Population Health Management:

Process Improvement in the Evolving World of Healthcare

A Major Qualifying Project

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By

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Abstract

This project explores the development and piloting of a comprehensive Emergency General Surgery Registry at UMass Memorial Medical Center. This registry will provide data necessary for using Analytics to improve care management on the EGS service. Such efforts are critical to Population Health Management (PHM), the process of improving a population's health outcomes and developing financially sustainable healthcare providers. Although only a small piece of the healthcare system, this registry represents the building blocks of a successful PHM initiative that can be used throughout the system to produce overall success.

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Introduction

As a child, I was filled with insatiable curiosity—as children tend to be. I wanted to know all the whats, hows, and whys. What caused gravity? How were babies made? Was the sky blue because it reflected the oceans, or were the oceans blue because they reflected the sky? There were questions for everything, and every answer produced even more queries. But I didn't mind, because it meant more to explore, more to discover, more to understand.

Looking back, I am amazed at the grace and patience with which my parents handled these questions. I remember my mother, pregnant with my baby sister, lying down next to my five-year-old self to read me a book about how babies develop in the womb. I remember my father picking me up off the couch and sitting me down on his lap as he considered my latest question. "Well," he would begin, with a twinkle in his eye. And then, those infamous words: "What if…?" And just like that, he would turn the question back on me, spinning a scenario and insisting that I think it through to its logical conclusions. When I got stumped, he would provide a bit more information, enough to get me going again. As I grew older, rather than give me the information himself, he suggested I look it up. And in the end, I would have not just an answer to my question and a far more thorough understanding of whole topic, but something even more valuable. The true value of those exploratory conversations was in the skills I practiced: reasoning, logic, drawing connections between seemingly unrelated facts, all the components of analysis. The tools I needed to go on and answer other questions, solve other problems.

These tools served me well throughout school, where my thirst for knowledge was sated even as it stretched and grew. It would be years before I realized how well they also served in everyday life, navigating jobs, relationships, hobbies—just about everything I would be involved in. Meanwhile, the questions never stopped or went away; they simply became more complex. More and more information was required to even approach answering them. Often, the amount of information necessary was outside my grasp. More often, even if the information was available, I simply didn't have the time to track it all down. I learned to focus my energy on the questions with the greatest relevance, interest, and impact, to discard the ones that were outside my grasp, and to come to terms with questions being left unanswered.

Then, three years into my undergraduate education, I discovered Analytics: the art of using vast, comprehensive data sets to identify trends and answer questions that could never otherwise be identified or answered. The curious, questioning child inside me

was utterly giddy at this discovery. Here was the tool I needed to garner the information necessary for those impossible questions! Of course, this only opened the door to even more questions, with even less time to address any of them. It became a greater challenge to select which ones to focus on. With so many options, how could I possibly choose where to begin?

As I considered options for my Major Qualifying Project in Professional Writing, I realized it provided an ideal platform for answering some (or at least one) of those waiting questions. With the power of analytics at hand, all I needed to do was choose a topic. So I turned to an area in which I already had a basic understanding, one which also had some of the greatest potential positive impact on people's lives: healthcare.

I was no stranger to the world of healthcare. My mother, a physical therapist, shared regular glimpses of the world she worked in over dinnertime conversation throughout my childhood. Meanwhile, we were in and out of the hospital every few years as my father suffered periodic heart attacks and related complications. Between that and my own regular doctor's visits, I was quite aware of the value of good healthcare—and of the vast room for improvement therein.

Given this background knowledge of healthcare, it struck me as an ideal field in which to focus my MQP. In particular, I chose to explore recent healthcare improvement initiatives, and the role of analytics in these efforts. The biggest current movement in healthcare right now is one toward Population Health Management. As this movement brings the industry into uncharted territory, there are infinite questions to be asked and answered. This Major Qualifying Project only begins to chart out the kind of work necessary to tackle these questions.

This paper will begin by defining and describing Population Health Management, its goals, and its advantages over more traditional healthcare. The second chapter goes into more detail about care-based areas in which healthcare providers can improve to achieve Population Health Management. The third chapter discusses some specific tools that can be used to make those improvements, including the incorporation of big data and analytics. The fourth chapter steps back to go into greater detail about how I discovered and came to appreciate the depth and capabilities of analytics. The fifth chapter then describes the process of developing and piloting a patient database at UMass Memorial Medical Center, which will be a stepping stone to using analytics to improve patient care, serving as one small component in a vast range of efforts to achieve Population Health Management. Finally, the sixth chapter ties everything together and describes the next steps for UMass Memorial and for healthcare in general in the pursuit of Population Health Management.

1. What is Population Health?

With the variety and ubiquity of diseases, injuries, and other health concerns worldwide, there is a constant demand for more and better health care. Meeting this demand is no small challenge for health care providers, particularly from a financial perspective. Many hospitals barely break even or even function at a loss, while patients are often unable to pay medical bills even after the portions covered by insurance. With financial hardship on every side, as well as the constant drive for more effective treatment and better patient outcomes, increasing emphasis is being placed on the need for healthcare reform. Such reform will not only require policy changes and cost-saving measures, but an entire reframing of the traditional perspective and approach to healthcare. To that end, there has been a recent shift to the perspective of Population Health Management.

1.1 Definition of Population Health Management

Population health has been defined as "the health outcomes of a group of individuals, including the distribution of such outcomes within the group" (Kindig and Stoddart, 2003). Thus, Population Health Management (PHM) refers to the management of those outcomes. In particular, an emphasis is placed on the distribution of outcomes. Traditional management methods follow a fee-for-service model addressing patients one at a time as they come in seeking care, which puts the majority of the focus on the chronically ill, accounting only somewhat for acute illness, and disregarding the generally healthy population. Conversely, PHM addresses not only both the chronically and acutely ill, but also those who are considered healthy, who rarely if ever seek medical care.

1.2 Goals of Population Health Management

There are two overarching goals to Population Health Management: improving the overall health of a population, and reducing costs to achieve financially sustainable health care systems (Hodach, 2012). These goals are inextricably intertwined. As the health of a population improves, costs will inherently decrease, as there will be less need for cost-intensive tests, exams, and treatments. Conversely, as costs decrease, funds can be better distributed to address health concerns more effectively, resulting in improved health throughout the population.

Achieving these goals requires effort and collaboration on every level of healthcare, from the doctors and nurses who directly influence patient outcomes to the administrators and executives who decide where to direct resources and implement those decisions. Indeed, to accomplish Population Health Management to the fullest extent, health care providers must collaborate with schools, businesses, and other contributors to the community, so as to truly encompass the entire community (Hodach, 2012).

1.3 Achieving Population Health Management

The Health Care Advisory Board describes three angles of approach to lowering costs and improving quality in a PHM initiative (Playbook for Population Health, 2013). These three angles (Plan Management, Partner Engagement, and Care Management) are illustrated in Figure 1 below, and each will be briefly described in the following sections.

