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## Evaluating the E-consult Process for Diabetes Care Delivery at an Outpatient Care Clinic

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**EVALUATING THE E-CONSULT PROCESS FOR DIABETES CARE  
DELIVERY AT AN OUTPATIENT CLINIC**

A thesis submitted in partial fulfillment of the  
Requirements for the degree of  
Master of Science in Engineering

By

Brian Michael Zoll  
B.S., Wright State University, 2012

2013

Wright State University

WRIGHT STATE UNIVERSITY  
GRADUATE SCHOOL

May 27, 2013

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Brian Michael Zoll ENTITLED Evaluating the E-consult Process for Diabetes Care Delivery at an Outpatient Clinic BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science in Engineering.

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## ABSTRACT

Zoll, Brian. M.S.Egr., Department of Biomedical Industrial and Human Factors Engineering, Wright State University, 2013. Evaluating the E-consult Process for Diabetes Care Delivery at an Outpatient Clinic

The occurrence of one of the most common chronic conditions in the U.S., diabetes, is expected to rise 53% from 24 million cases in 2003 to 37 million cases in 2023. The U.S. Veterans Health Administration (VHA) is not immune to this. The VHA has experienced an \$820 million increase spending on diabetes patients between 2000 and 2008. The VHA has tried to keep the growth of chronic care costs in check through improvements in patient access to care by expanding its network of community-based outpatient clinics. Other methods the VHA has used to curb chronic care spending costs are electronic health records (EHR), patient aligned care teams (PACT), telehealth, and e-consults. An e-consult is defined as an electronic communication between primary care physicians and specialists about general or patient-specific questions that may preclude the need for an in-person referral.

The objective of this study was to evaluate the effects of increased e-consult demand on time-based outcomes, quantify the sensitivity of these outcomes to walk-in patient arrival rates, electronic view-alert notifications, and primary care physician (PCP) unavailability, and provide recommendations to alleviate the detrimental effects of factors that are determined to have a significant effect on these outcomes.

We collected data from 5 different VHA outpatient clinics, which was used in a discrete event simulation (DES) model of a typical VA outpatient clinic. Factors analyzed in the model were e-consult demand, view-alert notification arrivals, walk-in patient arrivals, and PCP unavailability.

After the model was validated with real data, a detailed experimental study was conducted to determine factors that have a significant effect on e-consult time-based outcomes, such as cycle time. A total of 495 experiments were run and statistical analysis of the results indicated that all four factors had a significant effect on e-consult cycle time ( $p < 0.05$ ).

Results also showed that, generally, as e-consult demand increases, e-consult cycle time also increases. In a case where a PCP is always available, e-consult cycle time increases by only 5 days when demand is raised from 0.01 e-consults per day to 2.75 e-consults per day. However, the increase in cycle times is not linear. In the same case, as demand increases from 2.75 e-consults per day to 3.25 e-consults per day, cycle time increases by 17 days.

To reduce the detrimental effect of PCP unavailability due to sickness and/or vacation on e-consult cycle time, we recommend splitting the additional notification and walk-in patient demand incurred by a PCP's unavailability over the remaining available PCPs. In doing so, the cycle time does not increase drastically with an increase in e-consult demand, compared to the current strategy where the team leader assumes all the responsibility for the additional workload.

Further research in the areas, such as walk-in patient arrival rate reduction methods, notification arrival rate reduction methods, and notification prioritization strategies, is likely to improve the time-based outcomes and meet the VA-set goals for e-consult completion. For example, if notification arrival rates are reduced by 20%, a 75% decrease in e-consult cycle times can be expected.

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## 1 INTRODUCTION

Chronic conditions are becoming more prevalent in today's society. In 2005, 133 million Americans were living with at least one chronic condition. By 2020, this number is expected to grow to 157 million (Wu and Green, 2000). While the number of people with a chronic condition is expected to grow, the number of Americans with more than one chronic condition is also expected to rise from 63 million in 2005 to 81 million in 2020 (Wu and Green, 2000). This increase in the frequency of chronic illnesses can be attributed to a rise in the age of the population and in obesity. The population over 65 years of age is expected to increase by 73% between 2005 and 2025. This increase in age along with the fact that patients over 65 seek care from general practitioners twice as often as people under the age 65 indicates that America's problem of rising frequencies of chronic diseases is not going to solve itself (Colwill et al., 2008). The occurrence of one of the most common chronic conditions in the U.S., diabetes, is expected to rise 53% from 24 million cases in 2003, to 37 million cases in 2023 (DeVol, 2007). The U.S. Veterans Health Administration (VHA) is not immune to this.

The mission of the VHA is to provide healthcare for U.S. veterans. With over 1700 facilities, the VHA is the nation's largest health care system. The VHA is made up of 23 regional delimited Veteran Integrated Service Networks (VISNs). Included in the 23 VISNs, there are 152 hospitals and 821 Community Based Outpatient Clinics (CBOCs) (VA, 2013).

The total VA patient population has grown from 3,339,408 unique veteran patients in 2000 to 4,892,300 unique veteran patients in 2008 (Yoon et al., 2011). This increase is responsible for 84% of the \$820 million increase in VHA spending on diabetes patients between 2000 and 2008 (Yoon et al., 2011). The VHA has slowed the growth of chronic care costs through improving patient access to outpatient care by expanding its network of community-based outpatient clinics (CBOCs) (Ashton et al.,

2003; Kizer and Dudley, 2009). In fact, a study by Yoon et al. (2011) indicates that there was a 29% reduction in total diabetes care costs due to a reduction in individual diabetic patient care costs. However, this reduction in individual patient care costs is countered by a 46% increase in diabetes related expenditures. This increase is due to a rising prevalence of diabetes in the VHA patient population. While treating patients with CBOCs has had a significant impact on diabetes care costs, it is necessary to pursue additional ways of reducing patient care costs.

## **1.1 U.S. Care Continuum**

The U.S. care continuum consists of primary, secondary and tertiary care. A patient's health care typically begins in the primary care outpatient setting, where the most common health care needs are addressed. Similar to primary care, secondary care also takes place in the outpatient setting, but consists primarily of specialists who are usually not the first medical professionals to make contact with the patient when a health care issue arises. Some specialties that make up secondary care are endocrinology, dermatology, urology, and physical therapy. Tertiary care generally consists of inpatient care for treatment of complex medical issues that require constant monitoring, such as cancer management, inpatient surgery, and severe burn treatment.

Inpatient care typically requires a referral from either a primary care physician or a specialist. Inpatient care is expensive for health care providers because of overnight care functions, such as around-the-clock staffing, housekeeping, space for beds, and strict codes and regulations. Because inpatient care requires patients to stay overnight and sometimes for extended amounts of time, capacity planning is critical. Figure 1 depicts the different care stages as a patient's health and functional ability deteriorates.

## Deterioration in Health and Functional Ability

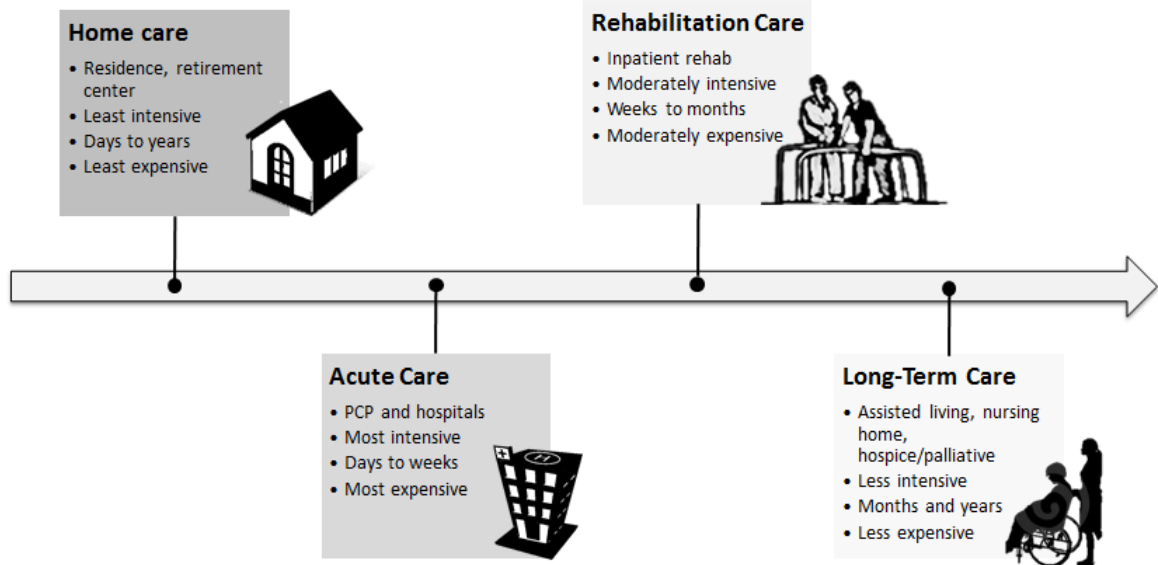


Figure 1: Stages in the care continuum (Crawford, 2012).

On the other hand, outpatient clinics are cheaper to build and operate, and allow for hospitals and health centers to consult with and treat more patients in less time. The outpatient clinic should be the first line of treatment when a patient is in need of health services. Only when it is necessary should a patient be sent to inpatient care. Outpatient primary care clinics are how a majority of personal health care needs are addressed. According to Bodenheimer (2010) there are about 400,000 primary care providers in the United States. When combining the predicted increased demand for health care with the decrease in the number of graduates in general internal medicine, Colwill et al. (2008) predict a 27% shortage in generalist physicians by 2025. The AAMC's Center for Workforce Studies estimates that in the next decade there will be 45,000 too few primary care providers (Dower and O'Neil, 2011). Skyrocketing demand coupled with decreasing resources, highlights the need for outpatient clinic managers to seek new ways of improving clinic efficiency and patient access, without sacrificing quality of treatment. Adopting new methods of care is one way to improve operations.

Because it is the first line of treatment in the healthcare continuum, primary care encompasses the most common types of care services. High patient demand necessitates that primary care must be both efficient and affordable. These necessities highlight the need for system and organizational developments that will improve the system capabilities of outpatient primary care clinics.

## **1.2 VHA Initiatives**

As one of the largest healthcare systems in the world, the VHA has adopted Health Information Technology (HIT) as a method of improving operations. The overall objective of the implementation of health information technology is to achieve improvements in quality of patient care, cost, and efficiency through the use of Electronic Health Records (EHR). Literature has shown both the advantages and ineffective nature of HIT. Wu et al. (2006) discusses the limited quality and cost benefits from HIT. Linder et al. (2007) and Henderson et al. (2010) study the effects of HIT on ambulatory care performance indicators, such as consultation length and medical management of common diseases. They conclude that implementing HIT has little effect on better quality ambulatory care.

Previous critiques of EHR systems have found that while patient quality of care is improved, the demands placed on a physician's time from this type of system creates resource allocation problems (Hunt et al., 1998; Mitchell and Sullivan, 2001). A trial using electronic reminders for the care of 13,000 diabetic patients has shown that most primary care physicians would rather not use an EHR system due to the time requirements associated with it (Baker et al., 2001). It is likely, that while implementations based upon EHR systems can and will benefit patients, great care must be taken during the design process in order to ensure that the PCP and their team members have a sufficient workload capacity in order to ensure that time requirements associated with the use of the system do not outweigh the benefits to the patients.

The implementation of HIT partially influenced outpatient clinics to develop new care team configurations in order to maximize the benefits from HIT (Marshall et al., 2011). HIT, along with the understanding that multidisciplinary teams are the most effective way to treat chronic diseases while maximizing quality of care and minimizing cost (Bodenheimer et al., 2009), led to the development and widespread implementation of the patient-centered medical home (PCMH). The PCMH is focused on team-based care, where physicians share responsibilities with nurses, care coordinators, social workers and other team members (Rittenhouse and Shortell, 2009). One principle of the PCMH is the tailoring of health care to fit the patient's needs; this is known as patient-centeredness (Rittenhouse and Shortell, 2009).

The VHA has begun implementing a care team model, based on the PCMH model, called the Patient Aligned Care Team (PACT). The PACT structure supports the VHA's Universal Health Care Services Plan to improve the delivery of healthcare by increasing access, coordination, communication and continuity of care (Primary Care Program Office, 2010). Primarily, the PACT consists of the following four members at a VA primary care clinic: one primary care physician (PCP), one registered nurse (RN), one licensed practical nurse (LPN) and one patient service assistant. The PACT gives patients the ability to be more actively involved in their treatment. The VHA believes that the PACT is associated with increased quality improvement, patient satisfaction, patient access to care, and a decrease in total costs due to decreased rates of patient readmission (Primary Care Program Office, 2010).

### **1.3 Telehealth**

HIT and PACT are techniques aimed at improving patient care while keeping costs in check. Another method of increasing care quality as well as clinic efficiency is telehealth. Telehealth is possible because EHR systems make patient charts more easily available to authorized viewers. The VHA has adopted telehealth as another method of treating patients. Field (1996) defines telehealth as the use of information and electronic technologies to provide and support healthcare when distance separates the participants.

Clear benefits of telehealth are provider cost reduction, improved patient access to specialty care, and the better utilization of specialist's time.

