

**A SYSTEMS ENGINEERING ANALYSIS OF OPPORTUNITIES FOR
PHARMACISTS ON DIABETES CARE TEAMS**

by

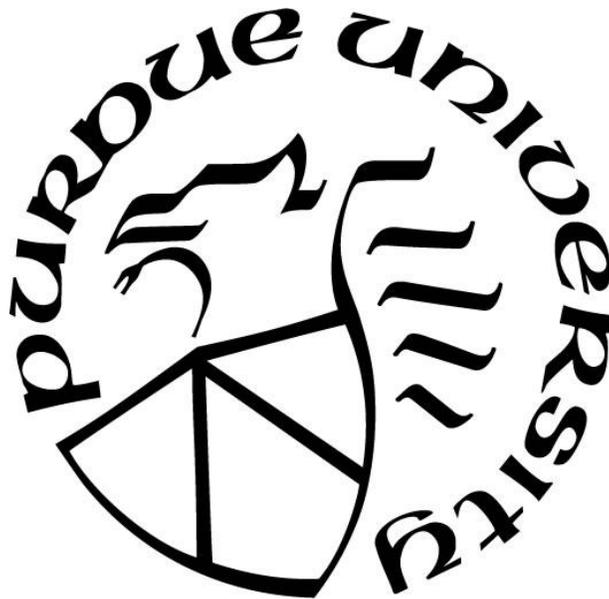
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LIST OF ABBREVIATIONS

ADE	Adverse Drug Event
CCM	Chronic Care Model
CDE	Certified Diabetes Educator
CDTM	Collaborative Drug Therapy Management
CGM	Continuous Glucose Monitoring
CHIPPER	Community Health Integration through Pharmacy Process and Ergonomics Redesign
DNE	Diabetes Nurse Educators
DRIFT	Diabetes care Roles Information Flows and Team Coordination
eHealth	Electronic Health
EHR	Electronic Health Record
END	Endocrinologist
FDA	Food and Drug Administration
HCP	Healthcare Professional
Health IT	Health Information Technology
HIPAA	Health Insurance Portability and Accountability Act
MD	Medical Doctors
MTM	Medication Therapy Management
NP	Nurse Practitioner
PA	Physician Assistant
PCMH	Patience-Centered Medical Home
PCP	Primary Care Provider (includes MDs, NPs, and PAs)
Pharm	Pharmacist
RD	Registered Dietitian
RN	Registered Nurse
SMBG	Self-Monitored Blood Glucose
SoS	System-of-Systems
SW	Social Worker

ABSTRACT

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Title: A Systems Engineering Analysis of Opportunities for Pharmacists on Diabetes Care Teams

Committee Chair: Barrett S. Caldwell

Diabetes is one of the most significant global healthcare challenges of the 21st century: it is estimated that one in three adults will have diabetes in the United States in the year 2050. As a result, healthcare organizations are integrating systemic changes to address the needs of expanding chronic care patient population, including shifting towards a patient-centered medical home philosophy and introducing new health information technology tools to help share the workload for diabetes care activities. Advanced educational opportunities, collaborative-practice agreements, and a shifting model towards community-based care clinics affords opportunities for pharmacy professionals to participate in a more central role on the diabetes care team.

This dissertation work explores the intersection of diabetes care coordination and health information technology (IT), with a specific focus on the potential for pharmacist involvement on the diabetes care team. Studies I and II aimed to define the existing diabetes care team as a system, with identifying the specific roles, information flows, tasks, and temporal and geospatial attributes for providing effective care. Study I used a questionnaire and social network analysis tools to identify the key members of the diabetes care team. The results indicated that these team members were the primary care provider, endocrinologist, nurse, pharmacist, dietitian, and social worker. Study II used semi-structured interviews and team task analysis for thirty (N=30) diabetes care team member participants (N=5 for each category indicated in Study I). The results from Study II led to the creation of a new systems engineering analytical framework, titled *Diabetes care Roles Information Flows and Team Coordination* (DRIFT). This framework expanded existing chronic care and healthcare systems engineering frameworks through the inclusion of granularity, temporal, and sociotechnical factors in a three-dimensional systems model. Study II also provided confirmatory support for the inclusion of pharmacists for sharing more care coordination activities on diabetes care teams.

The results from studies I and II were synthesized to identify potential engineering health IT solutions to gaps in diabetes care activities. The results synthesis was the foundation of a new health IT system prototype, *eVincio*, developed by the author for this dissertation work. *eVincio* is comprised of a patient-facing mobile application and a provider-facing desktop software that worked together to help healthcare professionals visualize patient care activities via the DRIFT analytical framework. Study III was a formative usability assessment of the *eVincio* prototypes with six (N=6) pharmacist participants. Results revealed that *eVincio* could be very beneficial for helping healthcare professionals visualize patient care activities and identify gaps in care coordination, particularly for professionals who work as case managers, population health analysts, or have some aspect of quality monitoring in their role. As the *eVincio* system is still in a prototype stage of development, additional studies need to be conducted to determine system requirements for interoperability, evidence-based guidelines, and fulfilling end-user requirements.

1. INTRODUCTION

Diabetes mellitus, more commonly known as *diabetes*, is one of greatest public health epidemics and healthcare system challenges of the 21st century (Rosella et al., 2016; Zimmet, Alberti, & Shaw, 2001). This disease occurs when people cannot produce insulin (type I diabetes) or effectively use insulin (type II diabetes) to break down blood glucose in the blood stream. The majority of people with diabetes are classified with type II diabetes, where the onset of the disease occurs later in life typically due to lifestyle factors (WHO, 2013).

The increasing rate of diagnoses, the growing economic burden on healthcare systems, and the generally preventable nature of type II diabetes make this disease a prime healthcare issue for targeted technological and process interventions. Research has shown promise for diabetes interventions, including medication therapy management (MTM), and other non-clinical intervention strategies (e.g., educational programming, community support) for increasing patient adherence and decreasing diabetes-associated costs (Chawla, 2011; Juvenile Diabetes Research Foundation, 2010; Herrick, 2007; Murphy et al., 2008; Or & Tao, 2014; J. C. Pickup, Freeman, & Sutton, 2011; Planas, Crosby, Mitchell, & Farmer, 2009; Porter, Huggins, Truby, & Collins, 2016; Viswanathan et al., 2015). However, these interventions are sometimes implemented in isolation without consideration for the surrounding system context or end users (Ellis, 2015; Kushniruk & Patel, 2004; Rodbard, 2016; Tung & Peek, 2015), thus making the intervention less effective (Ash, Berg, & Coiera, 2004). Furthermore, it is critical that people with diabetes receive the appropriate care at the optimal time due to the temporal dynamics of diabetes symptoms (Sherman, 2017). As a result, there is a need to implement and integrate diabetes management technologies and processes so that they can enhance coordination and information exchanges across a distributed care system (Everett et al., 2013; Hume et al., 2012; Kushniruk & Patel, 2004).

Spatially and temporally distributed pharmacy systems (e.g., community and ambulatory pharmacies) have the potential to fill gaps in diabetes management activities (Ellis, 2015; Stempniak, 2013; White & Hohmeier, 2015). The changing role of pharmacy professionals (Nahata, 2015), combined with recent health information technology (IT) advances, provides

new diabetes management opportunities for pharmacy professionals (Ellis, 2015). To explore this new research intersection of pharmacy systems and diabetes-focused health IT, this dissertation aims to address two main questions: 1) *what opportunities exist for spatially and temporally distributed pharmacists to participate effectively in diabetes care teams?*; and 2) *how can health information technology better support pharmacist information coordination for diabetes care?* The first question aims to understand the role of pharmacists on diabetes care teams and explore the interactions between pharmacists and team members with regards to information flows and task coordination. The second research question investigates the potential for involving pharmacists in diabetes care processes via a new health IT system designed to help coordinate care and information across healthcare systems.

The anticipated findings from this dissertation are expected to have both applied and theoretical impacts. Research results for the first research question will help define the diabetes care team structures and processes related to pharmacist coordination. The results from this question will be useful for addressing gaps in the chronic care model and healthcare team research as it relates to diabetes care. The second research question will explore the specific needs of pharmacists as an end user of a new health IT system for coordinating care for chronic disease patients. The data responding to the second research question can be generalized for medical software vendors interested in EHR systems and other data management systems for chronic care data tracking. It will also be helpful for medical software vendors interested in a new business case, as pharmacists are not typically viewed as the end users of diabetes software designed for healthcare professionals. The theoretical contributions of this work aim to extend previous work on improving systems engineering frameworks with respect to chronic care, granularity, temporal data, and information flows (Jahn, Heiden, & Caldwell, 2018).

This dissertation is organized as follows: literature review (Chapter 2), which addresses current research and identifies gaps; and research overview (Chapter 3), which outlines the specific research questions and justifications for the proposed methods; Studies I & II methodology (Chapter 4); Studies I & II results (Chapter 5); Study III methodology (Chapter 6); Study III results (Chapter 7); global discussion for studies I, II and III (Chapter 8); and conclusion (Chapter 9).

2. LITERATURE REVIEW

Diabetes is one of the most challenging healthcare concerns of this century due to its exponential growth in diagnoses and economic impact (Rosella et al., 2016; Zimmet et al., 2001). Fortunately, the complications from diabetes can be mitigated if patients and healthcare professionals (HCPs) work together to manage the disease (Seuring, Archangelidi, & Suhrcke, 2015). To improve the delivery of care for people with diabetes, it is critical to first understand the current state of healthcare system components and how they interact and affect diabetic patient care processes. The primary system of interest in this dissertation is the diabetes care team (using a U.S. healthcare perspective), where the system goal is effective information coordination between HCPs. The following literature review will examine the team structure, processes, and technology that affect information coordination for diabetes care teams (Garrett & Caldwell, 2009).

This chapter opens by explaining the impact of diabetes on the U.S. healthcare system as part of the justification for this work. Next, there is an overview of the types of diabetes and then a brief history of diabetes information technology to familiarize the reader with some of the common terminology involved with monitoring the disease state via health IT. Then the chapter explores the existing literature on the structure of diabetes care team and the processes involved for information coordination. The review of the technology, team structure, and processes will culminate in a section that identifies potential gaps and opportunities for research questions that this thesis intends to address. The chapter concludes with a review of relevant human factors work and applicable systems engineering methods for addressing the gaps in the research.

2.1 Overview of Types of Diabetes

Diabetes mellitus is a group of metabolic diseases where the body is unable to produce and/or effectively use insulin, resulting in high blood glucose values (hyperglycemia) (Thomas & Philipson, 2015). Insulin is a hormone that is produced in the pancreas, which helps the glucose from nutrients be absorbed by cells for energy. The most common forms of diabetes are type 1 (autoimmune) and type 2 (nonautoimmune) (WHO, 2013).

2.1.1 Type I Diabetes

Type I diabetes, or insulin dependent diabetes, occurs when the body does not produce any insulin, thus requiring patients to be very diligent with monitoring and insulin administration to stay alive. Type I diabetes is often referred to as *juvenile diabetes* because it typically appears earlier in life—although it may appear at any age (Thomas & Philipson, 2015). A subset of Type I diabetes, called Latent Autoimmune Diabetes of Adults (LADA) or 1.5 diabetes, has been discovered more recently, and seen in adults in their 40's where the disease slowly progressed to complete insulin dependence within six years (Thomas & Philipson, 2015; U.K. Prospective Diabetes Study, 1995). The cause of type I diabetes is not currently known, and it is not preventable at this time.

2.1.2 Type II Diabetes

Type II diabetes, sometimes referred to as non-insulin dependent or adult-onset diabetes, occurs when the body is not capable of effectively using insulin produced by the pancreas. This results in an excess of glucose in the blood stream that cannot be broken down or absorbed for nutrients. The majority of people with diabetes have type II diabetes, and the rise of the disease has been connected to an increase in sedentary lifestyles and poor diet (WHO, 2013). Type II diabetes may also occur in children (WHO, 2013). Treatment for people with type II diabetes can range from healthy eating and exercise, to medications, to insulin injections. Although people with type II diabetes may not need to test their blood glucose as frequently as those with type I diabetes, monitoring can still help patients manage their disease (Guerci et al., 2003).

2.1.3 Non-classified Diabetes

There are a few other forms of diabetes that do not occur as frequently and are often triggered by other diseases or conditions. One of the more common types of non-classified diabetes is gestational diabetes, which occurs during pregnancy (WHO, 2013). Other types of non-type I or II classified diabetes are monogenic, drug associated, or disease associated (e.g., cystic fibrosis, pancreatitis, or HIV) (Thomas & Philipson, 2015). Monogenic diabetes refers to diabetes that occurs from a genetic mutation (Thomas & Philipson, 2015). These non-classified forms of diabetes are outside the scope of this dissertation work.

2.1.4 Prevalence

An estimated 30.3 million people (9.4%) of the U.S. population are currently living with diabetes, and 7.2 million (23.8%) of those people are unaware that they have the disease (CDC, 2017). Many research surveys and approximations do not differentiate between type I or type II (CDC, 2017), however, it is estimated that between 90 to 95% of the diabetes population have type II diabetes, and approximately 5% of people with diabetes are type I (Menke, Casagrande, Geiss, & Cowie, 2015).

2.2 Diabetes Impact on Healthcare Systems

Diabetes contributes significantly to mortality, morbidity, and healthcare costs globally (NCD-RisC, 2016; Seuring, Archangelidi, & Suhrcke, 2015). People with diabetes typically have a lower quality of life (Rosella et al., 2016) and a higher rate of co-morbidities and complications, such as: cardiovascular disorders, obesity, cancer, blindness, lower limb amputation, and dyslipidemia (ADA, 2013). This debilitating chronic disease is the seventh leading cause of death in the U.S., and experts predict that one in three Americans will have diabetes by the year 2050 (CDC, 2010). The costs incurred from diabetes in the U.S. result in an economic burden of over \$245 billion annually, with \$176 billion in direct medical costs and \$69 billion in reduced productivity (American Diabetes Association, 2013). It is estimated that people with diabetes have annual medical expenditures that are 2.3 times that of patients without diabetes (American Diabetes Association, 2013). Several studies (Birnbaum, Leong, & Kabra, 2003; Minor, 2011; Vijan, Hayward, & Langa, 2004) have quantified the increasing costs of diabetes to demonstrate the potential for preventative measures to mitigate some of the economic burden (Seuring et al., 2015; Stratton et al., 2000).

Negative healthcare outcomes for people with diabetes (e.g., limb amputation, neuropathy, kidney failure, blindness) can be largely prevented through close monitoring of diabetic patient status and coordinating of information among members of a patient's diabetes care team. This information coordination oftentimes occurs with the aid of technology (e.g., diabetes monitoring devices and their supporting software and mobile applications). When designing these tools,

medical device companies should consider how the technology could best support user's cognitive tasks and information needs.

2.3 Diabetes Care Teams

A team is defined as “a small number of people with complementary skills who are committed to a common purpose, set of performance goals and approach for which they hold themselves mutually accountable” (Katzenbach & Smith, 1993). Although the study of teamwork is not new, it has more recently been recognized as a critical component of quality and effective healthcare delivery processes (Borrill et al., 2000; Manser, 2009). Research on provider collaboration has found that when the patients are at the center of their care, there are more complementary roles for other members of team, resulting in better coordination and more complete records of information (Fagin, 1992; Garrett & Caldwell, 2009; Goldszer, 2004). Furthermore, effective team coordination can result in members anticipating and responding to information or task needs without prompting from others (Garrett & Caldwell, 2009; Stahl, 2006). Like other teams in time-critical environments, healthcare teams may have a variety of experts with differing education and approaches to team activities (Manser, 2009), thus making it essential to identify the team structure, members, and processes (Garrett & Caldwell, 2009; Wagner, 2000). The following sections review the theoretical model for diabetes care teams, identifies team members, and reviews the diabetes care team tasks and roles.

2.3.1 Chronic Care Model (CCM)

With the rise of Type II diabetes and other chronic comorbidities (e.g., heart disease, arthritis), there has been an increased focus on the chronic care team and disease management (Wagner, 2000). One of the most oft-cited theoretical models in the chronic care literature is the Chronic Care Model (CCM) (**Figure 1**), which was developed in attempts to address deficiencies in chronic care processes and redesign the supporting healthcare system components (Wagner, 1998). The CCM has six domains: self-management support, delivery system design, decision-support, information systems, health systems, and community resources (Barr et al., 2003; Bodenheimer, Wagner, & Grumbach, 2002a, 2002b; B. L. Carter, Bosworth, & Green, 2012; Wagner, 1998, 2000). The health system includes self-management support, which aims to encourage patients to manage their own healthcare; delivery system design, which is for both

clinicians and self-management support processes; decision support, which is based on both patient preferences and evidence-backed research; and information systems, which organize both patient data for patients and providers as required (NIH, 2011).

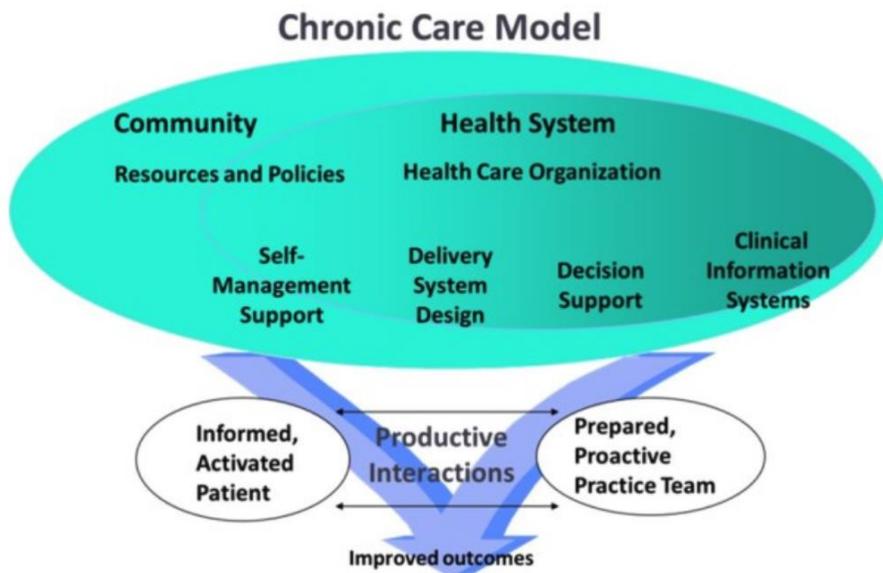


Figure 1. The Chronic Care Model, MacColl Institute, reprinted with permission from ©ACP-JSIM.

Diabetes care teams have been the main prototype for the development of the CCM over the past two decades (Clement, Harvey, Rabi, Roscoe, & Sherifali, 2013). Multiple studies have shown the importance of multidisciplinary teams with specific diabetes training and focus (Clement et al., 2013; Pimouguet, Le Goff, Thiébaud, Dartigues, & Helmer, 2011; Shojania et al., 2006; Tricco et al., 2012). CCM research has found several quality improvement strategies for improving glycemic control, such as: facilitated relay of clinical information, electronic patient registries, audit and feedback, clinician education, and clinician reminders (Clement et al., 2013; Tricco et al., 2012). These improvement strategies combine the various domains of CCM (i.e., information systems, decision support) to help support prepared and proactive diabetes care teams. Additional research has found that telehealth technologies and health IT can support disease management by facilitating collaboration with members of the distributed care teams (Clement et al., 2013; Verhoeven, Tanja-Dijkstra, Nijland, Eysenbach, & van Gemert-Pijnen, 2010).

In addition to focusing on specific chronic diseases, CCM researchers have reviewed tools that can help support self-management and clinical decision support more generally (Gee, Greenwood, Paterniti, Ward, & Miller, 2015). This research has resulted in a modified version of the CCM with an emphasis on electronic health (eHealth), which includes the Internet, social networking communities, telehealth, mobile health, electronic health records (EHRs) (**Figure 2**). This expanded model helps provide insight into the role of eHealth technology, specifically with highlighting the importance of eHealth education, enhanced interaction with eHealth communities, and completing feedback loops between technology-based interactions between patients and providers (Gee et al., 2015).

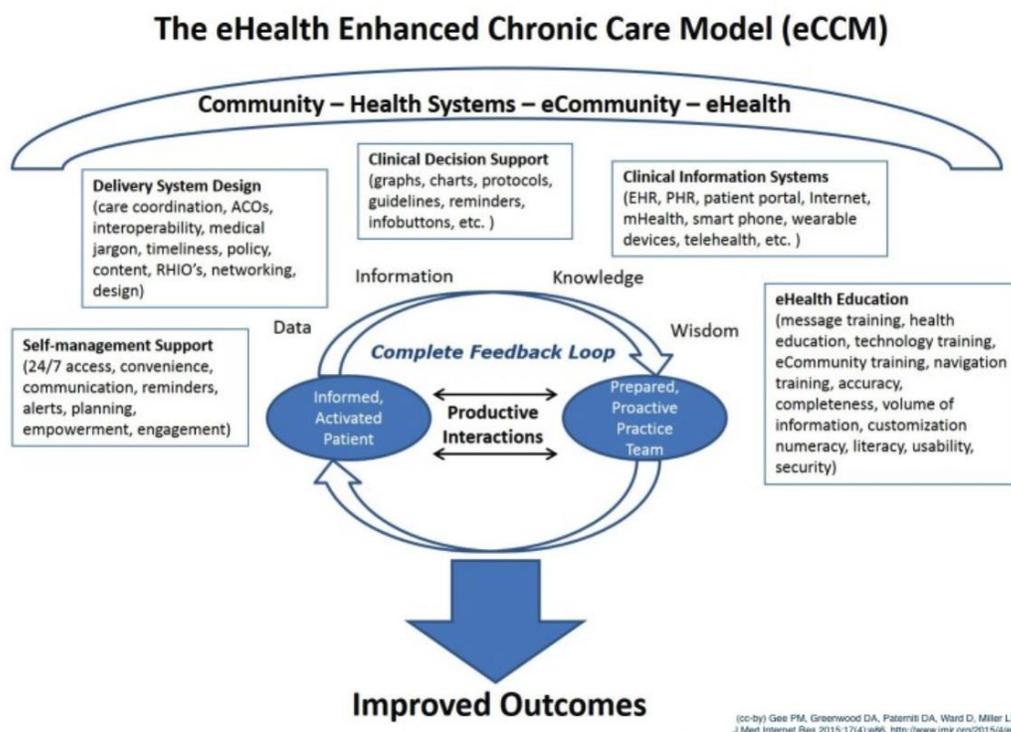


Figure 2. The eHealth Enhanced Chronic Care Model (Gee et al. 2015).

The culmination of CCM research suggests that healthcare systems should shift towards a Patient-Centered Medical Home (PCMH) model (**Figure 3**) (Bates & Bitton, 2010; Bitton, Martin, & Landon, 2010; Coleman, Austin, Brach, & Wagner, 2009; NIH, 2011; Reid et al., 2009; Stange et al., 2010). The PCMH is not a place, but rather a partnership a patient has with their primary care providers where the patient is at the center of their care (Nielsen, Buel, Patel, & Nichols, 2016). PCMH relies on technology (e.g., emails, phone calls, mobile applications,

electronic health records) for patients to communicate with their providers so that they can receive the right care at the right time (Bates & Bitton, 2010). Studies show that this framework of patient support can provide better support and communication, create stronger relationships between patients and their providers, and save time for patients and providers (Clarke et al., 2015; Coleman et al., 2009; Nielsen et al., 2016; Pourat, Davis, Chen, Vrungos, & Kominski, 2015; Rosenthal et al., 2016; Yoon et al., 2015)

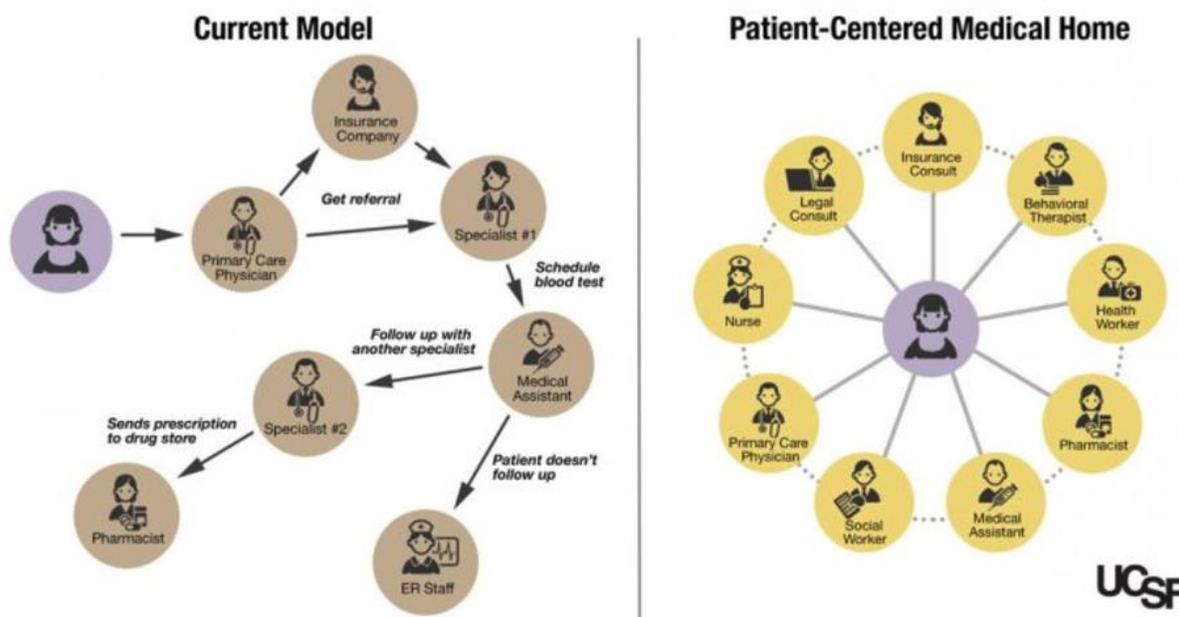


Figure 3. PCMH vs. Current Model (Masterson, 2014).

The left depicts the current, disjointed model of patient care. Here you can see how patients receive care from a variety of HCPs and there may not be appropriate technologies, tools, or processes in place for the HCPs to coordinate information. At right, the PCMH model has the patient engaged at the center of their care. There are mechanisms for the providers to also coordinate with one another (Masterson, 2014).

2.3.2 Diabetes Care Team Members

Chronic care team research has identified several best practices for the structure of chronic care teams for diabetes disease management. Clement et al. (2013) suggests that the diabetes care team should involve collaboration between a primary care provider (PCP) (including Nurse Practitioners and Physician Assistants) and an endocrinologist (i.e., diabetes specialist physician). This proposed team model has found that adults with type II diabetes may see improvements in A1C values, blood pressure, lipids, and other care processes, versus if the

patient just saw one of the two healthcare providers (Borgermans et al., 2009; Clement et al., 2013; Saxena et al., 2007; Van Bruggen, Gorter, Stolk, Klungel, & Rutten, 2009; Willens, Cripps, Wilson, Wolff, & Rothman, 2011).

Unfortunately, specialists and PCPs may face significant time constraints and resource limitations (B. L. Carter et al., 2012). PCPs see many patients with a variety of healthcare concerns, and they may not have the bandwidth to navigate the complexities of diabetes disease management all by themselves. Endocrinologists also typically see their patients annually or on an as needed basis, which limits the amount of support they can provide to PCPs. These constraints lead to the addition of nurses (RNs, NPs, DNEs) and pharmacists on diabetes care teams (Clement et al., 2013; NIH, 2011). Many activities for diabetes risk reduction involve long-term, ongoing monitoring activities (e.g., blood pressure screening, A1C monitoring) and patient education initiatives, which can be provided outside of the traditional office-based clinical care (B. L. Carter et al., 2012). These activities include nurses and pharmacists in the diabetes care processes in non-traditional environments (e.g., patient homes, community clinics) and via non-traditional methods (e.g., telemedicine, remote monitoring) (Aalaa, Malazy, Sanjari, Peimani, & Mohajeri-Tehrani, 2012; Armor, Britton, Dennis, & Letassy, 2010; B. L. Carter et al., 2012; Everett et al., 2013; Furler et al., 2014).

Although the definitions of the diabetes care team members vary slightly, the literature seems to reach consensus that the core team members are the PCP, endocrinologist, nurse, and pharmacist (Armor et al., 2010; Clement et al., 2013; Peimani, Tabatabaei-Malazy, & Pajouhi, 2010; Rodgers et al., 2014; Willens et al., 2011). Often, at least one member of the diabetes care team (typically the nurse or pharmacist) will have diabetes education certification to assist with patient counseling (Aalaa et al., 2012; Armor et al., 2010). The title “pharmacist” can cover a broad range of settings, responsibilities, and interactions with patients and providers. The literature indicates that the pharmacist role on the diabetes care team refers to pharmacists that are temporally and spatially distributed from team members (e.g., ambulatory, retail, community, and clinic pharmacy settings). The term “pharmacist” will refer to this type of pharmacist throughout the remainder of this document.

Other members on a diabetes care team could include podiatrists, optometrists, dental care professionals, dietitians, community health workers, and mental health professionals, but these professionals are sometimes omitted from the core diabetes care team because patients do not interact with these HCPs as frequently (Rodgers et al., 2014). Despite this working definition of a core diabetes care team and peripheral team members, the definition is somewhat limited in that it does not explore how the definitions of “core” team members vary by different HCP perceptions and their respective care settings.

2.3.3 Diabetes Care Team Tasks and Roles

A diabetes care team aims to help patients cope with the myriad of complications from the chronic disease (CDC, n.d.). The primary goal of each member of the diabetes care team is to assist with activities that support the patient’s overall health and safety, with an emphasis on preventative and proactive care. The specific goals and tasks can vary by the team member’s area of expertise and role on the team. Flexibility is also a key component of diabetes care team processes; teams may change and roles may expand in order to provide patients with the best possible care (Clement et al., 2013; Everett et al., 2013)

2.3.3.1 Primary Care Providers

Diabetes patients are typically diagnosed by their PCP, and PCPs provide more than 80 percent of all diabetes care in the U.S. (Peterson et al., 2008). If a patient has a medical emergency and the inpatient physician provides the diagnosis, the next step in continuing their care is with the patient’s PCP. However, system constraints make it difficult for PCPs to complete all aspects of diabetes care by themselves. These constraints include the PCPs ability to identify patients who are at risk for co-morbidities, conduct ongoing education and care interventions, remote monitoring of disease metrics, and provide periodic examinations for complications from the disease (NIH, 2011; Roman & Harris, 1997). These limitations lead to the broadening of the diabetes care team to include endocrinologists, pharmacists, nurses, and other care providers to support their care activities (NIH, 2011).

2.3.3.2 Endocrinologists

After an initial diabetes consultation, the PCP would refer the patient to specialists (e.g., endocrinologist, optometrist, psychologist, podiatrist, dentist) for additional care, if needed

(CDC, n.d.; Clement et al., 2013). The endocrinologist is the most common specialist that interacts with PCPs. Endocrinologists typically see their patients annually unless there are complications with the patient's care. During the annual visits, the endocrinologist and their supporting staff (DNEs, RNs) will discuss the patient's care plan, which can include lifestyle components (e.g., diet, exercise, tobacco use, stress), medications, and relevant health metrics (e.g., A1C, blood pressure, cholesterol) (CDC, n.d.). If a patient is using technology to monitor their disease (e.g., SMBG, CGM) the endocrinologist can review the trends and values from these devices during the appointment as well. The time is limited during the endocrinologist interactions, so patients may follow up their appointment with counseling with a CDE for further patient education.

2.3.3.3 Nurses

Nurses are key members of the diabetes care team. They contribute through prevention and early detection of diabetes processes, community education, and health systems management (Aalaa et al., 2012). Nurses typically assist PCPs, specialists, and inpatient units for supporting diabetes care with education, examination, and screening. The major goals of nurses focused on diabetes disease management are: health promotion, prevention of disease, patient care, and simplifying patient compliance (Aalaa et al., 2012). To achieve these goals, nurses may take any combination of the following roles: care connector, educator, consultant, leader, researcher, patient advocate, or health care provider (Aalaa et al., 2012). The presence of a nurse on a diabetes care team has shown to improve glycemic control, cardiovascular risk factors, and blood pressure outcomes (Clement et al., 2013; Saxena et al., 2007; Welch, Garb, Zagarins, Lendel, & Gabbay, 2010).

2.3.3.4 Pharmacists

The role of the pharmacist in diabetes care is rapidly changing globally as a response to the increasing number of diabetic patients, educational opportunities, practice agreements, and reimbursement opportunities (Armor et al., 2010; Dietz, 2016; Fazel, Bagalagel, Lee, Martin, & Slack, 2017; Feletto, Wilson, Roberts, & Benrimoj, 2010). Medication therapy management (MTM) services were introduced in the mid-2000s as a Medicare Part D initiative for prescription drug benefits, with the key goals of providing drug counseling, improving medication adherence rates, detecting adverse drug reactions, and improper drug use (Chawla,

2011). Since the start of MTM services, several studies have demonstrated that pharmacies have had a significant impact on clinical outcomes and costs for diabetes (APA, 2005; Barnett et al., 2009; Chawla, 2011; Collins, Limone, Scholle, & Coleman, 2011; Doucette, McDonough, Klepser, & McCarthy, 2005; Isetts, 2012; Olvey, Guy, Chang, & Skrepnek, 2014; Viswanathan et al., 2015). A recent survey on the pharmacy workforce found that over half of a pharmacist's time was spent providing medication therapy management (MTM) (Gaither, Schommer, Doucette, Kreling, & Mott, 2015; Nahata, 2015). Changes in healthcare policies and care reimbursements are also influencing shifts in the pharmacist role (Ellis, 2015; Mossialos, Naci, & Courtin, 2013). More pharmacists are getting additional residency experience and diabetes education certification to help expand their clinical roles (Armor et al., 2010; Shane-McWhorter et al., 2009). Collaborative Drug Therapy Management (CDTM) agreements are also allowed in nearly all 50 states, where pharmacists can provide certain clinical laboratory diabetes screenings with the appropriate waivers in place and physician collaborators on call (Armor et al., 2010; Dietz, 2016; McBane et al., 2015).

Pharmacists can be responsible for a variety of tasks as members of the diabetes care team. PCPs may refer their patients to pharmacists for diabetes counseling, adherence monitoring, and tracking of glucose, lipid, and blood pressure values (Armor et al., 2010). The pharmacists can then communicate directly with the PCPs about longitudinal data collected from their diabetic patients (Armor et al., 2010). Some pharmacists have defined scopes of practice that allow them to initiate or modify drug therapy and provide direct patient care (e.g., U.S. Department of Veterans Affairs) (Armor et al., 2010; Carmichael et al., 2004; Coast-Senior, Kroner, Kelley, & Trilli, 1998; Gong, 1999; Morello et al., 2006). A recent study by Fazel et al. (2017) found that the interventions provided by pharmacists improved diabetes therapeutic outcomes, thus highlighting that they play a key role in diabetes care beyond dispensing medications.

2.3.3.5 Other Healthcare Professionals

As previously mentioned, flexible healthcare teams help provide the best possible care for diabetic patients; not every team member has to be involved in a patient's care all the time (NIH, 2011). Some team members that may be integrated, as a patient requires their assistance, include: podiatrists, optometrists, dentists, psychologists, and social workers. Podiatrists help patients

who suffer from neuropathy and ulcerations if or when the blood supply to the feet becomes restricted. Optometrists and ophthalmologists will provide eye and vision exams to check for diabetic retinopathy (i.e., damaged blood vessels in one's retina). Psychologists or other mental health professionals can provide support via therapy and counseling for the stressful side effects (e.g., depression) that can coexist with a decline in health. Dentists provide support to the diabetes care team through oral examination and education to prevent infections in the gums and bones surrounding the oral cavity. Lastly, social workers can help people with diabetes by providing resources to help with any medical or financial needs a patient encounters.

2.4 Diabetes Information Technology

Diabetes information technology can generally be divided into medical devices (monitoring and/or delivery devices), software, and mobile applications (**Figure 4**). Each of these categories has both patient facing and provider facing technologies. Insulin pumps, self-monitored blood glucose (SMBG) systems, and CGM systems are usually designed as patient-facing medical devices to help assist patients with monitoring their blood glucose values to make sure they are maintaining glycemic control (i.e., to keep blood glucose values from varying too much). While there are some designs of tools for healthcare professionals serving multiple patients (e.g., a nurse checking blood glucose values for all patients in an inpatient care ward) (Furniss, Masci, Curzon, Mayer, & Blandford, 2014), the majority of the medical devices are designed as individualized and/or patient-facing tools. The supporting software and mobile applications tools are usually designed specifically for patient or provider use cases.