Partner Engagement:
Building a community healthcare network

Plan Management:
Improving health plan and employee benefit design

PHM

Care Management:
Addressing patient needs according to risk level
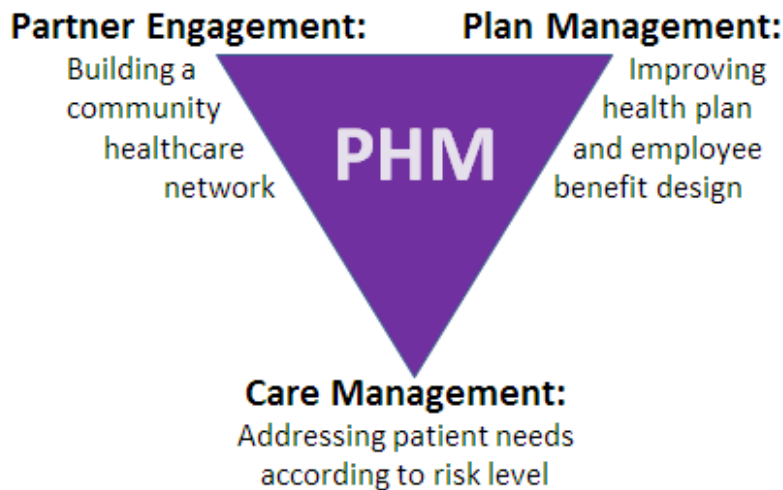
Figure 1: Angles of Approach to Population Health Management

1.3.1 Plan Management

Plan Management focuses on improving design of health plans and employee benefits. Many aspects of this angle involve improving efficiency, such as streamlining pre-authorization processes and implementing utilization management tools (Playbook for Population Health, 2013). These measures save time for both patients and hospitals, and saved time translates into saved money. Another significant aspect is Value-Based Benefit Design (VBBD), which encourages employees to structure and utilize health

benefits in ways that improve health-related behaviors, management of chronic conditions, and provider choice (nbch, 2014). This angle is complex and cannot be implemented rapidly on a wide scale by most health care providers, as it requires heavy collaboration with insurance companies and employers outside the health care system. It can and should, however, be used on a small scale, with a health care's own employees and through its interactions with businesses and insurance companies, until such a point that it can be expanded to a larger scale.

1.3.2 Partner Engagement

While hospitals present a significant player in a community's healthcare facilities, there are various other healthcare providers with which patients interact. One of the greatest measures a healthcare provider can take to achieve PHM is engaging with partner services, from primary care providers to specialists. Collaborating with other providers to develop a preferred partner network allows for consistent values, accountability, and shared information and resources between partners (Playbook for Population Health, 2013). The flow of information and resources through the network will lower costs, while consistency and accountability will lead to higher quality of care and access to a greater portion of the community.

1.3.3 Care Management

The third angle, Care Management, presents the most direct opportunity for healthcare providers to achieve Population Health Management. Rather than relying on cooperation from other entities, it can be achieved entirely internally. By putting a focus on direct improvement of patient care, it also has some of the greatest impact on cost and quality. Care Management involves stratifying the patient population according to risk level, then addressing each category separately according to its unique needs (Playbook for Population Health, 2013). This shifts the focus of robust care to those who need it most, while decreasing the likelihood of lower-risk patients becoming high-risk, all of which directly improves patient outcomes. Meanwhile, it reduces redundancy and focuses on preventive measures for low-risk patients, both of which decrease costs. As the most direct and influential angle available, Care Management is the primary focus of many healthcare providers seeking to achieve Population Health Management.

2. Care Management Methods

As the most direct and, arguably, most important angle to Population Health Management, it is important to understand the process behind care management. This chapter will explore the steps to this approach to improved PHM.

2.1 Dividing Patients into Categories

The core of effective Care Management is stratifying patients into categories according to their level of health risk, and approaching each category separately according to its needs. There are three basic categories: High-, Rising-, and Low-Risk. Figure 2 summarizes the key traits of each of these categories, including the relationship between cost to the system and portion of the overall population.
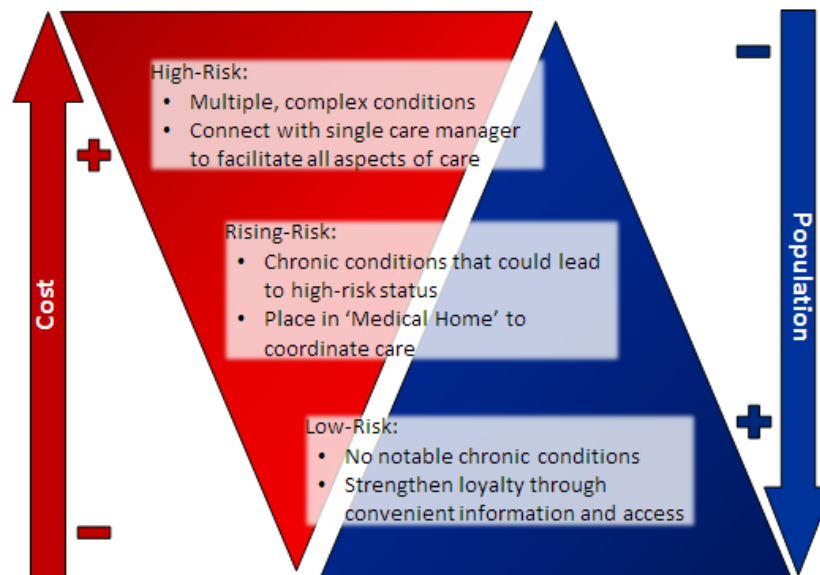
Figure 2: Patient categories

2.1.1 High-Risk

About five percent of patients fall into the high-risk category, which includes those with complex conditions and/or various comorbidities (Playbook for Population Health, 2013). Although this category contains the fewest patients, the volume and complexity of its patients' treatments mean it incurs the highest cost of the three categories. A patient might be considered high risk if he suffers from late-stage cancer,   morbid

obesity, or cystic fibrosis. High-risk patients may also suffer from a combination of several lesser ailments that, in combination, complicate treatment.

The primary objective in improving care management for high-risk patients is to connect each patient with a single high-risk care manager in a one-on-one relationship. This care manager's task is to be familiar with all aspects of the patient's care and integrate them together in a comprehensive plan. By having a single point of contact who understands the nuances of all of a given patient's complications and conditions, there are fewer communication mishaps between care providers within a health system responsible for different aspects of the patient's care, as well as between the patient and his care providers. Treatment methods can be selected based on what will work synergistically together. Ideally, treatments will be more effective, resulting in better outcomes and lower costs.

Another important aspect to care management for high-risk patients is addressing health issues outside the clinical setting. This includes minimizing barriers to care, such as transportation and cost, as well as attending to non-clinical needs such as behavioral and social challenges. High-risk patients with mental conditions such as depression or dementia may be unable or unwilling to seek care on their own. Using the care manager as the primary point of contact, a health care provider can partner with support services to address those non-clinical challenges and give the patient access to the needed clinical care as well. Successfully done, this has the potential to greatly influence patient outcomes. By partnering with other organizations, the work is divided, saving both time and money for the healthcare provider.

2.1.2 Rising-Risk

Rising-risk patients comprise 15 to 35 percent of a population. These patients tend to have chronic conditions which, if inadequately or inappropriately treated, will escalate and move them into the high-risk category (Playbook for Population Health, 2013). Such conditions might include diabetes, heart disease, or indulgence in behaviors such as smoking or excessive alcohol consumption, which increase health risks.

Because this category is larger and more varied than the high-risk category, the first step to addressing rising-risk patients is identifying them. This is largely accomplished using appropriate application of analytics, which will be described in greater detail in Chapter 3. Once they have been identified, the primary objective is to prevent these patients from becoming high-risk. To that end, rising-risk patients should be introduced to a medical home care team. Similar to the high-risk care manager, this 'medical home' is a primary care practice that coordinates all aspects of a patient's care. When a rising-

risk patient's overall health, social, and behavioral needs are met by a well-coordinated medical home team, they will less frequently require clinical care. When these patients do require clinical care, the focus is on shifting them back to primary care management as quickly as possible, keeping clinical resources free for high-risk patients.

2.1.3 Low-Risk

The remaining 60 to 80 percent of a population are considered low-risk. These people are overall healthy, and rarely need or seek medical attention. Their healthcare encounters tend to be limited to short-term illness or injury, possibly extending to management of low-level conditions such as mild asthma or food intolerances.