For chronic conditions that require frequent monitoring, and efficient communication between patients and providers, such as type 2 diabetes, telehealth is a convenient communication medium through which to manage the day-to-day needs of the patient. Although, some clinicians have expressed concerns about telehealth causing already capable patients to become dependent on outside input for everyday management of their chronic condition (Turner et al., 2009).

There are multiple mechanisms through which telehealth can be organized including real-time telehealth, remote monitoring, and electronic consultation (e-consults). Real-time telehealth consists of face-to-face or voice-to-voice consults via closed video television (CVT). CVT consults are useful for group education classes regarding issues like nutrition and lifestyle changes necessary for improving diabetes outcomes. Remote monitoring is the use of a monitoring device to track and eventually upload patient outcomes to the EHR system. An example of this in the VHA is the "telebuddy" a device used to monitor and upload diabetic patients' blood sugar levels. An e-consult is defined as electronic communication between clinicians about general or patient-specific questions that may preclude the need for an in-person referral (Horner et al., 2011).

#### **1.4 E-consult**

The VHA has implemented a computerized patient record system (CPRS) based e-consult system where several specialties, such as endocrinology, neurology, gastroenterology, and urology now offer e-consults. Other specialties that are appropriate for e-consults are "those in which referred Veterans do not require procedures or a face-to-face visit, but rather diagnostic and therapeutic advice; e.g., abnormal labs, incidental findings or chronic care advice" (Siepierski et al., 2012).



The specific goals of the e-consult program are the following (Siepierski et al., 2012):

- Reduced turnaround time for consult completion;
- Improved patient access within face-to-face clinics by converting some of the demand into desktop medicine reviews (e-consults), thereby reducing the overall demand for face-to-face appointments;
- Save specialist time by serving as a “pre-screen” for face-to-face appointments;
- Reduce the overall specialist consult volume by serving as a method of continuing education for PCPs by providing them the opportunity to manage more aspects of specialty care;
- Improve patient satisfaction by decreasing the wait time for face-to-face specialist appointments;
- Decrease the amount of travel required for patients to consult with specialists, thus improving patient satisfaction;
- Satisfy PCP’s through increasing access to specialty clinics;
- Reduce appointment interruptions and competing priorities by allowing the PCPs to address care concerns outside clinic hours;
- Mitigate the detrimental effects of missed patient opportunities, such as a specialty clinic no-show;
- Enhance the relationship between PCPs and Specialty care providers; and
- Reduce VHA travel expenditures by reducing the frequency with which patients must travel to the VA for specialty treatment.

During initial interactions with a Veterans Integrated Service Network (VISN) 10 Endocrinology specialty as well as various PACTs, it became apparent that there are many barriers preventing the successful implementation of the current e-consult system. Provider uncertainty about the proper criteria and prerequisites for the submittal of an e-consult indicate that some barriers are educational in nature.

In the VHA, the e-consult is expected to be implemented in a widespread fashion. Due to this, it is important to evaluate whether or not the VHA's PACTs have the capacity required to successfully implement a new system.

## **1.5 Problem Statement**

While the IT infrastructure to support an e-consult exists and the basic framework of an e-consult program is in place at the VHA, there are capacity and workflow related barriers in the system that require mitigation. Combining the study and evaluation of the workload and performance effects from the e-consult with the effects on the PACT when other PCPs become unavailable, due to either sickness or vacation, may help in identifying and alleviating workflow and utilization-related barriers. Appropriate recommendations will ensure that Primary Care teams are well-suited to efficiently handle the workflow and workload introduced by a rise in e-consult demand.

This study is relevant to the overall outcome of the diabetes e-consult process in VISN 10 because, if the system overloads the PACT, then e-consults will not be accomplished in a timely manner, thus causing delays in treatment implementation. E-consults are intended to benefit all entities involved in the delivery of care to the patient. That is, the patients who benefit from convenience and increased access to the specialist, the PACTs who are able to increase coordination of care with the patient and learn from the recommendations received through e-consulting a specialist, and specialty clinics because they are able to more efficiently extend their care to a greater number of patients.

## **1.6 Research Objectives**

The following are the objectives of our study:

- Evaluate the effects of increased e-consult demand on e-consult-related outcomes;

- Quantify the sensitivity of these outcomes to walk-in patient arrival rates, electronic view-alert notifications, such as test results, or medication requests, and PCP unavailability; and
- Provide recommendations to alleviate the detrimental effects of factors that are determined to have a significant effect on the e-consult, on non-clinical, time-based outcomes.

## 1.7 Contributions of Research

The contributions of this research are several, as indicated below:

- This research provides the first approach to quantify the effects of e-consult process at a VA facility. Previous research (and current practice that we have come to know) uses ad hoc approaches to provide a quick-fix for individual problems, without considering the system-level impact.
- We pioneer the use of Discrete Event Simulation methodology to analyze telehealth systems, and e-consults in particular. Such systems level modeling and quantification is vital when implementing and/or altering the workflow. It also helps conduct what-if analysis to predict future behavior when system parameters vary from the norm.
- Additionally, this work contributes towards the successful implementation of e-consults by providing recommendations of strategies to obtain the best possible non-clinical e-consult outcomes. This will be completed by providing insights about what factors to which the e-consult outcomes are sensitive, as well as methods of ensuring that the detrimental effects of significant factors are not experienced.

## 1.8 Thesis Outline

The remainder of this thesis is organized as follows. Literature relevant to this study is reviewed in Chapter 2. The simulation model is described in Chapter 3. Results from the experiment are detailed in Chapter 4. Chapter 5 presents managerial insights and recommendations for improvement. Finally, Chapter 6 discusses the limitations of this research and possible directions for future investigation.

## **2 LITERATURE REVIEW**

The motivation, objectives, and contributions of this research were defined in the previous chapter. This chapter introduces literature based on VHA initiatives, such as Telehealth, e-consults, and PACT. Also, the advantages of using DES modeling to improve non-clinical outcomes in outpatient clinics are discussed.

### **2.1 Telehealth**

Telehealth can be defined as the delivery of healthcare services at a distance, using any communication modality that allows the physical separation of patient and practitioner while communicating about health issues (Darkins and Cary, 2000). In a study of a telehealth implementation in a VHA network, Hopp et al. (2006) interviewed 37 telemedicine providers, PCPs, and administrators. The researchers identified better chronic disease management, frequent contact, and quick response times as benefits to home telehealth. Topics of organizational communication, staff availability, and staff knowledge about telehealth equipment were described as issues to be addressed in the future implementation of telehealth systems.

Due to rising health needs of the aging veteran population, Congress and the U.S. Department of Veterans Affairs introduced the Veterans Millennium Health Care and Benefits Act of 1999. One objective of this act was to prioritize non-institutional care. A crucial component of the VHA's emphasis on non-institutional care is the Care Coordination Home Telehealth (CCHT) program. A primary objective of the CCHT program is to reduce avoidable and costly VA healthcare services (Barnett et al., 2006). Telehealth is complemented by other VA initiatives, such as EHR systems (Chumbler et al., 2011) and PACT, the VHA's PCMH-based, care team model. While providing a reduction in patient travel reimbursement costs, telehealth also has the potential for

benefits, such as increased care efficiency and enhanced patient access to multidisciplinary healthcare professionals. Telehealth is a relatively young treatment modality and, thus, is a topic of interest in current literature.

Hill et al. (2010) reviewed 19 studies of controlled VHA-supported telemedicine intervention trials that were focused on health outcomes. Identified advantages of telehealth were the following:

1. Ongoing monitoring capability of telehealth technology;
2. Enhanced access to healthcare professionals through telemedicine;
3. An efficient medium for provider-patient interaction;
4. Quick access to electronic health records and other information relevant to the patients' ongoing condition and treatment needs; and
5. Facilitation of collaborative care models within an integrated service delivery system.

The researchers concluded that benefits of telehealth can be best utilized during treatment of patients with complex health issues, such as chronic diabetes and mental health.

In an effort to shed light on patient experiences with telehealth programs, Young et al. (2011) gathered perspectives from veterans who are served by a Veterans Health Administration telehealth program. The researchers conducted telephone interviews with patients in order to identify the benefits, challenges and frustrations that the veterans experienced. It was concluded that home telehealth holds value for both providers and patients. Additionally, it is identified that patients are empowered by being responsible for their own treatment, as long as their access to a care coordinator is maintained. The study also identified equipment failures and provider inaccessibility as barriers that must be mitigated in order for an expansion in telehealth programs to take place.

## 2.2 Electronic Health Records (EHR)

Telehealth is enhanced by the use of EHR systems. O'Malley et al. (2010) investigated how practices use EHR systems to support coordination tasks by conducting telephone interviews with 52 physicians from practices where a commercial EHR system has been in place for at least 2 years. The researchers noted the challenge that PCPs face when trying to manage the information overload from EHR systems. Additionally, they conclude that current EHR policies do not match up with the abilities of EHR systems to support the coordination of care. The authors suggest that policy makers should encourage the growth of EHR systems to allow for multi-provider clinical decision support.

## 2.3 PACT

Success of a PCMH model is described in Gilfillan et al. (2010), where the researchers implemented an experimental variant of the PCMH, called the ProvenHealth Navigator (PHN), in 11 different primary care practices. Regression analysis was used to prove that at intervention sites, PHN was associated with an 18% cumulative reduction in inpatient readmission rates ( $p < 0.01$ ). Additionally, PHN was associated with a 36% cumulative reduction in readmission rates ( $p = 0.02$ ) over the entire population.

Solimeo et al. (2013) acknowledge the advantage that EHR systems present to the PCMH implementation. They studied PACT implementation barriers and facilitators through the observation of 22 primary care teams across VISN 23. The researchers presented a set of lessons learned throughout the study. In conclusion, they note that the redesign of primary care functioning has the potential for great impact, but attention must be paid to the social adaptations necessary for transferring from individual to team based work, such as; practice, policy, expectations, and attitude.

## 2.4 View-Alert Notifications

In the Veterans Health Administration PACTs, PCPs communicate with necessary medical staff through note-based view alerts. The burden placed on the PCPs from the constantly growing queue of notifications places a strain on PACT operations. Because e-consults use view-alerts as the primary means of communication between the involved parties, (excluding the patient) the notification system is of high importance to this study.

There is a strain on PCPs due to the constantly growing queue of view-alert notifications that must be processed. These notifications may contain all types of data, such as test results, lab orders, medication requests, or note-based communication. Murphy et al. (2012) tracked and classified the electronic notifications delivered to 47 PCPs over four evenly spaced 28 day periods at a large VA outpatient clinic. A total of 295,792 notifications were classified into 31 types that were further classified into 6 groups. Additionally, the researchers conducted time studies of 26 PCPs in order to collect the time requirements associated with the processing of each type of notification as well as the demand that the observed PCPs experienced. The notification demand and processing times described in Murphy et al. (2012) serve as an important input for the DES model described in Chapter 3.3.

Literature recognizes the benefits of Telehealth, EHRs, and PACT, all three of which make e-consults possible. E-consults support the VHA's CCHT initiatives by providing a means to enhance telehealth-based, multi-provider, clinical-decision support. Although, great care must be taken when defining the management policies associated with the implementation of these new systems in order to ensure that they are used as intended, rather than to meet an arbitrarily defined quota.

## 2.5 Modeling in Telehealth Systems

Mathematical modeling techniques are frequently used when conducting improvement oriented research with outpatient clinics in areas, such as patient flow, variability reduction, appointment scheduling, capacity planning, and ancillary tasks.



Surprisingly, it appears that relatively no literature exists pertaining to the use of mathematical modeling techniques in the evaluation of telehealth systems. This is likely due to the fact that telehealth is to some extent, novel. As such, there is also a void in literature pertaining to mathematical modeling of outpatient clinics using telehealth-based e-consult systems. There are multiple modeling methods that may be employed as a means of investigating areas of improvement in complex healthcare systems. There is not one “right” method to evaluate staff utilization and workflow in health care settings, but in some cases, certain methods are better suited than others. Vanberkel and Blake (2007) suggested that DES is useful for analyzing complex systems in an industry setting. In the health care industry DES has been used as a research tool in multiple different case studies with a focus on improving specific operations, including patient flow, patient scheduling, staffing configurations and ancillary tasks. In a health care setting, Palvannan and Teow (2012) used an M/G/c/c queueing model to perform capacity sizing with patient wait time as the key performance measure. It was found that while a queueing analysis was effective for this specific problem, Discrete Event Simulation (DES) modeling is better-suited for analyses in health care because of the inherent variability in many health clinics. Telehealth, particularly e-consults, have an inherently complex workflow; thus, e-consults are well suited to be modeled by DES.

## **2.6 Application of DES in Outpatient Clinics**

The healthcare industry is a customer service oriented domain. As such, a key performance indicator of the quality of an outpatient clinic is patient wait time. There have been numerous studies where DES has been used to decrease patient wait time in an outpatient clinic. Chand et al. (2009) investigated ways to increase patient flow at an outpatient clinic affiliated with the Indiana University Medical Group. The researchers used DES to identify sources of variability in the patient flow and to investigate options to decrease the flow variability. After implementing a scattered arrival appointment scheduling system, returning patient wait time decreased by 40%, while new patient wait time was reduced by roughly 20%. Additionally, Parks et al. (2011) used Simul8 2010

DES software to analyze patient flow through an outpatient clinic. It was found that because of space limitations, medication administration processes were a major bottleneck. Increasing the amount of resources alleviated this bottleneck. This change combined with a reassignment of check out workstations reduced the average patient cycle time from 124 to 87 minutes.

