uphold the Health Insurance Portability and Accountability Act of 1996 (HIPAA). According to the CDC, HIPAA is a "federal law that required the creation of national standards to protect sensitive patient heath information from being disclosed without the patient's consent or knowledge" (CDC, 2022b, para. 1). The HIPAA Privacy Rule refers to the use of protected health information (PHI) with "covered entities" and for individuals to understand the use of their information. This rule strives to balance privacy with quality (CDC, 2022b). The HIPAA Security Rule applies to electronic protected health information (e-PHI) (Source 28). With the use of RPM and subsequent electronic data collection, providers and insurers must be cognizant of the HIPAA Security Rule. Upholding this rule connects to data security, integrity, and the use of personal data.

With an awareness of the regulations around medical data privacy, RPM can be implemented within multidisciplinary teams in a legal and ethical manner. Researchers report on a proposed framework to implement RPM legally and ethically regarding data collection and storage (Liao et al., 2019). First, before collecting data, patients must give their consent for electronic data collection and have a secure connection to a Wi-Fi or cellular network. Second, the collected data must be stored in a secure database. Third, managing the data must also occur in a secure manner. This framework ensures that patients approve of collecting their personal data electronically and upholds security of personal health information.

Additionally, the U.S. Department of Health and Human Services (HHS) acknowledges that providers must consider health equity in telehealth: "[the] shared responsibility to ensure equal access to quality telehealth care for everyone" (*Health equity in telehealth*, 2022, para. 1).

As stated previously, patients must have a secure connection to a Wi-Fi or cellular network to electronically transmit their health information. This could lead to inequities in the healthcare system in the rural population and with Americans who cannot afford a Wi-Fi or cellular data plan among other underserved communities. HHS identifies income, rurality, race and ethnicity, sexual and gender orientation, citizenship, disabilities, age, language, digital literacy, and insurance as factors and characteristics that result in underserved communities (*Health equity in telehealth*, 2022).

Underserved communities experience negative impacts on multiple aspects of their healthcare experience, including outcomes, costs, and accessibility (*Health equity in telehealth*, 2022). Regarding accessibility, underserved communities may not have the opportunity to capitalize on telehealth options due to accessibility barriers. Therefore, it is imperative that providers prioritize increasing the accessibility of telehealth. Implementing a government-sponsored telehealth program could allow more Americans to benefit from telehealth. While a government-sponsored program would increase public spending on healthcare in the U.S., underserved communities would experience improved health outcomes; this improvement would help advance towards a more equitable healthcare system in the U.S. Improving outcomes in the underserved communities would also contribute to making the U.S. population healthier. Public spending should theoretically decrease in the long run by improving the health outcomes of the entire U.S. population. This challenge of implementing RPM in an equitable and economical way provides an area for future consideration.

Chapter 5

Conclusion

The U.S. healthcare system ranks poorly compared to other countries on several metrics, specifically pertaining to outcomes for patients and expenses. Value-based healthcare provides a strategic idea for improving the effectiveness of the U.S. healthcare system; this evolving approach to healthcare seeks to maximize value by improving health outcomes and reducing expenses. This concept is rooted in the idea that proactive and preventive care through a multidisciplinary approach will improve long-run health outcomes and reduce costly complications. Specifically, the value-based healthcare approach provides a strategic approach for managing chronic conditions since these conditions can historically lead to complications, poor outcomes, and high costs. By striving to avoid complications and improve outcomes through a value-based healthcare approach, patients will live healthier lives and reduce overall spending on healthcare in the U.S.

The recent rise of telehealth, and specifically RPM, serves as an asset to advancing the concept of value-based healthcare. The goals of utilizing RPM align with the goals of value-based healthcare, and this intersection provides a unique opportunity for future exploration and advancement. RPM has been studied in various clinical studies for chronic conditions, and a significant amount of research in this area is ongoing. Existing studies resulted in improved health outcomes which generate cost savings.

The toy model included in this thesis takes a deeper look at the impact of RPM within the scope of IBD. This model analyzes recent data on the outcomes for IBD patients and associated

costs. The model could be expanded in several ways: incorporating a cost analysis of the healthcare delivery model, analyzing how the outcomes differ between demographic groups, and beyond. This fundamental analysis demonstrates the ability for RPM to advance the concept of value-based healthcare for IBD, one of many chronic conditions that affects the U.S. population. Future research in this area could analyze the intersection of value-based healthcare and RPM in the scope of other chronic diseases in multi-year studies to evaluate the long-run effects and holistic impacts on the U.S. healthcare system.

Beyond the strategic and financial aspects of these ideas, providers must consider the ethical aspects as well. Ethical considerations pertain to data security, privacy, and health equity, and these considerations would play a vital role in successfully advancing value-based healthcare through RPM in an ethical and equitable way.