With so few medical concerns associated with them, the primary objective in addressing low-risk patients is strengthening their loyalty to the healthcare system (Playbook for Population Health, 2013). These patients cost the least, so maintaining an ongoing relationship with them is beneficial to a healthcare provider's financial stability. This applies not only to those low-risk patients already in the system, but also to attracting new ones and establishing loyalty with them. This is accomplished by making it easy and convenient for low-risk patients to connect with the healthcare system, while reserving clinical resources for emergency intervention and care. Online patient portals are an excellent way of accomplishing this, providing patients with direct information about their recent and upcoming healthcare visits in an efficient, non-resource-intensive manner. It is also important to encourage regular check-ups, not only to catch and prevent possible health risks, but to maintain a connection between the patient and care provider.

2.2 Long-Term Improvement Measures

Population Health Management is a long-term process, and as such, it inherently places a large amount of emphasis on implementing improvement measures for long-term success. Two consistent themes in PHM that facilitate such long-term goals are patient-provider communication and patient compliance and follow-up. These are reflected in the approaches used for all three patient risk levels.

2.2.1 Facilitating Patient-Provider Communication

Communication between a patient and his or her care provider is critical for both sides, particularly with rising- and high-risk patients. When a patient is open and honest

about symptoms and concerns, it provides the care provider with necessary information for diagnosis and treatment decisions. Similarly, care providers can use that open line of communication to make the patient aware of what to expect and what options are available. This engenders trust and loyalty, and allows the patient to feel more invested in his or her care, leading to better decisions and thus better treatment plans.

Each category of patients has a unique method of achieving improved communication. It is improved for high-risk patients through the use of a high-risk care provider. This individual is intimately familiar of with the patient's condition, and serves as a single point of contact for the patient to ask questions and share new information. The medical home care team serves a similar purpose for rising-risk patients, while patient portals and regular check-ups do the same for low-risk patients.

2.2.2 Improving Patient Compliance and Follow-Up

One of the greatest challenges in improving the health of a population is patient compliance. If patients fail to follow medical orders after a healthcare visit—such as taking prescription medications as directed, refraining from physical exertion after surgery, or attending a follow-up appointment—the chances of them developing complications or otherwise requiring further, more involved medical care rise significantly. Such noncompliance is unfortunately very common, for reasons varying from forgetfulness to stubbornness to not being able to afford the prescribed follow-up.

Improved communication, as described in Section 2.2.1, is a significant step in improving compliance and follow-up. When a patient has a strong relationship of trust with his care provider, he is more likely to follow instructions. Aside from patient-provider communication, there are various ways to improve compliance. For instance, calling patients a set time after discharge may serve as a reminder. Educating patients about the importance of compliance through various programs can also help. In cases where behavioral, economic, or social challenges interfere, collaboration with outside support services provides patients access to the resources they need to make behavioral changes, afford various costs, or travel for a follow-up appointment.

2.3 Acute Care Improvement Measures

While the goals of Population Health Management are long-term, true financial stability and quality care cannot be accomplished without some attention to acute care—those times when a patient presents to a care provider needing immediate medical attention. Whether patients present to their primary care doctor with an illness, the emergency

department with a traumatic injury, or outpatient surgery for an operation, each of these offer direct opportunities for attention to patient outcomes and encounter costs. Small improvements in each encounter and across all acute care encounters have a large impact on costs and quality of care alike.

The first step to improving outcomes and lowering costs on the encounter level is ensuring localized attentiveness in every aspect of the encounter. Once that is sound, deeper improvements can be made through tracking trends across large samples of encounters.

2.3.1 Localized Attentiveness

In a given healthcare encounter, there can be more than a dozen different people responsible for the patient's care. Doctors, nurses, surgeons, and other specialists work together to address different aspects of patient care, from the emergency department nurse performing the initial evaluation to the doctor who signs the patient off for discharge. A mistake or miscommunication on the part of any one of these individuals could have drastic effects on the patient's well-being or the cost of the encounter.

Streamlining communication between the different contributors is a first, critical step for minimizing mistakes and complications. Effective communication will ensure the patient is receiving the right care, meals, and medications, at the right times. An accountability system can be implemented to enhance and ensure the benefits of that communication. Each care provider must be held to a high standard, and held accountable both by the system and other involved care providers. Breakdowns in communication and accountability may lead, for example, to procedures or medication doses being missed, which can be extremely dangerous to the patient; alternately, it may lead to extra administrations, which is not only dangerous but also costs the hospital extensively. By avoiding such errors, money is saved, and patients receive higher quality care.

2.3.2 Tracking Trends

While many errors in healthcare can be caught through localized attentiveness using communication and accountability, there may be underlying trends that are not readily available on the localized level. To unbury and address these trends, databases are developed to collect patient and encounter information. These databases contain comprehensive information which can be mined to determine correlations such as types of patients to certain diseases or common procedures to complications.

Because of the wide range of information that goes into them, and the large volume of data that must be included in order to find meaningful trends, these databases take considerable time to establish and maintain. However, given the wide range of potential discoveries they offer, they are well worth that time and effort. Section 3.2 goes into more detail regarding methods of data mining and the importance of such work, while Chapter 5 describes in detail the establishment of such a database, the goals behind it, and the work that went into it.

3. Tools of Improvement

Chapter 2 described some key overarching themes to improving care management. However, a care provider (or any other business) will be unable to achieve long- or short-term improvement without a deliberate and specific plan in place. This chapter will review some common philosophies behind such improvement plans, some specific tools that can be incorporated in those plans, and how these philosophies and tools can be applied to a healthcare system seeking to achieve Population Health Management.

3.1 Process Improvement Philosophies and Methods

In any organization that has various people working on different aspects of the same project, there is room for error and waste. Over the past several decades, various philosophies have arisen to address and minimize these challenges. The following sections will address two of the most successful and widely used process improvement philosophies, which are often used in conjunction with each other.

3.1.1 Toyota "Lean" Production

The concept of "lean" production comes from the Toyota Production System (TPS), which was established and then revised over the course of the 20th century (Becker, 2014). TPS professes three goals: providing customers with timely, low-cost, quality products; providing employees with job security and satisfaction in their work; and profiting as a company by reducing costs and establishing long-term prosperity (Toyota, 2014.). These goals feed back on each other; good products (or, in other industries such as healthcare, good services) will lead to customer loyalty, which improves profit, while satisfied employees will be more willing and able to contribute to lower costs and higher quality and speed. Proving to be overwhelmingly successful, TPS serves as a model for improving efficiency and minimizing waste in businesses and industries worldwide.

There are three key factors to the Toyota Production System: Kaizen, Just in Time, and Jidoka. Each of these is described below.

Kaizen

The first factor, Kaizen, refers to continuous improvement. This means that employees are expected to not only adhere to strict standards and expectations, but also continuously look for areas that can be made better (Toyota,2014). This improvement may be something as small as working faster or removing redundancies, or something

larger like suggesting and trialing new innovations. When each individual seeks improvement on a small scale, it is reflected in the company as a whole. This directly affects the quality, timeliness, and cost of products, and thus the profitability of the company. Meanwhile, employees who are actively involved in decision-making and improvements are more likely to be satisfied with their work.

Continuous improvement is universally pursuable, not only in a manufacturing industry but also in service-based industries such as healthcare. When every nurse, doctor, surgeon, and administrator focuses on improvements in his or her own sphere of influence, the entire healthcare system improves.

Just In Time

The second key factor to lean production is called the Just In Time approach. This approach centers around the concept of supply and demand, making sure that the supply is available precisely when it is needed, in exactly the amount that is needed (Toyota, 2014). If supplies are late in arriving, or not plentiful enough, the problem is obvious: the end product will be late—or, in healthcare, the patient will not receive the needed care. On the other hand, if too much arrives before needed, it takes up space and goes to waste, costing money. This is particularly important in healthcare, where medication or medical supplies that aren't used will expire. The Just In Time approach can also make treatment more efficient. For example, having the correct tools available in the correct amounts and in the right place during an operation can prevent delays and challenges which would put the patient at risk and cost the hospital money.