While patient wait time to see a provider is an important outcome to consider, it is not the focus of our study. Our study considers patient wait time in the context of the number of days a patient, for whom an e-consult was submitted by the PCP, must wait before receiving a treatment recommendation from the PACT. This is defined as the time from the patient and the PCP submitting an e-consult request to the time that the e-consult recommendation is implemented by the PACT.

DES provides a method to conduct what-if analyses to gauge the performance effects of changing resources like staffing, equipment, and facilities. One example depicting this was a study conducted by Santibanez et al., (2009). In this case, a Canadian ambulatory care clinic was analyzed. This analysis was unique because while assessing the impact of operations, such as resource allocation and scheduling techniques, on patient wait time the researchers used a DES software, Arena (Rockwell Automation, MD), to simultaneously model several different clinics operating independently within the system. In this case, it was found that incorporating dynamic room functions can reduce the total required room capacity by 25%. In other cases, benefits can be obtained from increasing resources, rather than decreasing them. For example, Rohleder et al. (2011) conducted a thorough analysis of patient flow within an orthopedic outpatient clinic, with the objective of diagnosing poor patient flow causes and providing recommendations for process improvement. The addition of one X-ray technician and the implementation of a revised appointment scheduling system resulted in patient cycle time to improve by 43.4%. Part of the reduction of patient cycle time was due to a reduction in patient wait time. That is, the number of patients with a wait time of less than 60 minutes was increased by 37%.

Patient scheduling is an integral part of all outpatient clinics. When creating patient schedules, it is important to consider sources of variability, such as appointment

durations, staff and resource availability, and walk-in patients. DES is frequently employed in outpatient clinics to analyze patient scheduling techniques as a method of improving operations, typically to reduce patient wait times and to improve utilization of resources, which often results in a reduction in cost. In one case, Glowacka et al. (2009) used DES to evaluate various scheduling techniques that employ association rule mining (ARM) for assigning no-show probabilities to patients. It was found that models employing the ARM technique detailed in the article, significantly outperformed models that do not employ an ARM technique.

Cost benefits of patient scheduling are depicted in Salzarulo et al. (2011), where the researchers investigated patient schedule sequencing policies based on patient classification by appointment variability. A DES model of the clinic was built in order to evaluate the sequencing policies. They observed that cost improvements up to 25% are possible when patients with high levels of variability in appointment length are scheduled later in the day. Both Cardoen et al. (2008) and Santibanez et al. (2009) had previously used DES in an outpatient clinic scheduling analysis. The results of Salzarulo et al. (2011) concur with these two studies in the finding that it is more beneficial to schedule consults characterized by a higher variability at the end of a consultation session. The clinic benefits in terms of shorter completion times, which translates into reduced cost and possibly, increased throughput.

Many outpatient clinics, including those operated by the Veterans Health Administration, experience walk-in patients. Walk-ins occur when a patient shows up in person, without a scheduled appointment, and expects to be treated by their provider. Findlay and Grant (2011) conducted one of the first studies on an outpatient clinic that experiences patient arrivals that are exclusively walk-in patients only. An Army Basic Combat Training Clinic, located at Fort Still Oklahoma, experiences a summer surge of walk-in patients in batch arrivals only as a result of rigorous training schedules. DES was used in order to analyze and improve clinic operations to eliminate the detrimental effects that batch arrivals had on the selected outcomes, such as patient wait time. It was identified that the addition of an appointment system would result in a reduction of patient time in clinic.

DES has been used to analyze the effects of different levels of staffing on cost. In one study, Sendi et al. (2004) set out to determine the optimal mix of resources between senior staff physicians and resident physicians in an outpatient environment. Colored Petri Nets, a graphically oriented DES language, was used to perform what-if analyses on staffing options. It was determined that for every 10 resident physicians, the addition of two senior physicians was justified. Another study by Rohleder et al. (2010) analyzed and designed alternative care team configurations for the Mayo Clinic. DES modeling was used to quantify cost savings, and explore the effects of reallocation of patient care and administrative tasks in order to free up physician time. With the addition of two LPN's along with workload reallocation, a 12% increase in patient throughput was achieved.

It is important to note the effect that minor interruptions have on clinic performance measures, such as patient cycle time. Salzarulo et al. (2011) investigated the tradeoffs of physicians' priorities of completing ancillary tasks and patient examinations. A DES model of a large outpatient primary care clinic was used to conduct what-if analyses on physician task priorities. It was determined that patient wait time is improved by a physician's emphasis on completing ancillary tasks, such as lab visits, prior to patient appointments. One objective of the e-consult innovation is to reduce the amount of PCP interruptions by allowing PCP's to conduct activities, such as review test results, and communicate with specialists electronically, at their own convenience, rather than in a fashion based on the availability of both parties. Additionally, e-consults allow for PCP's to access specialty care more easily, thus allowing for the PCP to have fewer ancillary tasks that must be completed when a patient arrives for a face-to-face appointment.

This study uses DES to quantify the effects of increased e-consult demand on non-clinical time-based outcomes. Additionally, DES is applied in order to identify the e-consult system's sensitivity to multiple factors including notifications, walk-in patients and PCP unavailability. Ultimately, the insights gathered will be used as justification for workflow based recommendations as a means of mitigating the negative effects of sensitive factors.

### **3 METHODS**

In the previous chapter we discussed literature related to telehealth, PACT, and the use of DES in outpatient clinics. This chapter provides insights about the process flow of a diabetes e-consult at the Dayton Veterans Affairs Medical Center (VAMC). Additionally, it describes important elements of the simulation model, and lays out the structure of the analysis.

#### **3.1 Current E-consult System**

There are multiple components that must interact in order to use telehealth systems to deliver care to patients. In the case of e-consults, demand is placed on the system by the patients requiring treatment from specialty care. To satisfy this demand, PCPs must request specialty care input via a CPRS template. In order to provide a treatment recommendation for the e-consult, specialty care must respond, via CPRS, to the e-consult request, Figure 2 shows the multiple components that interact during an e-consult.

Initial analyses of the endocrinology e-consult system at the Dayton VAMC have shown that the process flow of an e-consult can vary between cases, but generally it contains the following phases: (i) PCP and patient interaction; (ii) Specialist phase; and (iii) PCP follow-up phase. Figure 3 presents a timeline depicting the general order of events in an e-consult.

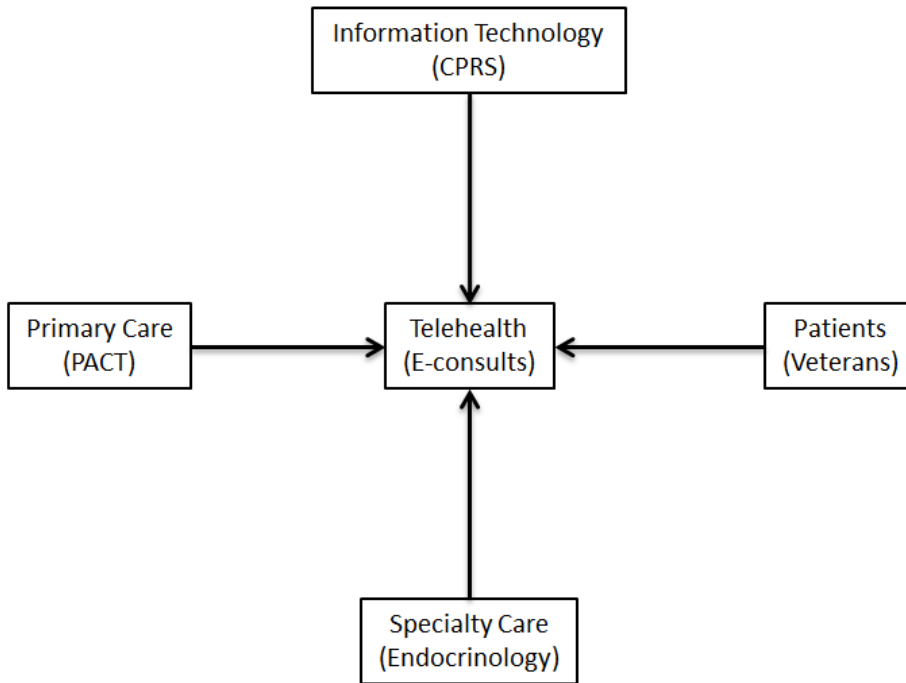


Figure 2: E-consult system components.

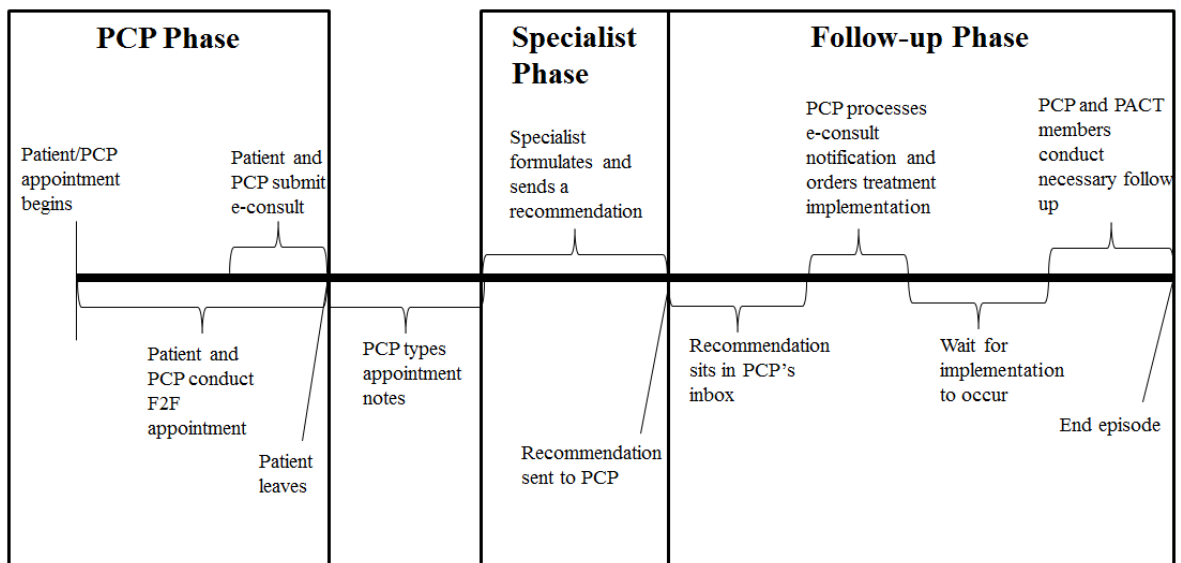


Figure 3: Order of events for the e-consult process.

### **3.1.1 PCP and Patient Interaction Phase**

During the PCP and patient interaction phase, a patient enters the system, thus marking the initiation of a treatment episode. The patient may enter the system via an in-person appointment, a telephone appointment, or an appointment through My HealtheVet (MHV), which is the VHA's method of allowing for patients to communicate with their PCP about simple health issues through secure email. Phone and MHV appointments are typically routed to the RN for treatment. If the patient being treated by the RN requires treatment or diagnosis outside of the scope of care for the RN, then the PCP will be contacted for approval. Face-to-face appointments between the patient and the PCP may yield an e-consult. The submission of a diabetes e-consult requires the provider to fill out and submit a template via CPRS. The template requires details regarding the patient's health measures, such as their HbA1c and their reason for consulting specialty care.

### **3.1.2 Specialist Phase**

After an e-consult template has been submitted to specialty care, the specialist phase begins. In this phase, the specialist uses CPRS to review the e-consult request and the patient's chart. At this point, an e-consult may be categorized as complex or simple.

A complex e-consult may take place when an e-consult is submitted for a patient that is in an advanced stage of diabetes and requires prolonged specialty care. In this case, the diabetes specialty team will meet with, treat, and follow-up with the patient until it is no longer necessary. If a complex e-consult is not needed, and an e-consult is sufficient, the specialist will review the patient's chart, and contact the patient if further information is required. From this point, the e-consult may be categorized as either a specialist only e-consult or a PCP involved e-consult.

### 3.1.3 Follow-up Phase

If the specialist contacts the patient via phone in order to gather more information about the patient's clinical measures, such as blood sugar levels, they may discuss the necessary treatment with the patient over the phone. In some cases, this treatment may be as simple as a diet or medication change. If this is the case, the treatment is discussed and "implemented" over the phone by the specialist. This case is referred to as the "specialist only" e-consult because it does not require any implementation on behalf of the primary care team.

If the specialist does not call the patient to implement the treatment, then the specialist will send a recommendation back to the PCP via the CPRS notification system. The recommendation will appear as a notification for the PCP containing treatment instructions for the PCP and their PACT to implement. This case is referred to as an "indirect" e-consult. In some cases, the Specialist will implement part of the treatment, while the PACT implements the other part. An example of this would be when the specialist orders a patient to change their diet, and attend diabetes education classes, while the PACT starts the patient on insulin. This case is referred to as a "combined" e-consult.