BIBLIOGRAPHY

Abbott. (2023). Abbott Cardiovascular. http://www.cardiovascular.abbott:443/us/en/patients/treatments-therapies/pulmonary-artery-pressure-monitoring-for-heart-failure.html

Aetna. (2023). *Better health at lower costs: Why we need value-based care now*. Aetna. https://www.aetna.com/employers-organizations/resources/value-based-care.html

American Hospital Association. (2023). *Fast facts on U.S. hospitals infographics*. American Hospital Association. https://www.aha.org/infographics/2020-07-24-fast-facts-infographics

Centers for Disease Control and Prevention (CDC). (2022a, April 27). *Hospitalizations for IBD among older adults*. Centers for Disease Control and Prevention. https://www.cdc.gov/ibd/features/hospitalizations-of-older-adults.html

Centers for Disease Control and Prevention (CDC). (2022b, June 27). *Health Insurance Portability and Accountability Act of 1996 (HIPAA)*. Centers for Disease Control and Prevention. https://www.cdc.gov/phlp/publications/topic/hipaa.html

Cleveland Clinic. (2020, October 19). *Value-based care*. Cleveland Clinic. https://my.clevelandclinic.org/health/articles/15938-value-based-care

Health equity in telehealth. (2022, June 3). Telehealth.HHS.Gov; Health Resources & Services Adm. https://telehealth.hhs.gov/providers/health-equity-in-telehealth

Kaiser, L. S., & Lee, T. H. (2015, October 8). Turning value-based health care into a real business model. *Harvard Business Review*. https://hbr.org/2015/10/turning-value-based-health-care-into-a-real-business-model

Landolina, M., Perego, G. B., Lunati, M., Curnis, A., Guenzati, G., Vicentini, A., Parati, G., Borghi, G., Zanaboni, P., Valsecchi, S., & Marzegalli, M. (2012). Remote monitoring reduces healthcare use and improves quality of care in heart failure patients with implantable defibrillators. *Circulation*, *125*(24), 2985–2992. https://doi.org/10.1161/CIRCULATIONAHA.111.088971

Liao, Y., Thompson, C., Peterson, S., Mandrola, J., & Beg, M. S. (2019). The future of wearable technologies and remote monitoring in health care. *American Society of Clinical Oncology Educational Book*, *39*, 115–121. https://doi.org/10.1200/EDBK_238919

Mohebali, D., & Kittleson, M. M. (2021). Remote monitoring in heart failure: Current and emerging technologies in the context of the pandemic. *Heart*, *107*(5), 366–372. https://doi.org/10.1136/heartjnl-2020-318062

Muller, E. (2023). *7 common remote patient monitoring devices*. Health Recovery Solutions; Health Recovery Solutions. https://www.healthrecoverysolutions.com/blog/7-common-remote-patient-monitoring-devices

Patient-Centered Outcomes and Research Institute. (2018, August 17). *Comparing two programs to treat patients with inflammatory bowel disease and behavioral health conditions*. Patient-Centered Outcomes and Research Institute. https://www.pcori.org/research-results/2018/comparing-two-programs-treat-patients-inflammatory-bowel-disease-and-behavioral-health-conditions

Peyroteo, M., Ferreira, I. A., Elvas, L. B., Ferreira, J. C., & Lapão, L. V. (2021). Remote monitoring systems for patients with chronic diseases in primary health care: Systematic review. *JMIR MHealth and UHealth*, *9*(12), e28285. https://doi.org/10.2196/28285

Siwicki, B. (2021, March 16). *UPMC uses RPM to study postpartum hypertension among Black and White women*. Healthcare IT News; HIMSS Media. https://www.healthcareitnews.com/news/upmc-uses-rpm-study-postpartum-hypertension-among-black-and-white-women

Snoswell, C. L., Taylor, M. L., Comans, T. A., Smith, A. C., Gray, L. C., & Caffery, L. J. (2020). Determining if telehealth can reduce health system costs: Scoping review. *Journal of Medical Internet Research*, *22*(10), e17298. https://doi.org/10.2196/17298

Teisberg, E., Wallace, S., & O'Hara, S. (2020). Defining and implementing value-based health care: A strategic framework. *Academic Medicine*, *95*(5), 682–685. https://doi.org/10.1097/ACM.0000000000003122

The technology, devices, and benefits of remote patient monitoring in the healthcare industry. (2023, January 19). Insider Intelligence; Insider Intelligence Inc. https://www.insiderintelligence.com/insights/remote-patient-monitoring-industry-explained/

Tikkanen , R., Osborn, R., Mossialos, E., Djordjevic, A., & Wharton, G. (2020). *International profiles of health care systems*. The Commonwealth Fund. https://www.commonwealthfund.org/sites/default/files/2020-12/International_Profiles_of_Health_Care_Systems_Dec2020.pdf

Tikkanen, R. (2020). *Multinational comparisons of health systems data, 2019*. The Commonwealth Fund. https://www.commonwealthfund.org/sites/default/files/2020-01/Tikkanen_multinational_comparisons_hlt_sys_data_2019_01-30-2020.pdf

Tikkanen, R., & Abrams, M. (2020, January 30). *U.S. health care from a global perspective, 2019: Higher spending, worse outcomes?* The Commonwealth Fund; The Commonwealth Fund. https://doi.org/10.26099/7avy-fc29