Jidoka

Jidoka, the Japanese word for automation, refers to the inclusion of a human touch in an automated process (Toyota, 2014). Referring to machines which have built-in stop mechanisms in case of problems arising (such as an automatic loom that stops immediately in the case of a broken thread), this concept states that every employee must be comfortable and able to bring production to a halt at the first sign of a problem. In manufacturing, this may mean pulling a cord to stop the production line; in healthcare, it means speaking up to address a concern before further action is taken. When employees feel confident to speak up in such ways, communication is improved, as is accountability. Mistakes are avoided, subtle problems are brought to light, and the quality of service improves. The nurse who speaks up to confirm that the right patient was brought to the operating room prevents an appendicitis patient from receiving a leg amputation.

3.1.2 The Six Sigma Toolkit

Another widespread approach to process improvement across industries is the Six Sigma DMAIC approach. This approach can be used to improve various aspects of a business, including customer satisfaction, liability costs, and waste (Dmaictools.com, 2014). It consists of five steps, which are indicated in Figure 3: Steps of the Six Sigma DMAIC Approach below.
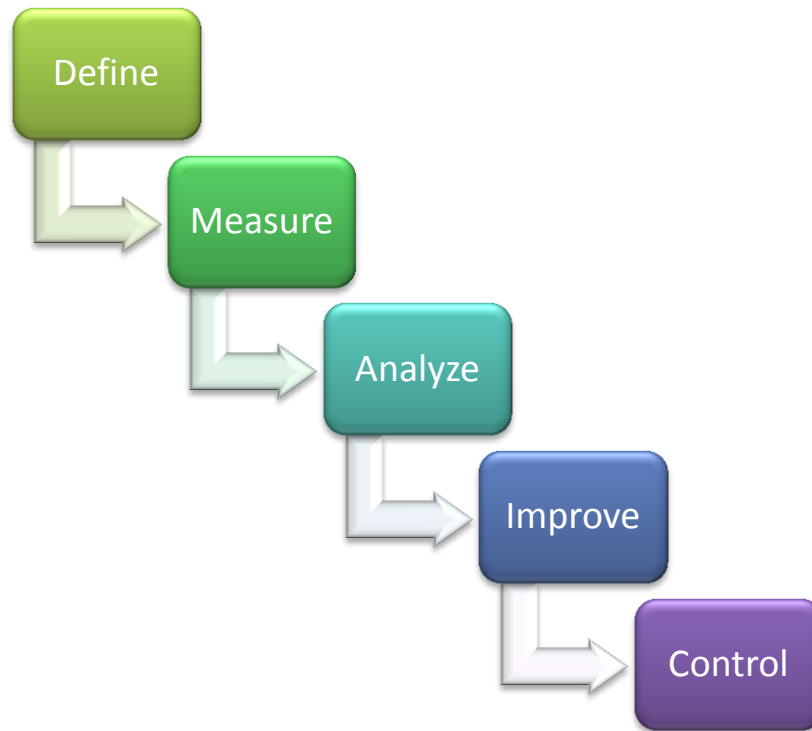
Figure 3: Steps of the Six Sigma DMAIC Approach

The first step is to define what aspects of the business need improvement. These aspects must be measurable metrics, such as costs, time, or waste. It is important to only select a few metrics to focus on, as spreading efforts too thin between several aspects will strain resources and result in failure to improve any of them. Once the key metrics are identified, the next step is to measure the historical performance of those aspects, to establish benchmarks and understand its baseline performance. The background information from those measurements makes it possible to analyze which areas have the greatest potential for improvement in the chosen metrics—that is, the top factors that influence performance. After identifying the target areas, efforts can be taken to improve those areas. Finally, the control phase seeks to take the changes made in the improvement phase and ensure that they persist, ideally with little or no needed ongoing monitoring.

The areas of focus, metrics, and measurement methods will be unique for each company, but the overall process can be applied to most situations. In health care, the chosen areas to improve will likely be various aspects of patient outcomes (morbidity, mortality, likelihood of return visits), costs, or amount of waste. The measurements used will reflect the area of focus, as will the improvements made. DMAIC is a straightforward, comprehensive method of addressing a few aspects of the system at a time, which in turn will iteratively improve the overall quality and success of the healthcare provider.

3.2 Data-Driven Process Improvement

When process improvement moves beyond day-to-day and small-scale measures, the next step is to take a data-driven approach. The collection and analysis of comprehensive data can be used to identify new areas to focus on, quantify improvement, and streamline and target improvement initiatives. This field is referred to as big data or analytics. The following sections describe analytics in greater detail and explore how it has been implemented in the healthcare setting.

3.2.1 Definition and Applications of Big Data and Analytics

Analytics is defined as "the process of developing actionable insights through problem definition and the application of statistical models and analysis against existing and/or simulated future data" (Cooper, 2012). Actionable insights are conclusions that offer the opportunity to do something about them. Cooper emphasizes that these conclusions must be qualified according to validity, to verify that action is appropriate or necessary. These actionable insights are achieved using data analysis to define problems.

While analytics can be achieved through standard statistical analysis, it is often accomplished with the use of big data—that is, large, comprehensive data sets containing the full story, as compared to the random or stratified samples used to represent a population. Because of its higher volume, big data requires different analysis techniques. Data must be entered into a carefully organized digital database. Once there, the data can be placed into various categories, allowing analysis according to different dimensions or angles in a process called data mining (Anderson.ucla.edu, 2014). By shifting and reorganizing categories, various relationships and correlations can be uncovered and explored.

3.2.2 Examples in Healthcare

Big data analytics is already in use in various aspects of healthcare. There is a huge amount of data that can be collected for a given medical encounter, including demographics, causes, treatments, and outcomes. Correlations then can be drawn between certain demographics and types of ailments, or between treatments and outcomes. Below are some examples of analytics used in healthcare.

Hot Spotters

The concept of Hot Spotting arose regarding police reform, and involved mapping out the locations that saw the highest rates of crime, so that police shifts and resources could be focused on the so-called hot spot (Gawande, 2011). This concept was carried over to healthcare by Dr. Jeffrey Brenner, who learned about it when serving as a consultant on a police reform commission in Camden, New Jersey. He discovered that by analyzing sets of healthcare-related data, he could identify noteworthy and sometimes alarming trends. In particular, he began mapping the city according to residents' healthcare costs. The highest-cost areas indicated 'hot spots,' areas which produce large volumes of patients, or particularly high-risk patients. Once identifying those areas, Brenner began exploring deeper to discover why those patients had such high costs, and how to both improve their medical care and reduce its costs.

Brenner's efforts, and other similar projects, showed preliminary but promising results, particularly regarding a decrease in healthcare costs. Healthcare hot spots serve as a starting point to begin earnest care management improvement, providing information and access to the costly high-risk patients. Identifying such hot spots is a key way in which healthcare providers can use analytics to achieve effective Population Health Management.

National Trauma Data Bank

The National Trauma Data Bank (NTDB) is the largest and most widespread healthcare-related database in use, with consistent data being collected by leading hospitals across the United States (Ntdbdatacenter.com, 2014). According to the NTDB website, "the goal of the NTDB is to inform the medical community, the public, and decision makers about a wide variety of issues that characterize the current state of care for injured persons" (*ibid*). Established in the 1970s, the database is continually changing, with new fields being introduced, and others phasing out as they become apparently irrelevant.