After the treatment has been implemented, the PACT may or may not need to follow up with the patient to determine the effect of the treatment. In some cases, the follow up may require the patient to come to the clinic to have labs conducted to gauge diabetes performance measures, such as HbA1c. E-consult follow-ups are treated as a new patient episode, and have the potential to yield another e-consult.

A flow chart detailing the e-consult process flow at a VHA hospital in Dayton, Ohio is presented in Figure 4. Currently, there is no set structure in place to collect and record outcomes related to the performance of e-consults. In order to obtain data to assess the system-based outcomes, multiple electronic shadowing sessions were conducted. Roughly 150 man hours were spent analyzing the charts of patients who have received e-consults.



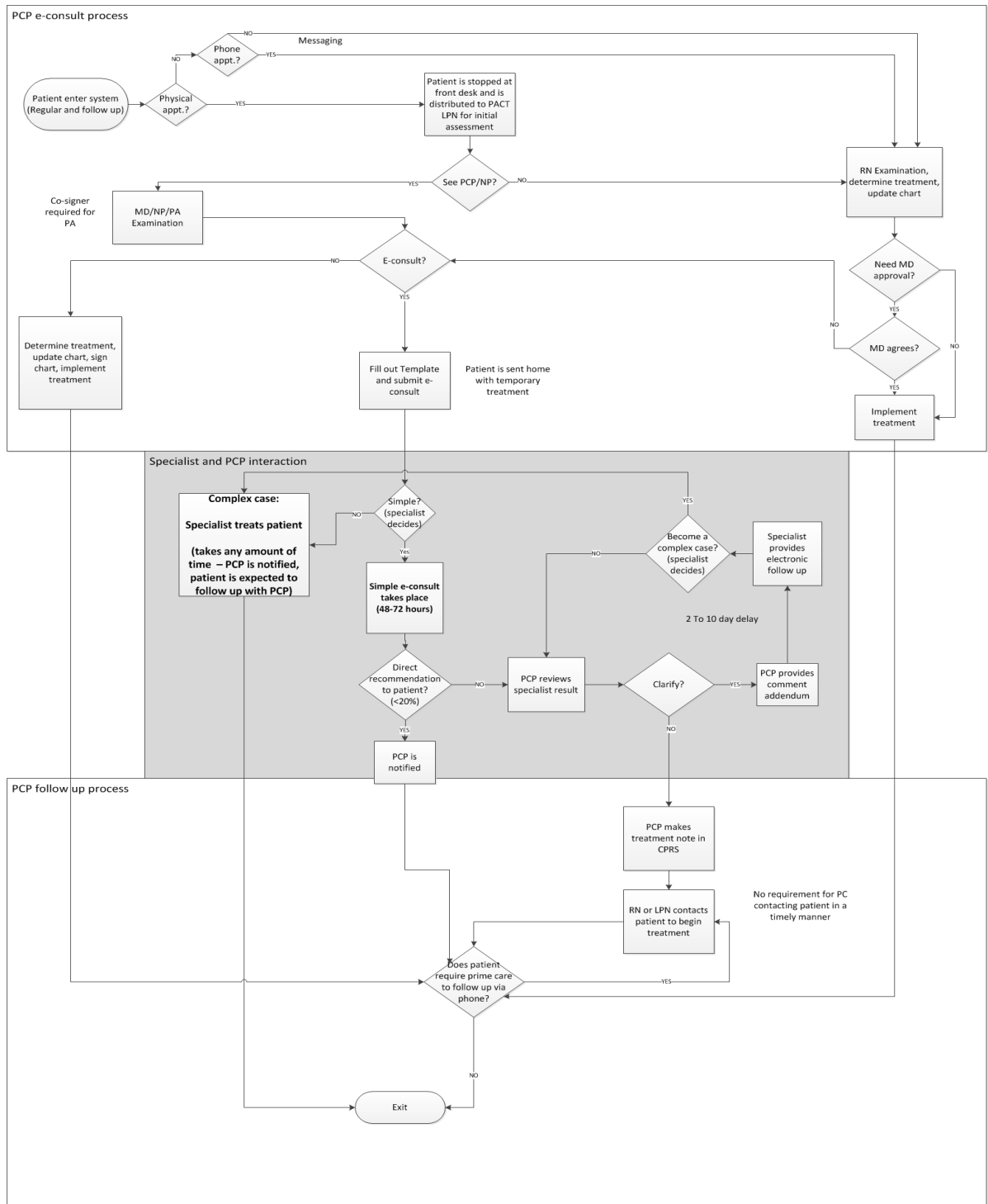


Figure 4: E-consult process flow at the Dayton VAMC.

The performance analysis on the existing diabetes e-consult system indicated that e-consults frequently were not implemented within the VHA-required 30 days of submittal to specialty care. Of the 80 e-consults that took place over a one year span, 22 e-consults were not implemented within the VHA mandated time limit of 30 days. Of the 22 e-consults that were not implemented within 30 days, 9 e-consults took over 60 days to implement treatment. A breakdown of the 80 observed e-consult cases is depicted in Figure 5.

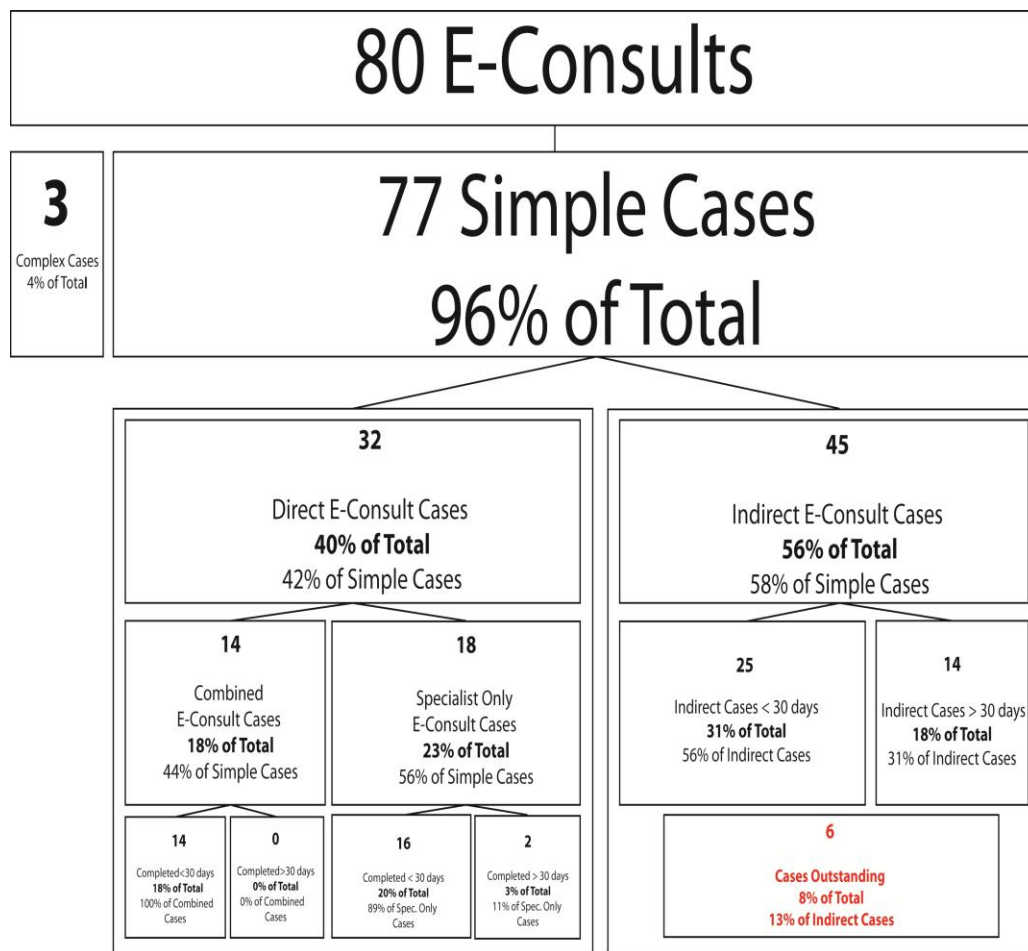


Figure 5: Breakdown of 80 e-consults by type.

It is important to note that several factors contributed to the failure of the e-consult to meet specific duration requirements. Some of the factors are the following:

1. Failure to specify PACT member follow-up responsibilities;
2. Lack of understanding of the proper workflow of the e-consult; and

3. Unknown effects of PACT workload and e-consult demand on non-clinical outcomes.

Our research objective was to assess the impact of increased e-consult demand and multiple other factors on e-consult non-clinical outcomes. This assessment would provide important managerial insights, thus identifying ways to ensure that the e-consult system leads to intended outcomes.

A DES methodology is well-suited to handle various stochastic elements inherent in such a complex, dynamic system as e-consults, and was thus chosen the preferred modeling approach. We now present an overview of a DES model built and validated in Arena.

### **3.2 Simulation Model Development**

The simulation logic models a single PACT, as e-consults take place between one PACT and usually one specialist. A primary care clinic may have multiple PACTs, but they all function in a similar way over a mutually exclusive patient panel. In the event of an absent nurse, or patient service assistant, there are exceptions when one PACT may support the other, but such flexibility is likely not integral to the e-consult process, which is the focus of this work.

Each PACT consists of four members with the following responsibilities.

1. Primary Care Physician (PCP) – The PCP is primarily responsible for conducting patient appointments, submitting e-consult requests, and formulating and coordinating treatment implementation plans based on specialist recommendations.
2. Licensed Practical Nurse (LPN) – The LPN is the first provider that treats the patients in the event of a patient appointment with the PCP. The LPN is primarily responsible for taking patient vitals, conducting medication reminders, and initiating treatment implementation with patients.

3. Registered Nurse (RN) – The RN is typically responsible for implementing patient treatments, such as administering shots. Often, the RN conducts both scheduled and unscheduled telephone and face-to-face appointments with patients. In the case of unscheduled walk-in patients, the RN triages the patients before the patient encounters the PCP.
4. Patient Service Assistant (PSA) – The PSA is the first PACT member that the patient encounters. The PSA is responsible for scheduling appointments, patient check-in, mailing letters and other clerical tasks.

### **3.2.1 Objectives**

The objectives of the simulation model were to accomplish the following:

1. Quantify the effects of increased e-consult demand on e-consult related outcomes;
2. Investigate the role that various factors, such as notifications, walk-in patients, and PCP unavailability, have on non-clinical outcomes; and
3. Provide recommendations to alleviate the detrimental effect of factors that are determined to have a significant effect on the e-consult, non-clinical based outcomes.

### **3.2.2 Methodology**

The methodology followed in order to accomplish these objectives was the following:

1. A DES model was developed based on the primary care workflow to simulate the e-consult process and PACT members during completion of their designated tasks;
2. Data was collected through visits to CBOCs and Dayton primary care, as well as by conducting interviews with primary care staff;
3. The simulation model was validated over a set of outcomes;

4. A sensitivity analysis was conducted to identify factors that have a significant effect on the outcomes; and
5. Alternate workflow strategies were designed and tested to improve non-clinical outcomes.

We now describe the details of the simulation model.

### 3.3 Model Details

The simulation model focuses on those PACT-member tasks that are directly related to e-consults. While the RN and PSA play a crucial role in the operation of the PACT, their role in the e-consult is negligible. In some cases, the RN may be responsible for implementing a treatment that was determined through the use of an e-consult. However, if this is the case, the implementation of the treatment would be treated as a separate patient episode, independent from the e-consult (e.g., an additional follow up appointment). Consequently, our model focuses on the two PACT members that are crucial to the progression of an e-consult, the PCP and the LPN.

The simulation model simulates both scheduled and walk-in patients arriving at a VA outpatient clinic. First, the patients are triaged by the LPN. Next they wait to be seen by the PCP. Some cases will yield a diabetes e-consult. In the case that an e-consult is not yielded, the patient exits after their appointment is complete. In cases including e-consults, the patient is present for the submission of the e-consult and then exits the system.

Once the e-consult has been submitted, a certain amount of time,  $\Delta t_1$ , elapses. Before which the specialist spends a certain amount of time,  $\Delta t_2$ , reviewing the e-consult, collecting additional data related to the case, and formulating a treatment recommendation to send to the PCP. Once the treatment recommendation has been sent from the specialist to the PCP, a variable amount of time,  $\Delta t_3$ , elapses before the PCP reviews the treatment notification. Upon review, the PCP formulates a treatment plan. Finally, the PCP initiates follow up procedures with the PACT members, in order to

contact the patient and implement the treatment. Figure 6 depicts these steps in the form of a flow chart.