UPMC Health Plan announces $6.3 million research contract from PCORI. (2018, September 24). Cision; Cision US Inc. https://www.prnewswire.com/news-releases/upmc-health-plan-announces-6-3-million-research-contract-from-pcori-300717667.html

U.S. health care spending highest among developed countries. (2019, January 7). Johns Hopkins Bloomberg School of Public Health; Johns Hopkins University. https://publichealth.jhu.edu/2019/us-health-care-spending-highest-among-developed-countries

What is value-based healthcare? (2017, January 1). NEJM Catalyst; Massachusetts Medical Society. https://catalyst.nejm.org/doi/full/10.1056/CAT.17.0558

Xu, F., Liu, Y., Wheaton, A. G., Rabarison, K. M., & Croft, J. B. (2019). Trends and factors associated with hospitalization costs for inflammatory bowel disease in the United States. *Applied Health Economics and Health Policy*, *17*(1), 77–91. https://doi.org/10.1007/s40258-018-0432-4

ACADEMIC VITA

KRISTEN CHOMOS

EDUCATION

The Pennsylvania State University | Schreyer Honors College — **University Park, PA**
Smeal College of Business | B.S. in Actuarial Science — *Class of 2023*
College of the Liberal Arts & Eberly College of Science | Minors in Economics & Statistics

ACTUARIAL EXAMS

Passed – Exam P/1, Probability Theory — *May 2020*
Passed – Exam FM/2, Financial Mathematics — *Jun 2021*
Passed – Exam IFM, Investment & Financial Markets — *Jul 2022*

PROFESSIONAL EXPERIENCE

Prudential – Actuarial Internship Program — **Newark, NJ**
Long-Term Care (LTC) Flex Intern — *Jun 2022 – Aug 2022*

- Gained exposure to LTC products, state filing procedures and regulations, monthly NPV reporting, data reconciliation, Access queries, assumption review, and organizational structure to build high-level understanding of LTC business
- Prepared 12 annual state filings for group LTC policies to monitor policy experience and projections following premium rate increases and verified reasonability using rate-stability requirements, A/E ratios, and historical filings
- Connected business processes to Prudential's Vision & Strategy and presented insights to LTC senior leaders and teams

Annuity Pricing Intern — *Jun 2021 – Aug 2021*

- Developed relativity factor grids, using Excel and VBA, for Prudential's flagship annuity product, FlexGuard, to efficiently estimate profitability metrics based on cell-level factors and presented methodology to 30 members of Annuity Pricing team
- Networked with U.S. and international-based senior leaders and associates across Actuarial organization to discuss COVID-19's impact on product lines, leadership, and remote work and delivered insights in culminating project
- Engaged in leadership sessions, regarding actuarial transformation, organizational structure, Agile framework, and DEI

LEADERSHIP EXPERIENCE

Lion Ambassadors, Penn State Student Alumni Corps — **University Park, PA**
President — *Jan 2021 – Present*

- Represented Penn State Alumni Association, largest dues-paying alumni network worldwide with over 174,000 members, on private tours with donors, alumni, and incoming Penn State President and through projects, special events, and service
- Led 100-member organization and oversaw 15 executive positions, with focus on strategic goals, including DEI and long-term leadership growth, organizational culture and change, internal operations, outreach, alumni relations, and membership
- Conducted prospective and accepted student tours, averaging 15 participants, to showcase University Park and leveraged University knowledge of 13 academic colleges, student organizations, and campus resources to promote Penn State

Sapphire Leadership Academic Program — **University Park, PA**
General Member (Professional & Leadership Development Captain, 2021) — *Aug 2019 – Present*

- Selected to cohort of 50 first-year Smeal students to engage in specialized 6-course leadership curriculum and minimum 12 events per semester focused on professional and leadership development and community service to uphold Sapphire pillars
- Collaborated with peers and developed new 6-week discussion series regarding DEI in workplace, sustainability, and business ethics to foster respect, understanding, and integrity among Sapphire students
- Planned and executed professional and leadership development opportunities for Sapphire students, including Student-Alumni Pairing Program, Global Perspectives on Leadership Panel, and Roundtable with MLB Inside Sales Manager

Penn State Actuarial Science Club — **University Park, PA**
Mentor — *Sept 2019 – Present*

- Formed relationships and mentored first-year students on Penn State courses, actuarial exams, and on-campus involvement
- Participated in Boot Camp to further develop technical, professional, and networking skills through projects and workshops

Penn State Women's Club Volleyball — **University Park, PA**
Vice President — *Sept 2019 – Present*

- Coordinated tryouts for 120 players with focus on maximizing efficiency, safety, and compliance with PSU Club Sports
- Arranged travel logistics, including housing and transportation, for 26 players on 4 trips, including 6 days in Kansas City

HONORS & SKILLS

Honors: Ralph H. Wherry Student Service, Robert W. Koehler Distinguished Service, President Sparks Award, Dean's List
Skills: Proficient in Microsoft Excel, Access, PowerPoint, and Word, written and verbal communication