Researchers who wish to explore a potential trend or correlation related to trauma hospitalizations can request access to the data by submitting an application to the American College of Surgeons Committee on Trauma (Facs.org, 2014). If approved, the researcher will be granted access to the relevant data and permitted to publish their findings. Many such studies have focused on establishing benchmarks for various aspects of trauma service, while others have explored ways to improve trauma care. However, there is little consistency in the approach these researchers take, and different analysis methods make it difficult to compare one study to another (Haider *et al.*, 2012). Based on these variations, it has been suggested that best practices be established to provide consistency and allow for greater crossover between studies. As it currently stands, the NTDB is a gold mine of information, and as it continues to develop with best practices and more information, it will prove to be an invaluable tool to the field of trauma surgery.

Emergency General Surgery

While trauma comprises a significant part of patients a hospital sees, there are many ailments that are not covered by the NTDB. Emergency General Surgery (EGS) is another category which would benefit from a consistent, widespread database. There is not yet a nationwide EGS database, but there have been some recent initiatives to begin developing one. The Acute Care Surgery Service at Wake Forest University School of Medicine took the first steps to building an EGS registry following the model of the NTDB, by undergoing a study to identify the standardized diagnostic codes that were specific to EGS (Becher *et al.*, 2012). Up to that point, defining EGS encounters had proved difficult, as most standard definitions only included patients who received operations within a given period of admission. This excluded patients who were treated nonoperatively, consulted from another primary service, and/or observed for a while before undergoing surgery. Identifying relevant diagnostic codes allowed easy identification of EGS encounters, which was prerequisite to developing a comprehensive EGS registry.

Becher *et al*. built a preliminary registry in the process of testing the diagnostic codes, structured based on the NTDB with some modifications to better suit EGS. They retrospectively reviewed EGS service data from a period of 9 months to identify the most common diagnostic codes, then tested the preliminary registry real-time for one month. Because of the focus on diagnostics code, there was less focus on the structure and information included in the registry as a whole. Considerably more work was required to develop a robust registry that can be used long-term. Still, this study served as a strong foundation for future efforts to develop an EGS registry.

4. Down the Rabbit Hole: Early Adventures with Analytics

As the previous chapters indicate, a lot goes into process improvement in healthcare. It can be easy to become overwhelmed, if not by the simple vastness of the industry, then by the volume of data, analysis, and effort required to make even a dent. Certainly there have been times, as I learned about PHM and how to achieve it, that I found myself wondering why I even cared. In those moments, it helped to remember how I discovered analytics in the first place.

I first encountered the field of Analytics near the end of my junior year at Worcester Polytechnic Institute, when I signed up for a senior-level writing class titled Analytics: Numbers to Arguments. As a last-minute addition to my schedule to fulfill a degree requirement I hadn't realized I was missing, I didn't have very high expectations. I'm not a big fan of last-minute changes, especially given that it replaced another course that I had particularly been looking forward to. Furthermore, it was an experimental course, which I'd known in the past to be rather hit-or-miss. Combined with the fact that I had no idea what level of challenge to expect from a senior-level writing course, I was at least partially convinced that it would be a disaster. I was prepared to just slog through it to complete the degree requirement and move on.

As it turned out, my misgivings were entirely misplaced. The challenge level was just enough to keep me engaged without becoming overwhelming. As an experimental course, it proved to be exciting and interesting rather than disorganized and chaotic. And, more importantly, I found myself unexpectedly intrigued by and invested in the subject. I wanted to know more, analyze new aspects, and discuss it in depth. Luckily, it was a very small class, with only three students; I felt completely comfortable sharing my thoughts and considering my classmates' perspectives. That alone made the class worthwhile.

I believe what I valued about it the most, however, was the way this course challenged the way I think. Not the facts and ideas, but how my thoughts align and rearrange themselves. How I learn. How I process, interpret, and analyze new information. Starting out, I had only a basic working understanding of statistics and data representation. I had never put too much thought into the process of figuring out what to do with them—what questions to ask, where to begin, how to refine the focus of a study. And from day one, discussing analytics in realms that I knew nothing about, I was faced with exactly those challenges.

4.1 Moneyball

The course began by focusing on the relatively recent implementation of analytics in baseball. It centered on the movie *Moneyball.* This movie illustrates the story of a disgruntled baseball recruiter who, frustrated with the poor performance of his team, turns to numerical data to select new players. He faces opposition from all fronts, but his method pays off, bringing his formerly unremarkable team, the Oakland Athletics, to the World Series with an unprecedented winning streak.

I've never cared much for baseball, and I never would have watched the movie of my own volition. Even so, I found it genuinely enjoyable. It brought forth some deep, difficult concepts that I spent the rest of the course trying to wrap my head around—concepts that I think need to be considered before undertaking any project in big data and analytics. At the core of those concepts was this question: to what extent, exactly, can computers and numbers replace human experience and intuition? Is it right to base every decision solely in data, in the cold hard facts? Or are there times when the intangible human intelligence is superior and, indeed, required?

In *Moneyball,* this question was framed in the conflict between Billy and the more traditional recruiters who based their decisions on observing players who demonstrated talent. Billy's method was clearly paying off; that was made evident by the record-breaking winning streak the Athletics experienced. Yet the traditionalists fought him every step of the way. And no wonder; they were afraid that if his number-crunching methods took off, they would be out of their jobs. But there was a deeper level to their resistance. Baseball is supposed to be a game, a competition between two teams, based primarily on skill with a touch of luck and chance. If number-crunching could be used to decide who should play, what else could it be used for? Predicting the winner? The exact score? At what point would the game become not about the skill of the players and their synergy as a team, but about who did a better job of arranging the numbers? If the outcome of a game could be so easily predicted through analytics, is it really even a game at all?

4.2 Analytics Done Right

Moneyball depicted a concern that can easily be extended to other arenas. If a dating website used analytics to match up potential romantic partners, one might fear that the analytics would take out the romance, the human element, making the resulting relationships shallow or weak. In healthcare, using analytics exclusively could result in patients going undiagnosed or improperly treated, where a doctor's intuition would

have noticed the problem and addressed it. In any situation, there is a justified worry that using numbers to drive decisions will reduce enjoyment or even cause more problems.

The solution, I realized, is to use the analytics to *enhance* the abilities of human experience and intuition, rather than replace them. Any new field of science comes with a risk of taking it to a harmful extreme. Chemistry could plunge the world into nuclear winter; analytics could lead to a robot-ruled world devoid of human creativity. But we haven't simply stopped practicing chemistry, because it is able to enhance our inherent humanness. Similarly, we should not eschew analytics altogether. Looking at the numbers can reveal trends that otherwise never would have become apparent. Then, using human logic, reasoning, and intuition, a human can make the necessary choices to respond to those trends.

4.3 Finding the Rabbit Hole

The primary goal of the analytics course was to choose a topic to analyze, gather relevant data, and answer a question about that topic using the data. I chose to focus on the demographic composition of a Live Action Role Playing (LARPing) community to which I belonged called the Realms. LARPing combines sports-like aspects with hobby-related activities, forming a unique community at the crossroads of sports and hobbies, which I illustrated as shown in Figure 4.

Sport

The Realms practices boff combat, which is a very physical activity requiring speed, precision, and skill. It provides opportunities for team and individual competition.

The foundation of roleplaying is improvisational acting. Other activities such as leatherworking, chainmail, sewing, and music are important aspects of the Realms.