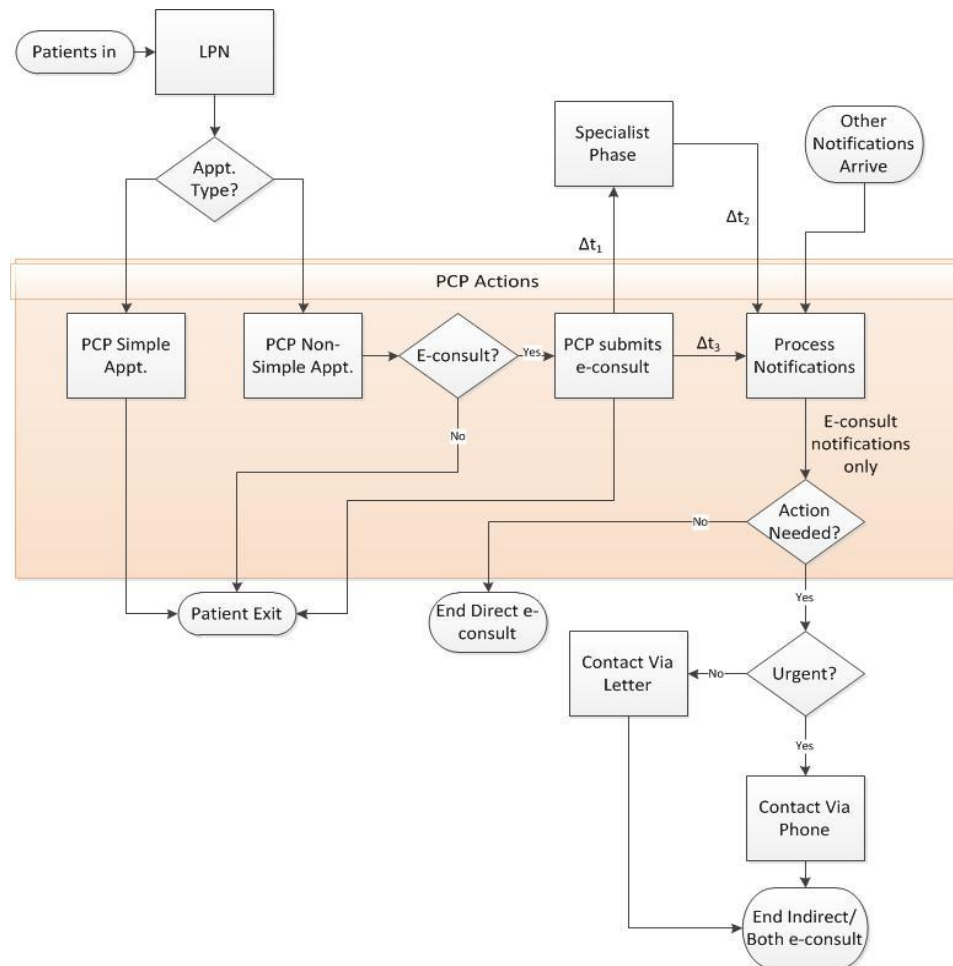


Figure 6: Basic simulation model flow chart.

### 3.3.1 Assumptions

Important assumptions that we make in developing our simulation model include the following:

1. The PCP does not have to go back at the end of the day to finish notes; instead, the next patient waits until notes for the previous patient are entered into CPRS;

2. Appointment duration distribution is identical for both e-consult and non e-consult patients; and
3. PCP waits until current appointment is over before treating walk-in patients.

### 3.3.2 Inputs

The model consists of several elements, such as inputs, entities, attributes, flow, and outcomes. The following is a broad list of the most critical inputs:

1. Scheduled and walk-in patient arrivals;
2. Patient appointment process time distributions;
3. E-consult demand;
4. E-consult-related process time distributions;
5. Notification arrivals and process time distributions; and
6. Notification priorities.

Table 1 provides a more comprehensive list of the input elements on which the model is based, as well as the parameters associated with each element.

Table 1: Simulation model input elements.

	Description	Source	Sample Size	Data Distribution
<b>Process Times</b>	PCP scheduled patient appointment duration	Time Study	41	N(19.76, 8.37) min
	LPN appointment duration	Time Study	29	LN(2.06, 0.56) min
	PCP typing notes after patient appointment	Time Study	15	TRIA(1.5, 4.2, 7.5) min
	PCP walk-in patient appointment duration	Expert Opinion	5	TRIA(2, 5, 7) min
	PCP time to submit e-consult	Expert Opinion	5	TRIA(2, 4, 8) min
	PCP time to read recommendation, process and order treatment	Expert Opinion	5	TRIA(3, 4, 5) min
	Specialist e-consult response time	E-shadowing	78	EXPO(6.76) days
<b>Patient Data</b>	Walk-in patient time between arrivals	DSS	67	4.5*BETA(0.509, 1.7) days
	Probability of a no-show	Reports	2,281	0.039
	% of patients that are diabetic	DSS	6,210	32.10%
<b>E-consult Demand</b>	% of diabetics that receive e-consult	Variable	-	0%, 5%, 10%, 15%, 20%, 25%
	Probability of PCP only e-consult	E-shadowing	80	0.7375
	Probability of direct e-consult	E-shadowing	80	0.225
	Probability of complex e-consult	E-shadowing	80	0.0375
<b>Notifications</b>	Test results alert processing time	Murphy et al., 2012	114,019	TRIA(23.75, 47.50, 71.25) s
	Test results alert arrivals per day	Murphy et al., 2012	114,019	31.10 alerts/PCP/day
	Note-based communication processing time	Murphy et al., 2012	35,653	TRIA(55.35, 110.70, 166.05) s
	Note-based communication alert arrivals per day	Murphy et al., 2012	35,653	9.70 alerts/PCP/day
	Patient status change alert processing time	Murphy et al., 2012	187	TRIA(42.50, 85.00, 127.50) s
	Patient status change alert arrivals per day	Murphy et al., 2012	187	0.05 alerts/PCP/day
	Referral alert processing time	Murphy et al., 2012	52,811	TRIA(12.40, 24.80, 37.2) s
	Referral alert arrivals per day	Murphy et al., 2012	52,811	14.40 alerts/PCP/day
	Order-related alert processing time	Murphy et al., 2012	4,080	TRIA(30.65, 61.30, 91.95) s
Order-related alert arrivals per day	Murphy et al., 2012	4,080	1.10 alerts/PCP/day	

Time distributions and frequency data for some inputs related to the PCP follow-up phase were not collected due to the unavailability of data for follow-up process time distributions. In order to account for the lack of data for the aforementioned inputs, expert opinion was used in order to establish the flow and time distributions related to these follow up processes.

### 3.3.2.1 Patient Demand

The rate of scheduled patient arrivals is an important input because the PCP spends a majority of their workday conducting face-to-face appointments with patients. The result of this is that their workload is substantially impacted by the percentage of their schedule that is full. Traditional PCP schedules have patients scheduled to arrive for each 30-minute time slot that the PCP is available. Thus, we model scheduled patient demand as patients arriving in constant and deterministic 30-minute time intervals. This



is because the e-consult process starts with PCP-patient interaction. Outcomes like patient wait time are partly driven by stochastic patient arrivals and although important, they are out of the scope of this study.

Scheduled patient no-shows are accounted for by incorporating the probability (3.9%) of a patient not attending a scheduled appointment into the model. This data was obtained from reports from VA outpatient clinic managers. Because data was not available pertaining to the frequencies of time slots that experience no-shows, we assumed the patient no-show events are distributed uniformly throughout the day.

Additional patient demand is placed on the PACT through walk-in patients. Walk-in patient demand data was gathered by collecting the inter-arrival times for walk-in patients from a PACT that, when compared to other PACTs, experienced an average level of walk-in demand. Walk-in patient inter-arrival times follow a Gamma Distribution described in Table 1.

### **3.3.2.2 View-Alert Notifications**

Another key component of the inputs to the model is the demand placed on PCPs' time by notifications. Notifications can contain information ranging from patient status updates to medication renewal requests. Seeing as how notifications are the medium through which e-consult data is transferred, the notifications processed by the PCP are an important input for the model. In a VHA-funded study, Murphy et al. (2012) created a taxonomy of 33 alert/notification types that can be categorized into six major groups. They also recorded the average time between arrivals and the average processing time associated with each type of notification. As such, the results detailed in Murphy et al. (2012) serve as the notification inputs for the simulation model.

### 3.3.3 Data Collection

We employed the following data collection techniques at five different VHA outpatient clinics:

1. One-on-one interviews with primary care staff in order to gain insights into the e-consult process flow as well as PACT member responsibilities (Appendix A);
2. Time studies in order to gather process time distribution data (Appendix B);
3. Requested electronic reports from the VHA's Decision Support Service (DSS) in order to collect pre-recorded data; and
4. Electronic shadowing in order to define the specific e-consult phases and gather e-consult time-based data with which the simulation model was validated against.

### 3.3.4 Performance Indicators

The following is a list of outcomes collected by the simulation model:

#### Time-Dependent Outcomes

1. Distribution of e-consult cycle time (the time that elapses between a patient's arrival and departure from the system);\*
2. Length of time between initiation of the e-consult by the PCP and the beginning of the treatment implementation;\*
3. Time between recommendation receipt by PCP and the beginning of treatment implementation by the PACT;\* and
4. Time between the PCP ordering a PACT member to begin treatment implementation and the PACT member implementing the treatment.

\* Represents outcomes that were used in the model validation phase given that we already have values for these outcomes associated with historical e-consults.

#### Workflow Outcomes

1. Notifications in process at the end of each day.

### **3.3.5 Verification and Validation**

In order to determine whether or not the simulation model reasonably modeled the current system, a baseline measurement was taken with the factors set as close to the “as is” state as possible. A description of each of the critical inputs in their “as is” state follows.

#### Scheduled Patient Demand

Scheduled patient demand was verified by collecting a sample of the visit frequencies for 1132 patients. The number of scheduled appointments each patient had with their PCP over a span of one year was recorded. The data was then broken down into the percentages of patients in the sample that visit their PCP once a year, twice a year, etc. On average, each patient has scheduled appointments with their PCP 2.03 times per year (Appendix A). For a panel of 1350 patients this equates to 2741 scheduled appointments, which is reasonably close (within  $\pm 2\%$ ) to the number of 2792 scheduled patient appointments obtained in the model.

#### E-consult Demand

Data collection showed that over a span of one year, for a sample of 29 PACTs, 80 diabetes e-consults were generated. This yields a ratio of 2.76 e-consults per PACT per year. If each PCP conducts roughly 2775 scheduled appointments per year, and the average panel contains 32.1% diabetic patients, then there are a total of 891 diabetic patient appointments per year. This work assumes that patients without diabetes do not submit e-consults, as well as that walk-in patients do not submit e-consults. Dividing the 891 diabetic patient appointments by 2.76 e-consults per pact per year, yields 0.0031 or 0.31%, which is the percentage of diabetic patients who receive an e-consult request. This number is very small, but note that the e-consult process is relatively young and increased levels of diabetes e-consults are expected in the future. Our sensitivity analysis quantifies the effect this would have on cycle time (Chapter 4.2).

### E-consult Notification Priority

Interviews with five different PCPs yielded five different notification prioritizing systems. Generally, e-consult notifications were towards the bottom of the notification priorities. Although because there was not one uniform method of prioritizing notifications, the validation trials were conducted with the e-consult notification priority set as FIFO.

### Other PCP Unavailability

The data with which we used to validate the outcomes against was collected from 29 PACTs from five different VHA clinics. Within the sample, there were some PACTs that had team leaders, and some PACTs that did not. During the data collection we were unable to tell whether or not the e-consult occurred during a period where a PCP was unavailable. Therefore, the validation trials were conducted without any periods of PCP unavailability.

The model outcomes were then compared to outcomes collected during the data collection phase of this project. During the data collection phase of this project, we electronically reviewed 80 patient charts containing e-consults in order to gain insights about the e-consult process as well as gather data regarding the duration of each step during the e-consult. The 80 e-consults took place over a span of one year. Of the 80 e-consults, 53 were e-consults that contained the three phases similar to all traditional e-consults; i.e., the specialist phase, the PCP phase, and the implementation phase. Of these 53 e-consults, only 20 patient charts contained enough time stamps to accurately capture the time-related outcomes.

The observed values were compared against the 95% confidence intervals of the simulated mean values, which were obtained from running 100 replications of our baseline simulation model. The results can be reviewed in Table 2.

Based on the results in Table 2, we conclude that our simulated results for the selected outcomes were reasonably close ( $p < 0.05$ ) to the values observed in the actual

system. Any differences in the outcomes are likely due to the small amount of existing data available for the model to be validated against.

Table 2: 95% confidence interval of simulated e-consult outcomes vs. observed values of e-consult outcomes.

System Outcomes	Observed Values (Days)				Simulated Values 95% C.I. (Days)
	Mean	Standard Deviation	n	95% C.I.	
e-consult cycle time	12.35	6.08	20	12.35 ± 2.66	11.18 ± 0.36
Length of time between initiation of the e-consult by the pcp and the beginning of treatment implementation	10.30	6.10	20	10.30 ± 2.67	10.63 ± 0.36
Time between recommendation receipt by PCP and the beginning of treatment implementation by the PACT	3.05	4.12	20	3.05 ± 1.81	3.94 ± 0.26
Notifications in queue at the end of day	80.81	70.49	37	80.81 ± 22.71	65.80 ± 1.15 (Notifications)

### 3.4 Sensitivity Analysis

E-consults involve communication between all parties involved in patient treatment; i.e., the patients, the PACT, and the specialist. Because of the mandatory involvement of a PACT during the completion of an e-consult, it is important to determine the effects that common factors experienced by individual PACT members, in particular, the PCP have on a PACT's workload. It was hypothesized that outcomes associated with e-consults, such as the e-consult cycle time, are likely affected by the workload demands that PACTs are faced with. As such, key factors expected to have an effect on PACT workload are described below.