The patient-facing diabetes information technology does not typically differ in the design based on the type of diabetes. This is because the general monitoring tasks are the same regardless of the type of diabetes. However, some technologies will allow patients to adjust features that are specific for their disease state. For example, people with type I diabetes may set alerts that remind them to test more frequently than people with type II diabetes.

This dissertation will focus primarily on diabetes software; however, medical devices and mobile applications are often used in tandem with the supporting software. A brief review of each area is included in the sections below.

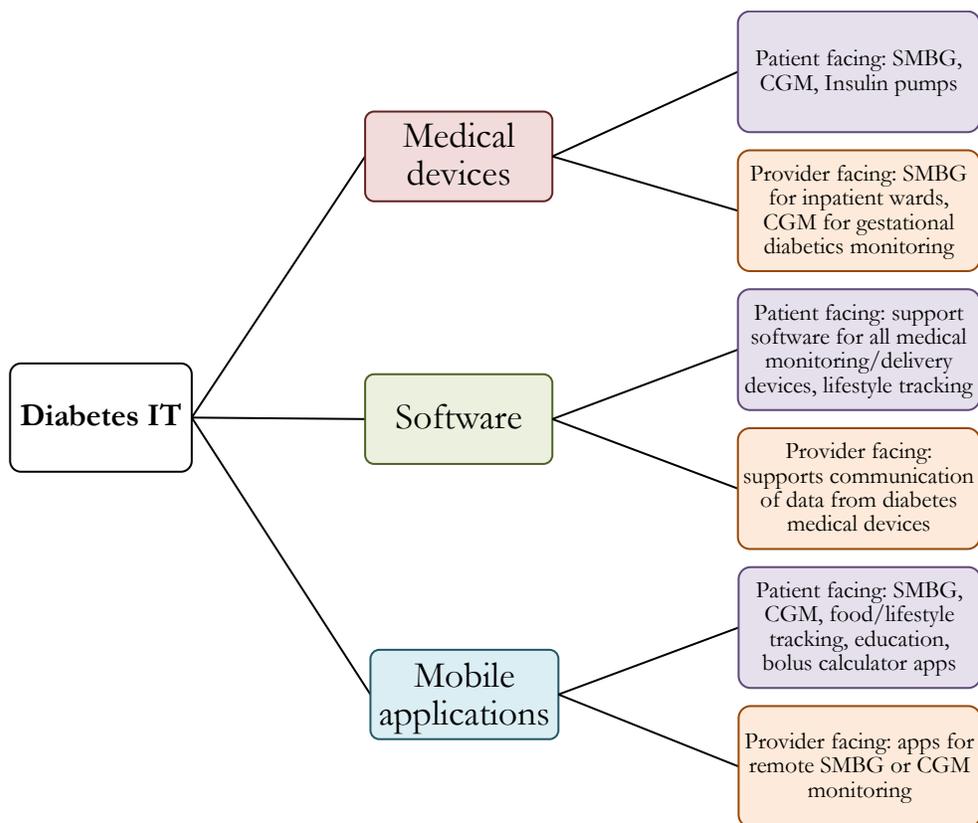


Figure 4. Types of Diabetes Health IT.

The tree diagram depicts types of diabetes information technology organized in the following groups: medical devices, software, and mobile applications. Patient facing technologies are located in purple boxes, while provider facing technologies are listed in orange boxes.

2.4.1 Medical Monitoring Devices

2.4.1.1 Self-Monitored Blood Glucose (SMBG) Systems

The oldest electronic diabetes self-monitoring device is the self-monitored blood glucose (SMBG) system, which was first introduced in the 1980's (Healy & Dungan, 2015). This technology involves patients pricking their finger for blood and then testing it via test strip and electronic blood glucose meter system. Original meter systems involved test strips and simple meters that patients could read the value and log it in a diary. Newer meter systems sync results via USB and Bluetooth Low Energy (BLE) technology to supporting software and mobile applications. Newer meters also allow patients to add information regarding their insulin and carbohydrate intake, often in the form of a “bolus advisor”. Other tools in newer meter systems

include logging for meals, exercise, health/stress events, alerts, and pattern recognition for trends.

While SMBG has been proven effective for people with type I and type II diabetes (Guerci et al., 2003; Klonoff et al., 2011; Sarol Jr, Nicodemus Jr, Tan, & Grava, 2005), there are several limitations that can hinder cognitive processes: manual input of logbook or diary values, structured testing requirements, alarm fatigue, lengthy procedures, and single data point values (Healy & Dungan, 2015; Klonoff et al., 2011; Rogers, Mykityshyn, Campbell, & Fisk, 2001; Xiang & Lu, 2011). Diabetes logbooks and diaries can have issues with manual entry whether they are analog or electronic. Analog tools are susceptible to transcription errors where the user does not hold the correct piece of data in their working memory (Klonoff et al., 2011). Similar errors can still occur electronically when a value is flagged incorrectly during the labeling input process (e.g., marked as pre- meal instead of post-meal). Another issue is that for the data to be effective, testing must occur in pairs. This means that blood glucose values must be recorded before and after a stimulus. Oftentimes patients can test before a meal but forget to test afterwards. Some SMBG systems have designed alerts to help enforce testing in pairs habits, but this can also result in alarm fatigue and unsafe workarounds (Shivers, Mackowiak, Anhalt, & Zisser, 2013). Lastly, the lengthy procedural steps to use an SMBG device (Rogers et al., 2001) combined with the single data point sampling mechanism (Xiang & Lu, 2011), can deter usage of SMBG systems. A study by Rogers et al. (2001) found that a simple SMBG meter required over 50 procedural steps to take a reading, and the instructional material was severely lacking. To support cognition, the meters should be simple to use with minimal, intuitive steps and the interactions with the meter should be logical and match the user's understanding of how the system works (Rogers et al., 2001). The inherent limitation of collecting a single data point per test strip limits the potential for cognitive offloading since patients are unable to get a holistic view of their blood glucose trends (Xiang & Lu, 2011).

These limitations with SMBG coupled with the ubiquitous nature of health information technology advancements gave way to a burgeoning field of diabetes management medical devices and supporting technologies (Davies, 2016; El-Gayar, Timsina, Nawar, & Eid, 2013). These technological innovations include insulin pumps and continuous glucose monitoring

(CGM) systems as well as computer software, mobile applications, and wearables (e.g., Fitbit activity tracker can integrate with diabetes mobile applications) (Medtronic, 2016).

2.4.1.2 Insulin Pumps

Insulin pumps and CGM systems are two parts of a new diabetic medical device intervention that can mimic the functions of the pancreas (Kovatchev et al., 2013). These devices together are often referred to as an “artificial pancreas”. Currently, they are used as independent interventions, but the first closed-loop system was approved by the FDA in early 2017 (FDA, 2017) and is expected to become more commonly prescribed once the devices enter the marketplace and there is further demonstration of its effectiveness via clinical trials (Heinemann & DeVries, 2016). The first part of the system, the insulin pump, helps control the amount of insulin delivered to a patient. These medical devices can deliver insulin set for a basal rate (i.e., long-duration insulin for between meals and while sleeping) or bolus rate (i.e., rapid-acting to cover carbohydrates in meals or to correct any dosages). The insulin is delivered through a catheter that is placed underneath the skin and the pump is typically worn clipped to a waistband. The insulin dosages are usually programmed into the pump, so the user interaction with the interface is minimal. The insulin pump was designed to take the place of multiple daily injections. The frequent injection of insulin via needle can lead to scarring of the tissue and it has been shown to be less effective for glycemic control compared to insulin pumps (J. Pickup, Mattock, & Kerry, 2002).

Insulin pumps are designed to reduce the amount of cognitive effort for insulin administration by their inherent purpose and design. Using an insulin pump is repetitive: users program their pump with their providers and insert packages of insulin every 2-4 days. The pump offloads the tasks of administering insulin and calculating basal and bolus insulin rates. Most users do not pay very close attention to the usability or features of their insulin pumps except when they change to a new model (Ziegler et al., 2013). Newer pumps have more features that support cognition, including a remote control, bolus calculators, and BLE communication links to SMBG meters and CGM systems (FDA, 2017; Herrero et al., 2012; Selam, 2010; Ziegler et al., 2013; Zisser et al., 2010). The bolus calculators are features that are typically part of a supporting software system that interact with the insulin pump. The calculator allows a patient to input the grams of carbohydrates for a meal, and the corresponding insulin value based on the patient’s health data

will be transmitted to the pump for insulin administration. This feature is particularly useful for patients who struggle with arithmetic. The synchronization also helps support information flows to other diabetes technologies in the user's arsenal, reducing the need for manual and/or redundant data entry.

Since the direct cognitive interactions with the insulin pump are routinized, the pitfalls for cognitive offloading and insulin pumps are minimal. One study, by Burton et al. (2009) found that insulin pumps should have voice output to assist the blind. While auditory feedback would help the visually impaired, this feedback could also reinforce cognition by supplying an alternative means for representing information. Other studies found key issues with insulin pumps including data entry, navigation, and information retrieval tasks (Schaeffer, 2012).

2.4.1.3 Continuous Glucose Monitoring (CGM)

While insulin pumps are designed to replace multiple daily injectors, CGM systems are designed to replace the SMBG meter systems. CGM systems consist of a sensor and a receiver. The current FDA approved CGM sensors are designed to be embedded into the skin and read blood glucose values from the interstitial fluid of the subcutaneous tissue every 1 to 5 minutes (Healy & Dungan, 2015). Advances in sensor technology have resulted in several new methods of CGM sensors that aim to further reduce the invasiveness of the monitoring element. Some of these technologies include skin patches, ear cuffs, and contact lenses (Davies, 2016). Once the sensor reads the blood glucose data, it is transmitted wirelessly to a receiver where the patient can see their real-time trends. Similar to newer SMBG meter systems, the data from the receiver can be pushed to software or mobile applications via BLE or pulled via USB connection. The CGM system is designed to work with insulin pumps to complete the feedback loop of the artificial pancreas. The CGM sensor reads the blood glucose values and the insulin pump self-corrects to help patients maintain control in real time.

Similar to the other technologies, the design of CGM and the overall purpose support cognitive offloading. CGM allows patients and providers to continuously assess blood glucose values in real time with minimally invasive techniques. The constant stream of blood glucose values can provide more holistic trends (Keith-Hynes et al., 2013), which can help both patients and

providers make informed decisions (Ellis, 2015). For example, CGM trends can help providers assess the speed and direction of the blood glucose levels through broader intervals and volumes of measurements (Bailey et al., 2015), whereas SMBG provides discrete points in time.

The limited research on continuous glucose monitoring (CGM) systems predominantly examines the effectiveness of the technology as it is still in early phases of release and adoption. For example, a few studies have shown that CGM technology is more effective than SMBG for maintaining glycemic control (Murphy et al., 2008; J. C. Pickup et al., 2011; Poolsup, Suksomboon, & Kyaw, 2013). Some articles (e.g., Bailey, Bode, Christiansen, Klaff, & Alva, 2015) mention usability findings, but this is largely related to physical ergonomics instead of cognitive usability issues. Despite the importance of usability, evidence regarding usability impacts is rarely published (Lyles, Sarkar, & Osborn, 2014). This could be due to confidentiality required by vendor research and development processes and/or a lack of academic-industry partnerships. Of the limited studies available, the most commonly published usability evaluation methods for diabetes IT include: questionnaires, focus groups and interviews, system usage data, usability testing, think-aloud tasks, cognitive walkthroughs, and heuristic evaluations (Lyles et al., 2014).

Although the body of CGM research is growing, the market penetration and usage of CGM systems remains low compared to SMBG (Hughes, 2009; Sharma, 2014). This could be due to issues with medical insurance reimbursement or other financial strains (Heinemann & DeVries, 2016; Rodbard, 2016). Nevertheless, it is expected that the usage of diabetes technology will continue to grow over time as clinical trials further highlight the effectiveness of the intervention strategies (Heinemann & DeVries, 2016). It is expected that the market value of artificial pancreas technologies (i.e., insulin pumps and CGM) will increase by over six hundred percent during the next decade (Pugh, 2017).

2.4.2 Mobile applications and software

The proliferation of smart phones and personal computers has expanded the market for diabetes software and mobile applications in recent years (Garcia, Martin, Garcia, Harrison, & Flood, 2011). CGM, SMBG, and insulin pumps are not automatic open-loop devices; they are often

linked with software and/or mobile application adaptive control systems. The supporting technologies are typically designed as patient facing or provider facing, and ideally have features that facilitate end user's needs when interacting with their medical device.

There are a few distinctions between the design and purpose of mobile applications versus software platforms for use with medical devices. Mobile applications tend to be streamlined, "light" versions of the supporting software, and they are typically used in real-time scenarios when users are interacting with their medical devices away from their computers. The features of the mobile applications that support medical devices are also usually designed to support daily, synchronous, activities. For example, mobile applications that support SMBG meters have several features that can assist with the appropriate insulin dosing or event trigger tasks (i.e., blood glucose is too low, prompt to eat a snack) in real time. Some of these features include: bolus calculators, health data tracking (weight, blood pressure, food, physical activity, stress), graphical representations of data, and data exportation (Demidowich, Lu, Tamler, & Bloomgarden, 2012). Some SMBG supporting mobile applications have robust databases that have a variety of food and activity options for logging health data (Demidowich et al., 2012), while others are limited and required more manual entry and effort for users to remember the appropriate information to log in their device. A common reason for decrease in adherence with these tools is the amount of time and effort to log all of the data (Lupton, 2013), which is a major limitation for diabetes monitoring support technologies (Demidowich et al., 2012; Urowitz et al., 2012).

The supporting software for diabetes monitoring medical devices is often designed as a more robust version of the mobile application, with a larger emphasis on utilizing the historical data to visualize patterns and trends in graphical representations. This historical data can include information on blood glucose values, insulin administration, carbohydrate and meal data, exercise details, stress/health logging, and notes related to diabetes monitoring events. For example, a patient can see how many times they had a hypoglycemic episode by toggling a button, instead of trying to retract that information from their memory. The SMBG support tools can also help assist the informational flow of diabetes data (e.g., patient-provider communication tools). For example, Glooko Kiosk software can help aggregate patients' biometric data across applications so that healthcare professionals can view it during consultations (Davies, 2016).

Recently, wearables and diabetes software companies are starting to create partnerships so that wearable data, like heart rate and physical activity, can be integrated with blood glucose values to provide a more holistic picture of patient activity (e.g., Fitbit & Medtronic) (Medtronic, 2016).

Both mobile applications and software can be designed for patient facing or provider facing interfaces. However, since mobile applications tend to focus more on the synchronous real-time activities, these tend to be more patient-focused, while software programs are typically designed more for healthcare providers (or the occasional very engaged, data-driven patient). Both the mobile applications and software can work together as part of a diabetes monitoring system that can show the appropriate information based on the temporal needs of the end user (e.g., synchronous real-time vs. historical data for decision-making and therapy adjustments).

Currently, the majority of mobile applications and software support are designed for SMBG and insulin pump systems. There are a few mobile applications and software platforms available for CGM, but they are not widespread yet due to slower adoption rates by consumers and insurance reimbursement rates (Heinemann & DeVries, 2016). Furthermore, the growing marketplace for diabetes applications requires vendors to develop high quality products to stay competitive. Usability is a critical concern for the successful adoption of a diabetes application by end users (Bellazzi, 2008). As CGM technology is still relatively new, the availability of published usability evaluation results for the technology or the supporting software is minimal. Preliminary CGM usability research has focused on general usability and patient acceptance of new CGM systems (Barnard, Mdingi, & Choudhary, 2016; Chen, Addaguduru, Mdingi, Rastogi, & DeHennis, 2018), as well as the effectiveness of the sensor-receiver system for helping patients maintain glycemic control (Poolsup et al., 2013). This clinical research is conducted in hopes of providing strong evidence to influence policy-makers to incorporate CGM reimbursement in healthcare insurance plans (Heinemann & DeVries, 2016). As patient adoption of health monitoring software increases, future CGM usability studies will need to determine effective methods of information visualization of CGM data. For example, some studies (Bergenstal et al., 2013; Rodbard, 2013, 2014) have shown that the Ambulatory Glucose Profile (AGP), a CGM visualization graph, needs to be standardized to ensure users can interpret and understand glycemic variability easily.

2.5 Human Factors and Systems Engineering Related Research

2.5.1 Human Factors Research Addressing Diabetes Care

Human factors and diabetes research can take many different forms due to the broad nature of the human factors discipline. Previous work in this area has explored the usability of various forms of health IT (reviewed in section 2.2 above), the team behaviors and processes of chronic care teams (reviewed in section 2.3 above). While there are other areas of human factors research applied to diabetes care problems, they are outside of the scope of this dissertation.

2.5.2 Healthcare Systems Engineering Research

Pharmacists are essential for healthcare systems and medication safety, but they are rarely the subjects of human factors engineering research (Chui et al., 2017). Research regarding the role of technology and technology implementation in pharmacy work systems has been minimal, partly due to a lack of meaningful use incentives for pharmacy organizations that are the recipient of electronic prescriptions (Chui et al., 2017) and academic research infrastructures (Gilbert, Mills, & Ward, 2006).

The existing work in human factors and pharmacy systems has utilized a sociotechnical systems engineering approach (Michelle A Chui, Halton, & Peng, 2008; Michelle A Chui, Mott, & Maxwell, 2012; Michelle A Chui, Stone, Martin, Croes, & Thorpe, 2014; Jahn, 2015; Martin, Chui, Thorpe, Mott, & Kreling, 2010; O. Odukoya & Chui, 2012; O. K. Odukoya & Chui, 2013; O. K. Odukoya, Stone, & Chui, 2014; O. K. Odukoya, Stone, & Chui, 2015; Phipps, Noyce, Parker, & Ashcroft, 2009; Walsh et al., 2011). This evaluative lens can help highlight complex system components and interactions of pharmacy systems prior to implementing major system changes to tools, technologies, or processes (Jahn, 2015). Work by Jahn & Caldwell (2017a) expands this evaluative lens by further incorporating temporal elements and levels of system granularity into the model of the information flows in the community pharmacy system. Similarly, a system-of-systems approach can also assist in evaluating pharmacy systems via utilizing the resources, economics, operations and policies as different lenses for addressing system dynamics at varying levels (Caldwell, Garrett, & Boustany, 2010). However, these systems engineering tools have gaps when applied to chronic care contexts (**Table 1**) (Jahn, Heiden, et al., 2018). Granularity, temporal dynamics, sociotechnical factors, and a focus on

chronic care and health IT integration are all key components for systems engineering tools (Jahn, Heiden, et al., 2018). The components will be combined to create a new systems engineering framework as part of the analysis of this dissertation work.

2.6 Opportunities & Gaps

Diabetes is a pervasive disease with a huge economic impact on the U.S. healthcare system (American Diabetes Association, 2013). Ambulatory and community pharmacies a critical yet often overlooked step in healthcare systems research (Goode, Mott, & Chater, 2007). Pharmacies offer cost effective services (Gammie, Vogler, & Babar, 2017; Isetts, 2012) that are often more easily accessible than PCPs or specialists (Herrick, 2007; Mercer, Li, & Grindrod, 2015). One study found that there is a community pharmacy, on average, within 2.36 miles of every U.S. citizen (Herrick, 2007). Community pharmacies, like Walgreens and CVS, are starting to open clinics with after-hours visits, no appointments, shorter waiting times, and lower prices than the emergency room (Win, 2016). These clinics often have compliance programs that can benefit both patients and the overall healthcare system by aiding in early disease detection, chronic disease education, and disease management (Herrick, 2007; Win, 2016). The geographical positioning, cost-effective services, and unique position in the healthcare delivery system, allows pharmacists to meet with their diabetic patients up to seven times more often than their PCP (Shane-McWhorter et al., 2009). In addition, the need for pharmacy services is expected to continue to increase due to the burden of chronic disease management, increasing life expectancies, and shifts in insurance coverage policies and reimbursements (Nahata, 2015).

The accessibility, availability, and frequency of contact put pharmacists in an ideal position to provide preventative services to diabetes patients and reduce the burden on PCPs (Hendrie, Miller, Woodman, Hoti, & Hughes, 2014). As ambulatory and community pharmacists are somewhat removed from other parts of the healthcare system, they also have less interaction with other healthcare professionals and often use IT systems (Nahata, 2015). Furthermore, the number of pharmacists in the U.S. is increasing, while there is a predicted shortage of 120,000 PCPs by the year 2030 (Markit, 2017). The highly trained skillset of pharmacists, combined with collaborative practice agreements and additional certifications (e.g., CDE) could help pharmacist fill the primary care gap of care, particularly for people with diabetes (Gums, 2016).

Recent advances in technology have yielded new opportunities for medical monitoring and team coordination processes, which can help increase the effectiveness of care and decrease costs (M. Nielsen et al., 2016). The integration of diabetes-focused technology into pharmacy systems could be a unique opportunity for improving coordination of care for people with diabetes (Ellis, 2015). For example, CGM systems are a new form of diabetes monitoring devices that have shown significant clinical outcomes for diabetes management, with more robust data sets for informed decision-making. Clinical information systems have also shown positive outcomes for delivering care to patients with chronic diseases (GHRI, 2016) and integrating patient data with existing health information systems to help facilitate care coordination (Dixon, Embi, & Haggstrom, 2018). The future of health IT will involve harnessing patient data to deliver customized care tailored for patient's specific needs (NRC, 2011).

The need for better coordination for diabetes care teams, combined with the aforementioned changes within the pharmacy profession presents an opportunity to explore new technologies and processes for bridging communication gaps and coordination processes (White & Hohmeier, 2015). The unique contributions of pharmacists to the assessment, development, and implementation of health IT can also expand human factors research knowledge of and designing for this particular end-user and system context (Nahata, 2015).

In addition to exploring these new opportunities at the intersection of health IT and pharmacy, there are several gaps in the literature that this dissertation aims to address. First, this work aims to identify the role of pharmacists on diabetes care teams, and the overarching diabetes care structure, function, and information flows to and from pharmacists. The literature contains many reviews of tasks and definitions of team members, but to the author's knowledge there is not a survey or review of the HCPs' perceptions on diabetes care team structures or interactions, or perceptions on the role of the pharmacist on these teams. The literature does contain some information on tasks that are involved in diabetes care processes; however, there could be more specificity and temporal data to help define the team processes from a systems engineering perspective. Temporal constraints and system granularity (i.e., levels of a system, such as individual-team-organization) are often omitted from human factors and systems engineering frameworks (Jahn & Caldwell, 2017a), and this dissertation aims to address these gaps. The literature on software designed for care coordination and chronic disease management is also

lacking, largely due to health IT systems interoperability issues that inhibit effective use and adoption (Samal et al., 2016). The proposed studies aim to provide usability facilitators and barriers for designing health IT systems to support pharmacists with diabetes care processes and care coordination activities.

Further, this work also has the potential to help support and expand the CCM literature. Research has shown that the patient-centered care model has many positive outcomes (Nielsen, Buelt, Patel, & Nichols, 2016); however, this model relies largely on the patient being highly engaged in their healthcare. Through the addition of information systems and system support features for HCP-HCP collaboration, there could be structures in place to protect against breakdowns in CCM processes (e.g., patient forgets to provide an update to an HCP). This work could highlight the need for stronger linkages and coordination between HCPs as a complementary healthcare quality improvement process (Garrett & Caldwell, 2009) in the event that the patient does not accurately transmit their health information or submit it in a timely manner. The focus on the pharmacist could also provide support for shifting the center of the informational hub from the patient-PCP dyad to the patient-pharmacist dyad.

Table 1. Comparing Systems Engineering Models for Chronic Care (Jahn, Heiden, et al., 2018).

	Granularity	Temporal Dynamics	Sociotechnical Factors	Chronic Care Applications	Health IT Integration
Importance of Attribute	<ul style="list-style-type: none"> Coordination across levels (e.g., individual, team, system) is required for effective care Visualizing granularity can help identify areas for cross-system interactions and process breakdowns 	<ul style="list-style-type: none"> Help capture sequences of events, temporal dependencies, and lagged effects Chronic care requires longer time scales and more handoff / care pathway transitions compared to acute care settings 	<ul style="list-style-type: none"> When treating patients with chronic diseases, social, organization, and process factors strongly affect care outcomes Lifestyle management and patient-centered monitoring permits proactive health paths for older adults, rather than passive response to physician-centered programs 	<ul style="list-style-type: none"> Some models are specifically designed to address chronic care, but they are not SE models Chronic care models emphasize patient safety and quality improvement outcomes, and community involvement 	<ul style="list-style-type: none"> Health informatics tools are the next wave in advancement for chronic care² SE models that address Health IT integration may help mitigate unintended consequences³
Models Incorporating Attribute	<ul style="list-style-type: none"> CHIPPER Model (Jahn & Caldwell, 2017) DiCoT-CL (Furniss et al., 2015) Mesoergonomics framework (Karsh, Waterson, & Holden, 2014) System-of-systems (Boustany, 2008) Information Flow Characterization (Boustany & Caldwell, 2007) 	<ul style="list-style-type: none"> CHIPPER Model (Jahn & Caldwell, 2017) DiCoT-CL (Furniss et al., 2015) Information Modeling (Williams, 2017) Operator Sequence Diagrams (Kurke, 1961) Event triggers Garrett & Caldwell, 2009; Heiden, 2018) 	<ul style="list-style-type: none"> CHIPPER Model (Jahn & Caldwell, 2017) DiCoT-CL (Furniss et al., 2015) Organizational Interaction Diamond Model (Wigand, 2007) SEIPS (Carayon et al., 2006) & SEIPS 2.0 (Holden et al., 2013) Sociotechnical work system (Trist, 1981) 	<ul style="list-style-type: none"> Chronic Care Model (CCM) (Barr et al., 2003) eCCM (Gee et al., 2015) 	<ul style="list-style-type: none"> Activity Theory (Kuutti, 1996) CHIPPER Model (Jahn & Caldwell, 2017) DiCoT-CL (Furniss et al., 2015) eCCM (Gee et al., 2015) SEIPS (Carayon et al., 2006) & SEIPS 2.0 (Holden et al., 2013)
Gaps	<ul style="list-style-type: none"> Two dimensional models are difficult to demonstrate all layers of a system It can be difficult to visualize all possible interactions between system layers Temporal aspects are not included, which provide context to system interaction frequencies 	<ul style="list-style-type: none"> Not all operations occur at the same time scale; thus increasing the complexity for displaying information at varying rates Due to the natural variability of humans, healthcare operations are variable as a result. This adds to the complexity when trying to standardize temporal representations 	<ul style="list-style-type: none"> Most sociotechnical systems models occur as a snapshot in time, which obscures necessary temporal contextual information Sociotechnical systems models require clear boundaries and system goals to determine the scope and granularity of application 	<ul style="list-style-type: none"> CCM related models do not consider systems engineering elements (e.g., technology, temporal constraints) Categories CCM models are broad, thus making it easier for organizations to mistake that they have applied CCM principles appropriately 	<ul style="list-style-type: none"> Health IT models range from very generalizable to very specific, with patient and provider-facing perspectives. They may be used ad-hoc as a lens to identify issues with integration organize findings Some models focus more heavily on the IT and less on the surrounding system, which could contribute to unintended consequences

3. RESEARCH OVERVIEW

The previous chapter reviewed literature related to diabetes IT, diabetes care team structures and processes, and human factors research. This literature review identified two main areas of further research: 1) *what opportunities exist for spatially and temporally distributed pharmacists to participate effectively in diabetes care teams?*; and 2) *how can health information technology support pharmacist information coordination for diabetes care processes?* This chapter reviews the rationale for the research questions and the proposed methodologies for completing each study.

This dissertation aims to answer the following research questions:

Research Question 1 (RQ1): what opportunities exist for spatially and temporally distributed pharmacists to participate effectively in diabetes care teams?

- **Study I:**
 - **RQ1.1** What are the specific roles on a diabetes care team?
- **Study II:**
 - **RQ1.2** What are the specific tasks for diabetes care team members?
 - **RQ1.3** What are the required information flow attributes for effective diabetes care team coordination?

Research Question 2 (RQ2): How can health information technology better support pharmacist information coordination for diabetes care processes?

- **Study III:**
 - **RQ2.1.** What are the data requirements for pharmacists monitoring people with diabetes?
 - **RQ2.2** What are the benefits and barriers of a universal patient appointment tracking feature?
 - **RQ2.3** What are the benefits and barriers of a universal messaging portal?

- **RQ2.4** What are the benefits and barriers of the proposed DRIFT analytical framework (i.e., care coordination feature) for HCPs providing diabetes care?

To answer these two overarching research questions, three separate studies were completed. The first study used a questionnaire to answer RQ1.1 to define the roles of the diabetes care team. The second study built upon the results of the RQ1.1 analysis, and used semi-structured interviews to answer RQs 1.2 and 1.3 to confirm the diabetes care team roles and identify the tasks and information flows related to diabetes care team coordination. The third study addressed RQ2, involving semi-structure interviews and formative usability testing of a new software prototype with pharmacist participants.

3.1 Study I (RQ 1.1) Rationale & Methodology Selection

3.1.1 Study I Rationale & Potential Research Contributions

The first research study aims to answer the question “*What are the specific roles on a diabetes care team?*” Although there are some reviews of tasks for diabetes care and general team members, diabetes care teams are not well defined, and no published studies were discovered prior to initiating the studies described in this thesis.

The number of people in various professional roles in healthcare settings is fluctuating and the rising rates of advanced certifications is allowing many HCPs have the ability to practice at the “top of their license”. For example, pharmacists may work under collaborative practice agreements to provide additional services, such as: drug therapy, contraception, immunizations, and physical examinations. Furthermore, the advancements in technology are also contributing to the disappearance of routine tasks that can be easily automated (Angelo, Christensen, & Ferreri, 2005; Franklin, O'Grady, Donyai, Jacklin, & Barber, 2007; Paoletti et al., 2007; Spinks, Jackson, Kirkpatrick, & Wheeler, 2016). These changes in healthcare roles, tasks, and technologies can affect the way care teams coordinate information. As a result, the systems may not be as effective at supporting the information coordination processes and the quality of care could degrade. To prevent poorly designed health IT systems from negatively affecting diabetes care, it

is essential to define the diabetes care team system components. This first research question aims to define the specific people involved in diabetes care.

The responses to this research question help lay the foundation for this dissertation, as well as contribute to the diabetes care research space with a more stable definition of core diabetes care team members. This team definition is a critical component for designing provider facing health IT systems, as medical device and software companies must define intended users and use environments early on in the design process. Furthermore, the results of this work could potentially contribute towards a change in reimbursement policies if more previously considered ancillary members of diabetes care teams are found to be critical members of the patient care team.

3.1.2 Study I Methodology Selection

There are several different methodological approaches that could provide evidence towards answering RQ 1.1, and they each have their benefits and limitations. Quantitative data collection, such as using administrative data from insurance claims, is one method used to track provider care coordination processes (Ostovari, Yu, & Steele-Morris, 2018). While this data would provide some concrete evidence towards the roles involved, it lacks the contextual information about the information exchanges, including the quality, mode, and timing of the information flows. For example, using administrative data may show that a patients and physicians may interact with laboratory technicians of a hospital because of the large number of labs billed to an insurance company. While this may technically be true from the insurance data, the patient and their healthcare team may have little direct communication with these team members beyond receiving laboratory report results. Furthermore, undergoing this type of analysis is limited to looking only at patients with health insurance; the coverage data may also include extraneous details related to comorbidities beyond the diabetes care team processes. This analysis may also fail to capture some activities and coordination that cannot be reimbursed for, such as diabetes education by a certified diabetes educator under some insurance coverage plans.

Due to the lack of contextual information with using purely quantitative methods, qualitative data collected from people who work frequently with people with diabetes can provide additional

insights on diabetes care team roles. As a variety of healthcare providers may help treat people with diabetes (Rodgers et al., 2014), diversity in healthcare provider roles can help provide a broader perspective of the state of diabetes care teams. While ethnographic data collection methods can provide in-situ evidence with rich details, it is not always feasible or necessary for exploratory studies (Denzin & Lincoln, 1994). Online, electronic questionnaire tools can be useful for collecting data from participants that may be difficult to access as they can be completed in the participants' own environments at times that are convenient for the individuals. This particular method could be useful for healthcare professionals who are often under significant time and workload constraints. Furthermore, the open-endedness of a brief online questionnaire can be used as an inexpensive, initial starting point (Mann & Stewart, 2000) to determine who to talk to within a complex chronic care team for subsequent studies.

Social network analysis methods, which were selected for analyzing the questionnaire data, involve the investigation of social structures through graph theory and networks (Otte & Rousseau, 2002). Social network analysis helps visualize the connections and weighting between parts of an organization, and capture organizational processes at different levels of analysis (Tichy, Tushman, & Fombrun, 1979), often exposing and mapping hidden channels of information flows and collaboration (Chambers, Wilson, Thompson, & Harden, 2012). The foundations of social network analysis have existed since the early work of sociologists in the 20th century (Freeman, 2004), and researchers have since expanded in refining the tools (e.g., computer modeling software) and applications of use (e.g., social media usage, terrorism networks, disease transmission, crime, etc.) (Ediger et al., 2010; Ortiz-Pelaez, Pfeiffer, Soares-Magalhaes, & Guitian, 2006; Ressler, 2006; Yang & Ng, 2007). This method is preferable for data sets with complex interactions that may not always be depicted easily with tables for exposing the different interactions in the system. Additional details on the social network analysis methods used are discussed in Chapter 4, section 4.1.3.

3.2 Study II (RQs 1.2 & R.3) Rationale & Methodology Selection

3.2.1 Study II Rationale & Potential Research Contributions

To provide engineering solutions in the diabetes care team coordination space, it is critical to first define the system components involved, such as roles, tasks, processes, resources, temporal constraints, and information flows (Jahn & Caldwell, 2017). Study I identified key roles in the diabetes care team, while Study II aimed to define specific tasks, tools, processes, and information flows with their relative temporal and spatial attributes. Specifically Study II aims to answer the following research questions: “*What are the specific tasks for diabetes care team members?*” (RQ 1.2), and “*What are the required information flow attributes for effective diabetes care team coordination?*” (RQ 1.3).

Answering these questions can address several gaps in diabetes care research. For example, a thorough analysis of the specific people, tasks, and temporal data can provide evidence towards design and functional requirements for health IT to support diabetes care team coordination. Currently, many software companies design diabetes health IT for more narrowly defined environments and roles (e.g., endocrinologist and diabetes nurse educator). The wide variety of environments and healthcare roles can provide a robust view of the complexity of the system, and potentially influence health IT development and/or strategy. Within the larger chronic care research landscape, this work can help provide temporal information to be used in the development of a new or updated frameworks and tools. Temporal data and levels of granularity are often omitted from chronic care frameworks, yet they are essential for fully defining the system and identifying potential process breakdowns (Jahn, Heiden, et al., 2018).

3.2.2 Study II Methodology Selection

For teams to function effectively, it is essential that teams have a shared mental model (Langan-Fox, Code, & Langfield-Smith, 2000). Team mental model research highlights several methods for measurement of team mental models, one of which is cognitive interviewing. Cognitive interviewing can help elicit mental models through open questioning and interview style questions (Langan-Fox et al., 2000). One example of cognitive interviewing is the question-form approach, where participants respond to questions about his or her domain of expertise (Cavaleri & Sterman, 1997; Langan-Fox et al., 2000). The question-form approach is designed to be

systematic so that linkages between system components and domain information can be identified.

While individual interviews can be useful for exploratory research and gathering rich data, the participants may be under some time constraints to participate. A mixed-method approach that allows data collection to occur asynchronously helped work around this data collection limitation. Survey tools and questionnaires, as previously utilized in Study I were some research methods that were combined with interview data collection. Specifically, participants answered specific questions related to determining the tasks and information flows related to RQs 1.2 and 1.3. Beyond direct questions related to the task and information flows, participants engaged in a visual card sort exercise, where participants listed and categorized concepts into relevant areas as per their domain knowledge (Langan-Fox et al., 2000). This open-ended approach allowed participants to use their natural language and terminology to describe the diabetes care team processes from their perspective. Quantitative team task analysis methods were also incorporated to compare the findings across the domain categories in the card-sorting exercises to determine the importance and team-relatedness of various tasks (Arthur Jr, Edwards, Bell, Villado, & Bennett Jr, 2005).

3.3 Study III (RQs 2.1-2.4) Rationale & Methodology Selection

3.3.1 Study III Rationale & Potential Research Contributions

As mentioned in the previous chapter, recent advances in diabetes health IT combined with the accessibility and skillset of pharmacy professionals, yields new opportunities for further inclusion of pharmacists with diabetes information coordination processes. This idea was hypothesized and confirmed through results from the first two studies. The third research study aimed to expand upon the information presented Chapter 2, and explore the following research question: *“How can health information technology better support pharmacist information coordination for diabetes care processes?”* (RQ 2). The answer to the overarching research question has implications for healthcare technology companies, human factors experts, and healthcare policymakers. For healthcare technology companies, this research presents insights for technical engineering requirements and overall market strategies related diabetes health IT.