Hobby

LARPing

By combining these aspects of sports and hobbies, the Realms LARP appeals to people of all walks of life.
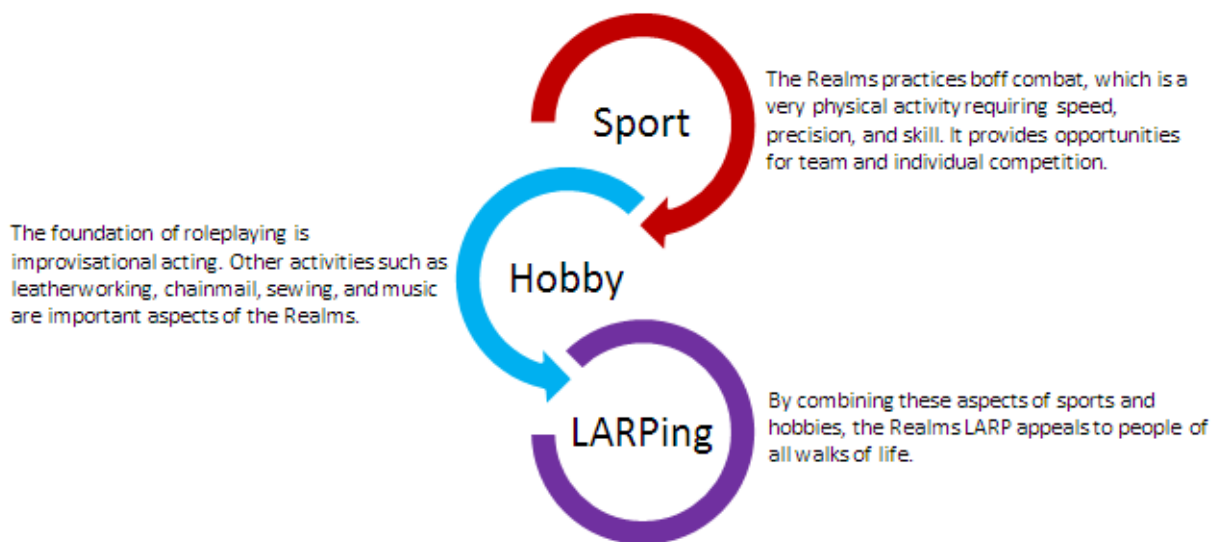
Figure 4: The LARPing community

Within the community, there were various well-established stereotypes about different types of players regarding preference for the sports or hobby aspects of the LARP. Some

of these stereotypes involved demographic information, such as sex, while others involved association with different in-game groups. Some of these stereotypes are indicated in **Error! Reference source not found.** below.
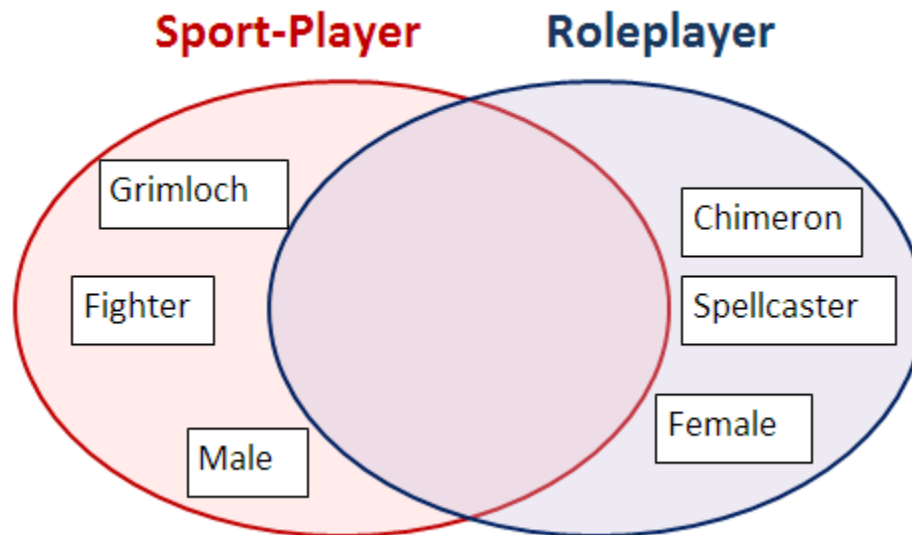

Figure 5: Stereotypes based on play preference. Note: Grimloch and Chimeron are names of in-game groups that are stereotypically associated with each play style preference.

I had been part of the Realms community for long enough to be well aware of these stereotypes, particularly as someone who defied some of them (I played a fighter but am female and was affiliated with Chimeron). However, I was curious whether there were any valid data to support these stereotypes. I chose to collate data regarding the sex, in-game affiliations, and the fighter/spellcaster status of each player, and analyze it to verify or refute the stereotypes.

As I delved into the analysis of this, I quickly reached the conclusion that a fear of robot overlords was misplaced. A computer would be incapable of accomplishing the hardest and most important parts of my work. Certainly the computer turned data management from an impossible task to one that was just time-consuming and tedious, not actually difficult. But the true challenge was in figuring out what to *do* with the data. What were the important factors to consider? Should I account for geographical location? Time spent in the community? What made those things important? Was there a possible correlation between play style and preferred type of event? How could I tweak the analysis to explore new facets of all those things? There was no way the computer would be able to make these kinds of decisions. It was up to me as the scientist to find the answers—and, even more importantly, to decide what questions needed to be answered to begin with.

I discovered that it's an endless rabbit hole, and once you jump down it, there's no knowing where you'll end up. There are the simple questions, of course, which barely scratch the surface: age, sex, geographic location. Then there are the questions that relate those factors to each other. Is there a correlation between age and location? What about between sex and location? If so, which causes which—or is there a separate cause for both? Once you've identified that other cause, maybe there's a relationship between that and yet another factor… and so on, and so forth. There's always more to discover, always more questions to ask, and they can only be asked by a human.

By the time I got used to thinking outside the box in uncovering questions, I found myself unable to stop. I constantly thought up new questions, new perspectives from which to approach a problem. I simply didn't have time to approach them all. Most questions were large and multi-faceted; they required several narrower questions to be answered before they could even be considered. This was particularly frustrating as I approached the end of the course. I put hours of effort into my final project, most of it cleaning up the data set. And then I simply ran out of time to do the large majority of the analysis that I'd hoped to do. Even as I presented what little I had, I thought of more ways I might have broken down the data, more questions I might have explored.

In comparison to all that I could have explored, what I did felt trivial, almost pointless. I had to remind myself that without the analysis I did, none of my other ideas would have been remotely possible. I completed the foundation work for any future analysis. It was more than it seemed, and it very effectively portrays the nature of analytics. Big data has huge potential, but it must be approached one step at a time, starting with the most basic steps. It must be analyzed intentionally and logically. And it will require massive amounts of time to complete even the simplest of analysis; it cannot be expected to give results overnight. But once the foundation is there, it will streamline massive and efficient data analysis projects that would otherwise be impossible.

I'd jumped down the rabbit hole. I don't know how deep it goes, and I'm not sure I'll ever get out. And that is as it should be. The skills I developed by asking questions about a sport-like hobby were ready to be applied to the larger, more widespread, and much more impactful realm of healthcare improvement. When offered a volunteer internship at UMass Memorial Medical Center building a patient database, I jumped at the opportunity to practice these new skills in a hands-on setting that would make a tangible impact.

5. Developing an Emergency General Surgery Registry

Just a few weeks after I discovered the thrill of analytics, I was invited to join a team of three other interns at UMass Memorial Medical Center to pilot and develop a registry of Emergency General Surgery patients. This six-week pilot allowed me to witness first-hand the process involved in forming a comprehensive database that can be used for short-term improvements in care management.

5.1 Emergency General Surgery

Emergency General Surgery (EGS) is a broad category of surgery and critical care that covers every case that cannot be readily assigned to a specialty. It refers specifically to emergency cases, including emergency department visits and consultations for patients that have already been admitted to another service, but not to cases of elective surgery. The most common cases include appendicitis, cholelithiasis and cholecistitis (gallstones and inflamed gallbladder), and bowel obstructions. Other ailments might include hernias or unidentified infections. EGS does not include trauma cases, such as injuries from falls or motor vehicle accidents; rather, it includes those cases in which there is no immediately evident cause for the ailment, but it cannot readily be assigned to a specialty such as cardiology, neurology, gastroenterology, or obstetrics and gynecology.