#### 3.4.1 E-consult Demand

E-consult demand is defined as the percentage of diabetic patient appointments that yield an e-consult. Once the e-consult is implemented at all VHA facilities and when the primary care staff becomes more familiar with it, demand is expected to increase. In

order to understand how the system will behave under a demand level that has not yet been reached, the e-consult demand was set at multiple levels in the model.

### **3.4.2 Notification Demand**

It is important to note the effect that notification demand may have on the actual system. Depending on the day and time, notification view alerts do not always arrive at the same constant, deterministic rate. Because notifications are the medium through which e-consult information is transferred, we hypothesize that the quantity of notifications received by the PCP has a significant effect on time-based measures. In order to determine the effects of increased levels of notification demand on the system, we varied the arrival rate of notifications.

### **3.4.3 PCP Unavailability**

When a PCP uses sick leave, or is on vacation, their unavailability may have a substantial impact on the e-consult related workflow of the PCP that is responsible for covering the walk-ins and notifications of the unavailable PCP. While unavailable PCP's scheduled appointments are cancelled, their walk-ins and notifications are routed to the covering PCP during the duration of their unavailability. This effectively doubles the number of walk-ins and notifications the covering PCP is responsible for. The simulation model takes this into account by simulating the increased notification and walk-in demand caused by the unavailability of other PCPs. Interviews with team leaders revealed that for approximately 25% of the time the team leader is covering notifications and walk-ins for an unavailable provider. This is accounted for in the model by simulating three different levels:

1. No PCP unavailability;
2. 1-day; i.e., PCP unavailable for a one-day duration, 25% of total time is unavailable; and

3. 1-week; i.e., PCP unavailable for consecutive five-days, 25% of total time is unavailable.

### 3.4.4 Walk-in Demand

Walk-in patients introduce variability into the system that may have an effect on non-clinical, e-consult outcomes. In the simulation model, we vary the levels of walk-in demand because it is important to understand the workload effects experienced from increased or decreased levels of walk-in patients.

The simulation model simulates multiple factors and combinations of factors that may have a significant effect on the non-clinical, time-based outcomes. Table 3 depicts the factors and the levels of each factor that will be included in the simulation model analysis.

Table 3: Factors and levels to be included and varied in the experiments.

<b>Factor</b>	<b>Levels</b>	<b>Values</b>
E-consult Demand (%)	11	0.31, 0.5, 0.75, 1, 2, 5, 10, 25, 50, 75, 100
PCP Unavailability	3	None, 1-day, 5-day
Walk-ins (days)	5	EXP(0.9615), $\pm 10\%$ , $\pm 20\%$
Notification Arrivals (mins)	3	Constant(8.51), $\pm 20\%$

This chapter presented the model flow, factors to be included in the analysis, and validation results. In the next chapter, the results from our experiments will be described.

## 4 RESULTS

In chapter 3, the process flow of diabetes e-consults at a VHA outpatient clinic was discussed. Additionally, the details of the simulation model were described. We now describe the results of our experimental study.

There were 4 factors with 11, 3, 5, and 3 levels, respectively. This equates to 495 different combinations of experiments. Each trial was simulated for 100 replications of 12 years each. A replication length of 12 years was chosen in order to allow for at least 30 e-consults regardless of the level of e-consult demand. While 30 e-consults over a span of 12 years may seem low, only one PACT is being modeled, and the “as is” diabetes e-consult demand level is roughly 2.76 e-consults per year per PACT (0.31% of scheduled diabetes patients require an e-consult). Additionally, e-consult demand is increased in order to investigate the effects from increased provider and patient buy-in, which likely will result in increased levels of usage of the electronic consult system.

### 4.1 Experimental Results

When comparing the no-PCP unavailability case with the 1-day and 5-day PCP unavailability cases, without splitting the workload for the remaining PCPs, the no-PCP unavailability case has a lower initial level than the other two cases. Also, the system experiencing the no-PCP unavailability case is able to handle much greater levels of e-consult demand (100% or 3.5 e-consults per day) before the cycle time rises to a level above 30 days. Once PCP unavailability is introduced into the model, which in fact is how the real system operates, the system performs much more poorly. In fact, the one-day PCP unavailability case can only handle 20% demand or roughly 0.65 e-consults/day before the system becomes overloaded and cycle times rise to a level greater than 30 days. The five-day PCP unavailability case performs even worse; an e-consult demand of



15% or 0.50 e-consults/day yields cycle times over 30 days. This result is intuitive, as manufacturing systems engineering literature suggests that systems experiencing short frequent outages significantly outperform identical systems experiencing long infrequent periods of PCP unavailability, even when the total “down time” is the same (Hopp and Spearman, 2008). Although the previous statement is true, it does not apply to all cases in this study. Figure 7 shows the one-day PCP unavailability and five day PCP unavailability cases to become statistically similar once demand reaches a point of 25% or 0.87 e-consults per day. After this point, the intervals of cycle times for these trials seem to converge.

The reason the no-PCP unavailability case significantly outperforms both the one and five-day PCP unavailability cases at all levels of e-consult demand is likely because when a PCP becomes unavailable, all of the unavailable PCP’s incoming view-alert notifications and walk-in patients are routed to another PCP who is designated as the team leader. The rerouting of walk-ins and notifications, effectively doubles the team leader’s notification and walk-in workload, thus overloading the system and resulting in drastically increased e-consult cycle times. Due to the routing of the unavailable PCP’s workload to the team leader only, other PCPs on the team do not experience the detrimental effects of an unavailable PCP, only the PCP responsible for covering the unavailable PCP is affected. One method of alleviating the effect of the increased notifications and walk-ins is to divide up the unavailable PCP’s workload over all of the remaining PCPs.

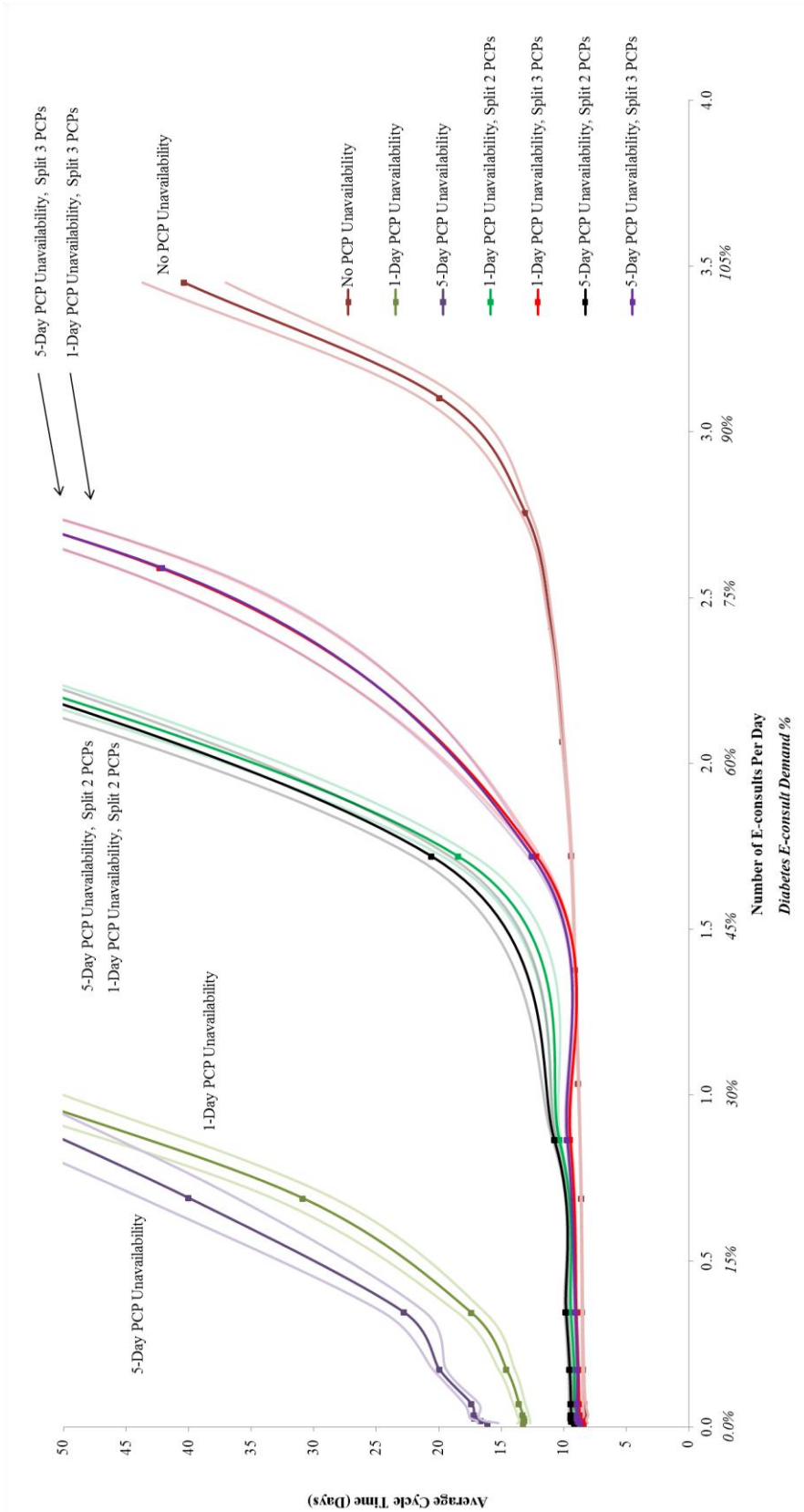


Figure 7: Effect of various e-consult demand rates, by PCP unavailability, on cycle time. (Note that the bold lines are means and the surrounding faded lines represent the 95% confidence interval of the mean).

The teams and outpatient clinics observed in this study consisted of three or four PACTs each. If one of the PCPs were to go on vacation, their walk-ins and notifications can be divided up amongst the remaining two or three PCPs. The results from this division are depicted in Figure 7. The four additional cases pictured here are one and five-day PCP unavailability, with the walk-ins and notifications being divided amongst the remaining two or three PCPs. As shown in Figure 7, the cases where the additional workload is split between two and three PCPs do not appear to have a significant difference until an e-consult demand level of 25% or 0.87 e-consults per day is reached. Once the demand is at that level or higher, both cases where the workload is divided amongst three PCPs significantly outperform both cases where the workload is divided amongst the two remaining PCPs.

Additionally, it is important to note that when the workload is not divided up between the remaining PCPs, the one-day PCP unavailability case significantly outperforms the five-day PCP unavailability case, when e-consult demand is less than 25%. However, in the cases where the additional workload is divided between the remaining PCPs, the duration of the period of PCP unavailability does not appear to have a significant effect on e-consult cycle time. In summary, Figure 7 shows that there is little difference between cases experiencing one-day and five-day durations of PCP unavailability, but there is a significant improvement in e-consult cycle time when the additional workload from an unavailable PCP is divided amongst the remaining two or three PCPs. Obviously, the case with more PCPs to share the increased workload outperforms the case with fewer PCPs.

The results previously described now bring to our attention the following question: *in the event of a PCP becoming unavailable due to sickness or vacation, is it better to route all additional workload to one PCP and let them experience substantially more detrimental effects while the remainder of the team is unaffected, or is it advantageous to split the additional workload amongst the remaining PCPs, thus reducing the intensity of the detrimental effects, but spreading them out between all PCPs?*

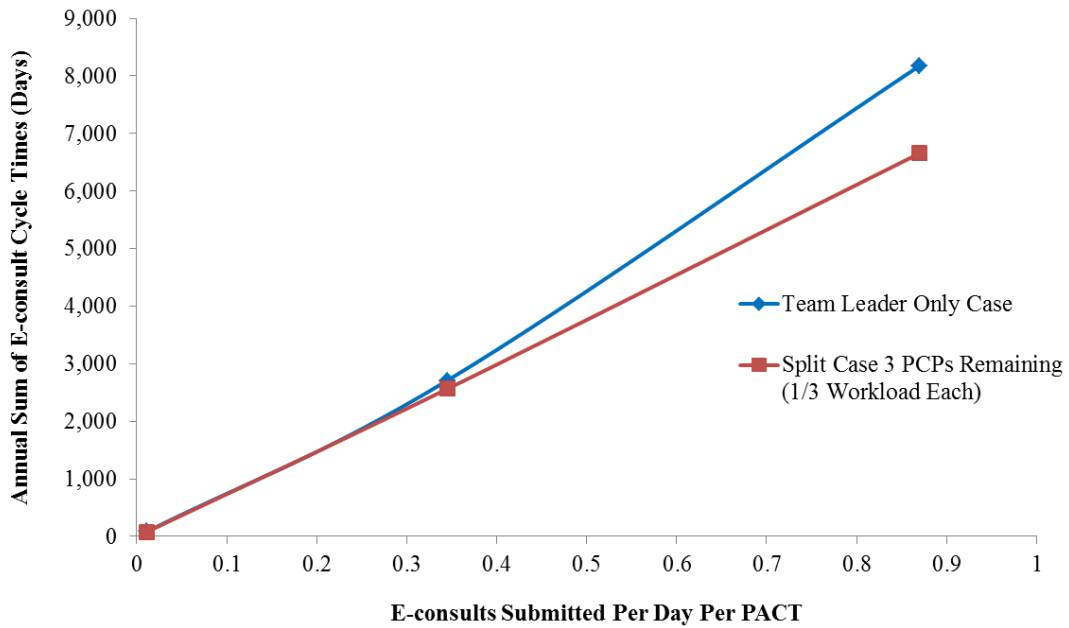


Figure 8: Total e-consult cycle time days over one year, by workload division strategy.