Human factors researchers working in healthcare may also find value in the findings related to information visualization of blood glucose monitoring, as well as understanding the pharmacy role and context more in depth for other, similar chronic care applications. Healthcare policy makers and administrators may also find value in this work, and consider making adjustments to their staffing structure, processes, or technologies as a result of the findings.

The sub research questions focus on more nuanced aspects of health IT, such as the data requirements for pharmacists to effectively monitor patients' diabetes disease states (RQ 2.1). The results of RQ 2.1 aim to provide data requirements for the design of health IT monitoring technologies specifically for the pharmacist intended user. The unique contributions of pharmacists to the design of health IT can also expand human factors knowledge for this particular end-user and system context (Nahata, 2015).

Initially, Study III aimed to look at a version of a new CGM software system for evaluation with pharmacy participants. Due to issues with access to a CGM system for testing, the author created a new health IT prototype from the findings from Study II. The new software prototype, named *eVincio*, stemming from the latin verb root "to link", aims to help healthcare professionals and administrative staff more effectively monitor chronic care patient activity overtime through a new information visualization. Research subquestions 2.2-2.4 evaluate the benefits and barriers of the prototype features that were implemented out of findings from Study II participants' health IT requests. It is anticipated that the evaluation of this new health IT in Study III will yield information about the product feasibility, and benefits and barriers to implementation for both the analytical framework (i.e. care coordination feature) and for other features of the software prototype.

3.3.2 Study III Methodology Selection

A critical goal of Study III is to identify key engineering issues with the new health IT developed from Study II findings. Therefore, the most appropriate approach would be to use preliminary and exploratory usability analyses for assessing the product's feasibility (FDA, 2016; Story, 2012), and identifying any significant barriers for future implementation and adoption. The FDA recommends contextual inquiry, interviews, function and task analysis, heuristic evaluation,

expert review, usability testing, and risk analysis as human factors methods available for use during preliminary analyses (Story, 2012). As the prototype was developed by a human factors researcher, a heuristic evaluation or expert review conducted by the same person who designed the software would not be as effective. Furthermore, since the design elements are not fully refined, the detailed analytical methods of usability testing, function/task analysis and risk analysis would also be considered premature. Therefore, the best methods for Study III would be a mixture of contextual inquiry and semi-structured interviews, where the user can explore the software and the researcher observes.

Usability testing and related tools can help further elicit user needs related to this specific piece of technology (Jakob Nielsen, 1994). Soliciting feedback directly from users interacting with the technology (e.g., think-aloud, system usage data, usability testing) yields more usability problems than other methods, while expert evaluations (e.g., cognitive walkthroughs, heuristic evaluations) have proven to be successful with detecting usability issues that users may not be aware of (Lyles et al., 2014). The most effective usability assessments include a combination of these methods (Yen & Bakken, 2012). Common usability metrics, such as success rate, time for task, error rate, and satisfaction can help provide quality metrics for health IT assessments.

4. STUDIES I & II METHODOLOGIES

4.1 Study I (RQ1.1) Methodology

4.1.1 Study I Design

To determine the different members of the diabetes care team, an online questionnaire was designed using Qualtrics© software tools (**Appendix A**). Due to the online questionnaire format, participants could participate from any geographic location at any time that fit within their schedule. The data were collected during November 2017 – January 2018.

Preliminary screening questions were used to ensure that participants were 1) over the age of 18; 2) currently licensed and practicing in the United States as an HCP; and 3) interacting with people with diabetes as a frequent function (i.e., at least a few times a month) of their clinical work tasks. Participants that passed these screening questions were then asked to identify their clinical role and provide a free text response to the following prompt:

*“What types of healthcare professionals would you include on a core diabetes care team? ‘Core’ can be defined as a function of the most common and critical healthcare care professionals to ensure safe and efficient care. Please list **at least 5** different types in order from the most to least critical team member to include on a core diabetes care team. Feel free to use the space to share any other thoughts you may have on core diabetes care team members.”*

The free text prompt was selected to allow participants to be more open and descriptive, and use the terminology for the team roles that is most appropriate from their perspective. It was anticipated that the questionnaire took participants about 2-5 minutes to respond.

4.1.2 Participant Sampling & Recruitment

After receiving Institutional Review Board (IRB) approval from Purdue University IRB (protocol # 1710019836), participants were recruited using snowball and convenience sampling methods (Ferber, 1977; Goodman, 1961) via social media (e.g., LinkedIn networking groups,

Facebook, and Twitter) and email platforms, with initial contacts at Midwestern healthcare facilities. The recruitment emails and social media posts included information regarding the study purpose and a hyperlink to the questionnaire.

Based on previous studies, it was anticipated that data saturation would be reached between 3-5 participants per role category (Mason, 2010). Therefore, recruitment goals were set at five participants per each key role identified in the literature (Rodgers et al., 2014) (i.e., primary care provider, endocrinologist, certified diabetes educator, pharmacist, and nurse), and set at three participants for secondary roles (i.e., dietician, podiatrist, psychologist, social worker, optometrist). Participant responses received in excess of these recruitment goals were still included in the study analysis. Snowball and convenience sampling efforts were continued until no new responses were recorded for 60 days.

4.1.3 Data Cleaning & Analysis

Data cleaning was conducted prior to data analysis. Participants were removed from the data set if they were not a currently licensed/certified and practicing medical professional, did not interact with people with diabetes frequently (i.e., more than a few times a year), and/or indicated that they did not treat people with diabetes as a main part of their clinical area of expertise. These requirements were selected to remove people that did not interact with people with diabetes and their care team as a regular function of their role.

Due to the free text format of participant responses, there were natural variations in the ways that participants listed the roles on a diabetes care teams. To reduce the number of categories and to help facilitate generalizations during analysis, the following categories were combined:

- Nurse Practitioners (NP) and Physician Assistants (PA) were combined into ‘NP’ due to their similar roles and tasks.
- Medical Assistants (MA) often have nursing degrees (e.g., LPN, CRNA). MAs were included with nurses (RN).
- Case managers were coded as ‘RN’ because it is a typical degree for someone with that role. Case managers were coded as social workers (SW) if an RN was already noted in the participant list.

- Discharge planners were coded as ‘SW’ because a social work degree is common for someone with that role.
- Two participants specified a distinct pharmacist (e.g., community pharmacist) in their list—all others just said “pharmacist”. Therefore, all pharmacist roles listed were combined.
- Roles that were listed as counselors, psychologists, therapists, and psychiatrists were all coded as “Psych”.
- Optometrists (OD) and Ophthalmologists (Eye MD) were combined into one category (OD) due to their similar roles and tasks.
- Medical specialties (e.g., cardiology) mentioned once were all combined into a “specialist” category.
- There were variations in responses related to Medical Doctors (MDs), Primary Care Physicians (PCP MDs), and Primary Care Providers (PCPs). It is suspected that these variations were a result of participants not wanting to provide duplicitous / nearly equivalent roles on the team. These categories are combined into one category (PCP / MD), which aims to be representative of Primary Care Providers and/or MDs.

After streamlining the participant responses into generalizable categories as indicated above, cleaning the data, the participant responses were organized into a matrix to be imported into Gephi ©, an open-source network analysis software tool, to determine which roles were deemed the core members of a diabetes care team. Each role is represented as a node in the social network, and the lines, or ‘edges’, between the nodes use varying shades of color and thickness of the lines to visualize the strength of the connections.

Measures of centrality (e.g., degree) are used during social network analysis to determine the impact of a particular node on the network (Barrat, Barthélemy, Pastor-Satorras, & Vespignani, 2004). Degree is a measure of the number of connections incoming and outgoing from each node. It is a measure of how connected one node is to other parts of the network; a higher degree indicates more connections across the network. Degree can be measured as in-degree (number of nodes directed towards focal node), out-degree (number of nodes that the node is directed towards) and total degree (in-degree + out-degree). A limitation of using degree measurements,

particularly out-degree measurements, is the potential for creating imbalances in the network due to varying participant sample size at different nodes. Since it was anticipated that the node sizes would be variable due to snowball and convenience sampling recruitment, only in-degree was used for the data analysis for the frequency of the node connections.

However, there are still other limitations with using in-degree as the only measure of centrality for network analysis (Opsahl, Agneessens, & Skvoretz, 2010) because in-degree only captures the frequency of connections, and does not capture the weight or *strength* of the node connections. Since the research question aimed to address the criticality of roles on diabetes care teams, it is necessary to have a measure of centrality that can help determine the weight and relative ranking of the roles (Opsahl et al., 2010). As participants were asked to list the team roles from most to least critical, this ordinal list was used as to determine a weighting scheme. The maximum number of roles listed by one participant was ten; therefore a maximum of 10 points was used for the first listed role, and it decreased by one point for each role listed after that (e.g., second role listed received 9 points, third role received 8, and so on). One participant listed several types of nurses (e.g., triage nurse, LPN). The role was only counted once (as RN) and it received the max weighting score for the first mention in the participant's list. Due to the potential for variations in participant sample sizes at different nodes, the data were normalized by each role/node and only in-strength weighted measurements were used. To normalize the in-strength weighted measurements, the values for each in-strength weight were presented as percentages of the total possible in-strength value for each directed cell of the weighted adjacency matrix. These values were then summed to determine the cumulative in-strength value for each node. The percentage of participants that mentioned the role was also captured as an additional measurement.

The final output of Study I data analysis includes social network visualizations for in-degree frequency and in-degree weighted measures of centrality, as well as percentages of participants that mentioned each role. A plot of cumulative in-strength values for the network nodes with a 90% threshold was also used to determine the critical and core members of the team based on the participant responses (Scott, 2017). A k-means clustering algorithm (Hartigan & Wong, 1979)

was also used to determine the clusters of participant roles that were more critical for diabetes care teams with the percentage data, using a 40% threshold.

4.2 Study II (RQ 1.2 & 1.3) Methodologies

4.2.1 Study II Design

To answer RQs 1.2 and 1.3, individual research interviews of members of diabetes care teams were conducted. The interviews consisted of a combination of semi-structured questions (Harrell & Bradley, 2009) (**Appendices D & E**) and worksheets with Likert-scale and multiple choice response options (Arthur Jr et al., 2005; Endsley, 2016; Langan-Fox et al., 2000) (**Appendices F & G**).

Prior to each interview, participants were asked to complete a participant screener form via email to determine eligibility (see section 4.2.2 and **Appendix C**). Once the participant was deemed eligible, an interview time slot was scheduled for one hour with the interview mode (i.e., in-person, phone, video) of the participant's choosing. Each interview started with a brief recap of the study goals, a verbal confirmation of interest in participation from the interviewee, and a confirmation of the participant screener data accuracy. The interviews consisted of several general questions about diabetes care teams, as well as specific questions about the participant's interactions with other members of the care team in the form of worksheet responses and questions. Each participant was given a number (e.g., Participant #1) to de-identify participant data. The interviews were audio-recorded to facilitate transcription for later qualitative data analysis.

4.2.2 Participant Sampling & Recruitment

After receiving IRB approval from Purdue University (protocol # 1711019889), participants were recruited to participate in individual research interviews. Study I results determined the key roles on diabetes care teams to recruit for Study II, which were Endocrinologists (MD or NP), Primary Care Providers (MD, NP, or PA), Registered Nurses (RNs, LPNs), Registered Dietitians (RD), Pharmacists (PharmD or RPh), and Social Workers (MSW). Participants had to be currently licensed and practicing in the United States, interact with people with diabetes as a main function of their job tasks at least a few times a month, and over 18 years old. A

preliminary screener was sent via email to all interested participants to verify participant eligibility prior to scheduling an interview (**Appendix C**). A combination of convenience and snowball sampling methods were used (Ferber, 1977; Goodman, 1961): participants were contacted via social media and email platforms, with initial contacts at Midwestern healthcare facilities and from Study I participants who indicated interest in participating in future studies. Participants were not compensated for their participation. Participant recruitment occurred from January 2018 to May 2018.

Participant recruitment channels were tracked to avoid excessive email communications with potential participants. Furthermore, participants that indicated interest in participating were contacted via follow-up reminders a maximum of three times, with one to two weeks between each email reminder. Participants were always reminded that they could opt out of the study at any time.

It was expected that the data would be saturated when approximately five ($n=5$) participants per role category were interviewed (Mason, 2010), with a total goal of $n=30$ participants. Once a recruitment role goal was met (i.e., 5 pharmacists were interviewed), other categories received more targeted attention for recruitment to avoid over saturation with more prevalent roles on the diabetes care team. Participants beyond the target goal of 5 per role were not removed from the data. Recruitment stopped when all target goals were reached and no additional recruitment emails or postings yielded new potential research participants for 30 days.

4.2.3 Data Cleaning & Analysis

Participants were assigned a number to de-identify the participant from their demographic data. The worksheets and interview audio records were each coded with the participant number. Once the interviews were transcribed, any remaining identifying information (e.g., names, employment locations, etc.) were removed from the transcription to protect participant anonymity.

The participant worksheets and interview transcripts were imported into a qualitative data analysis tool, NVivo 12 for Mac (© QSR International), where the data were then qualitatively coded using process and thematic, open coding methods (Saldaña, 2015). The process codes were predefined and iteratively refined in a code key (**Appendices H & I**) that aligned with RQs

1.2 and 1.3, which was revised as additional codes were added during the iterative, thematic open coding process (Saldaña, 2015). After the interview data was coded, the codes were verified with the code key for accuracy.

It was anticipated that the results collected from the interviews would highlight similarities and differences in mental models for varying members of the diabetes care team, as well as help map information flows and processes between team members. A combination of systems engineering tools were used to combine the qualitative data findings into meaningful representations from study participants (Benedict & Caldwell, 2011; Boustany & Caldwell, 2007; Caldwell, 2005, 2008, 2009; Carayon et al., 2006; Furniss, Masci, Curzon, Mayer, & Blandford, 2015; Garrett & Caldwell, 2006, 2009; Garrett, Caldwell, Harris, & Gonzalez, 2009; Holden et al., 2013; Jahn & Caldwell, 2017; Jahn, Heiden, et al., 2018) to answer RQs 1.2 and 1.3.

4.2.4 Data Synthesis for Studies I & II

After completing the analyses for Studies I and II, the results from each study will be compared and combined to inform the direction of Study III. It is anticipated that the findings from Study II will confirm the roles determined on the diabetes care team from Study I, and the rankings of team relatedness and importance from Study II will also be represented in the social network analysis weights and measures of centrality from Study I. The findings from both studies will be combined to create a diabetes care team systems engineering framework that depicts information flows and importance weightings of aspects of the system.

5. STUDIES I & II RESULTS

The following sections review results of Studies I & II for Research Question (RQ) 1, including research sub-questions (RQs) 1.1-1.3. Study I used snowball sampling methods to disseminate a questionnaire to healthcare providers to answer the question “*What are the specific roles on diabetes care teams?*” (RQ 1.1). Social network analysis methods presented in section 5.1 were used to highlight the key roles on diabetes care teams. The results of Study I influenced the participant sampling methods for Study II, where qualitative interviewing techniques were used to answer the questions: (RQ 1.2) “*What are the specific tasks for diabetes care team members?*”, and (RQ 1.3) “*What are the required information flow attributes for effective diabetes care team coordination?*” Section 5.2 below highlights results from Study II analysis. The final section (5.3) of this chapter synthesizes the results from Studies I and II with key findings and recommendations for Study III directions.

5.1 Study I Results

5.1.1 Participant Demographics

Participants were removed from the data set if they did not fit the initial screening criteria outlined for study participation (see Chapter 4, section 4.1.3). Participants were removed who were not certified medical professionals (n=4 students removed); did not interact with diabetes patients frequently (i.e., more than a few times a year) (n=3 nurses removed); indicated that they do not treat diabetes patients as part of their clinical area of expertise (n=1 speech language pathologist removed). There were n=59 participants for Study I that met all criteria (**Table 2**).

Table 2. Study I Participant Acronyms and Participation Rates

Role	Abbreviations	Participant Goal	# Participants
Certified Diabetes Educator	CDE	5	8
Dentist	DDS	3	2
Podiatrist	DPod	3	1
Endocrinologist	END	5	2
Primary Care Provider and/or Medical Doctor	PCP MD	5	5
Nurse Practitioner	NP	N/A	2
Optometrist	OD	3	0
Pharmacist	Pharm	5	16
Psychologist	Psych	3	2
Physical Therapist	PT	N/A	1
Registered Dietician	RD	3	5
Registered Nurse	RN	5	8
Medical Doctor Specialist	Specialist	N/A	2
Social Worker	SW	3	5
Total			59

The goal of five participants per primary role was met for all primary roles except for endocrinologist (2 participants); secondary roles of dentist, podiatrist, and psychologist had 1 or 2 participants per category; no responses for optometrist were received.

5.1.2 Methodology Deviations

There were a few small methodology deviations that occurred during data collection and analysis, but all were deemed minor and acceptable to proceed with data analysis. The first deviation was an accidental typographical error in the questionnaire, where the participant role intended to say “Primary Care *Provider*” said “Primary Care *Physician*” a few participants indicated as such if they were a PCP PA or NP within the “Other” section. These results were included with the PCP MD responses as the category intended to be all encompassing with types of primary care providers.

There were also some unanticipated variations with how participants listed the roles on the diabetes care team for medical doctors (MDs), primary care physicians (PCP MDs), and primary care providers (PCPs). It is expected that participants did not differentiate the type of provider (e.g., listing MD instead of specifically a PCP MD). These participant responses were combined into one category (PCP MD), which is supposed to represent primary care providers and/or MDs. Nurse practitioners and Physicians Assistants were combined together in their own category when they were mentioned distinctly and not part of a PCP category (see Chapter 4, section 4.1.3 for data cleaning details).

5.1.3 Frequency Measurements

The network analysis software Gephi[®] was used to determine which roles were listed most frequently by participants as key members of the diabetes care team. Frequency is measured as *degree* in social network analysis, where in-degree is the total number of incoming nodes or the number of participant roles that mentioned that particular role. The out-degree is the total number of nodes mentioned by people of a particular role, and the total degree is summation of the number of in-degree and out-degree values.

Figure 5 (below) depicts the frequency or degree of each role by the shading of the edges connecting the nodes and the degree numbers labeled next to each node. These results show that the pharmacist role was the highest connected role in the system, with 22 total degree values (9 in-degree, 13 out-degree). This was to be expected partly due to the large number of pharmacist participants and the potential for variation in their responses resulting in more roles listed on the diabetes care team. The in-degree value can be used to reduce the bias from the skewed participant responses from different roles, because more respondents in one role category over another (e.g., pharmacists with $n=16$ and endocrinologists with $n=1$) will cause over-inflation of the out-degree and total degree numbers. The most critical and common roles to include on a diabetes care team based on in-degree frequency measurements are: PCP MD (13), END (11), RD (11), CDE (9), Pharm (9), RN (9), NP (8), and SW (8). These roles are connected to at least half of the roles in the diabetes care team network.

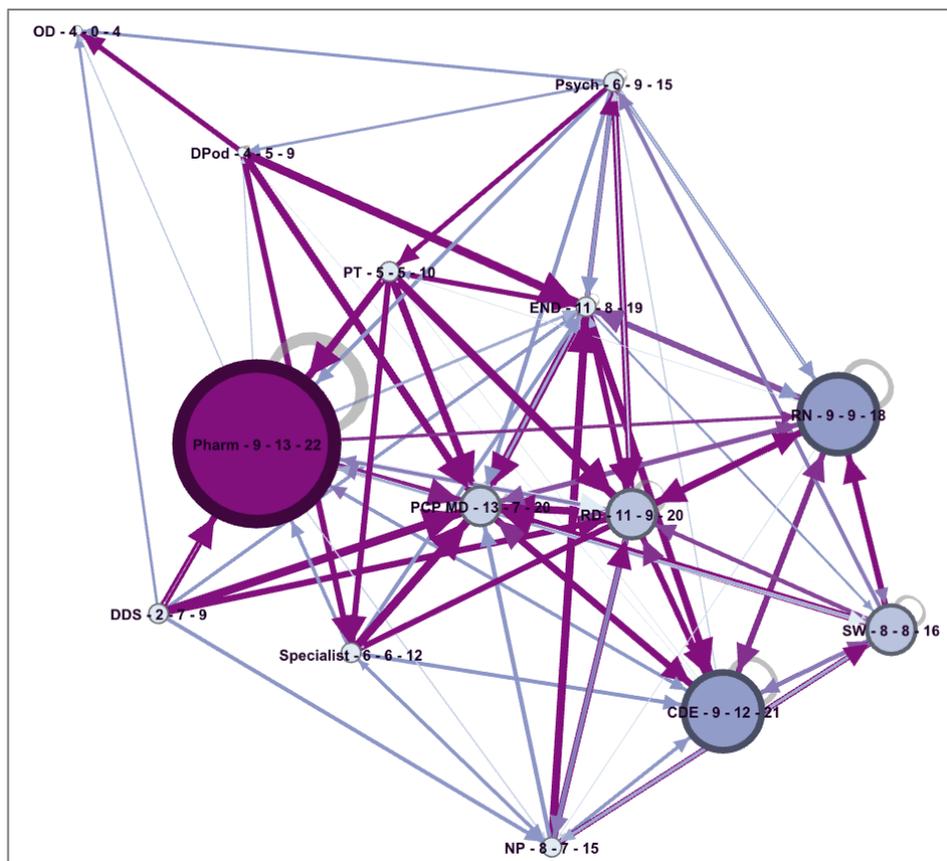


Figure 5. Study I Force Atlas 1 Visualization of the Diabetes Care Team Network.

The visualization depicts each participant role as a node, where the size is indicative of the number of participants in that role that participated in the questionnaire. The thickness of the edges (i.e., the connecting lines to other nodes) denotes the strength of the connections between the nodes as measured by the frequency that participants listed that role as a member of the diabetes care team. The numbers next to the labels indicated the in-degree, out-degree, and total degree for that participant role. If multiple participants listed the same role, the degree value is still listed as 1.0 for that edge, thus making the maximum degree possible for this network equal to 14.

5.1.4 Weighted Measurements

The list rankings from most to least critical were used to create weighted measurements for the diabetes care team network (see Chapter 4, section 4.1.3 for details). These weighted measurements, like the degree measurements, can use incoming, outgoing, or total weighted values. Due to the skewed participant sample, only cumulative, normalized in-strength values were used for the weighted measurement analysis.

The in-strength visualization (**Figure 6**) (Fruchterman & Reingold, 1991) indicated that the PCP MD role has the highest cumulative in-strength value. The roles with highest in-strength values were: PCP MD (10.48), RD (8.08), END (6.0), RN (5.38), CDE (5.33), Pharm (4.92), and SW (3.27). A heat map with the normalized in-strength values (**Table 3**) further depicts the clustering of the most critical roles on the diabetes care team.

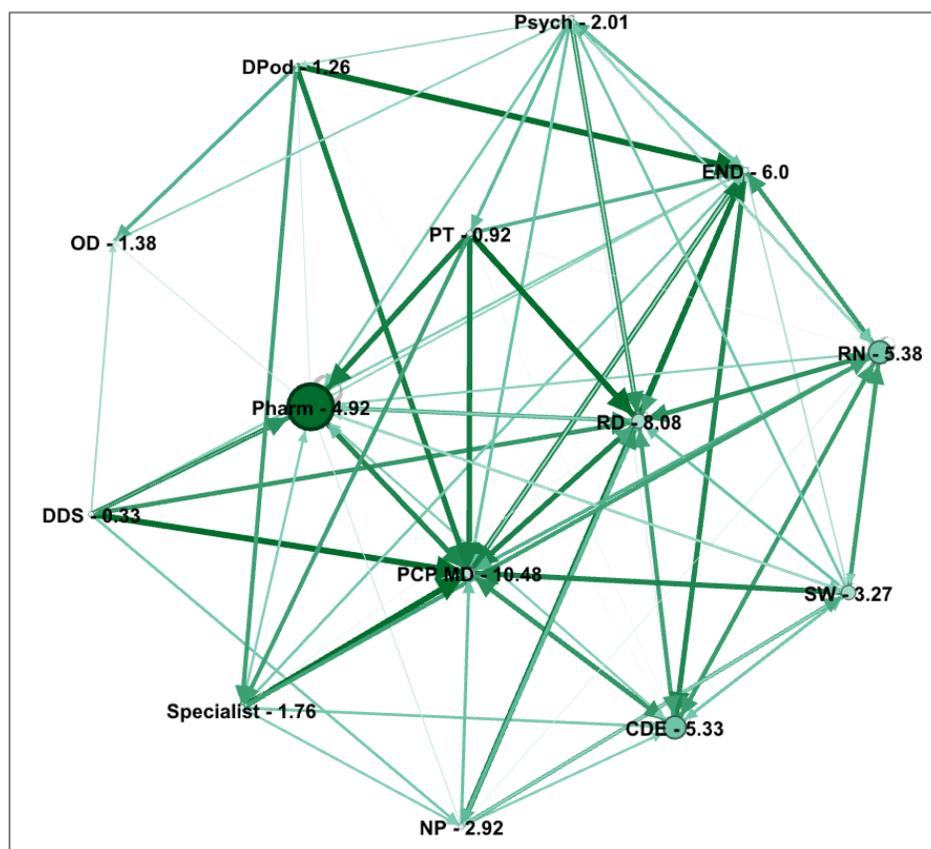


Figure 6. Study I Fruchterman-Reingold Visualization of Cumulative Normalized In-Strength Values.

The number next to each node is the summation of normalized weight of the role from all participants (including self-citations, i.e. participants listing their own role as critical). The edges show the strength of the connections between nodes with respect to normalized weight.

Table 3. Study I Heat Map of Normalized In-strength Values.

These normalizations are on a 0-1.0 scale, and can thus be thought of as percentages. The percentages at or above 50% (0.5-1.0) are shaded as green; percentages between 20-50% are shaded yellow (0.2-0.49); percentages below 20% (0.00-0.19) are shaded red. Participant self-citations (i.e., participants selecting their own roles as critical members of the diabetes care team) are bolded.

	Normalized In-strength values (%) for each role on diabetes care team														
	PCP MD	RD	END	RN	CDE	Pharm	SW	NP	Psych	Spec.	OD	DPod	PT	DDS	
CDE	0.81	0.68	0.26	0.71	0.59	0.40	0.51	0.20	0.11	0.01	0.00	0.03	0.04	0.00	
DDS	1.00	0.75	0.40	0.00	0.00	0.80	0.00	0.45	0.00	0.00	0.30	0.00	0.00	0.30	
DPod	0.90	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.60	0.80	0.00	0.00	
END	0.90	0.70	0.45	0.50	0.85	0.00	0.25	0.00	0.60	0.00	0.00	0.00	0.25	0.00	
NP	0.50	0.75	0.95	0.00	0.40	0.00	0.65	0.75	0.00	0.25	0.00	0.00	0.00	0.00	
PCP MD	0.78	0.66	0.32	0.54	0.76	0.50	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Pharm	0.85	0.69	0.34	0.37	0.40	0.79	0.44	0.14	0.00	0.04	0.13	0.13	0.03	0.03	
Psych	0.50	0.80	0.50	0.45	0.00	0.45	0.00	0.00	0.55	0.00	0.35	0.30	0.55	0.00	
PT	0.90	1.00	0.60	0.00	0.00	0.80	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	
RD	0.88	0.76	0.00	0.68	0.70	0.40	0.12	0.54	0.20	0.06	0.00	0.00	0.00	0.00	
RN	0.60	0.79	0.73	0.71	0.73	0.00	0.40	0.08	0.09	0.00	0.00	0.00	0.05	0.00	
Spec.	1.00	0.00	0.45	0.70	0.45	0.40	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	
SW	0.86	0.50	0.00	0.72	0.46	0.28	0.52	0.36	0.46	0.00	0.00	0.00	0.00	0.00	
sum	10.48	8.08	6.00	5.38	5.33	4.92	3.27	2.92	2.01	1.76	1.38	1.26	0.92	0.33	

While the heat map of the normalized in-strength values (**Table 3**) helps visualize some of the clustering of the network and the most critical roles, it still does not definitively answer the most critical roles to include on a diabetes care team. Therefore, the cumulative, normalized in-strength values were plotted in descending order with a 90% threshold to determine the most significant nodes in the network (Scott, 2017). The results (**Figure 7**) reveal that the core roles on a diabetes care team are the PCP MD, RD, RN, CDE, END, Pharm, SW, and NP roles.

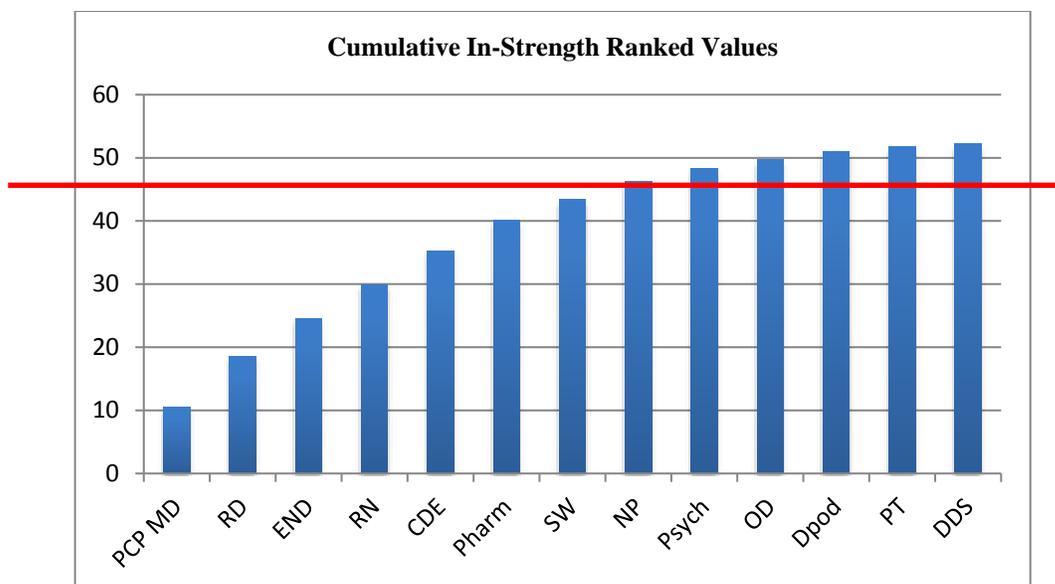


Figure 7. Study I Plot of Cumulative, Normalized In-strength Values.

The normalized in-strength values (see summation values for each role from Table 3) were ranked in descending order, and all roles were cumulatively added together. The 90% threshold of the cumulative in-strength values was approximately 47 (indicated by the red line above. (Scott, 2017).

5.1.5 Percentage Measurements

Percentages of participants selecting each role as a member of the diabetes care team were also captured as a method of visualizing the overall importance and activity between nodes in the network (**Table 4**). Due to the skewed sampling distribution, the percentages were also compared with percentage values without self-citations to help reduce bias (Fleenor, Smither, Atwater, Braddy, & Sturm, 2010). A self-citation is defined as a participant response where they listed their own role in the list of core members of the diabetes care team.

Table 4. Study I Percentage of Participants Including Roles on the Diabetes Care Team. An asterisk Indicates that there were no participants with this role, therefore the percentages with self-citations were equal to 0.

Role	Total % Participants Listing Role	Total % Participants Listing Role - % Self-Cite
PCP MD (n=5)	88% (n=52)	89% (n=47/54)
RD (n=5)	86% (n=51)	85% (n=46/54)
RN (n=8)	71% (n=42)	67% (n=34/51)
CDE (n=8)	64% (n=38)	63% (n=32/51)
Pharm (n=16)	58% (n=34)	43% (n=18/43)
SW (n=5)	54% (n=32)	54% (n=29/54)
END (n=2)	42% (n=25)	42% (n=24/57)
NP (n=2)	25% (n=15)	23% (n=13/57)
Psych (n=2)	19% (n=11)	16% (n=9/57)
OD (n=0) *	12% (n=7)	12% (n=7/59) *
DPOD (n=1)	12% (n=7)	10% (n=6/58)
PT (n=1)	10% (n=6)	10% (n=6/58)
Specialist (n=2)	10% (n=6)	11% (n=6/57)
DDS (n=2)	3% (n=2)	2% (n=1/57)

Comparing the percentages with and without the self-citations emphasizes that most of the roles were relatively stable with only a 0-3% difference, except for the pharmacist role, which had a 16% percentage drop when removing the self-citations. A k-means clustering algorithm (Hartigan & Wong, 1979) was used to determine the clusters of participant roles that were more critical for diabetes care teams with the percentage data from **Table 4**. Both with and without self-citations, the roles fell into two distinct clusters, where the most critical roles with the higher percentages (<40%) were: PCP MD, RD, RN, CDE, SW, Pharm, and END.

5.1.6 Summary of Key Findings from Study I

To determine the most common and critical members of a diabetes care team, social network analysis in-strength measurements for frequency and weight were used, as well as percentage data with and without self-citations. These three methods each indicated that the core members of a diabetes care team were: PCP MD, END, RD, RN, CDE, Pharm, and SW.

5.2 Study II Results

5.2.1 Pilot Testing

There were four (n=4) HCPs who participated in pilot testing the moderator guide: two pharmacists (n=2), one Certified Nursing Assistant (CNA) (n=1), and one Neurologist (n=1). The pharmacist participants participated prior to IRB approval to help provide feedback on the structure, flow, wording, and timing of the interview. The CNA and Neurologist participated after receiving IRB approval, and they were the first two participants scheduled. These two participants would originally have been deemed outside of the recruitment requirements as they did not treat people with diabetes frequently or as a main requirement of their job. Instead of dismissing them from participation, they were instead used to validate the final study protocol and test recording equipment. Their responses were omitted from the final study analysis.

5.2.2 Participant Demographics

Thirty (n=30) HCPs participated in interviews for Study II from January to May 2018 (**Table 5**). The recruitment goals of a minimum of 5 participants per each category were reached, and data collection was terminated when snowball and convenience sampling methods yielded no additional participants for three weeks. No additional participants beyond the initial recruitment goals completed the study tasks and no participants were removed from the data set beyond the pilot testing participants mentioned in section 5.2.1. The mean interview time was 48 minutes (median 50 minutes) and a typical interview was conducted over the phone with a HCP working in an outpatient setting with 13 years of experience.

Table 5. Study II Participant Demographics.

Category	Number of Participants
Professional Title	END (N=5) <ul style="list-style-type: none"> • END NP (N=2) • END MD (N=3) PCP (N=5) <ul style="list-style-type: none"> • PCP MD (N=2) • PCP NP (N=1) • PCP PA (N=2) PharmD (N=5) RD (N=5) RN (N=5) SW (N=5)
Gender	Male (N=2) Female (N=28)
Years in Role	Average: 13.2 years; Median: 9 years 0-5 years (N=13) 6-10 years (N=3) 11-15 years (N=3) 16-20 years (N=2) 21-25 years (N=2) 26-30 years (N=1) 30+ years (N=6)
Work Environment	Outpatient (N=21) <ul style="list-style-type: none"> • General (N=6) • Primary Care (N=5) • Specialty Clinic (N=5) • Internal Medicine (N=2) • Community Mental Health Clinic (N=2) • Private Practice (N=1) Inpatient (N=4) <ul style="list-style-type: none"> • Internal Medicine (N=2) • Primary Care (N=1) • Pediatrics Emergency Department (N=1) Inpatient & Outpatient (N=5)

Table 5 continued

Frequency of Interaction with People with Diabetes	Every Day (N=22) Few Times a Week (N=7) Few Times a Month (N=1)
Primary Patient Population Demographics	Adults only (N=22) Pediatrics only (N=3) Adults & Pediatrics (N=5)
Additional Certifications Related to Diabetes Care	END NP (N=1/5) <ul style="list-style-type: none"> • BC-ADM (N=1) Pharm (N=3/5) <ul style="list-style-type: none"> • BC-ADM (N=2) • BC-ADP (N=1) • CDE (N=2) • LDE (N=1) RD (N=5/5) <ul style="list-style-type: none"> • BC-ADM (N=1) • CDE (N=4) • LDN (N=2) RN (N=4/5) <ul style="list-style-type: none"> • CDE (N=4)
Interview Type	Telephone (N=17) Video-conferencing (N=13) In-person (N=0)

Participant retention rates are highlighted in **Table 6** with recruitment and study tasks. Participants were contacted via snowball and convenience sampling methods in-person, via email, and via social media. Many participants responded to the call for participation but did not ultimately participate due to schedule demands, time commitment of study, or lack of payment for participants.