In the context of acute care improvement as part of population health management, Emergency General Surgery is a key area that has received little attention thus far. The National Trauma Data Bank (see Section 3.2.2) was established because of the enormous number of trauma incidents and the lack of information available to track and understand those incidents. The NTDB allowed for the establishment of benchmarks which could be used by individual hospitals identify areas where they fell short, so they could focus on improving those areas. While EGS does not see as many patients as trauma, it would greatly benefit in the same ways from a consistent, comprehensive database.

5.2 EGS at UMass Memorial Medical Center

UMass Memorial Medical Center (UMMMC) is located in Worcester, Massachusetts. It is one of Central New England's primary academic medical centers, partnering with UMass Medical School. As an active participant in the National Trauma Data Bank, UMass has demonstrated an investment in using data collection to improve outcomes and costs. With several hundred EGS cases each year, it has the patient base to make an

EGS registry feasible and worthwhile. More importantly, it has people willing and able to make it happen.

Dr. Heena Santry is an Assistant Professor of Surgery y for UMass Medical School, primarily dealing with trauma and general emergency cases. Recognizing the value of the National Trauma Data Bank and how a similar registry would benefit Emergency General Surgery practices nationwide, she set about developing and piloting such a registry. While she began in the context of UMass Memorial, she was aware of the nation-wide need for an EGS registry (Becher *et al.,* 2011), and her goal was to develop a registry that could be used at hospitals throughout the United States. After receiving confirmation of interest from surgeons at various hospitals, she began the registry development process at UMass.

First, Dr. Santry developed a data dictionary of various potentially useful data points to collect. She presented this set of items to a team of computer programmers, who built an online database in which the data could be entered, collected, and eventually, analyzed. Once she had a complete 'rough draft' of the registry, she brought on four interns to perform a six-week pilot, during which they could test it and find ways to improve it in terms of content and structure.

I first learned about Dr. Santry's project while looking for a summer internship. At first I was skeptical; it was an unpaid position, and my primary concern was earning enough money over the summer to pay my fall tuition. But other opportunities kept falling through, and building a strong resume was as important as earning money. When I read the internship description, which discussed the need for an EGS registry, I realized it would be the perfect opportunity to put into practice some of the thought patterns I'd learned in the Analytics class I had just completed. After meeting with Dr. Santry and listening to the passion and excitement that laced her words as she described the project in more detail, I realized that, unpaid or no, this was exactly what I wanted to do that summer.

I was joined by three other interns. Two were medical students from Arizona who had just finished their first year of medical school. The third was an undergraduate studying biochemistry who had just finished her freshman year of college and had wanted to be a surgeon her entire life. As a rising undergraduate senior interested in biotechnology research with no plans to go to medical school, I rather felt the odd one out. But with our unique mix of experiences, we each provided a distinct and valuable perspective to the project.

Dr. Santry hoped to use evidence from the pilot to convince the hospital to hire data entry personnel to turn the piloted, revised registry into a full-time, ongoing registry similar to the NTDB. If successful, the registry could then be spread to other hospitals with an equal interest in improving outcomes. With her determination and the team of interns and computer programmers working with her, UMass was an ideal location to begin an EGS registry initiative.

The following sections will describe the process we followed to pilot the registry, the improvements made, and the remaining next steps at the end of the six-week pilot.

5.3 Deciding What to Include in the Database

5.3.1 Initial Categories

Drawing on her clinical experience as a surgeon, the National Trauma Data Bank, and extensive research into other health care database initiatives, Dr. Santry selected a set of data fields to be included in the UMass Memorial EGS registry. Both demographic and clinical fields were included. Most of the included information came directly from electronic medical records, including admission paperwork, doctors' orders, and nurses' notes. Some also came from daily rounds with the surgeons. Table 1: Initial categories of EGSR information below shows the initial categories of information included.

Table 1: Initial categories of EGSR information

Category	Included Information
Patient Information	Unique identifying information specific to the visit (Medical Record Number, admission date and time, diagnosis, demographics)
Admission Information	Vital signs, initial laboratory results, imaging available on arrival
Operative Data	Date and time, type of operation, general methods, general results
Procedures	Date and time, type of procedure, procedure-specific details
Imaging	Date, time, and results of images (x-rays, CT scans, ultrasounds)
Diet	Date and time of changes in diet, (e.g. low fat, cardiac, or none per oral)
VTE Prophylaxis	Date, time, and type of blood clot prevention methods
Code Status	Date and time of changes in code status
Complications	Date and type of complications from operations or procedures
Flow	Dates and times of patient movement between room, operating room, ICU, etc.
Transfer Data	Date and time of patient transfer to different services
Discharge Data	Date, time, and disposition of patients upon discharge

5.3.2 Refined Categories

The database was then refined to add new relevant fields, remove extraneous ones, and better define or present those already included. The refinement process is described in more detail in Section 4.4. Of the variables that were added, the most significant included additions to the Diet category, expansion of the VTE Prophylaxis section to include other therapeutic and prophylactic medications, and a thorough restructuring of the Patient Flow/Discharge Disposition section. The new categories can be seen in Table 2 below.

Table 2: Refined categories of EGSR information

Category	Included Information
Patient Identification	Unique identifying information specific to the patient (name, demographics, Medical Record Number)
Encounter Identification	Unique identifying information specific to the visit (admission information, diagnosis, vital signs and initial laboratory results, relevant surgical history)
Operative Data	Date and time, type of operation, general methods, more detailed results
Procedures	Date and time, type of procedure, more extensive procedure-specific details
Imaging	Date, time, body area, and results of images (x-rays, CT scans, or ultrasounds)
Nutrition	Date and time of changes in nutrition (e.g. low fat, cardiac, IV nutrition)
Key Medications	Date, time, type, and indication (therapeutic or prophylactic) of medication
Code Status	Date and time of changes in code status
Complications	Date and type of complications from operations or procedures
Patient Flow	Dates and times of patient movement between services, operating room, discharge, etc.

5.4 Process of refinement

5.4.1 Steps Taken

The majority of the registry refinement process took place during a six week pilot during the summer of 2013. A weekly cycle was established during this time to find ways to improve and enhance the registry.

 Each day, two of the interns rounded with the Acute Care Surgery team as they checked in on every patient currently on the Emergency General Surgery service,

including recent Emergency Department visits and consults to other services. This allowed us to hear first-hand updates and orders from the doctors and residents, as well as to get a feel for the nature of the EGS service. We gained an intimate, comprehensive understanding of each patient's situation, including daily developments through discharge. In particular, we noted recurring themes: common orders, frequent challenges, and the overall thought processes followed by the surgeons in diagnosing and treating patients. Any patterns we noticed were subject to discussion, to determine whether the registry should be modified to address those areas.

After rounds, we consulted the Electronic Medical Records (EMRs) to enter each new patient encounter into the registry, update ongoing encounters, and finalize entries for patients that had been discharged or signed off. Figure 6 below shows a snapshot of the registry, which contained nearly a dozen pages, each containing a range of fields.

Figure 6: Example of Encounter Data page in EGS Registry

While doing entering the data, we made note of any challenges we had, or anything we thought might be accomplished better in the registry. The resulting data was expected to be incomplete and of very poor quality, so no analysis was planned. Instead, the purpose of this data entry was to identify through trial and error ways to improve the registry. The first goal was to make the data entry process easier, by structuring the registry in an intuitive, logical manner. The second, more important goal was to make

the data more accurate, relevant, and comprehensive, by adding or removing fields or modifying fields to better reflect the intended purpose. As such, this was where most of the refinement took place.