This analysis illustrates the point that in the case of one-day PCP unavailability, it is more beneficial, over the course of a year, to split the additional workload amongst the remaining 3 PCPs whenever a PCP becomes unavailable (assuming a 4 PACT outpatient clinic). Rather than mandating that the team leader be solely responsible for handling the additional workload, splitting the workload between the remaining PCPs yields lower cumulative cycle times, which adds up to fewer patient days spent waiting for a treatment implementation. As e-consult demand increases, the effectiveness of splitting the additional workload between the remaining PCPs grows. Significantly different ( $p < 0.05$ ) results are observed from the split case after 0.35 diabetes e-consults are being submitted per day (10% e-consult demand level).

The reduction in total e-consult duration may cause increased patient satisfaction from receiving a treatment implementation in a timely manner. Additionally, if one PCP becomes overwhelmed with e-consults, the quality of care delivered by the overloaded PCP may diminish. This may introduce a higher probability of a treatment mistake, which can be both costly and dangerous. Lower quality of care may also elicit a drop in the level of satisfaction experienced by the veterans who are served by the PCP while in

an overloaded state. In summary, it is more beneficial in terms of time and quality to split the additional workload incurred by a period of PCP unavailability among the remaining PCPs.

## 4.2 Sensitivity Analysis

Interestingly, e-consult cycle time is far more sensitive to changes in the level of view-alert arrivals, when compared to walk-in rate. This is likely because of the fact that view-alert notifications are the medium through which e-consult information is transferred. Therefore, when the PCP is busy addressing other view-alerts, they are not available to address the e-consults. Additionally, the PCP spends much more time per day processing view alerts, rather than treating walk-in patients.

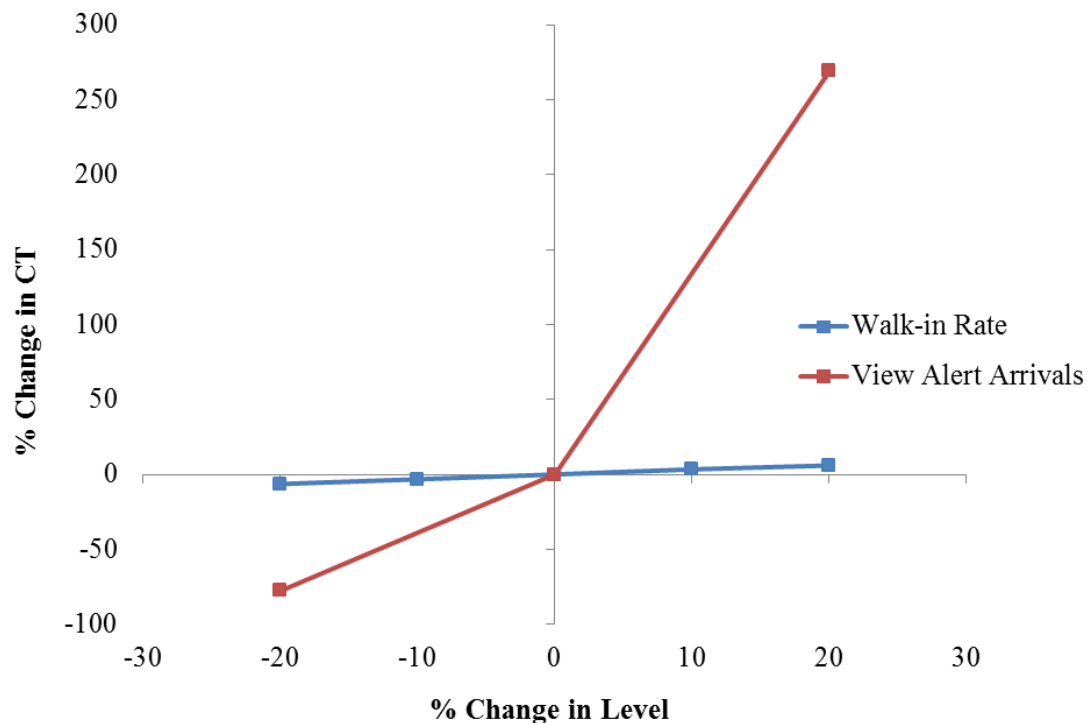


Figure 9: Sensitivity of e-consult cycle time to variations in view-alert arrivals and walk-ins.

The sensitivity of e-consult cycle time to notification demand provides evidence that time and effort should be spent in order to reduce either the number of notifications that are received by PCPs, or the amount of time that it takes for a PCP to read and address notifications. Additionally, great care must be taken to ensure that the level of notifications does not increase. Due to the fact that an increase in notification arrival rates by 20% yields an 275% increase in e-consult cycle time, yet a 20% decrease in notification arrival rates only yields a 75% decrease in cycle time, great attention must be paid to the quantity of notifications that PCPs are subjected to throughout their workday.

Figure 10 shows that the system is able to sustain increases in e-consult demand when walk-in patient arrival rates are varied. In fact, until a demand level of 70%, the cycle time in all five cases is roughly 10 days. This characteristic is likely due to the system's moderate sensitivity to walk-in patient arrivals, when compared to view-alert notification arrivals.

All three cases pictured in the Figure 11 graph exhibit an increasing trend. Based on the e-consult demand, the cycle time only slightly increases for the system experiencing a 20% reduction in notification arrival rate. For the actual system with a 0% change in notification arrival rate, the cycle time passes 30 days at a demand level of roughly 90%. Although, this system is able to remain stable for much longer than the system experiencing a 20% increase in notification arrivals. In this case, the cycle time passes 30 days at roughly 35% e-consult demand. Increasing the notification arrival rate by 20% drastically reduces the system's ability to accommodate increases in e-consult demand. Additionally, with the expected increased e-consult rate by PCPs, as a result to an ongoing marketing campaign, an increase in notification arrivals could prove to be disastrous for the system unless alternative measures are taken; e.g., walk-in patient arrival rates are reduced.

A comparison of Figure 11 to Figure 10 seems to reiterate the point that cycle time is much more sensitive to increases in notification arrival rates compared to increases in walk-in patient arrival rates.

All four of the identified factors proved to have a significant effect on the response, e-consult cycle time (see Table 4). This is indicated by each case yielding a p-value of  $< 0.0001$ . While the ANOVA helped in identifying the significant factors, a Tukey's test was necessary in order to determine the levels of each factor that were significantly different from one another.

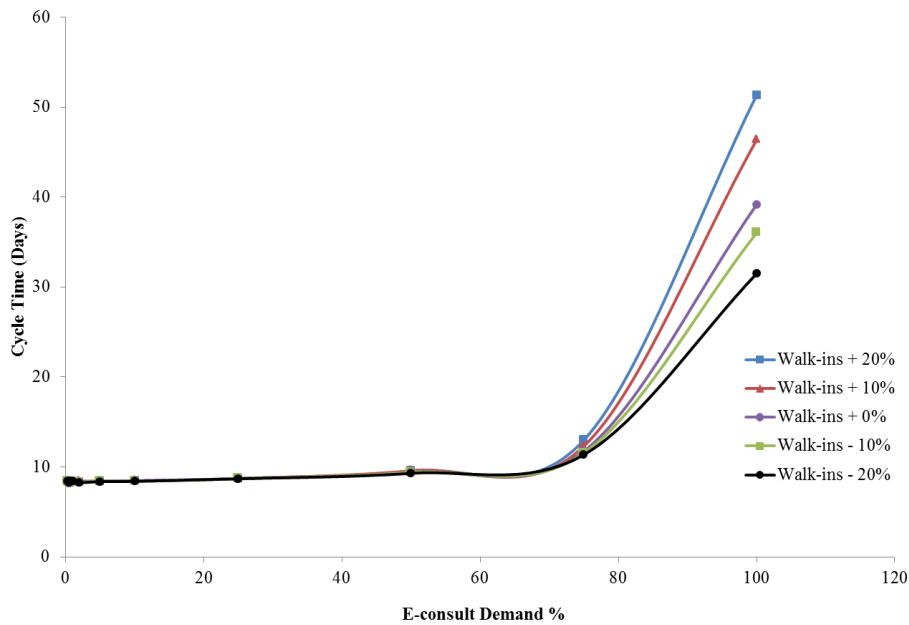


Figure 10: E-consult cycle time changes with e-consult demand and for various walk-in patient arrival rates.

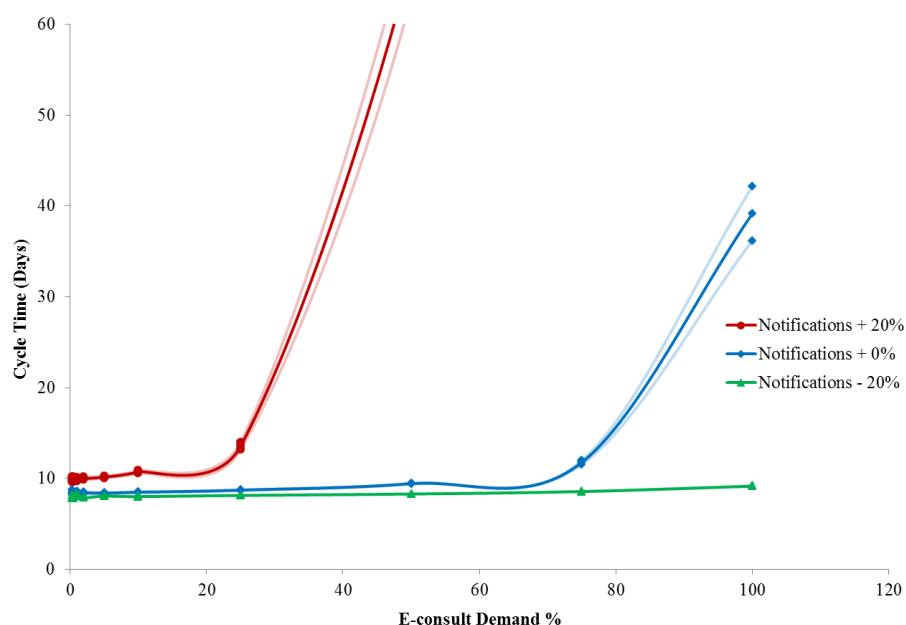


Figure 11: E-consult cycle time changes with e-consult demand and for various notification arrival rates.

Table 4: Results from multivariate analysis of factors' effects on e-consult cycle time. The R-square value is 0.982.

Factor	DOF	Statistically Significant?	P-value
E-consult Demand	10	Yes	< 0.0001
PCP Unavailability	2	Yes	< 0.0001
View Alert Arrivals	2	Yes	< 0.0001
Walk-in Rate	4	Yes	< 0.0001
E-consult Demand*PCP Unavailability	20	Yes	< 0.0001
E-consult Demand*View Alert Arrivals	20	Yes	< 0.0001
E-consult Demand*Walk-in Rate	40	Yes	< 0.0001
PCP Unavailability*View Alert Arrivals	4	Yes	< 0.0001
PCP Unavailability*Walk-in Rate	8	Yes	< 0.0001
View Alert Arrivals*Walk-in Rate	8	Yes	< 0.0001
E-consult Demand*PCP Unavailability*View Alert Arrivals	40	Yes	< 0.0001
E-consult Demand*PCP Outage*Walk-in Rate	80	Yes	< 0.0001
E-consult Demand*View Alert Arrivals*Walk-in Rate	80	Yes	< 0.0001
PCP Unavailability*View Alert Arrivals*Walk-in Rate	16	Yes	< 0.0001
E-consult Demand*PCP Unavailability*View Alert Arrivals*Walk-in Rate	160	Yes	< 0.0001



Table 5: Tukey's test to identify statistically significant differences between levels of the significant factors. (Note: Levels connected by the same letter are statistically similar. The connecting letter report does not apply between factors; its application is valid only between different levels within each factor.)

Factor	Levels	Connecting Letters Report							
E-consult Demand	0.31	A							
	0.5	A							
	0.75	A							
	1	A	B						
	2		B	C					
	5			C					
	10				D				
	25					E			
	50						F		
	75							G	
100								H	
PCP Unavailability	0	A							
	1		B						
	5		B						
View Alert Arrivals	7.09	A							
	8.41		B						
	10.64			C					
Walk-in Rate	0.8666	A							
	0.9398	A							
	1.04		B						
	1.156			C					
	1.3003			C					

In summary, all identified factors had a significant impact on e-consult cycle time. The system is much more sensitive to notifications compared to walk-ins. Additionally, PCP unavailability has a detrimental effect on e-consult cycle times. The negative effects of a period of PCP unavailability can be best mitigated by dividing up the additional workload between the remaining PCPs.