Table 6. Study II Participant Retention.

The columns include tasks that build upon each other to complete participation in the study. The estimated # contacted is from initial contacts and knowledge of where participants shared the study information. Secondary and tertiary shares of the study are not included in the estimation because these numbers are unknown.

Participant Role	Estimated # Contacted	# Responded	# Screener Completed	# Interview Completed	# Both Worksheets Completed
END	40+	7	6	5	4
PCP	100+	9	6	5	5
Pharm	300+	11	7	5	5
RD	200+	6	5	5	4
RN	200+	11	5	5	5
SW	40+	21	6	5	5
Total	880+	65	35	30	28

5.2.3 Diabetes Care Team Composition & Goals

After confirming patient demographic information, each research interview began by asking participants to share their perspective of the overall goals of the diabetes care team (**Table 7**). Participants were also asked to list the roles that they considered to be part of the diabetes care team to confirm the results of Study I (**Table 8**). The interview ended with asking participants whom they considered to be the hub of the diabetes care team (**Figure 8**).

Table 7. Goals of Diabetes Care Teams.

The results are listed by descending frequency by role. All participants (N=30) answered this question, and some listed more than one goal. The last row of the table lists the sum of the most frequently cited goals for diabetes care teams.

Role	Goal of Diabetes Care Team
END	<ul style="list-style-type: none"> • Provide optimal care (N=4) • Provide support (N=3) • Collaborate & coordinate with multiple areas of expertise (N=3) • Provide education (N=2)
PCP	<ul style="list-style-type: none"> • Improve A1c values (N=4) • Provide optimal care (N=3) • Collaborate & coordinate with multiple areas of expertise (N=3) • Provide education (N=2)
Pharm	<ul style="list-style-type: none"> • Provide optimal care (N=4) • Collaborate & coordinate with multiple areas of expertise (N=4) • Provide support (N=3) • Provide education (N=1)
RD	<ul style="list-style-type: none"> • Provide optimal care (N=3) • Provide support (N=2) • Collaborate & coordinate with multiple areas of expertise (N=2) • Provide education (N=1)
RN	<ul style="list-style-type: none"> • Provide education (N=3) • Collaborate & coordinate with multiple areas of expertise (N=2) • Provide optimal care (N=2) • Provide support (N=2)
SW	<ul style="list-style-type: none"> • Provide resources for managing disease (N=3) • Help patients lead happy, healthy lives (N=3) • Collaborate & coordinate with multiple areas of expertise (N=2) • Provide support (N=2) • Provide education (N=1)
Total	<ul style="list-style-type: none"> • Collaborate & coordinate with multiple areas of expertise (N=16) • Provide optimal care (N=16) • Provide support (N=12) • Provide education (N=10) • Improve A1c values (N=4) • Provide resources for managing disease (N=3) • Help patients lead happy, healthy lives (N=3)

Four key themes emerged from iterative coding of the participant responses for the overarching goal(s) of the diabetes care team (**Table 7**): provide optimal care, provide support to patients, provide education, and collaborate and coordinate with team members with multiple areas of expertise. One endocrinologist described the overarching goal as, “a collaboration of areas of expertise to help patients reach optimum care with quality outcomes” and the team as “an information distribution team”, which summarized the responses from many participants. A few participants mentioned more specific goals that related to their area of interest / expertise (e.g., N=4 primary care providers mentioned improving A1c values, N=3 social workers mentioned providing resources).

The responses for members of the patient care team (**Table 8**) confirmed the findings from the Study I results about the core members of the diabetes care team. The six roles interviewed for the study were confirmed by over half ($N \geq 15/30$) of the study participants. The other roles found in the previous study (e.g., therapist, exercise coach, various specialists, medical assistants) were also echoed in these findings at similar percentage rates. The results from Study I were expanded to include a more extensive list of specialists for annual screenings, which include optometrist/ ophthalmologist, nephrologist, podiatrist, and a cardiologist. In addition, two participants mentioned a new role that was not captured in Study I: a “promotora”, which is a person who provides support for patients out in their communities.

Table 8. Study II Members of Diabetes Care Team.

The results are listed by descending frequency by role. All participants (N=30) answered this question (N=5 per participant role). The last row of the table lists the sum of the most frequently cited members for diabetes care teams.

Participant Role	Frequency of Participants Listing Role as a Member of Diabetes Care Team
END	Healthcare Professionals <ul style="list-style-type: none"> • END (N=5) • CDE (N=5) <ul style="list-style-type: none"> ○ RN (N=3) ○ RD (N=3) ○ Pharm (N=1) • MA or other RNs (“Physician extenders”) (N=4) • NP (N=2) • PCP (N=2) • Pharm (N=2) • Therapist (N=2) Additional Support Team <ul style="list-style-type: none"> • Family (N=3)
PCP	Healthcare Professionals <ul style="list-style-type: none"> • PCP (N=5) • RD (N=5) • RN (N=5) • Pharm (N=4) • END (N=3) • MA (N=3) • SW (N=1) As Needed: <ul style="list-style-type: none"> • Nephrologist (N=2) • Ophthalmologist (N=2) • Podiatrist (N=2) Additional Support Team <ul style="list-style-type: none"> • Family (N=3)
Pharm	Healthcare Professionals <ul style="list-style-type: none"> • PCP (N=5) • RD (N=5) • Pharm (N=4) • RN (N=4)

Table 8 continued

	<ul style="list-style-type: none"> • SW (N=3) • END (N=3) • Health coach (N=3) • MA (N=1) • Promotora (N=1) <p>As Needed:</p> <ul style="list-style-type: none"> • Optometrist / ophthalmologist (N=2) • Nephrologist (N=2) • Physical therapist (N=1) • Podiatrist (N=1) <p>Additional Support Team Family (N=1)</p>
RD	<p>Healthcare Professionals</p> <ul style="list-style-type: none"> • PCP (N=5) • RN (N=5) • RD (N=5) • SW (N=4) • END (N=2) • Exercise physiologists (N=2) • Pharm (N=1) • Promotora (N=1) <p>As Needed:</p> <ul style="list-style-type: none"> • Optometrist / ophthalmologist (N=2) • Cardiologist (N=2) • Nephrologist (N=1) • Podiatrist (N=1) • Vascular surgeon (N=1) <p>Additional Support Team • Patient (N=1)</p>
RN	<p>Healthcare Professionals</p> <ul style="list-style-type: none"> • RN (N=5) • PCP (N=4) • RD (N=4) • END (N=3) • Pharm (N=3) • SW (N=2)

Table 8 continued

	<ul style="list-style-type: none"> • MA (N=1) Additional Support Team <ul style="list-style-type: none"> • Patient (N=1) Family (N=1)
SW	Healthcare Professionals <ul style="list-style-type: none"> • RD (N=5) • SW (N=5) • PCP (N=4) • RN (N=4) • END (N=4) • Pharm (N=3) • Health Coach (N=2) Additional Support Team <ul style="list-style-type: none"> • Patient (N=1) • Family (N=1)
Total	Healthcare Professionals <ul style="list-style-type: none"> • RD (N=27/30, 90%) • RN (N=26/30, 87%) • PCP (N=25/30, 83%) • END (N=20/30, 67%) • Pharm (N=18/30, 60%) • SW (N=15/30, 50%) • MA or other RNs (“Physician extenders”) (N=9/30, 30%) • Health coach (N=5/30, 17%) • NP (N=2/30, 7%) • Therapist (N=2/30, 7%) • Promotora (N=2/30, 7%) • Exercise physiologist (N=2/30, 7%) As Needed: <ul style="list-style-type: none"> • Optometrist / ophthalmologist (N=6/30, 20%) • Nephrologist (N=5/30, 17%) • Podiatrist (N=4/30, 13%) • Cardiologist (N=2/30, 7%) • Physical therapist (N=1/30, 3%) • Vascular surgeon (N=1/30, 3%) Additional Support Team <ul style="list-style-type: none"> • Family (N=9/30, 30%) • Patient (N=3/30, 10%)

Participants were asked, “*Who is the ‘hub’ of the diabetes care team?*” at the end of each interview. The results (**Figure 8**) show that before removing self-citations (e.g., a nurse saying “the nurse is the hub”), primary care provider and nurse are considered the top two hubs of the diabetes care team. After removing self-citations, these trends still hold for the participant sample, even though fifty percent (N=15) of the responses had to be removed. In some instances (N=5), participants elaborated on who they would choose to help offload some of the work for the primary care provider, which were as follows: nurses (N=3), medical assistants / support staff (N=2), certified diabetes educator (RN, RD, or Pharm) (N=1).

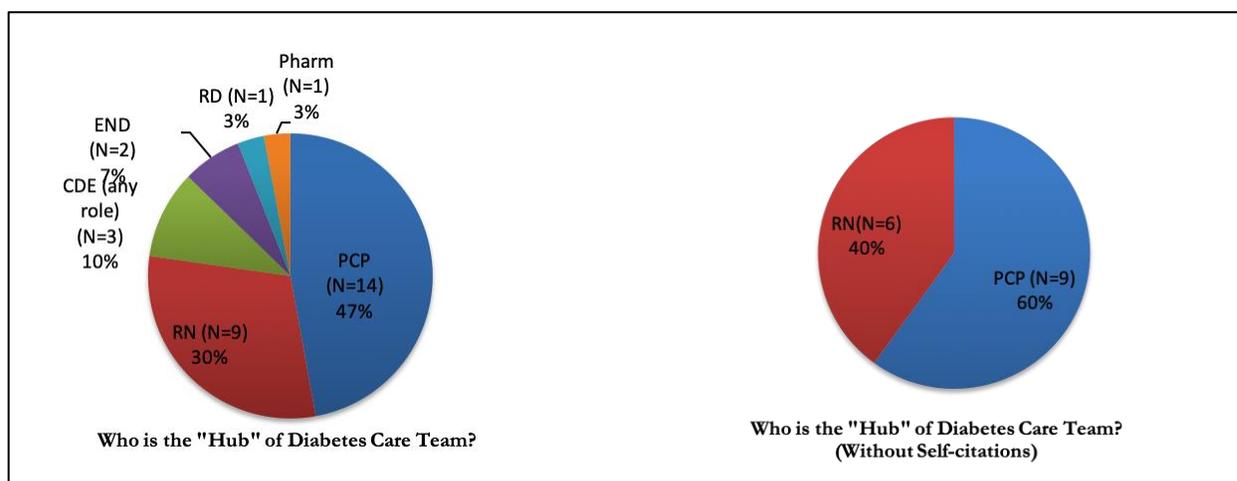


Figure 8. Hub of the Diabetes Care Team.

The pie chart on the left shows the participant response (N=30) for the hub of the diabetes care team. The pie chart on the right depicts the same responses except for ones where participants selected their own roles (N=15).

One primary care provider used an apt metaphor to describe the hub of diabetes care activity: “*In my office, it's the Medical Assistant [who is the hub of the diabetes care team]. In terms of the day to day [...] I would say the physician in terms of directing traffic, and the Medical Assistants are managing the traffic*”. A pharmacist echoed this perspective by sharing that nurses and medical assistances help providers by receiving messages and coordinating care on a regular basis due to a good working relationship with other members of the team. An endocrinologist highlighted a different perspective when comparing the differences between selecting a primary care provider/endocrinologist as the hub over a certified diabetes educator:

“When they sit down with an educator, I mean they often will get a full hour to an hour and a half visit at that one time. But then they may not go back and see them again. So, if you're adding up over five years, they're probably spending more time with me than anything else”- Endocrinologist

5.2.4 Diabetes Care Team Task Analysis

To answer research question 1.2, *“What are the specific tasks for diabetes care team members?”* a task analysis was conducted. The results from the first worksheet of Study II (**Appendix F**) were iteratively coded and compiled into **Tables 9-14** below to highlight key tasks for members of the diabetes care team. The frequencies that participants listed for each task are included in each table, and the tasks are sorted from the most frequently cited tasks to the least frequently cited tasks. There was one participant, a dietitian (RD), who did not complete the worksheet. There were a few other participants who omitted items for roles that they had no interactions with (i.e., one RD included no ratings for END; two SWs included nothing for Pharm). The average importance and team relatedness ratings were also captured for each task. A few participants listed all tasks at the same rating level, while others differentiated the ratings by task.

The most oft-cited tasks for the endocrinologist role (**Table 9**) focused on traditional provider tasks of assessment, diagnosis, and management of the patient disease and treatment. Tasks that were notably different from tasks from other team roles were the distinction that the endocrinologists were primary useful for managing more complicated patients (N=14/28) and for providing specialized treatment for patients (N=11/28), such as with medications and technology. The overall average importance rating was a 4.3, which is tied with the pharmacist role for the fourth most important role. The overall team relatedness rating was a 3.5, which is the overall lowest average team relatedness ranking of all roles. In the more general tasks that also were listed for the primary care provider role (e.g., perform assessment and diagnosis), the team relatedness ratings were lower, with the average primary care provider and endocrinologist participants listing these tasks at a less than 3.0 rating on a Likert Scale of 1 to 5.

Table 9. Endocrinologist Task Frequencies & Ratings.

Task Description	Frequency	Average Importance Rating (1- not at all important to 5- very important)	Average Team Relatedness Rating (1- not required for optimal team performance to 5- very much required for optimal team performance)
Perform Assessment & Diagnosis <ul style="list-style-type: none"> • Manage Complicated Patients (N=14) 	N=25/28 (89%) N= 3 END N= 5 PCP N= 4 Pharm N= 3 RD N= 5 RN N= 5 SW	Overall= 4.2 END= 4.2 PCP= 3.8 Pharm= 4.3 RD= 3.7 RN= 4.4 SW= 4.8	Overall= 3.0 END= 2.5 PCP= 2.6 Pharm= 2.5 RD= 4 RN= 3 SW= 3.9
Manage Patient Medications <ul style="list-style-type: none"> • Review, Order, & Amend Medication as Needed 	N= 17/28 (61%) N= 4 END N= 2 PCP N= 2 Pharm N= 2 RD N= 4 RN N= 3 SW	Overall= 4.1 END= 4.4 PCP= 5.0 Pharm= 4.5 RD= 3.8 RN= 4.0 SW= 5.0	Overall= 3.7 END= 3.1 PCP= 3.0 Pharm= 4.5 RD= 5.0 RN= 3.8 SW= 3.7
Provide Specialized Treatment for Patients <ul style="list-style-type: none"> • Medications (N=9) • Technology (N=6) 	N=11/28 (39%) N= 1 END N= 2 PCP N= 3 Pharm N= 2 RD N= 2 RN N= 1 SW	Overall= 4.6 END= 4.0 PCP= 5.0 Pharm= 5.0 RD= 3.5 RN= 5.0 SW= 5.0	Overall= 3.7 END= 4.0 PCP= 3.0 Pharm= 3.7 RD= 3.0 RN= 4.5 SW= 4.0
Provide Patient Education	N= 10/28 (36%) N= 3 END N= 2 PCP N= 2 Pharm N= 1 RD N= 1 RN N= 1 SW	Overall= 4.2 END= 4.3 PCP= 4.0 Pharm= 4.5 RD= 3.5 RN= 4.0 SW= 4.0	Overall= 4.0 END= 4.3 PCP= 1.5 Pharm= 5.0 RD= N/A RN= 5.0 SW= 5.0

Table 9 continued

Order & Review Patient Data <ul style="list-style-type: none"> Laboratory results monitoring (N=7) Reviewing BG and/or CGM logs (N=1) Review A1c measures (N=1) Review objective measures (N=1) 	N= 10/28 (36%) N= 2 END N= 1 PCP N= 2 Pharm N= 2 RD N= 2 RN N= 1 SW	Overall= 4.5 END= 4.0 PCP= 5.0 Pharm= 4.5 RD= 4.0 RN= 5.0 SW= 5.0	Overall= 3.9 END= 2.5 PCP= 5.0 Pharm= 4.5 RD= 5.0 RN= 3.0 SW= 5.0
Coordinate Information with Diabetes Care Team <ul style="list-style-type: none"> Provide consultation notes (N=7) Referrals as needed (N=3) 	N=9/28 (32%) N= 1 END N= 1 PCP N= 1 Pharm N= 1 RD N= 3 RN N= 2 SW	Overall= 4.3 END= 5.0 PCP= 5.0 Pharm= 5.0 RD= 4.0 RN= 4.0 SW= 4.0	Overall= 3.4 END= 5.0 PCP= 5.0 Pharm= 2.0 RD= 5.0 RN= 3.0 SW= 2.5
Develop Patient Treatment Plan & Goals	N= 7/28 (25%) N= 3 END N= 1 Pharm N= 2 RN N= 1 SW	Overall= 4.3 END= 4.0 Pharm= 4.0 RN= 5.0 SW= 5.0	Overall= 3.6 END= 2.3 Pharm= 4.0 RN= 4.5 SW= 5.0
Follow-up with Patients as Needed	N= 6/28 (21%) N= 2 END N= 1 PCP N= 1 Pharm N= 2 SW	Overall= 4.3 END= 3.5 PCP= 5.0 Pharm= 5.0 SW= 4.5	Overall= 3.5 END= 3.5 PCP= 1.0 Pharm= 5.0 SW= 4.0
Encourage Patients Towards Healthy Living	N= 2/28 (7%) N= 1 END N= 1 SW	Overall= 3.5 END= 4.0 SW= 3.0	Overall= 5.0 END= 5.0 SW= 5.0
Manage Acute Kidney Injuries	N=1/28 (4%) N= 1 SW	Overall= 4.0 SW= 4.0	Overall= 3.0 SW= 3.0
Total Average Ratings		4.3	3.5

The Primary Care Provider tasks (**Table 10**) had some overlap with the tasks for the endocrinologist role, particularly the perform assessment and diagnosis, manage medications, and order and review patient data tasks. The PCP tasks were different from other roles on the

diabetes care team in that there was a strong emphasis on coordination and referrals to other members of the care team. Over half of the study participants (N=19/29) mentioned that the PCP role was critical for connecting patients to other healthcare professionals and coordinating information among the team. These tasks were also deemed the most important and the most team related compared to the other tasks for PCPs. Several participants (N=5/29) also mentioned that the PCP role manages less complicated patients and/or patients who are more compliant with following their diabetes treatment plan. The PCP role was tied for the highest ranked importance at 4.5 (tied with social work role). The overall team related rating was 3.6, which is marginally higher than the results for the endocrinologist role, but it is still the second lowest in the overall average team relatedness rating.

Table 10. Primary Care Provider Task Frequencies & Ratings.

Task Description	Frequency	Average Importance Rating (1- not at all important to 5- very important)	Average Team Relatedness Rating (1- not required for optimal team performance to 5- required for optimal team performance)
Coordinate Overall Patient Care Activity <ul style="list-style-type: none"> • Continuity of Care with Specialists (N=6) • Inform Diabetes Care Team of Treatment Plan Changes (N=3) 	N= 19/29 (66%) N= 3 END N= 4 PCP N= 4 Pharm N= 5 RD N= 1 RN N= 2 SW	Overall= 4.5 END= 4.7 PCP= 5.0 Pharm= 4.0 RD= 4.0 RN= 4.5 SW= 5.0	Overall= 3.9 END= 3.7 PCP= 3.75 Pharm= 4.75 RD= 4.7 RN= 5.0 SW= 3.5
Screen and Refer to Specialists	N=18/29 (62%) N= 3 END N= 2 PCP N= 4 Pharm N= 3 RD N= 3 RN N= 3 SW	Overall= 4.7 END= 4.7 PCP= 5.0 Pharm= 4.5 RD= 5.0 RN= 4.7 SW= 4.7	Overall= 4.0 END= 3.3 PCP= 3.5 Pharm= 4.3 RD= 5.0 RN= 4.3 SW= 4.0

Table 10 continued

Manage Patient Medications <ul style="list-style-type: none"> • Review, Order, & Amend Medication as Needed 	N= 17/29 (59%) N= 2 END N= 3 PCP N= 2 Pharm N= 3 RD N= 5 RN N= 2 SW	Overall= 4.5 END= 4.5 PCP= 5.0 Pharm= 4.0 RD= 3.5 RN= 4.6 SW= 5.0	Overall= 3.4 END= 1.5 PCP= 3.0 Pharm= 3.5 RD= 4.0 RN= 3.6 SW= 5.0
Perform Assessment & Diagnosis <ul style="list-style-type: none"> • Manage less complicated / more compliant patients (N=5) • Provide Preventative Care (N=5) 	N= 16/29 (55%) N= 2 END N= 2 PCP N= 3 Pharm N= 3 RD N= 4 RN N= 2 SW	Overall= 4.3 END= 5.0 PCP= 5.0 Pharm= 4.7 RD= 3.7 RN= 4.0 SW= 4.0	Overall= 3.3 END= 2.5 PCP= 3.5 Pharm= 4.0 RD= 4.5 RN= 3.0 SW= 2.5
Order & Review Patient Data <ul style="list-style-type: none"> • Eye Exam (N=1) • Neuropathy Exam (N=1) • BP Lipids (N=1) 	N= 11/29 (38%) N= 3 PCP N= 1 Pharm N= 3 RD N= 2 RN N= 2 SW	Overall= 4.5 PCP= 5.0 Pharm= 3.0 RD= 4.5 RN= 5.0 SW= 4.0	Overall= 3.2 PCP= 2.8 Pharm= 2.0 RD= 5.0 RN= 3.5 SW= 3.0
Encourage Patients <ul style="list-style-type: none"> • Encourage Lifestyle Modifications (N=4) • Encourage Interaction with Other HCPs (N=3) • Encourage Preventative Care (N=1) 	N= 7/29 (24%) N= 1 END N= 1 PCP N= 2 Pharm N= 2 RN N= 1 SW	Overall= 4.1 END= 4.0 PCP= 3.0 Pharm= 4.5 RN= 4.5 SW= 4.0	Overall= 3.1 END= 4.0 PCP= 1.0 Pharm= 3.5 RN= 3.8 SW= 2.0
Provide Patient Education	N= 5/29 (17%) N= 1 END N= 1 PCP N= 1 RD N= 1 RN N= 1 SW	Overall= 4.5 END= 4.0 PCP= 5.0 RD= N/A RN= 4.0 SW= 5.0	Overall= 5.0 END= 5.0 PCP= 5.0 RD= N/A RN= 5.0 SW=

Table 10 continued

Follow-up with Patients as Needed	N= 4/29 (14%) N= 1 END N= 2 PCP N= 1 RN	Overall= 4.5 END= 4.0 PCP= 5.0 RN= 4.0	Overall= 2.5 END= 3.0 PCP= 3.0 RN= 1.0
Update Knowledge of Diabetes Standards of Care Metrics	N=1/29 (3%) N= 1 RN	Overall= 5.0 RN= 5.0	Overall= 2.0 RN =2.0
Total Average Ratings		4.5	3.6

Nearly every participant (N=26/27, 96%) mentioned medication management as a task for the pharmacist role (**Table 11**). This included the starting, stopping, and adjustment of medications (N=21/27); medication reconciliation (N=12/27); and reviewing medications for interactions (N=6/27). Over half of the participants (N=14/27) also mentioned that patient education was a key task for pharmacists on diabetes care teams. The overall importance rating for this role was a 4.3, and the overall team relatedness rating was a 3.7, both of which were median values compared to the ratings for the other team member roles.

Table 11. Pharmacist Task Frequencies & Ratings.

Task Description	Frequency	Average Importance Rating (1- not at all important to 5- very important)	Average Team Relatedness Rating (1- not required for optimal team performance to 5- very much required for optimal team performance)
Manage Medications <ul style="list-style-type: none"> • Start, Stop, Adjust Medications (N=21) • Medication Reconciliation (N=12) • Review Medications for Side Effects & Interactions (N=6) 	N= 26/27 (96%) N= 4 END N= 5 PCP N= 5 Pharm N= 4 RD N= 5 RN N= 3 SW	Overall= 4.3 END= 4.3 PCP= 4.2 Pharm= 4.8 RD= 3.0 RN= 4.4 SW= 4.7	Overall= 3.6 END= 3.25 PCP= 3.2 Pharm= 4.2 RD= 3.5 RN= 3.4 SW=4.3

Table 11 continued

Provide Patient Education <ul style="list-style-type: none"> • Medication Administration Education (N=6) • Drug Effects Education (N=2) • Technology Education (N=2) 	N= 14/27 (52%) N= 2 END N= 4 PCP N= 4 Pharm N= 1 RN N= 3 SW	Overall= 4.3 END= 4.5 PCP= 4.4 Pharm= 4.3 RN= 3.0 SW= 4.7	Overall= 3.9 END= 4.0 PCP= 4.0 Pharm= 3.5 RN= 1.0 SW= 3.7
Navigation Insurance Coverage <ul style="list-style-type: none"> • Find Alternatives that Reduce Cost, Improve Outcomes, and Combine Medications to Reduce Quantity of Medications Needed for Patients (N=4) 	N= 13/27 (48%) N= 2 END N= 1 PCP N= 3 Pharm N= 3 RD N= 3 RN N= 1 SW	Overall= 4.3 END= 3.5 PCP=4.0 Pharm= 4.3 RD= 3.0 RN= 4.0 SW= 5.0	Overall= 3.5 END= 4.5 PCP=4.0 Pharm= 4.0 RD= 3.5 RN= 2.8 SW= 4.0
Refer Patient to Other Members of the Care Team As Needed	N= 8/27 (30%) N= 2 PCP N= 1 Pharm N= 1 RD N= 3 RN N= 1 SW	Overall= 4.3 PCP= 3.5 Pharm= 4.0 RD= N/A RN= 4.7 SW= 5.0	Overall= 3.5 PCP= 2.5 Pharm= 5.0 RD= N.A RN= 3.2 SW= 5.0
Order and Review Patient Data <ul style="list-style-type: none"> • Monitor BG and/or CGM Logs (N=4) • Lab Ordering and Monitoring (N=4) • Monitor A1c Values (N=2) 	N= 6/27 (22%) N= 3 Pharm N= 1 RD N= 1 RN N= 1 SW	Overall= 4.0 Pharm= 4.3 RD= N/A RN= 4.0 SW= 3.0	Overall= 3.8 Pharm= 4.7 RD= N/A RN= 3.0 SW= 2.0
Advocate for Patients	N= 1/27 (4%) N= 1 END	Overall= 5.0 END= 5.0	Overall= 5.0 END= 5.0
Total Average Ratings		4.3	3.7

Tasks listed for the dietitian role (**Table 12**) overwhelmingly mentioned providing patient education (N=29/29, 100%). The education tasks included nutrition therapy (N=19/29), carbohydrate counting (N=10/29), technology usage (N=5/29), exercise (N=5/29), medication information (N=3/29), and advice on other lifestyle changes due to the disease (N=2/29).

Although nearly all tasks for all healthcare professionals ranked below a 4.0 for average team relatedness, dietitians referring patients to other members of the care team ranked very highly (4.7) on the team relatedness scale. The overall importance rating for dietitians was a 4.4, which is the second highest of the roles (behind PCP and SW), and tied for the highest overall average team relatedness rating with 3.8 (tied with RN).

Table 12. Dietitian Task Frequencies & Ratings.

Task Description	Frequency	Average Importance Rating (1- not at all important to 5- very important)	Average Team Relatedness Rating (1- not required for optimal team performance to 5- very much required for optimal performance)
Provide Patient Education <ul style="list-style-type: none"> • Nutrition Therapy (N=19) • Carbohydrate Counting (N=10) • Technology usage (N=5) • Exercise (N=5) • Medications (N=3) • Lifestyle Changes (N=2) • Group Classes (N=2) 	N= 29/29 (100%) N= 5 END N= 5 PCP N= 5 Pharm N= 4 RD N= 5 RN N= 5 SW	Overall= 4.4 END= 4.8 PCP= 4.8 Pharm= 4.3 RD= 4.0 RN= 4.2 SW= 4.5	Overall= 3.6 END= 3.7 PCP= 3.3 Pharm= 4.0 RD= 4.5 RN= 2.8 SW= 4.1
Develop Patient Treatment Plan <ul style="list-style-type: none"> • Assess Needs (N=5) • Set Goals (N=13) • Follow Up and Re-assess Plan (N=7) 	N= 17/29 (59%) N= 2 END N= 2 PCP N= 3 Pharm N= 4 RD N= 4 RN N= 2 SW	Overall= 4.3 END= 4.5 PCP= 4.0 Pharm= 4.0 RD= 4.0 RN= 4.7 SW= 4.5	Overall= 3.5 END= 4.5 PCP= 2.5 Pharm= 3.2 RD= 4.5 RN= 3.6 SW= 5
Refer Patient to Other Members of the Care Team As Needed	N= 7/29 (24%) N= 1 END N= 1 Pharm N= 2 RD N= 1 RN N= 2 SW	Overall= 4.2 END= 5.0 Pharm= 4.0 RD= 3.0 RN= 4.0 SW= 4.5	Overall= 4.7 END= 5.0 Pharm= 5.0 RD= 4.0 RN= 5.0 SW= 4.5

Table 12 continued

Share Patient Progress with Diabetes Care Team	N= 6/29 (21%) N= 1 PCP N= 2 RD N= 2 RN N= 1 SW	Overall= 4.5 PCP= 5.0 RD= N/A RN= 4.0 SW= 5.0	Overall= 4.0 PCP= 5.0 RD= N/A RN= 3.0 SW= 5.0
Encourage Patients	N=3/29 (7%) N= 1 PCP N= 2 SW	Overall= 4.3 PCP= 5.0 SW= 4.0	Overall= 5.0 PCP= 5.0 SW= 5.0
Total Average Ratings		4.4	3.8

The nurse role (**Table 13**) tasks were very similar to ones mentioned for dietitians (**Table 12**), particularly for providing education to patients and patient assessment. The roles differed in that the nurse role emphasized more education on general diabetes disease information (N=19/29), technology education and troubleshooting assistance (N=11/29), while the dietitian role focused heavily on nutrition education (N=19/20). Nurses were also rated highly for importance (4.2) and team relatedness (4.6) for providing information coordination support to the diabetes care team (N=21/29). Thirteen (N=13/29) participants mentioned that nurses help serve as liaisons between different healthcare professionals, as well as between the patient and the diabetes care team. The nurse had the lowest overall average importance rating (4.2), but tied with dietitians for the highest overall average team relatedness rating (3.8).

Table 13. Nurse Task Frequencies & Ratings.

Task Description	Frequency	Average Importance Rating (1- not at all important to 5- very important)	Average Team Relatedness Rating (1- not required for optimal team performance to 5- very much required for optimal team performance)
Provide Patient Education • General Diabetes Information	N= 22/29 (76%) N= 3 END	Overall= 4.1 END= 4.6	Overall= 3.2 END= 3.1

Table 13 continued

<ul style="list-style-type: none"> • (N=19) • Technology Instruction and Trouble Shooting (N=11) • Provide Handouts (N=2) • Exercise Classes (N=1) Carb Counting (N=1)	N= 5 PCP N= 4 Pharm N= 4 RD N= 3 RN N= 3 SW	PCP= 4.4 Pharm= 3.5 RD= 3.7 RN= 4.3 SW= 4.1	PCP= 3.4 Pharm= 3.5 RD= 4.0 RN= 2.7 SW=3.6
Provide Information Coordination Support to Diabetes Care Team <ul style="list-style-type: none"> • Serve as a Liaison between Healthcare Professionals (N=13) • Serve as a Liaison between Patient and Diabetes Care Team (N=13) • Triage Patient Issues (N=4) • Case Manager Role (N=4) 	N= 21/29 (72%) N= 4 END N= 2 PCP N= 3 Pharm N= 4 RD N= 4 RN N= 4 SW	Overall= 4.2 END= 4.3 PCP= 4.0 Pharm= 4.7 RD= 3.3 RN= 4.4 SW= 4.3	Overall= 4.6 END= 4.9 PCP= 4.5 Pharm= 4.9 RD= 5.0 RN= 3.8 SW= 4.8
Assess Patient <ul style="list-style-type: none"> • Diabetes Assessment (N=9) • Potential Complications (N=2) • Physical Assessment (N=1) • Lifestyle (N=1) 	N= 10/29 (34%) N= 1 PCP N= 1 Pharm N= 1 RD N= 5 RN N= 2 SW	Overall= 4.6 PCP= 5.0 Pharm= 3.0 RD= 3.0 RN= 4.9 SW= 5.0	Overall= 4.1 PCP= 4.0 Pharm= 3.0 RD= N/A RN= SW=5.0
Collect & Monitor Patient Data <ul style="list-style-type: none"> • Download BG or CGM Data (N=6) • Review labs (Renal, iSTAT, etc.) (N=2) 	N= 8/29 (28%) N= 2 PCP N= 4 Pharm N= 2 RN	Overall= 4.0 PCP= 4.5 Pharm= 3.3 RN= 5.0	Overall= 3.3 PCP= 2.5 Pharm= 3.8 RN= 3.0
Assist with Medications <ul style="list-style-type: none"> • Adjust and/or Reorder Medications as per Protocol (N=3) • Administer Medication (N=1) • Navigate Insurance Coverage (N=1) • Medication Reconciliation (N=1) 	N= 8/29 (28%) N= 1 END N= 1 PCP N= 2 RD N= 2 RN N= 2 SW	Overall= 4.1 END= 4.0 PCP= 5.0 RD= 3.0 RN= 4.3 SW= 4.3	Overall= 3.0 END= 2.0 PCP= 4.0 RD= 3.0 RN= 5.0 SW=3.5

Table 13 continued

Encourage Patients	N= 3/29 (10%) N= 1 END N= 1 PCP N= 1 RN	Overall= 5.0 END= 5.0 PCP= 5.0 RN= 5.0	Overall= 3.3 END= 4.0 PCP= 4.0 RN= 2.0
Provide Support for END and/or PCP (e.g., scheduling, paperwork)	N=2/29 (7%) N= 1 END N= 1 RD	Overall= 4.5 END= 5.0 RD= 4.0	Overall= 5.0 END= 5.0 RD= 5.0
Advocate for Patients	N= 1/29 (3%) N= 1 SW	Overall= 5.0 SW= 5.0	Overall= 5.0 SW= 5.0
Total Average Ratings		4.2	3.8

The most often cited task for a social worker (**Table 14**) was to help patients obtain resources (N=25/28), ranging from financial services (N=13/28), to diabetes management resources (N=10/28), to community support groups (N=5/28), to other services (e.g., housing, transportation, insurance, etc.). As many social workers often have counseling certifications, participants mentioning counseling (N=12/28) as another key task for the social work role. These two tasks were rated fairly highly for importance (4.4), but they were ranked on the lower side comparatively for team relatedness (3.5 and 3.2, respectively). The only tasks that overlapped with other roles within the social work task were provide patient education (N=3/28) and advocacy (N=1/28). The social work role was tied with the primary care provider role for the overall average importance rating (4.5) and tied for third with the pharmacist for the overall team relatedness rating (3.7).

Table 14. Social Worker Task Frequencies & Ratings.

Task Description	Frequency	Average Importance Rating (1- not at all important to 5- very important)	Average Team Relatedness Rating (1- not required for optimal team performance to 5- very much required for optimal team performance)
Help Patients Obtain Resources <ul style="list-style-type: none"> • Financial Services (N=13) • Diabetes Management Resources (N=10) • Support Groups (N=8) • Insurance Coverage (N=5) • Mental Health Support (N=5) • Transportation Services (N=4) • Housing Assistance (N=2) • Child & Social Services (N=2) 	N= 25/28 (89%) N= 5 END N= 4 PCP N= 5 Pharm N= 4 RD N= 5 RN N= 2 SW	Overall= 4.4 END= 4.4 PCP= 4.0 Pharm= 4.7 RD= 4.5 RN= 4.5 SW= 4.5	Overall= 3.5 END= 3.2 PCP= 3.0 Pharm= 4.1 RD= 3.5 RN= 4.0 SW= 2.9
Provide Counseling Services for Patient and/or Family Members	N= 12/28 (43%) N= 2 END N= 1 PCP N= 2 Pharm N= 1 RD N= 2 RN N= 4 SW	Overall= 4.4 END= 3.5 PCP= 5.0 Pharm= 4.5 RD= N/A RN= 4.0 SW= 4.8	Overall= 3.2 END= 4.0 PCP= 3.0 Pharm= 3.5 RD= N/A RN= 1.5 SW= 3.4
Communicate Patient Information with Diabetes Care Team	N= 7/28 (25%) N= 1 PCP N= 2 RD N= 2 RN N= 2 SW	Overall= 4.5 PCP= 5.0 RD= 5.0 RN= 4.5 SW= 4.0	Overall= 4.3 PCP= 5.0 RD= 5.0 RN= 3.5 SW= 4.5
Assess Barriers to Patient Care	N= 6/28 (21%) N= 1 PCP N= 2 RN N= 3 SW	Overall= 4.5 PCP= 5.0 RN= 4.0 SW= 4.7	Overall= 4.4 PCP= 3.0 RN= 5.0 SW= 4.5

Table 14 continued

Provide Patient Education	N= 3/28 (11%) N= 1 PCP N= 1 RN N= 1 SW	Overall= 4.7 PCP= 5.0 RN= 4.0 SW= 5.0	Overall= 3.7 PCP= 1.0 RN= 5.0 SW= 5.0
Advocate for Patients	N= 1/28 (4%) N= 1 SW	Overall= 5.0 SW= 5.0	Overall= 5.0 SW= 5.0
Total Average Ratings		4.5	3.7

There were four main tasks that were mentioned for at least half of the diabetes care team roles: patient monitoring and assessment, medication management, patient education, and team coordination and information sharing. These tasks were plotted in **Figure 9** to demonstrate the frequency that participants mentioned each task, where a larger role area depicted a higher frequency. This visualization demonstrates that the RN and RD roles focus more on patient education and information coordination. The pharmacist had less involvement in team information coordination and patient monitoring assessment tasks, but was involved in medication management and patient education. The END and PCP roles were the most central with all four tasks, but the PCP role had more emphasis on information coordination, and the END role had slightly more emphasis on patient monitoring and assessment.