Once a week we met with Dr. Santry and the computer programmers who built the registry. This was an opportunity to present out ideas and suggestions for improvement, for Dr. Santry to make suggestions based on her vision for the registry, and to discuss how to incorporate our ideas given the programmers' limitations. In addition, we would review how the previous week's changes had been implemented, and make adjustments as necessary.

Finally, at the end of the six weeks, we met with Dr. Santry to go line by line through the data dictionary. In this final refinement step, we updated the dictionary to reflect all the changes throughout the pilot, made some final rearrangements to present a more logical and intuitive progression, and eliminated some remaining fields that had not served a purpose throughout the project. In one last meeting, we presented these changes to the programmers and discussed the registry's next steps.

5.4.2 Modifications Made

In the first week, improvements centered on technical errors and other surface improvements, bringing the registry to a place where it could effectively be used. There were many small changes made as we became familiar with where to find information in the EMRs and how to enter it into the registry. In particular, several of the fields did not allow the correct ranges of numbers to be input, while others had confusing or misleading abbreviations. Errors such as these prevented correct and complete input of data.

Once those aspects were corrected, deeper refinement could be pursued. New fields were added based on factors that frequently came up either during rounds or in the EMRs. Some fields were renamed to be more comprehensive; for example, *Diet* was changed to *Nutrition,* to allow for IV-provided nutrition as well as oral diets. New options were added to existing fields. Many fields were rearranged to be more intuitively presented, or to be grouped with other, more related fields.

By the fourth week, we had an integral understanding of both the registry and the EMRs. We began proposing deep, structural changes, based on our growing understanding of the purpose and potential applications of the registry. The first and perhaps most instrumental of these changes was defining each entry as an encounter, rather than an admission. In general, an encounter was defined as starting the moment

a patient was seen by EGS, and stopping when EGS stopped tracking that patient's progress. This allowed for better integration of consults who were admitted to different services long before EGS saw them, and Emergency Department patients who were never actually admitted. It allowed for a series of further changes to define the encounter source (Emergency Department, Consult, or Direct Admit), specify start and stop times for the encounter, and otherwise better define the encounter.

From there, each category of data was closely evaluated and revised. Insurance was moved from *Patient Identifier* to *Encounter Identifier,* as we realized that recurring patients may change insurance between visits. The *Procedures* and *Operations* categories each saw a complete structural overhaul in the order and presentation of each field. The *Patient Flow* and *Discharge Disposition* categories were combined together, with discharge being incorporated as an option for patient flow. This put more emphasis on patients being transferred from one hospital service to another, and allowed for encounters to end before patients were discharged from the hospital. Finally, the *VTE Prophylaxis* category was changed to *Key Medications*. Dr. Santry initially included the category to track potential VTE complications in relation to prophylactic treatment. However, VTE prophylaxis was often not specified, while other medications frequently came up in the EMRs. The broader category included antibiotics and other medications in addition to blood thinners, and accounted for therapeutic as well as prophylactic medication.

At the end of the pilot, with the major structural changes implemented, particular attention was paid to the *Complications* category and *Comorbities* field. Some that had never arisen were removed. Others were added based on commonly-listed complications and comorbidities found in literature. Several were divided into subcategories to better define them, such as cancer (based on type, location, and type of treatment) and alcohol/drug abuse (based on past or present use). Finally, all changes were reviewed and verified, and the data dictionary finalized. The registry was complete and ready for full implementation.

5.5 Next Steps

There is still room for improvement in the EGSR, but that is to be expected; any ongoing database undergoes constant development and revision to match current best practices. The immediate next step would be to analyze the data generated during the six-week pilot. Because the registry was constantly changing during that period, the resulting data was scattered and incomplete, so no thorough analysis would be possible. However, some preliminary findings might be possible. In particular, the number of

encounters entered would be a valuable piece of information. So would some of the demographic information, such as the distribution of sex, age, or ethnicity. Other interesting values might include the number of patients who had operations or complications or the most frequently performed procedures. There was not time within the scope of this project to analyze these factors, but future research into such preliminary findings would offer a glimpse of what a full-scale registry could provide.

Data analysis aside, the major next step is to scale up implementation of the registry, first at UMMMC, and then at other hospitals across America. Ideally, UMass Memorial will hire personnel to enter data into the EGS registry full-time. This first requires Dr. Santry to convince the hospital that the benefits of the registry in terms of financial gains and patient outcome improvements outweigh the cost of the hired personnel. Once the registry is successfully established at UMass memorial, Dr. Santry will be able to use the resulting data and analysis to demonstrate to other hospitals the benefits of an EGSR. As more hospitals join, the registry will hopefully spread to be used across America, providing a wide base of information to be analyzed and benefiting emergency general surgery practice as a whole.

6. Conclusions

Achieving Population Health Management is a massive, multi-faceted undertaking. In order for a healthcare provider to achieve complete transformation, it must not only implement changes in all internal aspects, but also collaborate with external businesses and organizations to develop the appropriate plan management and establish a strong network of partners. Still, internal improvements to achieve better care management are a foundational part of any successful PHM initiative, and provide a good starting place for a healthcare provider just beginning down the road toward Population Health Management.

In order to improve care management, a healthcare provider must establish intentional process improvement methods. This begins with an overarching philosophy such as the "lean" philosophy originating from Toyota, which requires all members of the organization to be invested in doing what they are able within their sphere of influence. With such a philosophy in place, step-by-step plans can be put in place to begin improving one area at a time. Where appropriate, these plans will include collection and analysis of comprehensive datasets, which can bring to light new, more subtle areas for improvement, as well as track progress over time.

This project aimed first to define PHM and how to achieve it, and then to describe the process undergone to develop and pilot a database that could be used to improve care management in one facet of a PHM-driven healthcare provider. The UMass Memorial Medical Center Emergency General Surgery department was the ideal location to establish such a database. The medical center already participated fully in the National Trauma Data Bank, and more importantly, it had individuals motivated and excited to make it happen.

Over the course of developing and piloting the EGS Registry, a few important considerations came to light. Deciding what information to include was an ongoing process. There was a consistent drive to include more, in order to make it as comprehensive as possible. At the same time, it became apparent that including irrelevant data cluttered the database, took up unnecessary time, and had the potential to skew results. One of the most important aspects, however, was not deciding what information to include, but rather how to organize and present the data fields. Because the registry required humans to input the data, the fields needed to be presented in a logical, intuitive way, to make the data entry process as efficient as possible.

With appropriate funding, the UMass EGS Registry will be fully implemented, and used to find and track areas of improvement in the department of Emergency General Surgery. From there it will be able to spread to other hospitals, ideally forming an eventual nationwide collaborative data collection. It also may serve as an inspiration and example for developing registries for other specialties. By focusing on one facet at a time, healthcare providers can slowly improve in all areas. They can then move from there to reaching out and engaging partners in a network, and collaborating with other external businesses and organizations to improve plan management throughout a community. The UMass Memorial EGS Registry represents only a very small piece of the puzzle that builds Population Health Management, but it is an important one, and a powerful catalyst for the rest of the pieces.

My interest in healthcare stems from a childhood spent exposed to it in various capacities. That interest, when combined with an insatiable curiosity and a newly discovered passion for analytics, provided the perfect platform for this Major Qualifying Project. In turn, Dr. Santry's pilot project at UMass Memorial Medical Center provided the structure necessary to make this project a reality. Throughout this journey toward understanding Population Health Management and the pieces and processes that go into it, I have experienced joy, excitement, frustration, and fulfillment. I look forward to seeing how the EGSR develops in the future. As I go on to interact with healthcare systems in varying capacities, I expect I will keep in the back of my mind an understanding of PHM, and look for ways in which those systems are incorporating its ideals. Above all, I will take what I have learned about process improvement, analytics, and how to identify and explore questions, and use those lessons in whatever career I find myself. To that end, this Major Qualifying Project has been an overwhelming success.

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