## 5 MANAGERIAL INSIGHTS

In the previous chapters, the model was described and validated. The analysis showed that the e-consult cycle time was significantly affected by PCP unavailability, view-alert notifications, walk-in patients and diabetes e-consult demand.

Due to the cost savings incurred by the implementation of telehealth, particularly e-consults, the VHA is eager to see increases in the usage of the e-consult process. The low adoption rate since the system's implementation in 2010 provided motivation for a marketing campaign targeting patients and PCPs to inform them of the benefits of e-consults and to encourage increased adoption of the system. The cost and time savings, as well as the added convenience of e-consults are also causes for more specialties to implement e-consult systems. All three of these factors lead us to believe that an increase in e-consult demand is imminent. This study identified multiple factors that significantly impact the non-clinical, time-based e-consult outcomes. It is imperative that measures are taken to reduce the effects of these factors on e-consults. Following, are some insights as to how this can be achieved.

Patient walk-ins have a significant effect on e-consult cycle times, therefore efforts should be made in order to reduce the frequency of arrivals of walk-in patients to VHA outpatient clinics. A walk-in patient demand reduction method that is employed at VHA outpatient clinics is termed as scrubbing. Scrubbing the schedule is where once a week nurses review the schedule and identify face-to-face patient appointments that may be suitable for a switch to a telephone appointment. The staff then contacts the patients to ask if they would like to change their face-to-face appointment to a telephone appointment. If the patient agrees, then a face-to-face appointment slot is opened. Time is also saved by switching to telephone appointments, because, generally, telephone appointments have shorter durations than face-to-face appointments. The slots opened up by scrubbing the schedule now allow for greater flexibility for the PACT to

accommodate walk-in patients. Another method of walk-in patient demand reduction is the encouragement of patients to call their PACT RN any time they have a question. This encourages telephone appointments and empowers the patient to call their RN, rather than walk-in and utilize the PCP's time for a face-to-face appointment. Although walk-in patient arrival rates significantly affect e-consult cycle time, the system is far more sensitive to view-alert notification arrivals (Figure 9).

The sensitivity of e-consult time-based outcomes to the arrival rate of view-alert notifications indicates that great care must be taken when determining what view-alerts the PCP should and should not be subjected to. Obviously some level of view alerts is necessary, but view alerts not imperative to the PCP, should be routed to a more appropriate pact member, such as an RN or LPN. For example, at a demand level of 3.50 e-consults per day, a 20% reduction in notification arrival rate would reduce the average e-consult cycle time from 39 days to 9 days.

Due to the system's sensitivity to notifications and walk-in patients, PCP unavailability has a substantial effect on e-consult cycle times. In the current system, PCPs with the designation of "team leader" are responsible for accommodating the additional notifications and walk-ins introduced into the system by the temporary unavailability of a PCP. Substantial reductions in e-consult cycle time can be achieved for all levels of diabetes e-consult demand by splitting the additional workload among the remaining PCPs on the team. In a 4 PACT CBOC, if a PCP is unavailable, then the shared workload between the remaining 3 PCP's will be  $1/3$ , compared to the team leader taking all the workload. In this case, at an e-consult demand level of 0.50 e-consults per day, splitting the workload can decrease the cycle time from 31 days to 9 days. As the number of PCPs that share the additional workload increases, the additional workload incurred by any one PCP becomes more manageable. Implementation of this workflow strategy likely will result in a significant improvement in e-consult cycle times.

In summary, e-consult non-clinical, time-based outcomes are sensitive to increases in e-consult demand, notification arrival rates, walk-in patient arrival rates, and PCP unavailability. Great care must be taken to ensure none of the aforementioned factors rise to levels that are unsustainable.

## 6 CONCLUSION AND FUTURE RESEARCH

The primary goal of this project was to improve the flow of e-consults between all of the major components of the system, including PACTs, specialty care, patients, and CPRS. The objectives of this study were to identify the effect of increased e-consult demand on non-clinical, time-based outcomes, quantify the sensitivity of the system to multiple factors and provide justification for recommendations to alleviate the detrimental effects of factors that significantly impacted the e-consult time-based outcomes.

We built and validated a DES model of the workflow of a Patient Aligned Care Team at a Veterans Health Administration (VHA) primary care clinic that employs a CPRS-based e-consult system. Although challenged by the unavailability of workflow and process time data, we conducted electronic shadowing, interviews with VA personnel, and time studies to acquire inputs for our model. Due to limits in the availability of workflow based data, some elements had small sample sizes. What-if analyses were performed with the simulation model by varying factors, such as e-consult demand, priorities, walk-in patient arrival rates, view-alert notification arrival rates and PCP unavailability.

All four factors included in the analysis were found to have a significant effect on e-consult cycle time ( $p < 0.05$ ). Significant reductions in cycle time can be achieved by abating the detrimental effects of PCP unavailability through splitting the unavailable PCP's workload between the remaining PCPs, rather than the current method of re-routing any additional workload to the team leader. For example, in the case of a 4 PACT clinic, the 5-day PCP unavailability case experiencing an e-consult demand of 15% or 0.50 e-consults per day yields e-consult cycle times greater than 30 days. The identical case yields an average cycle time of 9 days, if the workload is split between the

remaining three PCPs. Other recommendations are based on investigating methods of reducing walk-in patients and notification arrival frequencies.

The simulation model presented in this research models the workflow and parameters associated with diabetes e-consults only. Modeling increased levels of diabetes e-consult demand provides insights regarding what will happen when diabetes e-consults become more frequent, but these insights are limited to outcomes related to diabetes e-consults only. In some cases, the insights provided can apply to other specialties conducting e-consults, such as the system's sensitivity to the arrival rate of view-alert notifications. Great care must be taken when applying the strategies discussed in this research to other e-consult specialties because e-consults for other subspecialties may have different workflows.

Although out of the scope of this research, which focuses on time based e-consult outcomes, utilization based measures and patient-wait times are also important. Our model can be enhanced, to capture these elements, such as RN workload, stochastic patient arrival times, and patient-wait times, if appropriate workflow and process time data are available. This would give the VA a complete picture of the operations at a primary care clinic.

## **6.1 Future Research Opportunities**

A key outcome of this research is the quantification of a 75% decrease in e-consult cycle time by reducing the notification arrival rate by 20%. This result suggests that it would be beneficial to conduct a research study regarding the elimination of superfluous view-alert notifications. One possible notification reduction method would be to analyze and discern whether the more common notifications are being sent to the right member of the PACT. Perhaps some notifications sent to the PCP could be more appropriately handled by a PSA.

Other benefits may come from the development of more efficient information transfer mechanisms. Multiple PCPs suffer from excessive time delays when processing

notifications because of their inability to type with speed and accuracy. One method of alleviating this, currently employed by the VHA, is the use of a voice to text service. With this service, providers call into a call center and leave a voice message that they want translated into text and placed into a patient chart. This system is cumbersome, and requires that PCPs wait before a note is transferred into a patient's file. Interviews with PCPs indicated that the slow nature of this system is likely a cause for lack of PCP adoption. It may be more beneficial to adopt voice-to-text software so that PCPs can quickly speak their response to a view-alert notification directly into a patient chart. The adoption of voice-to-text software could be incorporated into our simulation model by measuring the reduction in time it takes for the PCP to interact with their computer at all stages in the e-consult process.

E-consults are significantly affected by the rate of walk-in patient arrivals. Improvements in e-consult, time-based outcomes may result from the study and implementation of strategies that can be employed in order to reduce the level of walk-in patients experienced by VHA clinics. Currently, some VHA clinics employ scrubbing, a method of transferring upcoming face-to-face patient appointments into cheaper and quicker telephone appointments, thus leaving face-to-face appointment slots open to accommodate walk-in patients. Another approach employed by some VHA outpatient clinics to reduce the occurrence of walk-in patients is cold calling. This is where providers and PSAs will call patients who either have not had an appointment lately, or have complex conditions that require frequent interaction with their provider. The calling of the patient to assess their health status may yield a telephone appointment or face-to-face appointment. This helps to reduce the number of walk-ins because at risk patients may be called and treated before their condition worsens to the point where they need an immediate walk-in appointment.

It would be advantageous to implement an automatic e-consult performance feedback system so that non-clinical, system-based outcomes can be efficiently collected. Aside from the alleviation of time requirements associated with the manual review of patient EHRs, this implementation would result in increased management and provider awareness of the performance of the e-consult system. With more frequent insights into

the performance of the e-consult system, accurate and realistic goals can be set in order to encourage improvements in performance. Also, with the implementation of an automatic e-consult non-clinical, time-based, outcome tracking system, the effect of the implementation of new workflow strategies could be easily quantified.

Once more data becomes available regarding the workload and workflow associated with other subspecialties that have adopted e-consults, this model could be easily adapted to incorporate the demands placed on the PACT by e-consults from other specialties. Our proposed model is generic enough to capture additional e-consult workflows and help in analyzing the interaction effects of multiple types of e-consults on a single PACT.

Additional detail can be incorporated by extending the DES model to include the patient arrival and scheduling process. The addition of modeling patient arrivals and scheduling may affect the level of workload experienced by the PSA, RN, and LPN. This addition would complement this research because it would provide the ability to further investigate the effect of e-consults on PACT utilization rates.

A further level of detail can be captured by incorporating separate time distributions of PCP-patient interactions for face-to-face visits that do and do not yield e-consults. Because of the infrequent use of the e-consult system at the time of this research, this data was not available and so this detail was not captured by the simulation model.

Another factor, the priority with which e-consult notifications are processed by the PCP, likely has a significant effect on e-consult cycle time. Because of the lack of a common prioritization system employed in VHA outpatient clinics; all notifications were modeled in this work as FIFO. The implementation of a common notification prioritization system would ensure that e-consult notifications are prioritized in the proper manner, and allow for this aspect to be more accurately captured in the simulation model.

Additionally, the simulation model can be extended to simulate the workload effects of e-consults on specialty care. This extension would be of great value to the

VHA because specialty care is one of the primary parties intended to experience benefits from the implementation of e-consults. It would be useful to quantify the workload effects of e-consults on members of specialty care, as well as the increase in the number of patients who are served by specialty care through e-consults and/or decrease in the wait times for the patients needing face-to-face consultation. This extension would also benefit this research because the time distribution of the specialist phase would be better captured.

Additionally, this work could be extended by simulating the handling of e-consults by specialties across VISN 10. The location and allocation of specialist resources could be analyzed with the intent of pooling specialists' time in order to maximize the efficient handling of e-consults, as well as contribute to reduced e-consult cycle times.

Assuming the availability of data, it would be beneficial to model the therapeutic implementation of e-consults. If this aspect were included, then the impact of e-consults on patient follow-up visits could be quantified. Aside from the other benefits of e-consults, quantifying the effect of e-consults on patient follow-up visits would provide additional justification for further investment into the e-consult innovation.

In summary, the e-consult process initiated at the VA is complex and dynamic. Numerous sociotechnical factors are involved due to the interdependencies among humans, technology, and the workflow itself. Our research presents an adaptable model, capable of quantifying workflow effects on non-clinical, time-based outcomes and has already identified multiple feasible areas of improvement.



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## APPENDIX A

Table 6: Breakdown of sample by visit frequencies for 1200 patient panel.

Visit Freq	Percentage of Sample	Number of Pts	Visits Per Year
1	0.43	513	513
2	0.33	399	797
3	0.14	170	509
4	0.04	50	199
5	0.03	33	164
6	0.01	10	57
7	0.01	15	104
8	0.00	4	34
9	0.00	3	29
10	0.00	3	32
Total	100%	1199	2438

Table 7: Fiscal year 2012 diabetic patients and e-consult demand.

Provider	Total Patients Assigned	Diabetic Patients	% Diabetics of Total	e-consults	% That Had e-consults
PCP 1	1,048	351	33%	6	0.57%
PCP 2	1,137	329	29%	2	0.18%
PCP 3	1,403	482	34%	3	0.21%
PCP 4	1,350	409	30%	2	0.15%
PCP 5	1,272	423	33%	4	0.31%
Total	6,210	1,994		17	
Percentage		32.11%			0.27%

Table 8: Scheduled patient arrivals are based on a full PCP schedule.

<b>Time Slot</b>	<b>Monday</b>	<b>Tuesday</b>	<b>Wednesday</b>	<b>Thursday</b>	<b>Friday</b>
8:30	x	MTGs	x	x	x
9:00	x	MTGs	x	x	x
9:30	x	x	x	x	x
10:00	x	x	x	x	x
10:30	x	x	x	x	x
11:00	x	x	x	x	x
11:30	x UC	x UC	x UC	x UC	x UC
12:00	Lunch	Lunch	Lunch	Lunch	Lunch
12:30	Notes	Notes	Notes	Notes	Notes
1:00	x	x	x	x	x
1:30	x	x	x	x	x
2:00	x	x	x	x	x
2:30	x	x	x	x	x
3:00	UC/P	UC/P	UC/P	UC/P	UC/P
3:30	UC/P	UC/P	UC/P	UC/P	UC/P
4:00	Notes	Notes	Notes	Notes	Notes