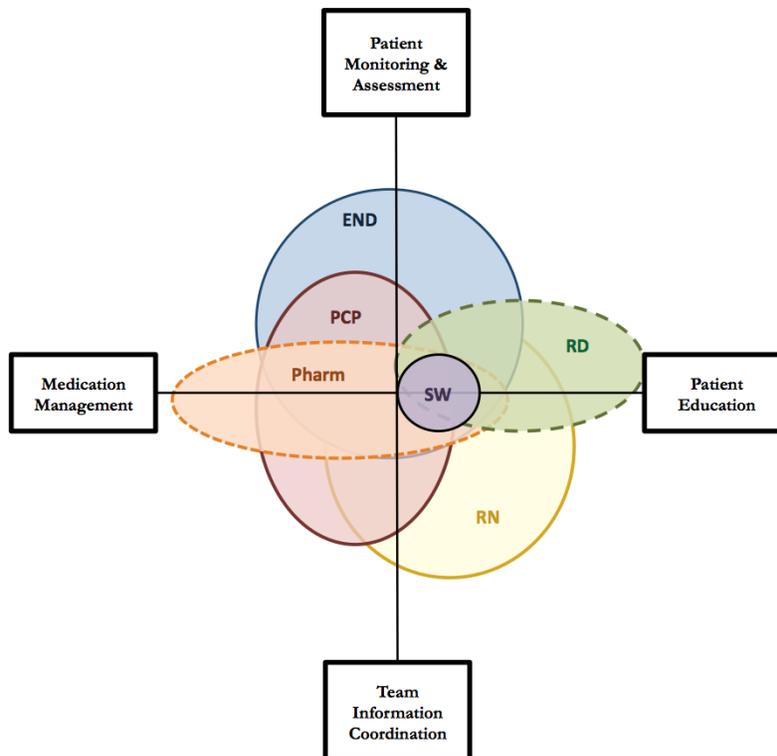


Figure 9. Overlapping Diabetes Care Team Taskwork.

The size of each role is depicted by the frequency of participants mentioned that task. The more participants that mention a task, the farther the role moved towards that axis and the larger the size of the role.

Several tasks were distinct for each team role. **Figure 10** reviews these distinct tasks for each role as found from the most frequently cited tasks in the task analysis.



Figure 10. Distinct Tasks for Each Member of the Diabetes Care Team.

5.2.5 Information Flow Analysis

The next research question for Study II, was “*What are the required information flow attributes for effective diabetes care team coordination?*” (RQ 1.3). To answer this question, participants were asked to fill out a worksheet (**Appendix G**) with information about how frequently they interacted with other members of the diabetes care team, the actual and preferred modes of communication, the content of information shared, and the perceived frequency of communication between each role and their patients. These results provide necessary temporal data and information channels attributes for effective information coordination for diabetes care team processes.

5.2.5.1 Frequency of Information Flows Between Diabetes Care Team Roles

Participants were asked how frequently they interacted with other members on the diabetes care team, ranging from daily to never (**Table 15**). One endocrinologist did not fill complete this portion of the study and participants were not required to fill out frequency of interactions for their own role, therefore a max possibility of 24 responses was possible for each role (25 for endocrinologists). The results revealed that most members of the diabetes care team interact with nurses daily; primary care providers and dietitians weekly; and endocrinologists, pharmacists, social workers monthly. The social worker category had the highest number of participants indicating that they rarely or never interact with this role (N=8/24).

Table 15. Frequency of HCP Interactions on Diabetes Care Teams.

Each category can have a total potential of 24 responses, as one participant did not fill out the worksheet, and participants did not rank how frequently they interacted with people within their discipline. The darker colors represent the higher frequency of participants selecting that frequency option.

Frequency of Interaction	Interacting Participant Role					
	END	PCP	Pharm	RD	RN	SW
Daily	Total: N= 3 N= 1 PCP N= 1 RN N= 1 SW	Total: N= 7 N= 2 Pharm N= 1 R N= 3 RN N= 1 SW	Total: N= 2 N= 2 RN	Total: N= 7 N= 1 END N= 1 Pharm N= 4 RN N= 1 SW	Total: N= 13 N= 3 END N= 3 PCP N= 2 Pharm N= 3 RD N= 2 SW	Total: N= 3 N= 1 PCP N= 1 RD N= 1 RN
Weekly	Total: N= 4 N= 1 RD N= 2 RN N= 1 SW	Total: N= 7 N= 1 END N= 2 Pharm N= 2 RD N= 2 RN	Total: N= 5 N= 1 END N= 2 PCP N= 2 SW	Total: N= 7 N= 2 END N= 3 Pharm N= 2 SW	Total: N= 2 N= 2 SW	Total: N= 3 N= 1 END N= 1 Pharm N= 1 RD
Monthly	Total: N= 7 N= 2 PCP N= 3 Pharm N= 1 RD N= 1 RN	Total: N= 3 N= 1 END N= 1 Pharm N= 1 SW	Total: N= 9 N= 2 END N= 2 PCP N= 2 RD N= 2 RN N= 1 SW	Total: N= 4 N= 1 PCP N= 1 Pharm N= 2 SW	Total: N= 4 N= 1 END N= 1 Pharm N= 1 RD N= 1 SW	Total: N= 7 N= 2 END N= 4 Pharm N= 1 RN
Quarterly	Total: N= 3 N= 1 PCP N= 2 RD	Total: N= 2 N= 1 END N= 1 RD	Total: N= 2 N= 2 RD	Total: N= 1 N= 1 PCP	Total: N= 1 N= 1 Pharm	Total: N=0
Yearly	Total: N= 2 N= 2 Pharm	Total: N= 1 N= 1 END	Total: N= 0	Total: N= 1 N= 1 PCP	Total: N= 1 N= 1 PCP	Total: N= 3 N= 1 PCP N= 1 RD N= 1 RN
Rare / Never	Total: N= 6 N= 1 PCP N= 1 RD N= 1 RN N= 3 SW	Total: N= 4 N= 1 RD N= 3 SW	Total: N= 6 N= 1 END N= 1 PCP N= 1 RD N= 1 RN N= 2 SW	Total: N= 4 N= 1 END N= 2 PCP N= 1 RN	Total: N= 3 N= 1 PCP N= 1 Pharm N= 1 RD	Total: N= 8 N= 1 END N= 3 PCP N= 2 RD N= 2 RN
Median	Monthly	Weekly	Monthly	Weekly	Daily	Monthly

The values for each role in **Table 15** were compared to check for differences between provider opinions. **Table 16** has the frequency of participant interactions listed to facilitate comparisons. The majority of participants had similar perspectives on how frequently they interacted with each other. The median values for the RD-PCP, RD-Pharm, RD-SW, and SW-RN were slightly off. Median responses across roles indicated that Dietitians interact with primary care providers weekly, while primary care providers said they interacted with dietitians yearly; dietitians indicated interactions with pharmacists quarterly, while pharmacists indicated weekly; and dietitians indicated interactions with social workers weekly, while social workers indicated yearly. Social workers also said that they interacted with nurses weekly, while nurses said they interacted with social workers yearly.

Table 16. Review of Discrepancies between HCP Ratings of Frequency Interaction.

The left column is the participant role and the responses are their perspectives on their frequency of interaction with that role. The white cells have the same median value for frequencies. The lighter shaded values are where the medians are slightly off (e.g., weekly vs. monthly), and the darker shades are where the medians are considerably different.

Role	Role to be Rated for Frequency of Interaction					
	END	PCP	Pharm	RD	RN	SW
END	X	Weekly N=1 Monthly N=1 Quarterly N=1 Yearly N=1	Weekly N=1 Monthly N=2 Rarely N=1	Daily N=1 Weekly N=2 Rarely N=1	Daily N=3 Monthly N=1	Weekly N=1 Monthly N=2 Rarely N=2
PCP	Daily N=1 Monthly N=2 Quarterly N=1 Rarely N=1	X	Weekly N=2 Monthly N=2 Rarely N=1	Monthly N=1 Quarterly N=1 Yearly N=1 Rarely N=2	Daily N=3 Yearly N=1 Rarely N=1	Daily N=1 Yearly N=1 Rarely N=3
Pharm	Monthly N=3 Yearly N=2	Daily N=2 Weekly N=2 Monthly N=1	X	Daily N=1 Weekly N=3 Monthly N=1	Daily N=2 Monthly N=1 Quarterly N=1 Rarely N=1	Weekly N=1 Monthly N=4
RD	Weekly N=1 Monthly N=2 Quarterly N=1 Rare N=1	Daily N=1 Weekly N=2 Quarterly N=1 Rarely N=1	Monthly N=2 Quarterly N=2 Rarely N=1	X	Daily N=3 Monthly N=1 Rarely N=1	Daily N=1 Weekly N=1 Yearly N=1 Rarely N=2
RN	Daily N=1 Weekly N=2 Monthly N=1 Rarely N=1	Daily N=3 Weekly N=2	Daily N=2 Monthly N=2 Rarely N=1	Daily N=4 Rarely N=1	X	Daily N=1 Monthly N=1 Yearly N=1 Rarely N=2
SW	Daily N=1 Weekly N=1 Rarely N=3	Daily N=1 Monthly N=1 Rarely N=3	Weekly N=2 Monthly N=1 Rarely N=2	Daily N=1 Weekly N=2 Monthly N=2	Daily N=2 Weekly N=2 Monthly N=1	X

5.2.5.2 Communication Modes Between Diabetes Care Team Roles

During Study II, participants were asked what their actual communication mode and preferred communication modes (**Table 17**) were with the other members of the diabetes care team. One participant (endocrinologist) did not fill out this worksheet, and another participant (dietitian) did not fill out information for the preferred role communication modes.

The overall mode values for the actual mode of communication and preferred mode of communication were the same for each role except for the endocrinologist and primary care provider roles. For these roles, the current mode of communication for endocrinologists is via EHR / EMR record and for primary care providers it is via secure messaging. Participants indicated for both roles that face-to-face communication would be their preferred form of communication. For every role except for the pharmacist, the overall preferred mode of communication is face-to-face, while for pharmacists it is via phone.

Table 17. Frequency of HCP Actual vs. Preferred Communication Modes.

Each role can have more than the total potential of 24 responses, as some participants mentioned multiple modes of communication per role. One participant did not fill out the worksheet, and participants did not list the ways they communicated with people within their own profession. The darker colors represent the higher frequency of participants selecting that frequency option.

Mode (Actual vs. Preferred)	Frequency that Participants Mention Communication Mode with Provider Role					
	END	PCP	Pharm	RD	RN	SW
Secure Messaging (Actual)	Total: N= 8 N= 1 PCP N= 1 Pharm N= 3 RD N= 3 RN	Total: N=12 N= 3 END N= 1 Pharm N= 4 RD N= 2 RN N= 2 SW	Total: N= 9 N= 3 END N= 2 RD N= 2 RN N= 2 SW	Total: N= 7 N= 2 END N= 1 PCP N= 1 Pharm N= 1 RN N= 2 SW	Total: N= 9 N= 3 END N= 1 PCP N= 3 RD N= 2 SW	Total: N= 7 N= 2 END N= 2 Pharm N= 3 RD
Secure Messaging (Preferred)	Total: N= 6 N= 2 PCP N= 1 Pharm N= 1 RD N= 1 RN N= 1 SW	Total: N= 6 N= 2 END N= 1 RD N= 2 RN N= 1 SW	Total: N= 8 N= 2 END N= 1 PCP N= 1 RD N= 2 RN N= 2 SW	Total: N= 6 N= 1 END N= 2 PCP N= 1 Pharm N= 1 RN N= 1 SW	Total: N= 5 N= 2 END N= 1 PCP N= 1 RD N= 1 SW	Total: N= 6 N= 2 END N= 1 PCP N= 1 Pharm N= 1 RD N= 1 RN

Table 17 continued

EHR Record (Actual)	Total: N= 12 N= 2 PCP N= 5 Pharm N= 1 RD N= 2 RN N= 2 SW	Total: N= 6 N= 1 END N= 3 Pharm N= 1 RD N= 1 RN	Total: N= 1 N= 1 RN	Total: N= 7 N= 1 END N= 2 PCP N= 1 Pharm N= 2 RN N= 1 SW	Total: N= 4 N= 1 PCP N= 2 Pharm N= 1 SW	Total: N= 2 N= 1 END N= 1 Pharm
EHR Record (Preferred)	Total: N= 6 N= 1 PCP N= 3 Pharm N= 2 RN	Total: N= 4 N= 1 END N= 1 Pharm N= 1 RD N= 1 RN	Total: N= 1 N= 1 RN	Total: N= 5 N= 1 END N= 2 PCP N= 2 RN	Total: N= 3 N= 2 PCP N= 1 Pharm	Total: N= 1 N= 1 END
Phone / Fax (Actual)	Total: N= 3 N= 2 RN N= 1 SW	Total: N= 5 N= 2 RD N= 2 RN N= 1 SW	Total: N=10 N= 2 END N= 3 PCP N= 2 RD N= 2 RN N= 1 SW	Total: N= 4 N= 2 PCP N= 1 Pharm N= 1 RN	Total: N= 4 N= 1 PCP N= 2 RD N= 1 SW	Total: N= 4 N= 1 END N= 1 PCP N= 1 RD N= 1 RN
Phone / Fax (Preferred)	Total: N= 3 N= 1 RD N= 1 RN N= 1 SW	Total: N= 2 N= 1 END N= 1 SW	Total: N= 9 N= 3 END N= 2 PCP N= 1 RD N= 2 RN N= 1 SW	Total: N= 0	Total: N= 2 N= 1 Pharm N= 1 RD	Total: N= 2 N= 1 PCP N= 1 RD
Face-to-Face (Actual)	Total: N= 4 N= 1 PCP N= 1 RD N= 2 SW	Total: N= 10 N= 3 Pharm N= 2 RD N= 2 RN N= 3 SW	Total: N= 3 N= 1 PCP N= 2 SW	Total: N= 12 N= 2 END N= 3 Pharm N= 3 RN N= 4 SW	Total: N=14 N= 3 END N= 2 PCP N= 2 Pharm N= 2 RD N= 5 SW	Total: N= 9 N= 2 END N= 2 PCP N= 2 Pharm N= 3 RN
Face-to-Face (Preferred)	Total: N= 8 N= 1 PCP N= 1 Pharm N= 1 RD N= 2 RN N= 3 SW	Total: N= 14 N= 5 Pharm N= 2 RD N= 3 RN N= 4 SW	Total: N= 5 N= 1 PCP N= 1 RD N= 3 SW	Total: N= 14 N= 2 END N= 1 PCP N= 4 Pharm N= 2 RN N= 5 SW	Total: N=13 N= 2 END N= 2 PCP N= 2 Pharm N= 2 RD N= 5 SW	Total: N=10 N= 1 END N= 1 PCP N= 4 Pharm N= 1 RD N= 3 RN

Table 17 continued

N/A or None (Actual)	Total: N= 3 N= 1 PCP N= 1 RD N= 1 SW	Total: N= 1 N= 1 SW	Total: N= 3 N= 1 PCP N= 1 RD N= 1 SW	Total: N= 0	Total: N= 1 N= 1 Pharm	Total: N= 4 N= 2 PCP N= 1 RD N= 1 RN
N/A or None (Preferred)	Total: N= 3 N= 1 PCP N= 1 RD N= 1 SW	Total: N= 1 N= 1 SW	Total: N= 3 N= 1 PCP N= 1 RD N= 1 SW	Total: N= 0	Total: N= 1 N= 1 Pharm	Total: N= 4 N= 2 PCP N= 1 RD N= 1 RN
Total	Actual: EHR Record Preferred: Face-to- Face	Actual: Secure Messaging Preferred: Face-to- Face	Actual: Phone Preferred: Phone	Actual: Face-to- Face Preferred: Face-to- Face	Actual: Face-to- Face Preferred: Face-to- Face	Actual: Face-to- Face Preferred: Face-to- Face

The communication modes were compared against each role for discrepancies (**Table 18**). The majority of the communication mode flows were the same for each role. A few notable exceptions were with people's actual and preferred preferences for the pharmacist role. Each participant role mentioned preferring to contact pharmacists via phone, yet only one pharmacist mentioned contacting others via phone (the dietitian and nurse roles, respectively). The pharmacists had a stronger desire for face-to-face communication or technology-mediated communication modes (e.g., via secure messaging or EHR).

Table 18. Review of Discrepancies between HCP Actual & Preferred Communication Modes. The left column is the participant role and the responses are their perspectives on the actual and preferred modes of communication with each role. The values are stated in frequencies throughout the table, where SM=secure messaging, F2F=Face to Face, Phone = Phone and/or Fax, and N/A=Not Available and/or None. The white cells have roughly the same mode value for frequencies (e.g., endocrinologist opinion of how to communicate with a pharmacist is the same mode as pharmacist communicating with endocrinologist). The lighter shaded values are where the modes are slightly off, and the darker shades are where the modes are considerably different.

Role	Role to be Rated for Frequency of Interaction					
	END	PCP	Pharm	RD	RN	SW
END	X	<u>Actual</u> SM N = 3 EHR N=1 N/A N=1	<u>Actual</u> SM N = 3 Phone N=2	<u>Actual</u> SM N = 2 EHR N=1 F2F N=2	<u>Actual</u> SM N = 3 F2F N=3	<u>Actual</u> SM N = 2 EHR N=1 Phone N=1 F2F N=2
		<u>Preferred</u> SM N=2 EHR N=1 Phone N=1 N/A N=1	<u>Preferred</u> SM N=2 Phone N=3	<u>Preferred</u> SM N=1 EHR N=1 F2F N=2	<u>Preferred</u> SM N=2 F2F N=2	<u>Preferred</u> SM N=2 EHR N=1 F2F N=1
PCP	<u>Actual</u> SM N = 1 EHR N=2 F2F N=1 N/A N=1	X	<u>Actual</u> Phone N=3 F2F N=1 N/A N=1	<u>Actual</u> SM N=1 EHR N=2 Phone N=2	<u>Actual</u> SM N=1 EHR N=1 Phone N=1 F2F N=2	<u>Actual</u> Phone N=1 F2F N=2 N/A N=2
	<u>Preferred</u> SM N=2 EHR N=1 F2F N=1 N/A N=1		<u>Preferred</u> SM N=1 Phone N=2 F2F N=1 N/A N=1	<u>Preferred</u> SM N=2 EHR N=2 F2F N=1	<u>Preferred</u> SM N=1 EHR N=2 F2F N=2	<u>Preferred</u> SM N=1 Phone N=1 F2F N=1 N/A N=2
Pharm	<u>Actual</u> SM N = 1 EHR N=5	<u>Actual</u> SM N=1 EHR N=3 F2F N=3	X	<u>Actual</u> SM N=1 EHR N=1 Phone N=1 F2F N=3	<u>Actual</u> EHR N=2 F2F N=2 N/A N=1	<u>Actual</u> SM N=2 EHR N=1 F2F N=2
	<u>Preferred</u> SM N=1	<u>Preferred</u> EHR N=1		<u>Preferred</u> SM N=1	<u>Preferred</u> EHR N=1	<u>Preferred</u> SM N=1

Table 18 continued

	EHR N=3 F2F N=1	F2F N=5		F2F N=4	Phone N=1 F2F N=2 N/A N=1	F2F N=4
RD	<u>Actual</u> SM N = 3 EHR N=1 F2F N=1 N/A N=1	<u>Actual</u> SM N=4 EHR N=1 Phone N=2 F2F N=2	<u>Actual</u> SM N=2 Phone N=2 N/A N=1	X	<u>Actual</u> SM N=3 Phone N=2 F2F N=2	<u>Actual</u> SM N=3 Phone N=1 F2F N=3 N/A N=1
	<u>Preferred</u> SM N=1 Phone N=1 F2F N=1 N/A N=1	<u>Preferred</u> SM N=1 EHR N=1 F2F N=2	<u>Preferred</u> SM N=1 Phone N=1 F2F N=1 N/A N=1		<u>Preferred</u> SM N=1 Phone N=1 F2F N=2	<u>Preferred</u> SM N=1 Phone N=1 F2F N=3 N/A N=1
RN	<u>Actual</u> SM N = 3 EHR N=2 Phone N=2	<u>Actual</u> SM N=2 EHR N=1 Phone N=2 F2F N=2	<u>Actual</u> SM N=2 EHR N=1 Phone N=2	<u>Actual</u> SM N=1 EHR N=2 Phone N=1 F2F N=3	X	<u>Actual</u> Phone N=1 F2F N=3 N/A N=1
	<u>Preferred</u> SM N=1 EHR N=2 Phone N=1 F2F N=2	<u>Preferred</u> SM N=2 EHR N=1 F2F N=3	<u>Preferred</u> SM N=2 Phone N=2 EHR N=1	<u>Preferred</u> SM N=1 EHR N=2 F2F N=2		<u>Preferred</u> SM N=1 F2F N=3 N/A N=1
SW	<u>Actual</u> EHR N=2 Phone N=1 F2F N=2 N/A N=1	<u>Actual</u> SM N=2 Phone N=1 F2F N=3 N/A N=1	<u>Actual</u> SM N=2 Phone N=1 F2F N=2 N/A N=1	<u>Actual</u> SM N=2 EHR N=1 F2F N=4	<u>Actual</u> SM N=2 EHR N=1 Phone N=1 F2F N=5	X
	<u>Preferred</u> SM N=1 Phone N=1 F2F N=3 N/A N=1	<u>Preferred</u> SM N=1 Phone N=1 F2F N=4 N/A N=1	<u>Preferred</u> SM N=2 Phone N=1 F2F N=3 N/A N=1	<u>Preferred</u> SM N=1 F2F N=5	<u>Preferred</u> SM N=1 F2F N=5	

5.2.5.3 Information Content Flows between Diabetes Care Team Members

Participants were asked to share the content of the information they communicated to members of the diabetes care team and the information they received from each member in return (**Table 19**). The results reinforce many of the findings from the team task analysis. The endocrinologist shares treatment plan changes and requests for additional team support, and receives updates from team members as appropriate. The primary care provider receives patient questions from nurses (*“they are more comfortable talking to us than the doctor”-RN*), and does not share or receive much information with social workers. The pharmacist fields questions related to insurance coverage and medication management from all roles, and some pharmacists with collaborative-practice agreements share non-diabetes concerns with their connected primary care provider. Nurses share their assessments with the endocrinologists and primary care providers. Nurses, dietitians, and social workers share and receive barriers to patient care with other members of the care team frequently, which reflect their areas of expertise on the team. For example, the nurse will share barriers that affect nutrition with the dietitian and barriers that affect medication with the pharmacist. Lab reports (e.g., blood glucose levels, A1c), blood glucose logs, updates to patient medical history, and patient notes are also frequently shared and received throughout the communication flows between members of the diabetes care team.

There is limited information sharing between social workers and dietitians, social workers and pharmacists, and social workers and primary care providers. Dietitians and pharmacists also do not have as much interaction according to the information content analysis.

Table 19. Information Content Flows between HCPs.

The left column is the participant role and the responses are the information content that they share and receive with each team role. The values are stated in frequencies throughout the table. Items with N>=3 frequencies are bolded and in blue to highlight trends in information content sharing for individual roles; items with a mode of N>4 are summarized in the last row of the table.

Role	Information Content Sharing with each Team Role					
	END	PCP	Pharm	RD	RN	SW
END	X	<u>Share:</u> <ul style="list-style-type: none"> • Patient Assessment (N=2) • Treatment plan (N=2) • Recommendations (N=2) • Lab results (N=2) • Medication changes (N=2) • Patient concerns (N=1) • N/A (N=1) 	<u>Share:</u> <ul style="list-style-type: none"> • Treatment plan & any changes (N=2) • Education requests (N=1) • Prescriptions (N=1) • Medication questions (N=1) • N/A (N=1) 	<u>Share:</u> <ul style="list-style-type: none"> • Treatment plan & any changes (N=4) • Education requests (N=2) • Patient assessment (N=1) • Medications (N=1) • Lab work (N=1) • Patient diet (N=1) • N/A (N=1) 	<u>Share:</u> <ul style="list-style-type: none"> • Education requests (N=3) • Treatment plan & any changes (N=2) • Concerns about patient (N=2) • BG data (N=1) • N/A (N=1) 	<u>Share:</u> <ul style="list-style-type: none"> • Concerns about patient barriers to care (N=2) • Counseling request (N=2) • Patient notes (N=1) • Financial concerns (N=1) • Social issues (N=1) • N/A (N=1)
		<u>Receive:</u> <ul style="list-style-type: none"> • Changes in patient record (e.g., medications, surgeries, other 	<u>Receive:</u> <ul style="list-style-type: none"> • Recommendations based on patient insurance coverage (N=3) • Errors or issues 	<u>Receive:</u> <ul style="list-style-type: none"> • Patient assessment & progress update (N=3) • Barriers to care 	<u>Receive:</u> <ul style="list-style-type: none"> • Questions regarding treatment plan (N=2) • Concerns about 	<u>Receive:</u> <ul style="list-style-type: none"> • Concerns about patient barriers to care (N=2) • Follow up questions (N=1)

Table 19 continued

		<ul style="list-style-type: none"> • providers) (N=2) • Lab results (N=2) • Current medications (N=1) • Treatment plan (N=1) • Changes in BG (N=1) • Concerns about diabetic complications (N=1) • Reasons for consult (N=1) • Follow up questions (N=1) N/A (N=1) 	<ul style="list-style-type: none"> • with medication (N=2) • N/A (N=1) 	<ul style="list-style-type: none"> • (N=1) • Nutrition plan (N=1) • Questions regarding treatment plan (N=1) • Information about patient adherence (N=1) • N/A (N=1) 	<ul style="list-style-type: none"> • patient (N=2) • Medication issues (N=2) • Insurance issues (N=1) • Messages from patients (N=1) • BG data (N=1) • N/A (N=1) 	<ul style="list-style-type: none"> • N/A (N=1)
PCP	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Patient notes (N=2) • Lab results (N=2) • Updates on 	X	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Medication information (N=3) • Goals (N=1) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Patient goals (N=1) • Patient note (N=1) • Blood glucose 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Medication information (N=2) • Lab results (e.g., A1c) (N=2) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Request for intervention (N=1) • Education request (N=1)

Table 19 continued

	<ul style="list-style-type: none"> • patient status and compliance (N=1) • Updates on changes in medical history (N=1) N/A (N=2) 		<ul style="list-style-type: none"> • Lab results (N=1) • Treatment plan (N=1) N/A (N=1) 	<ul style="list-style-type: none"> • information (N=1) • Medications (N=1) • N/A (N=2) 	<ul style="list-style-type: none"> • Blood glucose logs (N=1) • Patient goals (N=1) • Patient barriers (N=1) N/A (N=1) 	<ul style="list-style-type: none"> • N/A (N=3)
	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Patient notes (N=2) • Therapy recommendations (N=1) • Recommendations for specific medications (N=1) • Insurance coverage (N=1) • Lab results (N=1) • N/A (N=2) 		<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Patient adherence (N=2) • Medication interactions (N=2) • Recommendations for medications based on insurance (N=1) • N/A (N=1) 	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Patient note (N=2) • Nutrition information (N=2) • Carb counting instructional (N=1) • Barriers to care (N=2) 	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Patient questions (N=3) • Patient barriers (N=1) • Patient compliance update (N=1) • Request for refills (N=1) • Medication information (N=1) • N/A (N=1) 	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Patient questions (N=2) • Barriers to care (N=2) • Request for refills (N=1) • Insurance help (N=1) • N/A (N=3)
Pharm	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Patient notes (N=3) • Challenges with care (e.g., insulin 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Patient concerns outside of practice 	X	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Eating habits (N=3) • Patient goals (N=2) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Care coordination concerns for transitions (N=2) • Triage questions 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Financial issues (N=4) • Barriers to care (N=2)

Table 19 continued

<ul style="list-style-type: none"> • resistance) (N=2) • Reason / expectation for consult (N=2) • Lab results (e.g., A1c) (N=1) <p>Synopsis of medication therapies and results (N=1)</p>	<ul style="list-style-type: none"> • agreement (non-diabetes) (N=3) • Medication information (N=2) • Follow up questions about treatment plan (N=2) • Patient notes (N=2) • Requests for refills (N=1) • Patient progress (N=1) <p>Patient barriers (N=1)</p>		<ul style="list-style-type: none"> • Barriers to care (N=2) • Education requests (N=1) • Reason for consult (N=1) • Patient notes (N=1) 	<p>(N=1)</p> <ul style="list-style-type: none"> • Lab monitoring needs (N=1) • Patient notes (N=1) • Medication information (N=1) • Requests for weight loss programs (N=1) <p>N/A (N=1)</p>	<ul style="list-style-type: none"> • Transportation issues (N=2) • Housing issues (N=2) • Adherence issues (N=1) • Mental health issues (N=1)
<p><u>Received:</u></p> <ul style="list-style-type: none"> • Patient notes (N=3) • Clarifications for notes (N=1) • How they can assist the patient (N=1) 	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Follow up questions about treatment plan (N=3) • Reason for consultation 		<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Patient notes (N=3) • Patient goals (N=1) • N/A (N=2) 	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Medication questions (N=2) • Diabetes disease related questions (N=2) • Patient questions (N=1) 	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Follow up from outcomes of the request (N=2)

Table 19 continued

	<ul style="list-style-type: none"> • Recommendations for medications (N=1) 	<ul style="list-style-type: none"> • (N=2) • Lab results (N=2) • Patient goals (N=1) Medication questions (N=1) 			<ul style="list-style-type: none"> • Information about patient coordination activity (N=1) • Blood glucose logs (N=1) N/A (N=1) 	
RD	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Patient notes (N=2) • Barriers to patient care (N=2) <ul style="list-style-type: none"> ○ Hypoglycemia/Hyperglycemia concerns (N=1) ○ Medications issues (N=1) • Blood sugar logs (N=1) • N/A (N=1) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Patient nutrition information (N=1) • Lifestyle assessment (N=1) • Patient notes (N=1) • Patient barriers (N=1) • N/1 (N=1) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Lifestyle assessment (N=1) • Information about some diabetes medications (N=1) • N/A (N=3) 	X	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Lifestyle assessment (N=2) • Patient medication information (N=1) • Medication issues (N=1) • Blood glucose logs (N=1) • N/A (N=2) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Mental Health concern (N=2) • Financial assistance (N=1) • N/A (N=3)
	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Patient notes (N=3) • Clarification about patient treatment plans (N=1) 	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Patient notes (N=1) • Answers to follow up questions 	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Answers to questions about medications (N=2) • Confirmation of medication 		<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Barriers to communication information (N=1) • Patient medication information (N=1) 	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • N/A (N=5)

Table 19 continued

	<ul style="list-style-type: none"> • New medication and therapy advancements (N=1) • Lab data (N=1) • Education class topics (N=1) N/A (N=1) 	<ul style="list-style-type: none"> • (N=1) • Education request (N=1) • Case reports (N=1) • N/A (N=1) 	<ul style="list-style-type: none"> • information (N=1) • Medication costs and insurance information (N=1) N/A (N=2) 		<ul style="list-style-type: none"> • Lifestyle information (N=1) • Dietary concerns (N=1) N/A (N=2) 	
RN	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Patient assessment (N=3) • Patient status (e.g., compliant & stable or not) (N=3) • Barriers to care (N=2) • Medication information (N=1) • Lab reports (N=1) • Blood glucose readings (N=1) • N/A (N=1) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Patient assessment (N=3) • Patient progress (N=1) • Recommendations for referrals (N=1) • Vital signs (N=1) • Lab coordination (N=1) • Patient history (N=1) • Barriers to care (N=1) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Barriers to patient care (e.g., costs, interactions, social systems) (N=3) • Noncompliance issues (N=2) • Insulin pump settings (N=1) • Medication orders (N=1) • Concerns about drug interactions (N=1) • Issues with insurance (N=1) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Patient questions (e.g., diet, lifestyle) (N=2) • Patient diet (N=1) • Education request (N=1) • N/A (N=1) 	X	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Compliance issues (N=2) • Family / social concerns (N=2) • Request for intervention (N=2) • Financial concerns (N=1) • Housing issues (N=1) • N/A (N=2)

Table 19 continued

		<ul style="list-style-type: none"> • Medication suggestions (N=1) • Treatment questions (N=1) • Medication corrections (N=1) 	<ul style="list-style-type: none"> • Patient assessment (N=1) 			
	<u>Receive:</u> <ul style="list-style-type: none"> • Treatment plan (N=2) • Patient notes (N=2) • Medication Information (N=1) • Lab reports (N=1) • Blood glucose readings (N=1) • Reason for referral (N=1) • Topics for education (N=1) 	<u>Receive:</u> <ul style="list-style-type: none"> • Patient assessment (N=2) • Adherence issues (N=2) • Treatment plan (N=2) • Changes in treatment (N=2) • Answers to questions (N=1) • Barriers to care (N=1) • Blood glucose 	<u>Receive:</u> <ul style="list-style-type: none"> • Insurance coverage information (N=4) • Medication consultation (N=3) • Alternative medication recommendations (N=1) • Patient assessment (N=1) 	<u>Receive:</u> <ul style="list-style-type: none"> • Questions about disease from patient (N=1) • Questions about medications from patient (N=1) • N/A (N=1) 		<u>Receive:</u> <ul style="list-style-type: none"> • Updates to requests (N=2) • Psychosocial assessment (N=2) • Barriers to care (N=1) • Family dynamics (N=1) • Lifestyle assessment (N=1) • Patient support system information (N=1) • N/A (N=2)

Table 19 continued

		<ul style="list-style-type: none"> data (N=1) • Medication information (N=1) • Lab work (N=1) 				
SW	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Barriers to Care (N=3) • Updates on psychosocial issues (N=2) <ul style="list-style-type: none"> ○ Family issues (N=1) ○ Depression (N=1) ○ School (N=1) ○ Insurance (N=1) ○ Abuse (N=1) • Recent hospitalizations (N=1) • Questions with medications (N=1) • N/A (N=1) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Follow up with request (N=1) • Progress report (N=1) • Symptoms (N=1) • Treatment history (N=1) • Compliance concerns (N=1) • Barriers to care (N=1) • Patient goals (N=1) • Patient motivation level (N=1) • Psychosocial issues (N=1) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Barriers to medication adherence (N=1) • Barriers to disease educations (N=1) • Resources for education (N=1) • Insurance coverage concerns (N=1) • N/A (N=3) 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Goals of patient (N=2) • Psychosocial issues that impact self care (N=2) • Coping mechanisms (N=1) • Available resources (N=1) • Compliance issues (N=1) • Barriers to care (N=1) • Mental health status (N=1) • Patient needs (N=1) • Treatment plan 	<p><u>Share:</u></p> <ul style="list-style-type: none"> • Psychosocial issues that impact self care (N=3) • Compliance issues (N=1) • Barriers to care (N=1) • Mental health status (N=1) • Issues with medications (N=1) • Symptoms (N=1) • Patient coordination concerns (N=1) • N/A (N=1) 	X

Table 19 continued

	<ul style="list-style-type: none"> • N/A (N=2) 		<ul style="list-style-type: none"> (N=1) • N/A (N=1) 		
<u>Receive:</u> <ul style="list-style-type: none"> • Potential barriers to treatment (N=1) • Mental health concerns (N=1) • Insurance issues (N=1) • Medication recommendations (N=1) • Updates on medical information (N=1) • Blood glucose logs (N=1) • A1c values (N=1) • N/A (N=1) 	<u>Receive:</u> <ul style="list-style-type: none"> • Symptoms (N=2) • Need for follow up labs (N=1) • Medical history (N=1) • Scientific side of patient issues (N=1) • Barriers to care (N=1) • Treatment goals (N=1) • N/A (N=2) 	<u>Receive:</u> <ul style="list-style-type: none"> • Access issues (N=1) • Compliance issues (N=1) • Request for behavioral counseling (N=1) • Insurance coverage information (N=1) • N/A (N=3) 	<u>Receive:</u> <ul style="list-style-type: none"> • Professional recommendations (N=1) • Dietary goals (N=1) • Blood Glucose data (N=1) • Patient assessment (N=1) • Mental health concerns (N=1) • Insurance issues (N=1) • Barriers to care (N=1) • Requests for treatment (N=1) • N/A (N=1) 	<u>Receive:</u> <ul style="list-style-type: none"> • Barriers to care (N=3) • A1c and Blood Glucose levels (N=2) • Mental health concerns (N=2) • Patient assessment (N=2) • Insurance coverage issues (N=2) • Symptoms (N=1) • Doctors appointments (N=1) • Patient bad habits (N=1) • N/A (N=1) 	

Table 19 continued

Mode	<p><u>Share with END:</u></p> <ul style="list-style-type: none"> • Barriers to care (N=11) • Patient notes (N=7) • Updates on patient progress (N=6) • Lab results (N=4) • Patient assessment (N=4) • N/A (N=5) 	<p><u>Share with PCP:</u></p> <ul style="list-style-type: none"> • Patient assessment (N=9) • Referral (N=7) • Barriers to care (N=6) • Medication information (N=5) • N/A (N=4) 	<p><u>Share with Pharm:</u></p> <ul style="list-style-type: none"> • Medication information (N=5) • Barriers to care (N=4) • Treatment plan (N=4) • N/A (N=8) 	<p><u>Share with RD:</u></p> <ul style="list-style-type: none"> • Patient diet (N=7) • Treatment plan (N=5) • Patient goals (N=5) • Education request (N=4) • N/A (N=5) 	<p><u>Share with RN:</u></p> <ul style="list-style-type: none"> • Medication information (N=8) • Patient goals (N=5) • Blood glucose logs (N=4) • Lab results (N=4) • Barriers to care (N=4) • N/A (N=7) 	<p><u>Share with SW:</u></p> <ul style="list-style-type: none"> • Financial issues (N=7) • Request for intervention (N=6) • Barriers to care (N=4) • N/A (N=9)
	<p><u>Receive from END:</u></p> <ul style="list-style-type: none"> • Patient notes (N=10) • Care recommendations (N=5) • Lab results (N=4) • N/A (N=4) 	<p><u>Receive from PCP:</u></p> <ul style="list-style-type: none"> • Questions (N=5) • Treatment plan and patient goals (N=5) • Lab results (N=5) • N/A (N=4) 	<p><u>Receive from Pharm:</u></p> <ul style="list-style-type: none"> • Insurance coverage information (N=9) • Medication errors / corrections (N=4) • N/A (N=7) 	<p><u>Receive from RD:</u></p> <ul style="list-style-type: none"> • Patient assessment (N=9) • Barriers to care (N=4) • N/A (N=5) 	<p><u>Receive from RN:</u></p> <ul style="list-style-type: none"> • Blood glucose data (N=4) • Barriers to care (N=8) • Patient questions (N=5) • Medication questions (N=4) • N/A (N=6) 	<p><u>Receive:</u></p> <ul style="list-style-type: none"> • Follow up from request (N=5) • Barriers to care (N=5) • N/A (N=11)

5.2.5.4 Information Flows between Patients and Diabetes Care Team Members

Participants shared the perceived frequency of communication with patients (**Table 20**), their mode of communication with patients (**Table 21**), and the content of information they shared and received with patients (**Table 22**).

Participants were asked their perceptions of how frequently healthcare providers saw their patients (**Table 20**). The overall median values were compared with the median values that participants chose for their own role. The overall median values matched for individual roles for every role on the diabetes care team except for the nurses and social workers. The nurses had “daily” as their median frequency for seeing patients, while the overall median was “monthly”. The social workers had “weekly”/ “quarterly” for the median frequency of patient interaction, but overall participants said “yearly” / “as needed”. Some participants (N=2) mentioned that for some specialty roles like dietitians and social workers, that non-compliant patients may see them more often and not every person with diabetes will see these particular roles because they aren’t always necessary.

Table 20. Perceived Frequency of HCP-Patient Interaction.

Green indicates agreement between the median participant’s perception of how frequently they interact with patients and other healthcare professionals median perception of how often they meet with patients. Red indicates a mismatch between the perceptions.

Role	Frequency of Patient Interaction					
	END	PCP	Pharm	RD	RN	SW
END	Quarterly (N=2) N/A (N=2)	Monthly (N=1) Quarterly (N=3)	Monthly (N=3) N/A (N=1)	Weekly (N=1) Monthly (N=2) Yearly (N=1)	Daily (N=1) Weekly (N=1) Monthly (N=2)	Monthly (N=2) Yearly (N=1) As Needed (N=1)
PCP	Monthly (N=2) Quarterly (N=2) N/A (N=1)	Monthly (N=2) Quarterly (N=3)	Monthly (N=4) N/A (N=1)	Monthly (N=2) Yearly (N=3)	Monthly (N=1) Quarterly (N=1) Yearly (N=1) As Needed (N=1) N/A (N=1)	Monthly (N=1) As Needed (N=2) N/A (N=2)
Pharm	Monthly (N=1) Quarterly (N=2) Yearly (N=1)	Monthly (N=1) Quarterly (N=2) Yearly (N=2)	Weekly (N=1) Monthly (N=4)	Monthly (N=5)	Monthly (N=4) N/A (N=1)	Monthly (N=3) Yearly (N=2)
RD	Quarterly (N=3) N/A (N=2)	Quarterly (N=4) N/A (N=1)	Quarterly (N=2) As Needed (N=1) N/A (N=2)	Weekly (N=1) Monthly (N=2) Yearly (N=1) As Needed (N=1)	Monthly (N=1) Quarterly (N=3) N/A (N=1)	Monthly (N=1) As Needed (N=1) N/A (N=3)
RN	Daily (N=2) Quarterly (N=2) As Needed (N=1)	Daily (N=2) Monthly (N=2) As Needed (N=1)	Monthly (N=2) Rarely (N=2) As Needed (N=1)	Daily (N=1) Weekly (N=2) Monthly (N=1) Quarterly (N=1)	Daily (N=3) Weekly (N=1) N/A (N=1)	Daily (N=1) As Needed (N=3) N/A (N=1)
SW	Daily (N=1) Monthly (N=1) Quarterly (N=2) Yearly (N=1)	Weekly (N=1) Monthly (N=2) Yearly (N=1) N/A (N=1)	Weekly (N=2) Monthly (N=1) N/A (N=2)	Daily (N=1) Monthly (N=3) Quarterly (N=1)	Daily (N=2) Monthly (N=2) Quarterly (N=1)	Weekly (N=2) Quarterly (N=1) As Needed (N=1) N/A (N=1)

Table 20 continued

Total	Daily (N=3) Monthly (N=4) Quarterly (N=13) Yearly (N=2) As Needed (N=1) N/A (N=4)	Daily (N=2) Monthly (N=8) Quarterly (N=12) Yearly (N=3) As Needed (N=1) N/A (N=2)	Weekly (N=3) Monthly (N=14) Quarterly (N=2) Rarely (N=2) As Needed (N=2) N/A (N=6)	Daily (N=2) Weekly (N=4) Monthly (N=15) Quarterly (N=2) Yearly (N=5) As Needed (N=1)	Daily (N=6) Weekly (N=1) Monthly (N=10) Quarterly (N=5) Yearly (N=1) As Needed (N=1) N/A (N=4)	Daily (N=1) Weekly (N=2) Monthly (N=7) Quarterly (N=1) Yearly (N=3) As Needed (N=8) N/A (N=7)
Median	Quarterly	Quarterly	Monthly	Monthly	Monthly	Yearly / As Needed

Of the thirty study participants, N=25 provided answers to questions about how they communicate with patients (**Table 21**). Five participants did not provide answers due to time constraints during the interview. Nearly all participants (N=24/25) indicated that they had in-person communication with their patients. One nurse said that their communication was predominantly on the phone serving as a CDE who helps patients prepare for upcoming surgeries. Nearly all participants communicate with their patients over the phone as well: the majority (N=23/25) use the phone as needed and/or for follow up calls, while some (N=3/25) use the phone for their main appointments with patients. Two physicians (PCP MD and END) and one pharmacist also mentioned that they allow patients to reach them by personal cell phone as needed. Three primary care providers (N=3) mentioned that medical assistants help them with fielding of phone calls from patients.

About a quarter of participants (N=6/25) use email and/or EHR patient portals to communicate with patients. Participants indicated that the EHR portal is useful for sharing blood glucose data and lab results with their patients. Three primary care providers (N=3) mentioned that medical assistants help them with fielding of phone calls and secure messages when communicating with their patients.

Table 21. HCP-Patient Actual Communication Modes.

Role	Mode of Communication
END	<ul style="list-style-type: none"> • In-person (appointments) (N=2/2) • EHR patient portal (lab results, BG logs) (N=1/2) • Phone (as needed) (N=2/2)
PCP	<ul style="list-style-type: none"> • In-person (appointments) (N=5/5) • Phone (as needed) (N=5/5) • EHR patient portal (lab results) (N=3/5) • Email (as needed) (N=2/5)
Pharm	<ul style="list-style-type: none"> • In-person (appointments) (N=5/5) • Phone (N=5/5) <ul style="list-style-type: none"> ○ As needed (N=5/5) ○ Appointments (N=1/5) • Email (as needed) (N=2/5) • EHR patient portal (N=1/5)

Table 21 continued

RD	<ul style="list-style-type: none"> • In-person (N=4/4) <ul style="list-style-type: none"> ○ Appointments (N=4/4) ○ Classes (N=1/4) • Phone follow ups (N=3/4) • Online communities (N=1/4) • Phone app unique to hospital system (N=1/4) • EHR patient portal (lab results, BG logs) (N=1/4)
RN	<ul style="list-style-type: none"> • In-person (N=4/5) <ul style="list-style-type: none"> ○ Appointments (N=4/5) ○ Classes (N=1/5) • Phone (N=4/5) <ul style="list-style-type: none"> ○ As needed (N=3/5) ○ Appointments (N=1/5) • Email (as needed) (N=1/5)
SW	<ul style="list-style-type: none"> • In-person (N=4/4) <ul style="list-style-type: none"> ○ Appointments (N=3/4) ○ Home visits (N=1/4) • Phone (N=3/4) <ul style="list-style-type: none"> ○ Follow up (N=3/4) ○ Appointments (N=1/4) • Mail (resources) (N=1/4) • Email (as needed) (N=1/4)
Total	<ul style="list-style-type: none"> • In-person (N=24/25) • Phone (N=24/25) <ul style="list-style-type: none"> ○ As Needed (N= 21/25) ○ Appointments (N=3/25) • EHR portal (N=6/25) • Email (N=6/25) • Online community (N=1/25) • Phone App (N=1/25) • Mail (N=1/25)

Participants shared the information that they receive from patients during their interactions, as well as information they share back to patients to help them manage their care (**Table 22**). There were four main categories of information that healthcare professional received from patients: health history; laboratory results, records, & testing; social & environmental information; and

care coordination information. There were two main categories of information that healthcare professionals shared with their patients: diabetes education and treatment assistance.

The endocrinologist participants were the most in depth with sharing their information content flows. The information endocrinologists request from their patients tends to be very detailed, laboratory results and health history information. Endocrinologists still review potential social and environmental information with their patients so that they can use this information for care coordination and referrals as needed. The primary care provider role is also focused on the patient history and laboratory results, although a little bit less than the endocrinologist role. The pharmacist role is similar to the primary care provider role, except for that there is a stronger emphasis on gathering information on the medication history and less emphasis on laboratory data beyond the A1c values. The pharmacist role also shares a lot of information with patients regarding counseling (e.g., nutrition, medications, exercise). The endocrinologist, primary care provider, and pharmacist roles all mentioned needing care coordination information from patients so that they can connect with other members of the diabetes care team, whereas the other roles did not mention care coordination information requests from their patients.

The nurse and dietitian roles were very similar with respect to information they receive and share with their patient. Both roles focus more heavily on obtaining balanced records of health history, laboratory results, and social and environmental information. These roles had a much larger emphasis on the social and environmental information acquisition compared to the other roles. Both roles described more diabetes education information and tools that they share with their patients as well. The social work role focused almost exclusively on obtaining patient information related to mental health history and the social and environmental information related to the patient's disease. The social workers interviewed did not mention providing any diabetes education to their patients but rather sharing resources to help them overcome barriers to care and providing counseling to help patients cope with their disease.

Table 22. HCP-Patient Information Content Flows.

Role	Information Received from Patients	Information Shared with Patients
END	<ul style="list-style-type: none"> • Health history (N=5/5) <ul style="list-style-type: none"> ○ Medications (N=4) ○ Treatment successes and failures (N=3) ○ Nutrition habits (N=4) ○ Co-morbidities (N=4) <ul style="list-style-type: none"> ▪ Renal impairment (N=2) ▪ Diabetic retinal disease (N=1) ▪ Coronary artery disease (N=1) ▪ Neuropathy (N=1) ▪ Cardiovascular disease (N=2) ▪ Blood pressure (N=1) ▪ Cholesterol (N=2) ○ Changes in health (N=2) ○ Weight problems (N=2) ○ Family history (N=2) ○ Blood glucose logs (N=2) ○ History of UTIs (N=1) ○ For women, size of babies at birth (N=1) ○ Surgeries (N=1) • Laboratory results, records, & testing (N=5/5) <ul style="list-style-type: none"> ○ A1c value every 3-6 months (N=4) ○ CMP lab for kidney function annually (N=2) ○ Lipid panel (N=2) ○ Microalbumin creatinine ratio annually (N=2) ○ Any abnormal labs (N=1) ○ Eye exam annually (N=1) ○ Foot exam annually (N=1) ○ TSH for thyroid annually (N=1) ○ CBC check if history of anemia (N=1) ○ Cholesterol panel (N=1) • Social & environmental information (N=5/5) 	<ul style="list-style-type: none"> • Diabetes education (N=5/5) <ul style="list-style-type: none"> ○ Information about diabetes (N=5) ○ Misconceptions about diabetes (N=2) ○ Review lab results and meaning (N=2) ○ How co-morbidities affect diabetes (N=1) • Treatment assistance (N=4/5) <ul style="list-style-type: none"> ○ Tips for self-care (N=2) ○ Innovations in diabetes treatments (e.g., medications, technologies) (N=2) ○ Personalized dietary plan (N=1) ○ Bariatric surgery options (N=1) ○ Encouragement (N=1) ○ Record of care (N=1) ○ Insurance coverage help (N=1)

Table 22 continued

	<ul style="list-style-type: none"> ○ Lifestyle habits (N=4) ○ Financial information (N=3) ○ Barriers to care (N=3) ○ Support system (N=2) ○ Motivation & goals (N=2) ○ Patient understanding of diabetes (N=2) ○ Occupation (N=1) ● Care coordination information (N=1/5) <ul style="list-style-type: none"> ○ PCP doctor information (N=1) ○ Specialist information (N=1) 	
PCP	<ul style="list-style-type: none"> ● Health history (N=4/5) <ul style="list-style-type: none"> ○ Blood glucose records (N=4) ○ Nutrition habits (N=3) ○ Medication history (N=3) ○ Health complications (N=3) ○ Treatment successes and failures (N=2) ○ History of diabetes (N=1) ● Laboratory results, records, & testing (N=5/5) <ul style="list-style-type: none"> ○ A1c (N=5) ○ Eye exam (N=3) ○ Renal function (N=2) ○ Annual assessment (N=1) ○ Neuropathy (N=1) ○ Foot exam (N=1) ○ Metabolic count (N=1) ○ Electrolytes and creatinine (N=1) ○ Lipid panel (N=1) ● Social & environmental information (N=4/5) <ul style="list-style-type: none"> ○ Understanding of the disease (N=2) ○ Preferences for medications (N=2) ○ Financial information (N=1) ○ Barriers to care (N=1) ○ Motivation (N=1) ● Care coordination information (N=2/4) 	<ul style="list-style-type: none"> ● Diabetes education (N=4/5) <ul style="list-style-type: none"> ○ Lab results meaning and importance (N=3) ○ Pathology of the disease (N=1) ○ Draw pictures of how the disease progresses (N=1) ○ Co-morbidities affect on diabetes (N=1) ○ Misconceptions about diabetes (N=1) ● Treatment assistance (N=3/5) <ul style="list-style-type: none"> ○ Encouragement (N=2) ○ Treatment plan with goals (N=2) ○ Record of care (N=1) ○ Referrals (N=1) ○ Medication discussion (N=1) ○ Mitigating concerns (N=1)

Table 22 continued

	<ul style="list-style-type: none"> ○ Other providers' information (N=2) 	
Pharm	<ul style="list-style-type: none"> ● Health history (N=5/5) <ul style="list-style-type: none"> ○ Medication information (N=5) ○ Medication compliance (N=4) ○ Nutrition information (N=4) ○ BD/CGM data (N=3) ○ Treatment successes and failures (N=3) ○ History of disease (N=3) ○ Co-morbidities (N=2) ○ Exercise (N=2) ○ Symptoms (N=1) ○ Disease management (N=1) ○ Changes in care (N=1) ● Laboratory results, records, & testing (N=1/5) <ul style="list-style-type: none"> ○ A1c (N=1) ○ Past lab work (N=1) ● Social & environmental information (N=5/5) <ul style="list-style-type: none"> ○ Lifestyle (N=4) ○ Barriers to care (N=3) ○ Motivation and goals (N=2) ○ Financial issues (N=2) ○ Questions about disease (N=1) ○ Patient understanding of disease (N=1) ○ Schedule (N=1) ○ Family issues (N=1) ● Care coordination information (N=1/5) <ul style="list-style-type: none"> ○ Other provider visits (N=1) 	<ul style="list-style-type: none"> ● Diabetes education (N=5/5) <ul style="list-style-type: none"> ○ Information about diabetes (N=5) ○ Lab results and meanings (N=3) ○ How to test (N=3) ○ Complications with diabetes (N=2) ○ Misconceptions with diabetes (N=1) ● Treatment assistance (N=4/5) <ul style="list-style-type: none"> ○ Treatment plan and goals (N=4) ○ Medication counseling (N=3) ○ Referrals (N=1) ○ Share info from other providers if necessary (e.g., lab results) (N=1) ○ Medication list (N=1) ○ Encouragement (N=1) ○ Nutrition counseling (N=1) ○ Exercise counseling (N=1)
RD	<ul style="list-style-type: none"> ● Health history (N=5/5) <ul style="list-style-type: none"> ○ Nutrition records (N=3) ○ Medication information (N=3) ○ Treatment success & failures (N=2) ○ Disease history (N=2) 	<ul style="list-style-type: none"> ● Diabetes education (N=5/5) <ul style="list-style-type: none"> ○ Information about diabetes (N=5) ○ Link between blood glucose and diet (N=4) ○ Complications with diabetes (N=2) ○ Carbohydrate counting (N=2)

Table 22 continued

	<ul style="list-style-type: none"> ○ Family history (N=2) ○ Blood glucose records (N=2) ○ Exercise records (N=1) ○ Medical history (N=1) ○ Review healthcare goals from PCP (N=1) <ul style="list-style-type: none"> ▪ Blood pressure (N=1) ▪ Weight loss (N=1) ▪ Medications (N=1) ● Laboratory results, records, & testing (N=4/5) <ul style="list-style-type: none"> ○ Dental records (N=2) ○ Sleep apnea issues (N=1) ○ Previous physicals (N=1) ○ Foot screening (N=1) ○ Eye exam (N=1) ○ A1c value (N=1) ● Social & environmental information (N=5/5) <ul style="list-style-type: none"> ○ Motivation & goals (N=4) ○ Lifestyle (N=4) ○ Patient understanding of disease (N=3) ○ Emotional / social stress (N=2) ○ Overall feeling / mood (N=2) ○ Financial issues (N=2) ○ Occupation (N=1) ○ Mental health concerns (N=1) ○ Sexuality (N=1) 	<ul style="list-style-type: none"> ○ Training for testing (N=1) ○ Informational handouts (N=1) ○ Demonstrations about sugar and blood flow (N=1) ● Treatment assistance (N=3/5) <ul style="list-style-type: none"> ○ Encouragement (N=3) ○ Discuss treatment plan from PCP (N=1) ○ Referral (N=1) ○ Modify goals as needed (N=1) ●
RN	<ul style="list-style-type: none"> ● Health history (N=5/5) <ul style="list-style-type: none"> ○ Nutrition information (N=4) ○ Medication information (N=4) ○ Blood glucose records (N=3) ○ Testing frequency (N=3) ○ Treatment success & failures (N=1) ○ Diabetes history (N=1) ○ Hospitalizations (N=1) 	<ul style="list-style-type: none"> ● Diabetes education (N=2/5) <ul style="list-style-type: none"> ○ General disease information (N=1) ○ Medication instructions (N=1) ● Treatment assistance (N=5/5) <ul style="list-style-type: none"> ○ Review treatment plan (N=3) ○ Nutrition recommendations (N=1) ○ Self care recommendations (N=1) ○ Encouragement (N=1) ○ Set goals (N=1)

Table 22 continued

	<ul style="list-style-type: none"> • Laboratory results, records, & testing (N=3/5) <ul style="list-style-type: none"> ○ Previous lab results (N=2) ○ A1c (N=2) ○ Kidney function (N=1) ○ Cholesterol (N=1) • Social & environmental information (N=3/5) <ul style="list-style-type: none"> ○ Motivation & goals (N=3) ○ Financial issues (N=2) ○ Exercise (N=1) ○ Schedule (N=1) ○ Lifestyle (N=1) ○ Barriers to care (N=1) 	
SW	<ul style="list-style-type: none"> • Health history (N=5/5) <ul style="list-style-type: none"> ○ Mental health issues (N=4) ○ Nutrition records (N=2) ○ Disease management (N=2) ○ Substance abuse (N=1) ○ Medication usage (N=1) • Social & environmental information (N=5/5) <ul style="list-style-type: none"> ○ Frustrations (N=3) ○ Barriers to care (N=3) ○ Social issues (N=3) ○ Financial issues (N=2) ○ Motivations (N=2) ○ Exercise (N=2) ○ Expectations (N=1) 	<ul style="list-style-type: none"> • Treatment assistance (N=5/5) <ul style="list-style-type: none"> ○ Resources for barriers (N=4) <ul style="list-style-type: none"> ▪ Financial (N=2) ▪ Community (N=2) ▪ Mental health help (N=1) ▪ Substance abuse (N=1) ○ Counseling for navigating barriers (N=4) ○ Encouragement (N=2) ○ Developing healthy habits & goals (N=1)

5.2.6 Diabetes Care Team System

In addition to sharing details about diabetes care team tasks and information flows, participants were asked to share how their role fit within the overarching processes for diabetes care teams. These data were iteratively coded and used to create several systems diagrams to describe the overarching flows and processes of diabetes care teams. Data from earlier sections, such as

defining the team purpose, confirmation of team member roles, and information flow attributes were all used to refine the following system diagram models.

5.2.6.1 Diabetes Care Team Settings & Overall Flow

Participants shared nine unique settings that they worked in, and several additional settings that they interact with as part of their work tasks. These settings are reviewed in **Figure 11**, where the main settings are organized by inpatient and outpatient care. Two participants (N=2) did mention working at the U.S. Department of Veterans Affairs, but due to the distinct VA attributes, it would not be easily generalizable for inclusion in the following system diagrams.

When a patient enters the healthcare system as a new patient (**Figure 12**), this is usually due to an event trigger that results in a diagnosis. Examples of event triggers include hospitalizations, flagged values at annual primary care physicals and routine lab work, and screenings at community clinics when patients come in for care. For example, one social worker said that they screen patients and test for high A1c values in their mental healthcare community clinic, and they have actually caught many people that were living without a diagnosis. After these event triggers occur, an official diagnosis from a primary care provider, physician, or specialist will result. Depending on the severity of the patient state (e.g., high A1c value, complications, Type I vs. Type II), the diagnosing provider will then refer the patient to a team led by either their primary care provider or an endocrinologist. The endocrinologist is typically reserved for more complicated, uncontrolled, non-compliant patients as well as people with Type I diabetes, and the primary care provider sees all other patients.

After a patient connects with their primary care provider, they are then referred to diabetes education, which can be accomplished by a combination of nurse, dietitian, and pharmacists, many of whom are certified diabetes educators. A primary care provider will refer patients to social work and specialist services as needed. An endocrinologist seeing a new patient will refer the patient to diabetes education if the patient has not received education yet or if they think it could help improve the patient's disease control and compliance. If a patient becomes non-compliant after starting care with a primary care provider, the primary care provider will refer the patient to an endocrinologist to escalate their level of care. Ideally, the primary care provider

will work with the endocrinologist and follow-up with the patient's care, but sometimes these two teams can work independently.

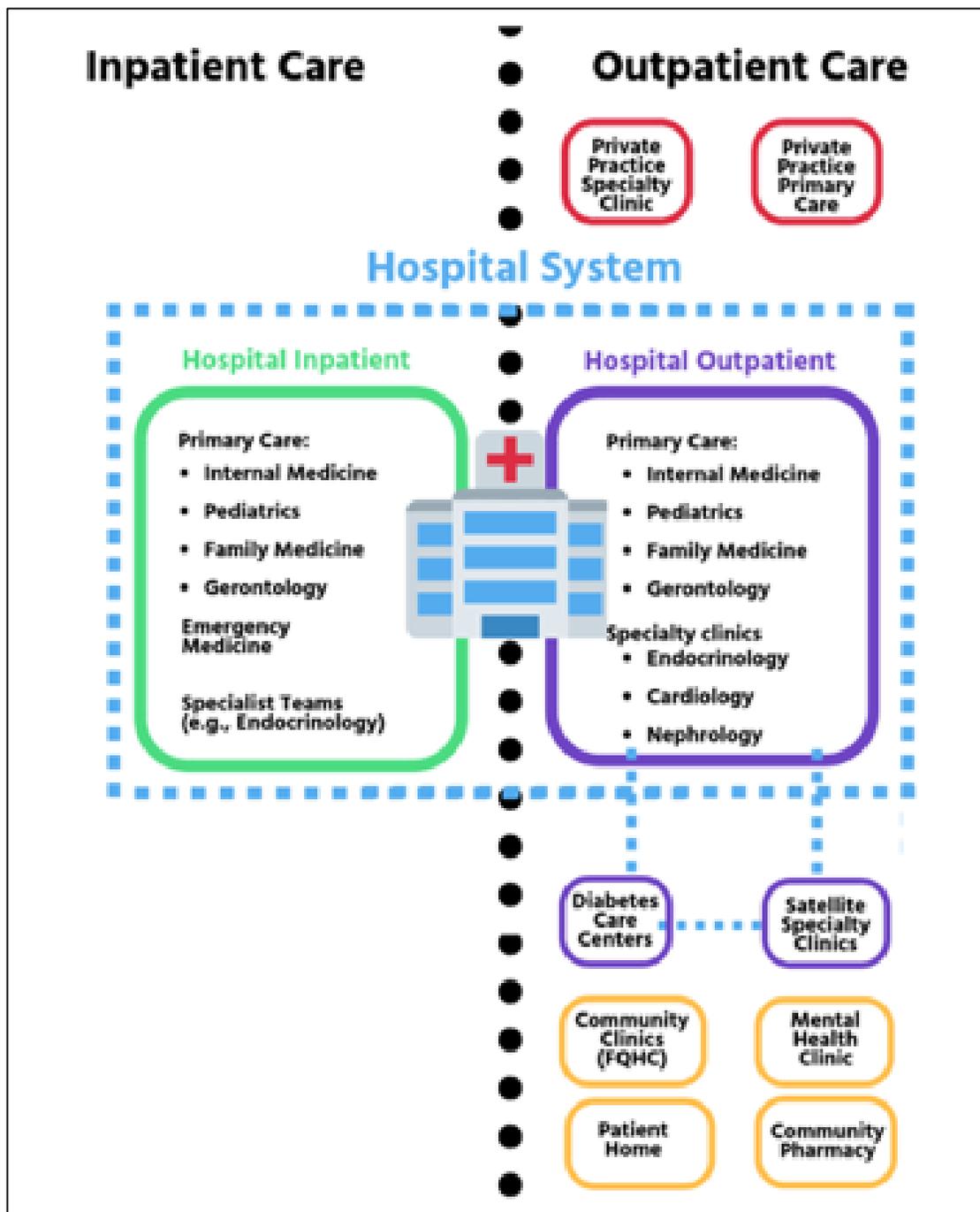


Figure 11. Overall Healthcare System with Members of Diabetes Care Teams.

The blue dashed line represents the boundaries of the hospital system. There are two external locations that are often affiliated with hospital outpatient organizations (in purple, and connected with blue dashed line). Orange boundary lines denote community clinics and pharmacies, as well as home care health. Red boundary lines denote private practice organizations.

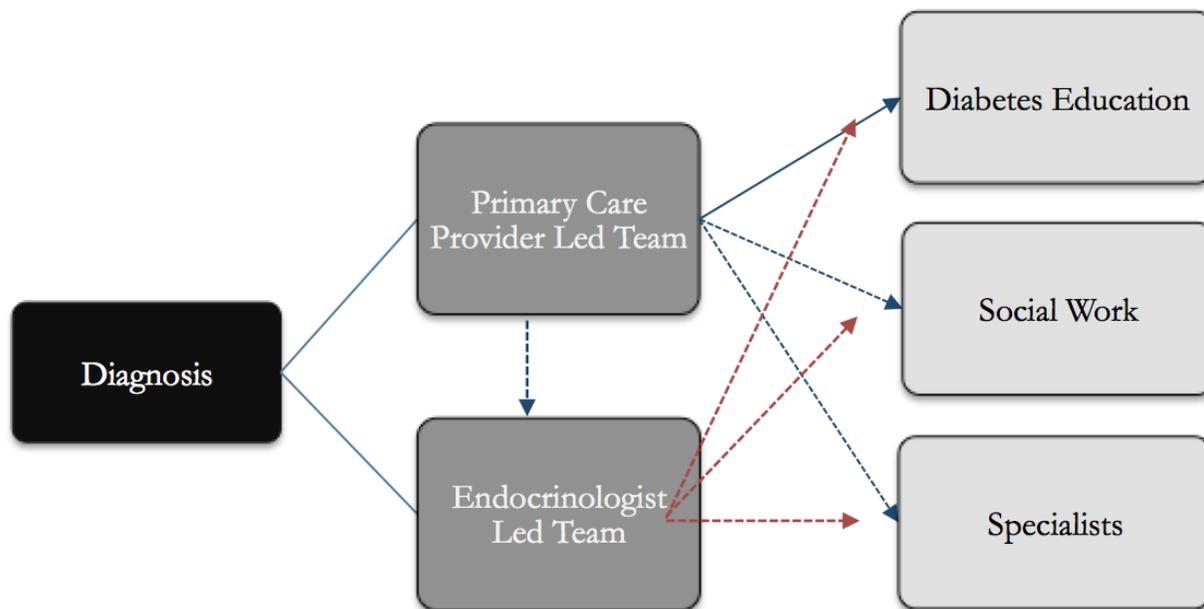


Figure 12. Overall Flow of a Newly Diagnosed Patient in a Healthcare System.

The patient starts with a diagnosis, and is then referred to either a primary care provider led team or an endocrinologist led team, depending on their level of compliance and control with managing their disease. The solid lines represent flows that occur often, while the dashed lines represent flows that only occur on an as needed basis.

5.2.6.2 Systems Engineering Analysis of Diabetes Care Team System

Operator sequence diagrams and systems engineering models depicting diabetes care team processes were drafted using systems engineering analysis tools (Damelio, 2011; Graham, 2004; Holden et al., 2013; Jahn & Caldwell, 2017; Jahn, Heiden, et al., 2018). The purpose of the diabetes care team system used to develop these models (defined in section 5.2.3) is to provide optimal care and support for patients via a collaboration of providers with multiple areas of expertise. The examples depicted represent typical flows through the system, as summarized by participants working in that care setting. Each operator sequence diagram is a typical, idealized flow without significant issues or patient complications.

Drawing upon the process mapping literature, **Table 23** defines the symbology used in the operator sequence diagrams of the diabetes care team processes. A few key changes were made to the standard symbology to help better describe the processes of the diabetes care team reviewed in previous sections: 1) the shading of the information receipt, and 2) the distinction between system and team member auto-generated event triggers.

Table 23. Process Mapping Symbology.

Symbol	Meaning	Definition
	Decision	To evaluate and determine a course of action or inaction based upon the receipt of information
	Action	An action function to continue or complete a process
	Transmit Information	To share information
	Receive Information	To receive information. The color shading represents the individual team member's overall knowledge of the state of the patient, where the darker the color the more knowledge the individual has about the patient
	Phone communication	Communication by phone for transmission of information and/or completing an action
	Computer communication	Communication by computer (e.g., electronic health record, secure messaging, or email) for transmission of information and/or completing an action
	Face-to-Face communication	Face-to-face communication for transmission of information and/or completing an action
	Automatic transmission of information triggered by team member action	Transmission of information that is generated by a team member action, such as updating a patient electronic health record and the system sending an alert or note to another team member in response to the update
	Automatic transmission of information triggered by system generated action	Transmission of information that is generated by the system when patient values are present (e.g., when a patient has blood glucose values <200 for two or more readings, or <300 for one reading, health care providers will be alerted for a consult)
	Manual transmission of information	Transmission of information that is manually generated by a team member (e.g., phone call, email)
	Time	Representation of the passing of time during patient care processes

5.2.6.2.1 Inpatient Care Sequence Progression

As patient care typically starts as a result of an event, such as a hospitalization, the first operator sequence diagram reviews key tasks and information flows in the inpatient setting (**Figures 13-15**). Data from seven (N=7) participants, including primary care providers, pharmacists, nurses, and endocrinologists, were used to create the visualizations of the inpatient care processes. In general, the findings indicated that the bedside nurse and/or case manager for the patient tends to have the most involvement with the patient and be aware of the patient status compared to other team members. They are responsible for coordinating care with many of the members of the team. Other differences in this setting are that it is a lot more fluid in that anyone can refer for diabetes education—other settings require that referral for education should be initiative by a primary care provider or physician. Another difference is the reliance on the EHR system to generate automatic alert triggers for consults by the diabetes care team (endocrinologist, dietitian, nurse, and pharmacist if available) when patients have: 1) one blood glucose reading over 300 mg/dL; 2) two blood glucose readings over 200 mg/dL; and/or an A1c value greater than 8.5.

Typically in the inpatient setting, the pharmacist role tends to primarily be in a dispensing role, and a nurse or dietitian fills the educator role. The education and social work referrals, if needed, are also typically set up during or after patient discharge. Some patients elect to come back for a “diabetes education day” after leaving the hospital. The educators can also work on teams in “intensive bursts” for helping prepare patients for surgeries or post-operative care counseling.

Operator Sequence Diagram

Setting: Inpatient Hospital Care

Team members: Patient, Bedside RN, Primary Care Provider, CDE (RN, RD, or PharmD), Dispensing Pharmacist, Social Worker

Information Flow: Team knowledge of patient status

Process Flow: Patient care over time

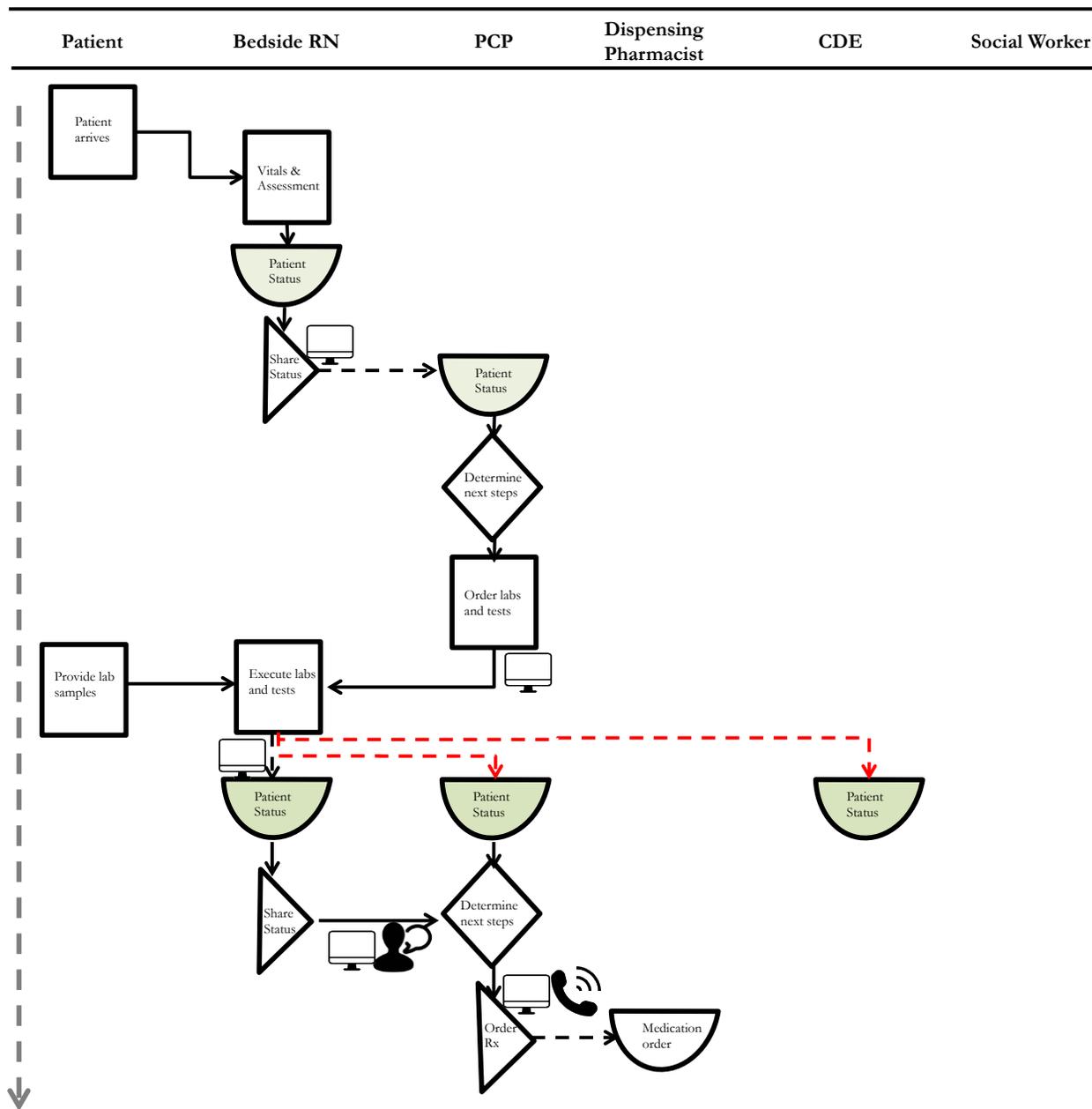


Figure 13. Operator Sequence Diagram for Inpatient Hospital Care (part 1 of 3).

The first phase of the inpatient care involves an initial intake assessment, followed by meeting with the PCP to order labs, which the results are then shared with other members of the care team.

Operator Sequence Diagram

Setting: Inpatient Hospital Care

Team members: Patient, Bedside RN, Primary Care Provider, CDE (RN, RD, or PharmD), Dispensing Pharmacist, Social Worker

Information Flow: Team knowledge of patient status

Process Flow: Patient care over time

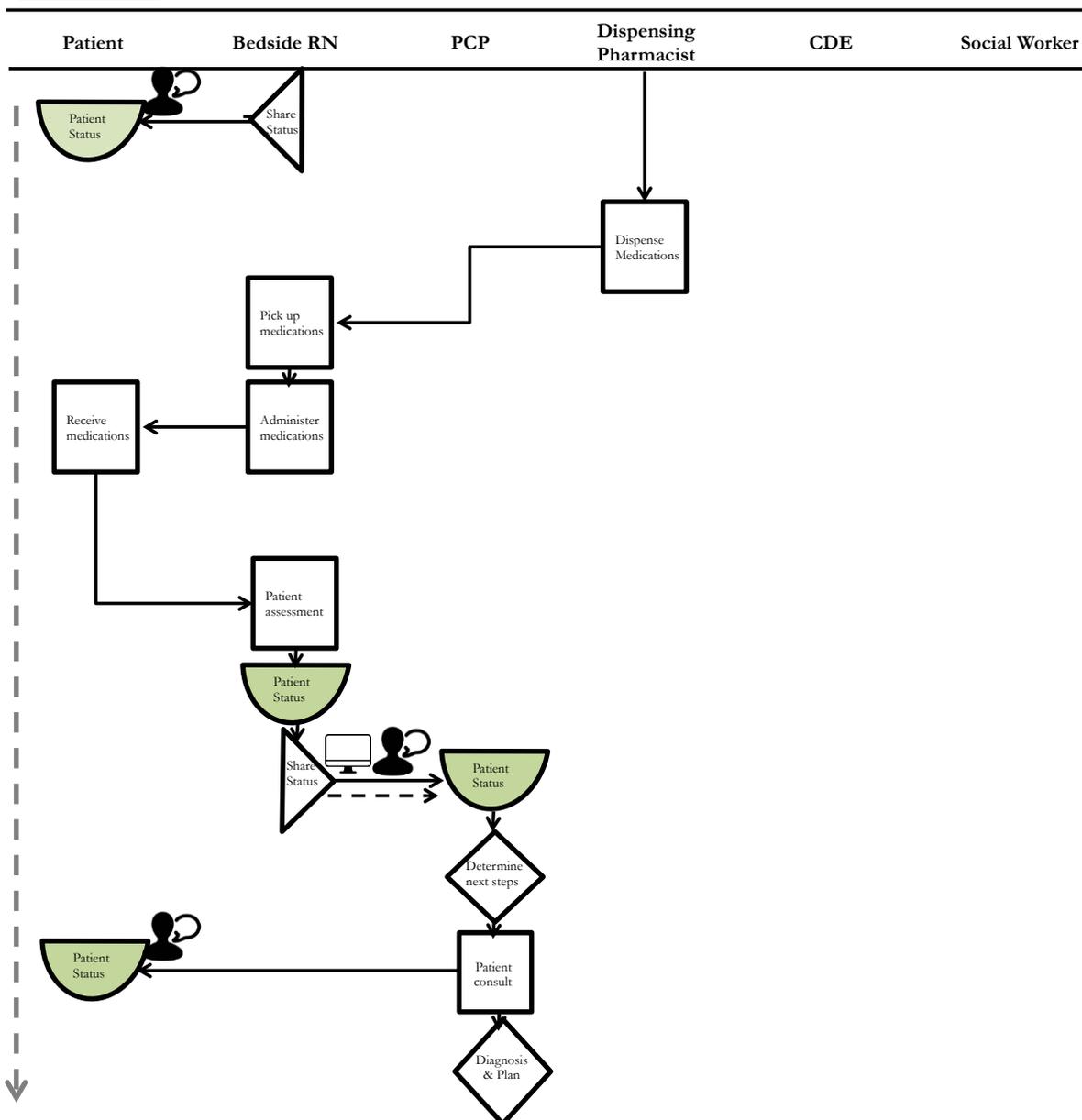


Figure 14. Operator Sequence Diagram for Inpatient Hospital Care (part 2 of 3). The second part of the inpatient care activity involves the dispensing and administration of medications, followed by additional monitoring and assessments for next steps.

Operator Sequence Diagram

Setting: Inpatient Hospital Care

Team members: Patient, Bedside RN, Primary Care Provider, CDE (RN, RD, or PharmD), Dispensing Pharmacist, Social Worker

Information Flow: Team knowledge of patient status

Process Flow: Patient care over time

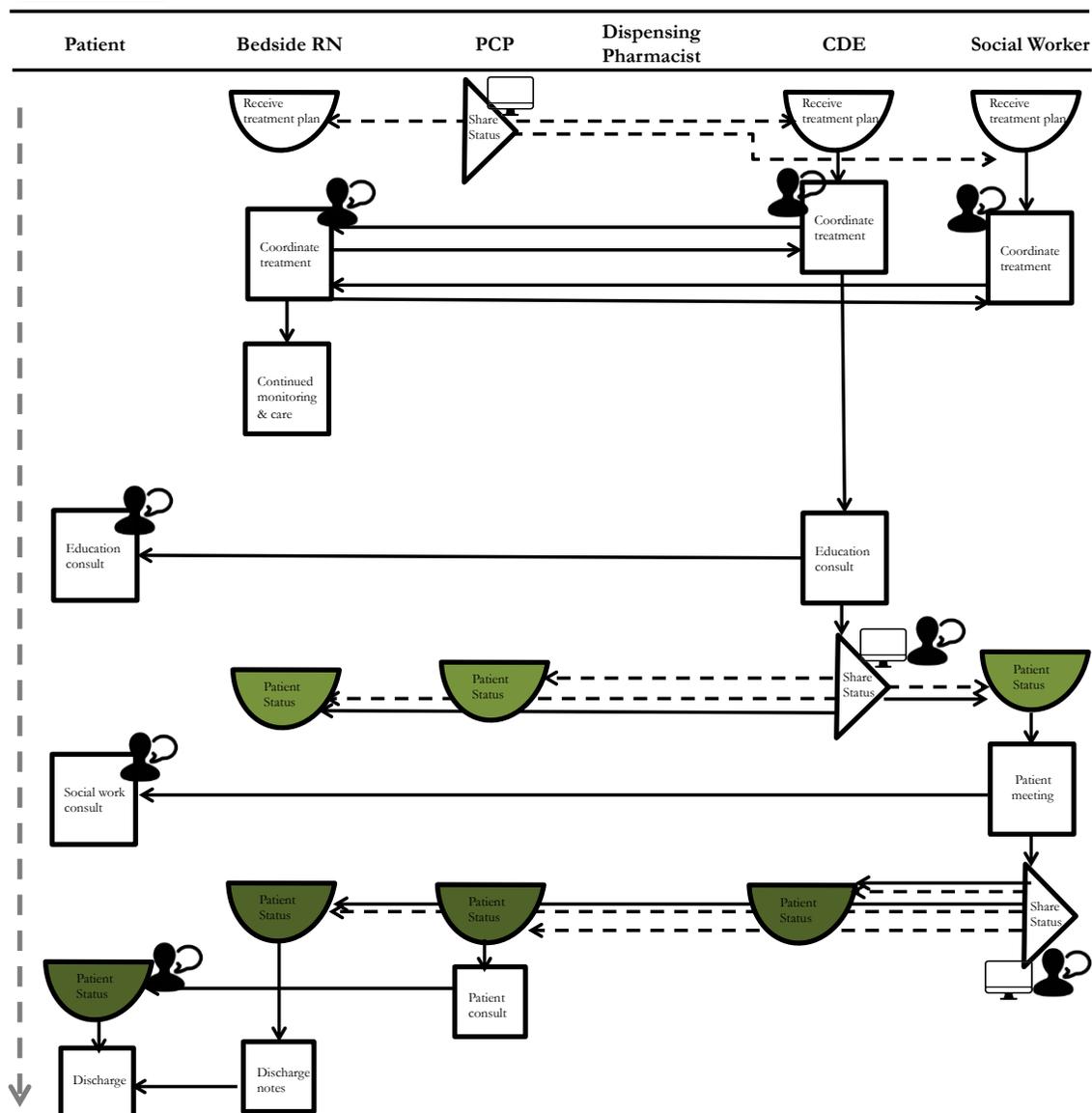


Figure 15. Operator Sequence Diagram for Inpatient Hospital Care (part 3 of 3).

The last part of the inpatient hospital care occurs when the patient is preparing for discharge. The members of the diabetes care team receive the treatment plan from the PCP and coordinate their activity with each other. The patient will often be discharged and come back on a separate day for consults with social workers, diabetes educators, dietitians, etc.

5.2.6.2.2 Outpatient Care Sequence Progression

After a patient diagnosis from a hospitalization, a patient will start care coordination with either their primary care provider or an endocrinologist led team in an outpatient setting. Several participants (N=3) mentioned that the majority of care for people with diabetes is accomplished in the outpatient setting. The processes at primary care clinics and endocrinology clinics for newly diagnosed people with diabetes are very similar. The main differences between these two settings beyond the endocrinologist vs. primary care provider led team are the patient population and the specialization of care: endocrinologists see more complicated patients and focus more on the endocrine aspects of the disease, while primary care providers have less complicated patients and take a more holistic and comprehensive approach. If a patient is being cared for by a primary care provider and their blood glucose becomes out of control (e.g., “*three instances greater than a 9.0 A1c*”) they will be referred to the endocrinologist for continued treatment. If a patient returns to control, the endocrinologist may choose to de-escalate their care and have the primary care provider resume leading the diabetes care team efforts.

The operator sequence diagram for the outpatient setting can be for either a primary care clinic or an endocrinology clinic due to the similarities in flows and high level processes (**Figures 16 & 17**). At the beginning of a patient appointment in an outpatient setting, a nurse or a medical assistant will see the patient first and gather patient history, medication information, vitals, and start collecting data for laboratory testing (e.g., A1c value). If a patient is already diagnosed with diabetes and using any technology (e.g., meters, pumps, CGM), they will download the data from the device to prepare for the provider to see during the patient meeting.

During the patient meeting, the provider will perform an assessment and do a foot exam and eye exam, if necessary. After they complete the assessment, the provider will refer to other team members as needed. One nurse described the primary care provider as the “*gatekeeper*” who decides if a patient should go to an educator, pharmacist, and/or social worker. In some settings, participants (N=3) said that primary care providers have pharmacists who help offload some of the work from the primary care provider. The pharmacist can perform the assessment and complete the consultation with the provider signing off on the plan of care. In other settings with pharmacist involvement, providers will refer to pharmacists for help with medication

management, education, and device instruction. The pharmacist typically will occur after the interaction with the provider, and then the patient will meet with a nurse or dietitian for nutrition counseling and education next. New patients are always supposed to receive diabetes education from a primary care provider referral. In the endocrinology clinic, they will refer patients if they

Operator Sequence Diagram

Setting: Outpatient Primary Care or Outpatient Endocrinology Clinic

Team members: Patient, Primary Care Provider OR Endocrinologist, Medical Assistant (or RN), CDE (RN and/or RD), Pharmacist, Social Worker

Information Flow: Team knowledge of patient status

Process Flow: Patient care over time

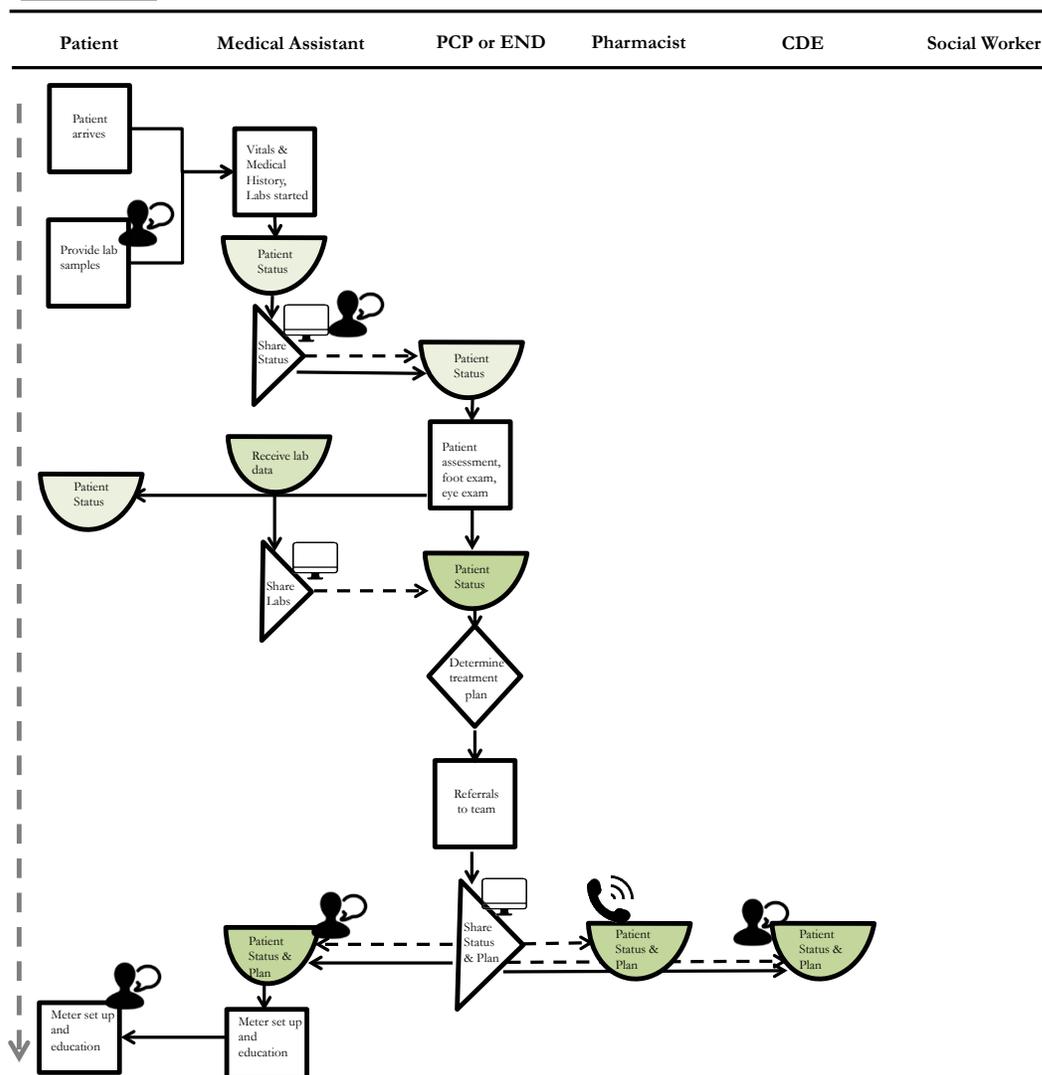


Figure 16. Operator Sequence Diagram for Outpatient Endocrinology Clinic (part 1 of 2). The first part of outpatient care at an endocrinology clinic involves a vitals assessment and gathering of initial intake information. Then the patient will see the PCP or END, who will determine the treatment plan and make referrals as needed.

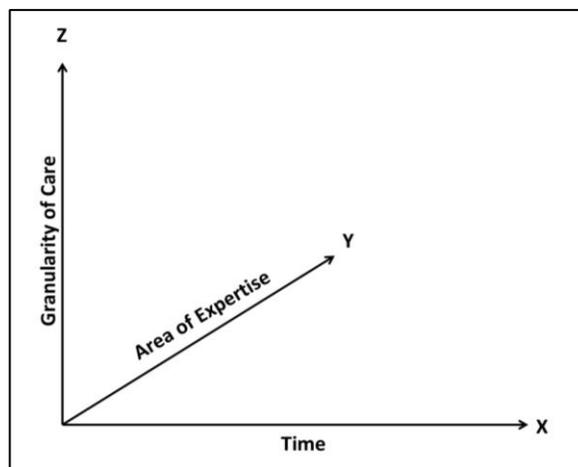


Figure 18. Axes for Development of the DRIFT Model.

DRIFT uses three axes to demonstrate the system: time (X), area of expertise (Y), and granularity of care (Z) (**Figure 18**). The time and granularity of care axes were selected based off of previously identified needs in the chronic care and systems engineering literature, which show that these areas are needed to depict system flows over time and across system levels (Jahn, Heiden, et al., 2018) The levels of granularity of care from lowest to highest level of care complexity are: home care, community clinics (e.g., diabetes care centers, mental health clinics), community pharmacies, outpatient primary care clinics, outpatient endocrinology clinics, outpatient hospital, and inpatient hospital. As a patient moves through these settings, their care is more critical and sensitive to time delays. Each level of care is also subject to its own sociotechnical factors (e.g., environment, distinct technologies, organizational factors, etc.) that can influence flows at that level of care. On the time (X) axis, three distinct phases of diabetes were defined: event trigger (e.g., hospitalization); maintenance (e.g., ongoing care with a PCP or END); and escalation (e.g., an increase in care granularity, such as from PCP to END, typically due to an event trigger). An example of a patient going through these phases after two hospitalizations, where the first resulted in a diagnosis, and the second resulted in an escalation of care from primary care to endocrinologist was used to create these systems engineering models. The phases, settings, and patient care over time are show in **Figure 19** (time (X axis) vs. granularity of care (Z axis)).

In **Figure 19**, information flows for patient communication are depicted by symbology also used in the operator sequence diagrams (**Table 23**). In cases where the patient interaction is as needed,

the lines are dashed. The frequency data was collected via information flow analyses (see section 5.2.5).

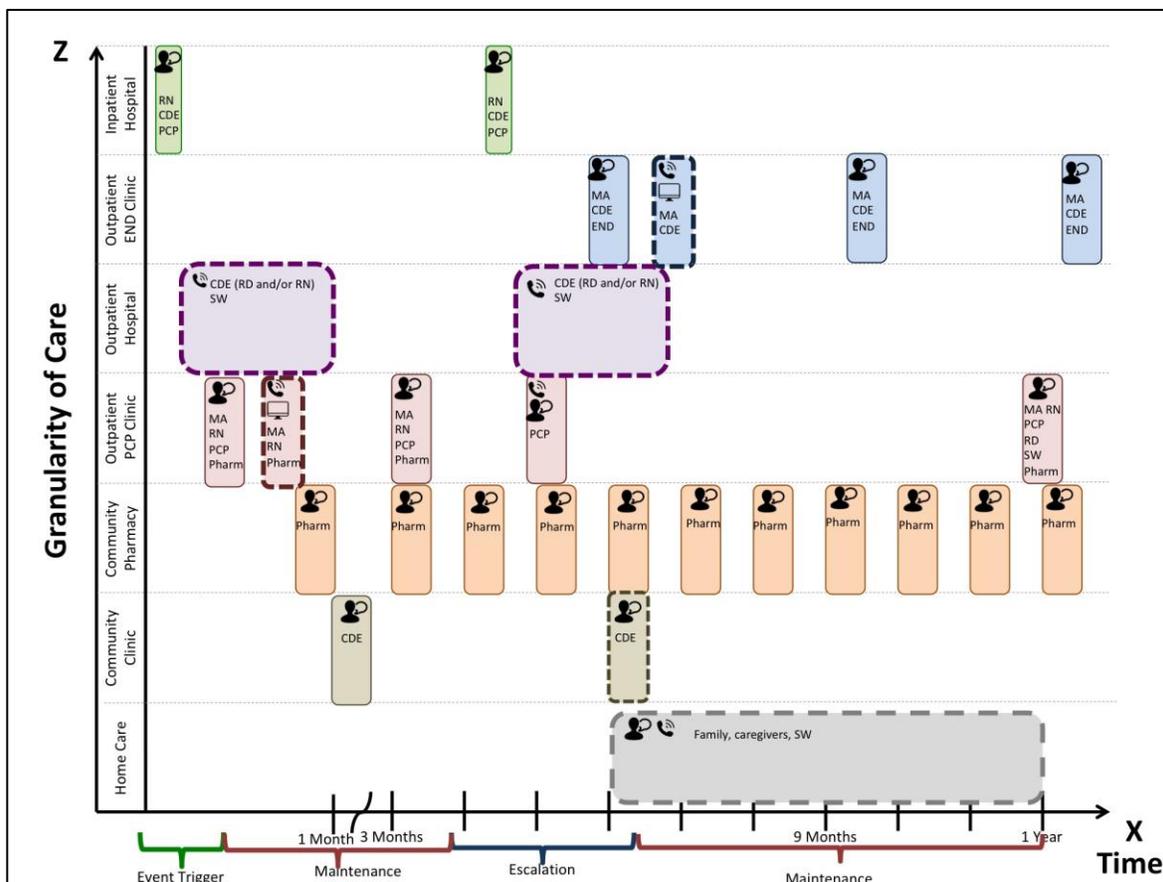


Figure 19. Time vs. Granularity of Care for DRIFT.

This figure depicts the seven levels of granularity of care; the three main phases of diabetes care events; and modes and frequencies of HCP-patient communication over time. An example patient of someone who experiences two hospitalizations, where the first results in an initiation of care with a primary care provider, and the second involves a handoff to care with an endocrinologist is depicted throughout the DRIFT examples.

The area of expertise (Y axis) was selected for inclusion in DRIFT to help visualize care coordination activities specifically at each care setting (Z axis). The areas of expertise were gleaned from the task and information content analyses from Study II. The roles were mapped over time with how their expertise contributed to the system goal for each level of care (**Figures 20-26**).

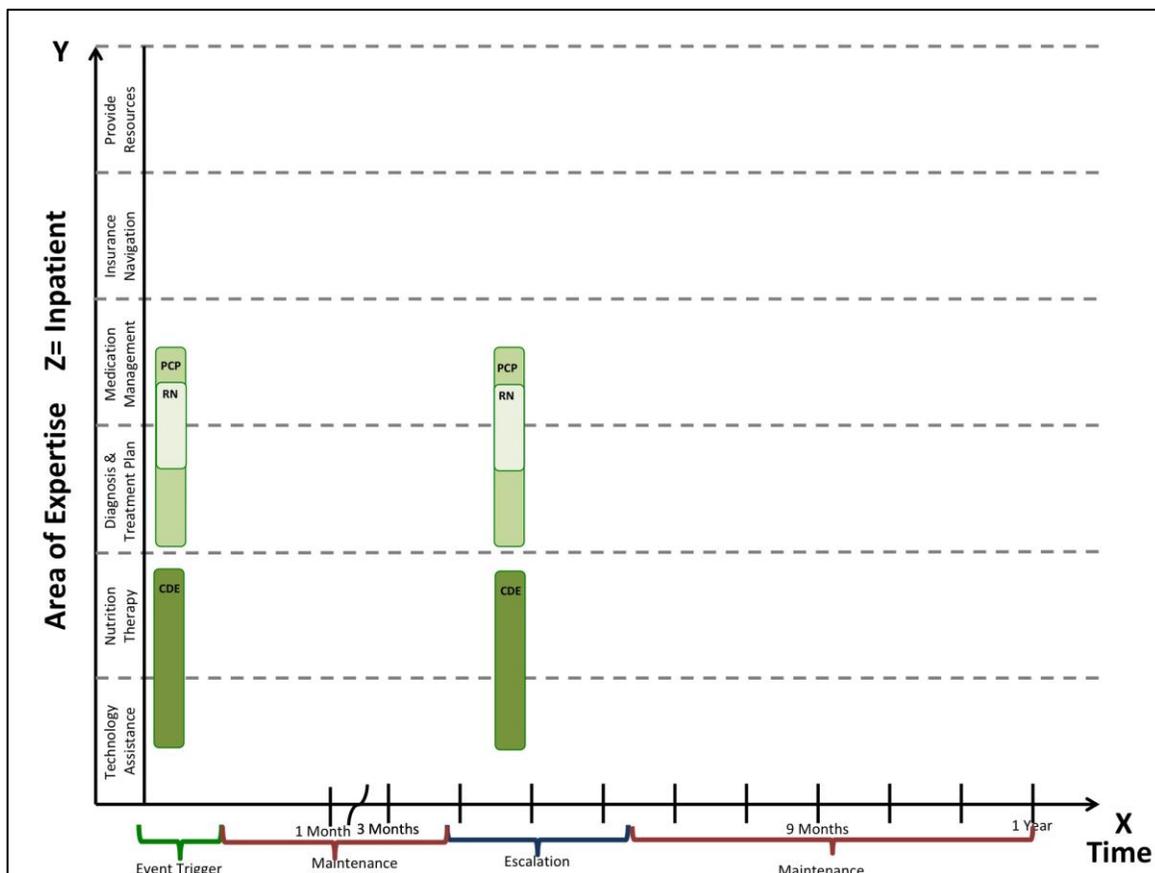


Figure 20. Inpatient Hospital Care with DRIFT.

The core team members in the inpatient setting for diabetes care are the bedside nurse (RN) and/or case manager; the certified diabetes educator, and the overseeing provider (e.g., attending, resident, primary care doctor, etc.). These three providers help prepare the patient with their initial diagnosis and treatment plans, and starting the diabetes education processes.

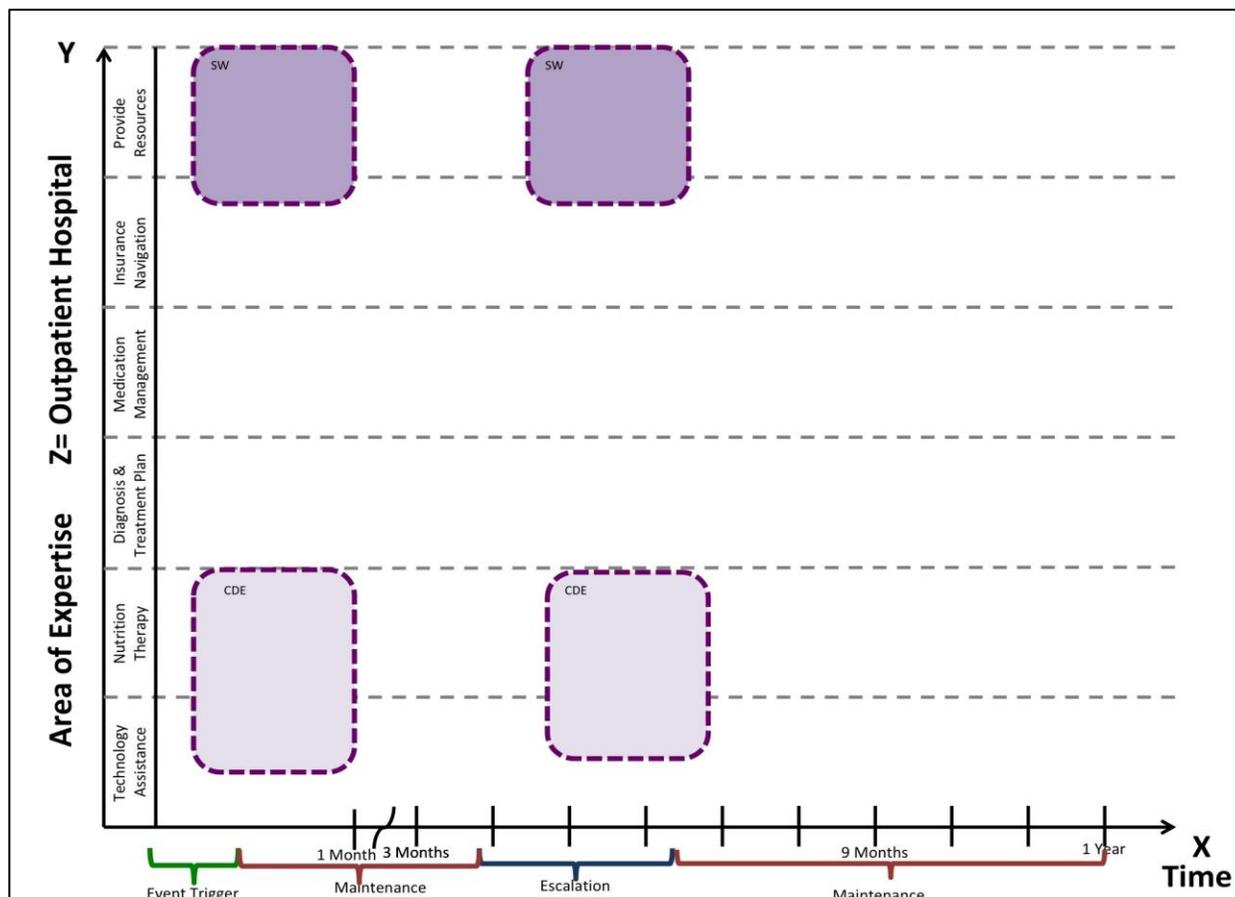


Figure 21. Outpatient Hospital Care with DRIFT.

The outpatient care post a hospitalization primarily involves certified diabetes educators and social workers following up with patients on an as needed basis for 2-6 weeks. These providers can help with transitions in care and cover gaps in education and resources that patients may need.

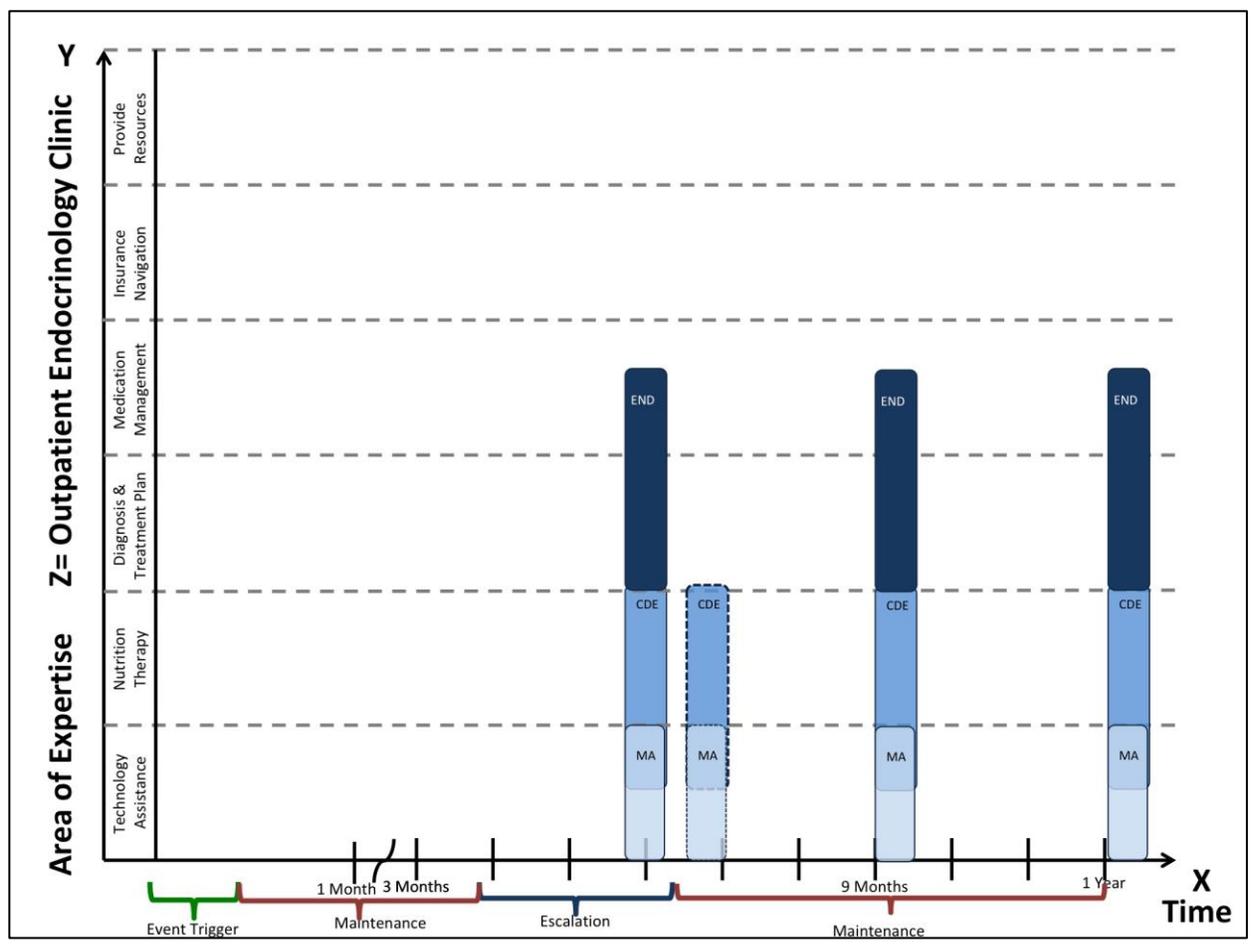


Figure 22. Outpatient Endocrinology Clinic with DRIFT.

The endocrinology team gets involved in a patient’s care after a referral from their primary care provider when their care processes become more complex and/or they become less compliant. They interact with patients on a quarterly basis, but they may follow up via phone as needed after an appointment with an educator or medical assistant assisting the endocrinologist. The medical assistances primary help with technology data downloads and clerical work, while the educators also may help with technology (e.g., training on how to use an insulin pump) as well as provide nutrition therapy.

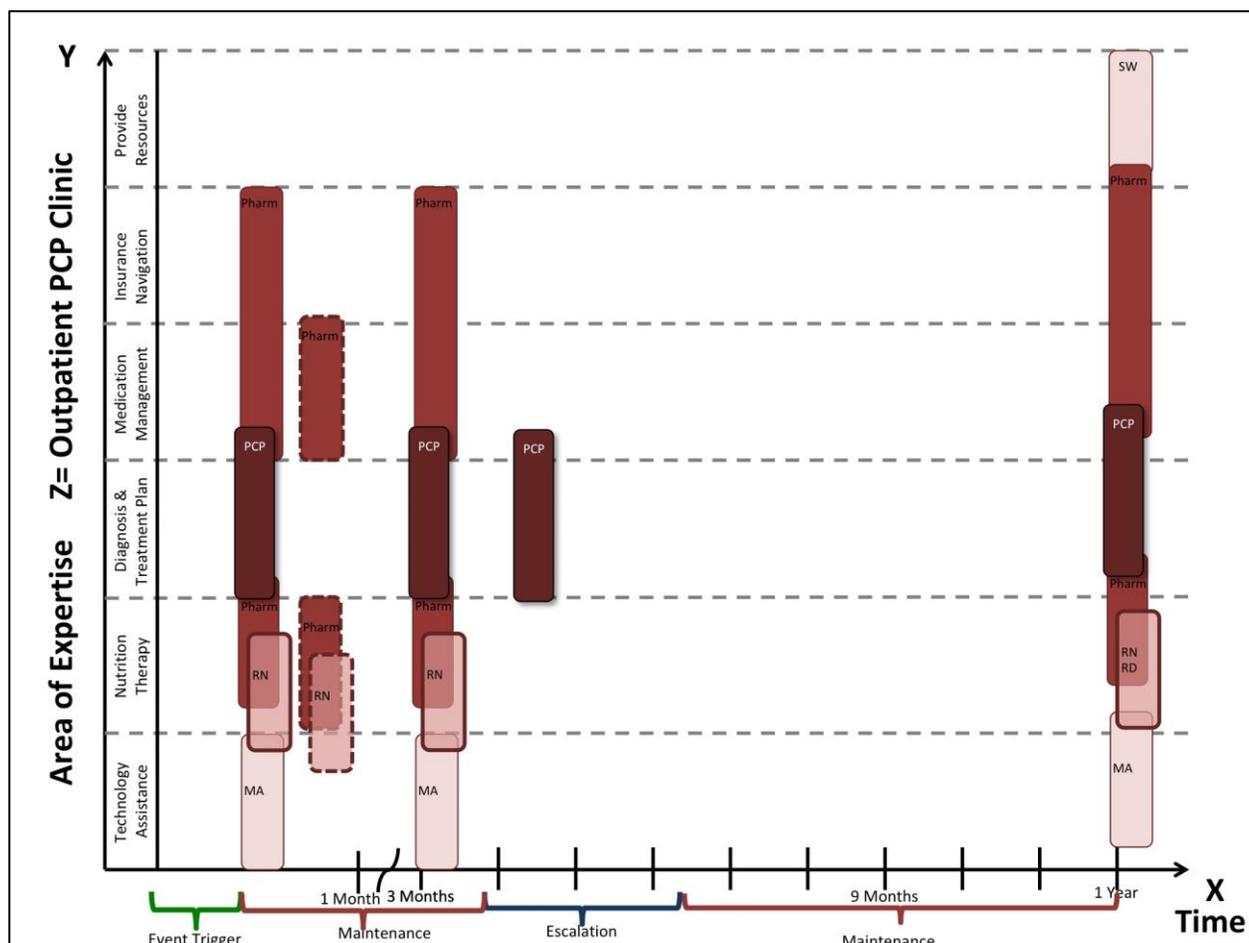


Figure 23. Outpatient Primary Care Clinic with DRIFT.

The primary care provider will establish contact after a patient is hospitalized and diagnosed. Although not all team members may be present at every primary care clinic (e.g., pharmacists, dietitians, and social workers are not always available), the ideal situation is depicted here. The dashed lines represent as-needed care that may occur as a follow-up via phone. At the escalation phase, there is a handoff that occurs between the primary care provider and the endocrinologist, but the patient will still check back in with their primary care provider for an annual visit even if the endocrinologist primarily leads their care. There are more providers that assist the patient at their annual check-up as well, such as the annual dietitian screening and social work services review.

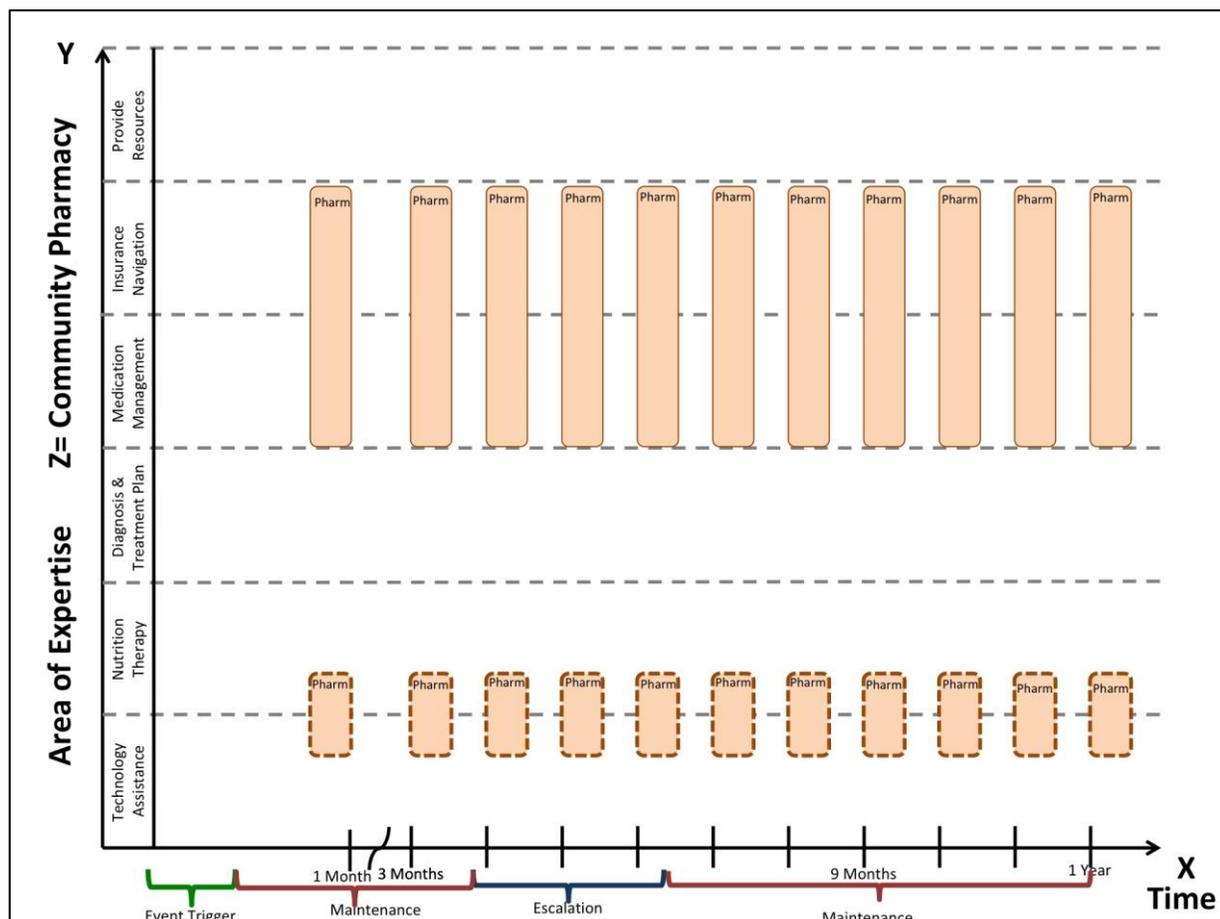


Figure 24. Community Pharmacy with DRIFT.

The patient will fill their medications with the pharmacist, often a community pharmacy, every 30-90 days. The patient may request counseling for nutrition or their devices (e.g., pumps, meters, etc.) as needed.

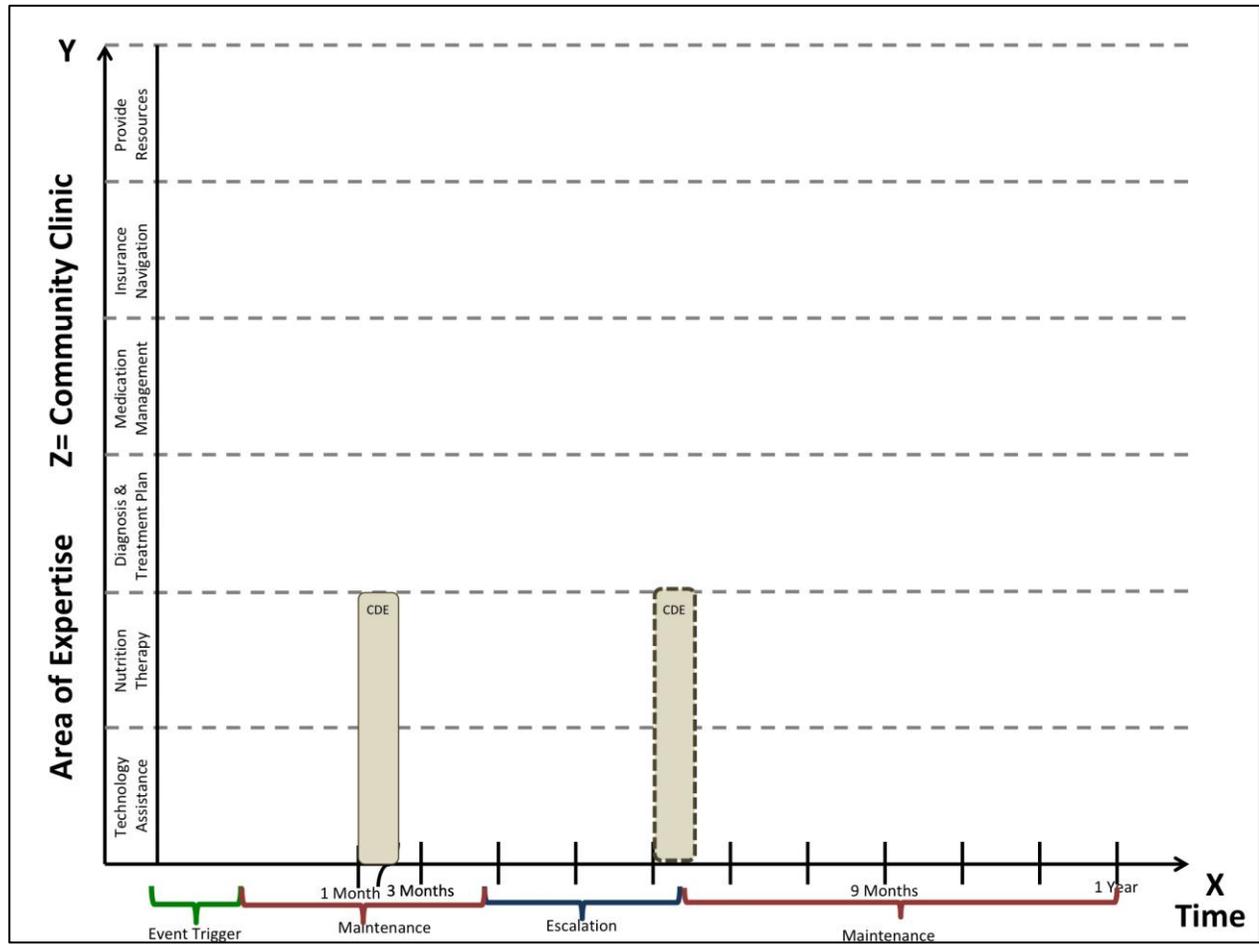


Figure 25. Outpatient Community Clinic with DRIFT.

There are a variety of community clinics that provide resources, additional education, and support for patients (e.g., diabetes care clinics, mental health clinics, support groups). Patients are typically referred to these places after an initial diagnosis and after escalation to an endocrinologist, as needed, especially when there isn't an educator that works in the facility that is leading the patient care. These groups usually meet 1-3 times in brief bursts and aren't typically ongoing.

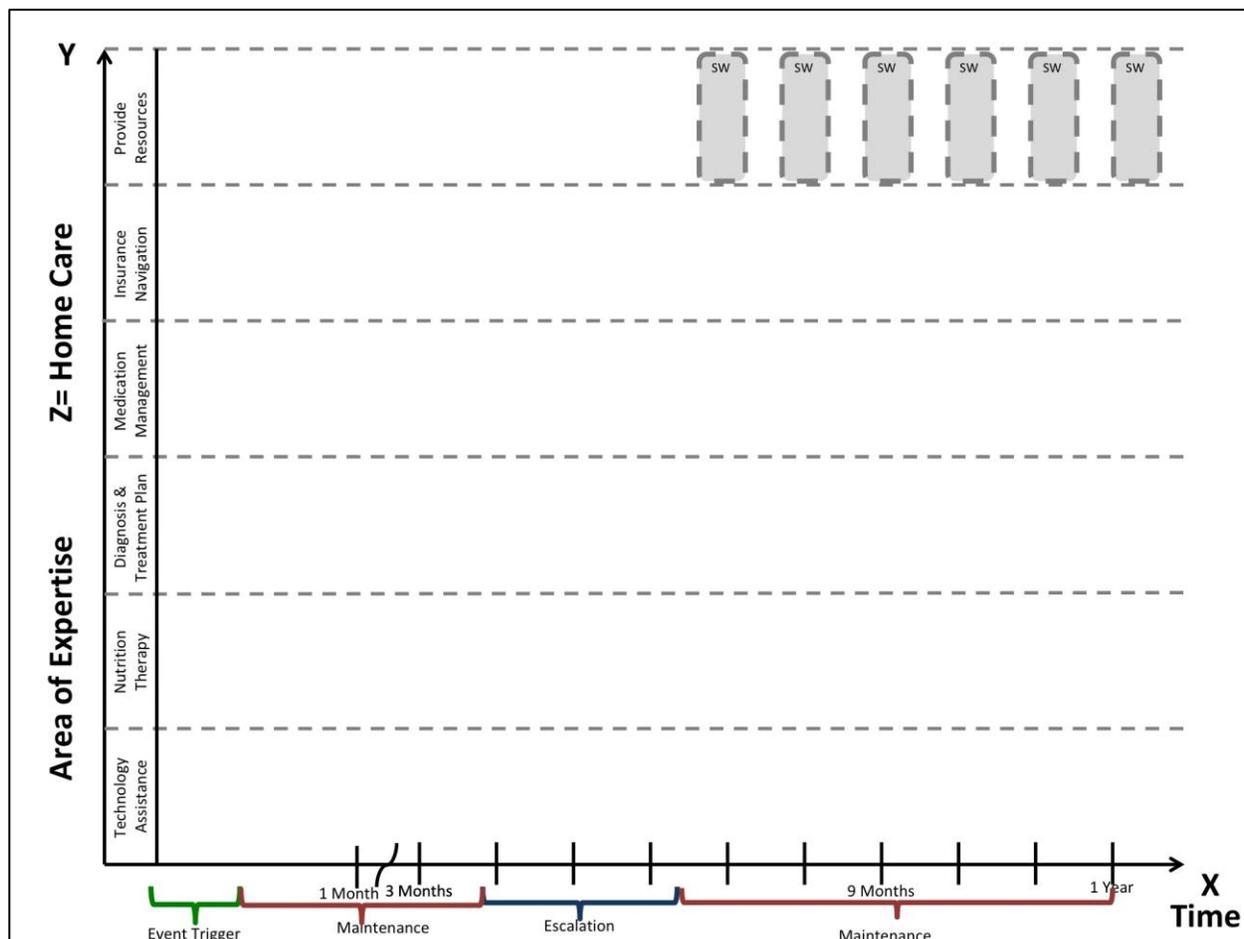


Figure 26. Home Care with DRIFT.

Patients primarily receive support and reinforcement for their care from family members and caregivers, especially after a hospitalization. In extreme cases with many comorbidities and complications, social workers may make home visits to help provide resources and counseling to patients.

The areas of expertise at each level of granularity were layered on top of each other to show the full system and display potential gaps in care (**Figure 27 & 28**).

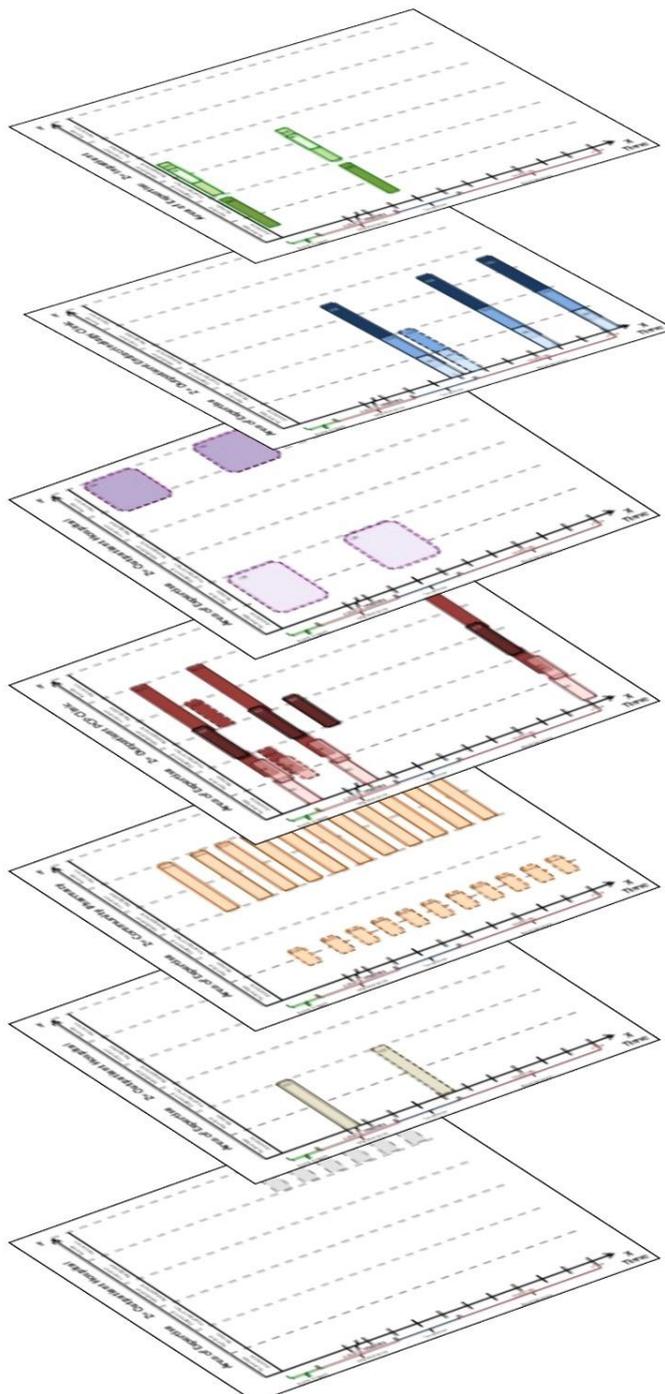


Figure 27. DRIFT Overall System Model.

Depicting Time (X), Area of Expertise (Y), and Granularity of Care (Z) for each level of the system.(Figures 20 – 26 from top to bottom).

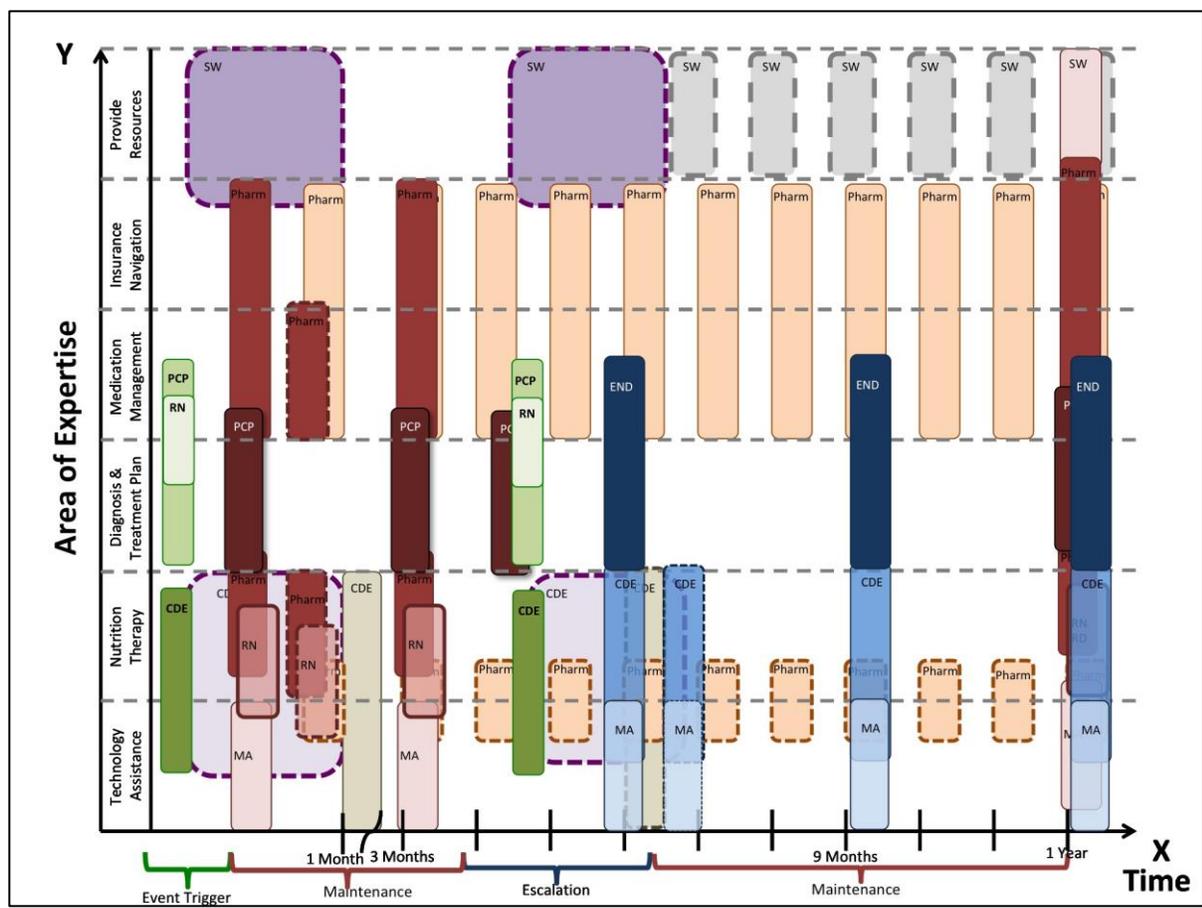


Figure 28. Aerial View of DRIFT with All Levels of Granularity.

The aerial view of the DRIFT model (**Figure 28**) shows the multitude of providers that patients see over time, and the need for careful coordination of information across levels of granularity of care. This view also demonstrates that patients may receive education in bursts after event triggers or escalations, but ancillary levels of care can provide ongoing education, such as via the community pharmacist. Patients may also not have interaction with their primary care provider or endocrinologist except during quarterly appointments, so the interactions with the pharmacists are critical for helping inform the providers of the patient’s current status on the medications and providing care updates. Strong information flows between pharmacists and care teams are critical for coordination of patient care and information freshness. This depiction of the diabetes care team also shows a significant amount of overlap, especially in the beginning of starting care with education services. While reinforcing education can be beneficial for patient care, it is critical that patients are not being overloaded and that the messages they are receiving from their various care teams are all in sync.

5.2.7 Opportunities & Challenges for Diabetes Care Teams

The overarching goal of RQ 1 was to identify opportunities for spatially and temporally distributed pharmacists to participate effectively in diabetes care teams. The analyses presented previously help identify some new findings, gaps, and opportunities for how we define and describe diabetes care team interactions, particularly with pharmacists.

However, to ensure a comprehensive list of specific gaps and opportunities for improving diabetes care team processes, participants were interviewed further about specific barriers and challenges that they experience in their daily work. The following sections review the barriers that healthcare professionals encounter when caring for people with diabetes that were mentioned organically during the interview; information gaps during coordination; technology intervention requests; and facilitators and barriers of using continuous glucose monitoring (CGM) technology to care for people with diabetes.

5.2.7.1 Barriers to Diabetes Care Team Processes

Throughout the interview, participants share barriers and frustrations that they encounter while providing care for their patients. These barriers to diabetes care were captured in **Table 24** with six overarching themes: patient access, patient engagement & motivation, patient education, provider resources, provider time, and team coordination. Over half of the participants that mention barriers to care during their interviews mentioned team coordination (N=12/20) and patient access (N=10/20) as the most frequently cited barriers. Team coordination barriers include incomplete patient data (such as missing labs, medication history, blood glucose logs, or referral requests); minimal coordination between endocrinologist and primary care provider teams; and bottlenecks due to lack of authority for ancillary staff members (e.g., RNs, RDs, Pharms). Patient access issues mentioned include cost of care, insurance coverage, and access to CGM technology. Provider time was also highly mentioned (N=8/20, 40%) as a barrier to care, specifically with providers mentioning the lack of time they have to complete documentation activities combined with the lack of insurance companies reimbursing for these documentation activities.

Table 24. Barriers to Diabetes Care.

The results are listed in descending order by frequency that patients mentioned the item in the interview by one of six overarching themes. Because these responses came up organically, the total number of participants was twenty (N=20) and the total number for each role is listed in the role column below. The last row of the table provides a summary of the total frequencies for the six high level themes and a few descriptions of common (N>2) sub themes.

Role	Barriers to Diabetes Care
END (N=5)	<p>Patient Access (N=4)</p> <ul style="list-style-type: none"> • Cost of medications (N=3) • Insurance coverage issues (N=1) • Travel to see providers (N=1) <p>Provider Time (N=3)</p> <ul style="list-style-type: none"> • Lack of time to complete patient documentation activities (N=3) • Insurance companies do not reimburse for documentation (N=1) <p>Team Coordination (N=3)</p> <ul style="list-style-type: none"> • Access to patient blood glucose logs (N=1) • Access to patient labs (N=1) • Access to accurate medication information (N=1) • Providers not understanding the concept of a patient-centered medical home (N=1) • Patients forget appointments (N=1) <p>Patient Engagement & Motivation (N=2)</p> <ul style="list-style-type: none"> • Not communicating honestly (N=1) • Stressors (N=1) • Embarrassment about disease (N=1) <p>Patient Education (N=2)</p> <ul style="list-style-type: none"> • Patient not receiving education via the PCP (N=2) <p>Provider Resources (N=1)</p> <ul style="list-style-type: none"> • Shortage of endocrinologists (N=1) • Shortage of support staff (N=1)
PCP (N=3)	<p>Patient Access (N=1)</p> <ul style="list-style-type: none"> • Insurance coverage (N=1) • Cost of care (N=1) <p>Provider Time (N=1)</p> <ul style="list-style-type: none"> • Insurance companies do not reimburse for education (N=1) <p>Patient Engagement & Motivation (N=1)</p> <ul style="list-style-type: none"> • Lack of patient motivation (N=1) <p>Team Coordination (N=1)</p> <ul style="list-style-type: none"> • Minimal coordination between endocrinologists and PCP teams (N=1)

Table 24 continued

<p>Pharm (N=4)</p>	<p>Team Coordination (N=4)</p> <ul style="list-style-type: none"> • Gap in provider coordination with incomplete medical records (N=3) • Lack of face-to-face communication (N=1) • Difficulties due to HIPAA for obtaining patient information (N=1) • Lack of medication information (e.g., doses, history, compliance) (N=1) • Required to escalate Type I's to endocrinologists, even though others have the skills to manage their care (N=1) <p>Provider Time (N=3)</p> <ul style="list-style-type: none"> • Primary care providers are overloaded and do not have time to care for as many patients (N=2) • Lack of reimbursement for pharmacists providing additional services (N=2) • Time consuming navigating insurance issues (N=1) <p>Patient Access (N=2)</p> <ul style="list-style-type: none"> • Insurance coverage (N=1) • Cost of care (N=1) • Difficult to get access to CGM (N=1) <p>Patient Engagement & Motivation (N=2)</p> <ul style="list-style-type: none"> • Not wanting to stick fingers (N=1) • Psychological distress (N=1) <p>Patient Education (N=2)</p> <ul style="list-style-type: none"> • Not understanding the importance of keeping medical records (N=1) • Lack of patient knowledge about understanding the role of the pharmacist (N=1) <p>Provider Resources (N=1)</p> <ul style="list-style-type: none"> • Lack of space to fit all members of the team in one space (N=1)
<p>RD (N=3)</p>	<p>Patient Access (N=2)</p> <ul style="list-style-type: none"> • Costs of care (N=2) <p>Team Coordination (N=2)</p> <ul style="list-style-type: none"> • Incomplete referral documentation (N=1) • Team members working in parallel with the patient (N=1) <p>Provider Time (N=1)</p> <ul style="list-style-type: none"> • Pharmacy overloaded with medication dispensing activities (N=1) <p>Patient Education (N=1)</p> <ul style="list-style-type: none"> • Lack of continuing education classes for people with diabetes (N=1)

Table 24 continued

<p>RN (N=4)</p>	<p>Team Coordination (N=2)</p> <ul style="list-style-type: none"> • Too much is required by the primary care provider / physician roles, bottlenecks other team members tasks (N=1) • Difficulties with coordinating medication information (N=1) <p>Provider Resources (N=2)</p> <ul style="list-style-type: none"> • Shortage of endocrinologists (N=2) <p>Patient Engagement & Motivation (N=1)</p> <ul style="list-style-type: none"> • Patients don't want to stick themselves for blood glucose testing (N=1) <p>Patient Education (N=1)</p> <ul style="list-style-type: none"> • Not all providers refer patients to diabetes education (N=1) <p>Patient Access (N=1)</p> <ul style="list-style-type: none"> • Cost of care (N=1) • Insurance coverage (N=1) • Access to CGM (N=1)
<p>SW (N=1)</p>	<p>Provider Resources (N=1)</p> <ul style="list-style-type: none"> • The ability for more providers to provide more home care for patients (N=1)
<p>Total</p>	<p>Team Coordination (N=12/20)</p> <ul style="list-style-type: none"> • Incomplete patient data (labs, medication history, blood glucose logs, referral requests etc.) • Minimal coordination between endocrinologists and PCP teams • Too much control for END/PCP roles; bottlenecks other members of the team <p>Patient Access (N=10/20)</p> <ul style="list-style-type: none"> • Cost of care • Insurance coverage • Access to CGM <p>Provider Time (N=8/20)</p> <ul style="list-style-type: none"> • Lack of time to complete documentation • Insurance companies do not reimburse for documentation or education activities • Primary care providers are overloaded and do not have time to care for as many patients <p>Patient Education (N=6/20)</p> <ul style="list-style-type: none"> • Patient not receiving education referral via the PCP • Lack of patient knowledge about understanding the role of the pharmacist <p>Patient Engagement & Motivation (N=5/20)</p> <ul style="list-style-type: none"> • Not communicating honestly • Not wanting to stick fingers

Table 24 continued

<ul style="list-style-type: none"> • Psychological distress Provider Resources (N=5/20) <ul style="list-style-type: none"> • Shortage of endocrinologists • Lack of space to fit all members of the team in one space
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5.2.7.2 Information Gaps in Diabetes Care Information Flows

After participants shared the information content they share and receive with patients and with other members of the diabetes care team, they were probed about information they would ideally like to receive that they may not always have access to (**Table 25**). There were four key themes that emerged for gaps in information flows: Medical History (N=22/30), Medication Records (N=19/30), Lifestyle Information (N=19/30), and Patient Honesty (N=17/30).

Within the medical history theme, half of all participants (N=15/30) wanted to know how often patients are taking their medications. This was closely connected with the patient honesty theme (N=17/30), where many participants mentioned these two issues in tandem. For example, several providers mentioned that they would like patients to be honest and share exactly how they taking their insulin so that they don't over prescribe and cause a patient to crash if they start taking it as prescribed. This also was connected with the top finding for the medical history theme, which is knowing patient blood glucose records (N=12/30). Participants mentioned needing to know patient blood glucose records in conjunction with their medication administration habits to see how effective the treatment is for helping the patient reach their goals. One pharmacist said, *"When we don't know blood sugar, it can be hard to make safe medication adjustments"*. Most pharmacists (N=4/5) and one primary care provider also mentioned the importance of having accurate medication records. A primary care provider shared that, *"Medication reconciliation is the single most difficult thing we do. What I have on my list of medications that the patient is taking is almost never right."* The top Lifestyle information subthemes included nutrition (N=10/30), exercise (N=7/30), and financial issues (N=4/30).

Within each role, there were only four subthemes that emerged where four or five out of the participants in that role category reached consensus on a particular gap in information. The majority of endocrinologists (N=4/5) and nurses (N=4/5) requested wanting to know how

patients were taking their medications; all pharmacists (N=5/5) wanted to know patient blood glucose records and most pharmacists (N=4/5) mentioned needing accurate medication lists; and all nurses (N=5/5) and nearly all dietitians (N=4/5) mentioned that patient honesty was critical to obtaining information for patient care.

Table 25. Gaps in Information during Diabetes Care Team Coordination.

The results are listed in descending order by frequency that patients mentioned items in response to the question “What information would you like to have in an ideal situation” during the interview. The overall summation in the last row of the table omits specific requests that were mentioned by only one participant and were unique to that role.

Role	Gaps in Information Flows
END	Medication Records (N=5) <ul style="list-style-type: none"> • How patients are taking their medications (N=4) • Effectiveness of previous medication therapies (N=1) • Adjustments to medication therapy from other doctors (N=1) Medical History (N=5) <ul style="list-style-type: none"> • Records from other providers (N=3) • Laboratory results (want to avoid repeating labs) (N=2) • Blood glucose records (N=2) • Surgeries (N=1) Lifestyle Information (N=4) <ul style="list-style-type: none"> • Nutrition (N=3) • Exercise habits (N=2) • Changes in living situation (N=1) • Financial issues (N=1) Patient Honesty (N=1)
PCP	Medication Records (N=3) <ul style="list-style-type: none"> • How patients are taking their medication (N=1) • Accurate medication lists (N=1) • Effectiveness of previous medication therapies (N=1) Medical History (N=4) <ul style="list-style-type: none"> • Previous lab results (avoid redundant labs) (N=2) • Blood glucose records (N=2) • Records from other providers (N=1) Lifestyle Information (N=2) <ul style="list-style-type: none"> • Nutrition (N=2)

Table 25 continued

	<ul style="list-style-type: none"> • Exercise (N=1) • Any questions patients may have about their care (N=1) Patient Honesty (N=3)
Pharm	Medication Records (N=4) <ul style="list-style-type: none"> • Accurate medication lists, including medications filled at other pharmacies (N=4) • How patients are taking their medication (N=3) • Effectiveness of previous medication therapies (N=1) Medical History (N=5) <ul style="list-style-type: none"> • Blood glucose records (N=5) • Previous lab results (avoid redundant labs) (N=1) • Records from other providers (N=1) • History of diabetes treatment (N=1) • Allergies (N=1) • Goal for referral from other providers (N=1) Lifestyle Information (N=3) <ul style="list-style-type: none"> • Blood glucose testing habits (N=2) • Exercise (N=1) • Contact information (N=1) Patient Honesty (N=2)
RD	Medication Records (N=2) <ul style="list-style-type: none"> • How patients are taking their medication (N=2) Medical History (N=1) <ul style="list-style-type: none"> • Previous lab results (N=1) Lifestyle Information (N=3) <ul style="list-style-type: none"> • Financial issues (N=2) • Nutrition (N=2) Patient Honesty (N=4)
RN	Medication Records (N=4) <ul style="list-style-type: none"> • How patients are taking their medication (N=4) Medical History (N=4) <ul style="list-style-type: none"> • Records from other providers (N=3) • Blood glucose records (N=2) • Diagnosis (N=1) Lifestyle Information (N=3) <ul style="list-style-type: none"> • Exercise (N=3)

Table 25 continued

	<ul style="list-style-type: none"> • Nutrition (N=2) • Testing habits (N=1) • Financial issues (N=1) Patient Honesty (N=5)
SW	Medication Records (N=1) <ul style="list-style-type: none"> • How patients are taking their medication (N=1) Medical History (N=3) <ul style="list-style-type: none"> • Records from other providers (N=1) • Blood glucose records (N=1) Lifestyle Information (N=4) <ul style="list-style-type: none"> • Overall mood and mental state (N=2) • Nutrition (N=1) • Sleep habits (N=1) • Substance use (N=1) Patient Honesty (N=2)
Overall	Medication Records (N=19) <ul style="list-style-type: none"> • How patients are taking their medication (N=15) • Accurate medication lists, including medications filled at other pharmacies (N=5) • Effectiveness of previous medication therapies (N=3) • Adjustments to medication therapy from other doctors (N=1) Medical History (N=22) <ul style="list-style-type: none"> • Blood glucose records (N=12) • Records from other providers (N=9) • Previous lab results (avoid redundant labs) (N=6) Lifestyle Information (N=19) <ul style="list-style-type: none"> • Nutrition (N=10) • Exercise (N=7) • Financial issues (N=4) • Blood glucose testing habits (N=3) • Overall mood and mental state (N=2) Patient Honesty (N=17)

5.2.7.3 Opportunities for Technology Interventions

Participants were asked to share their health information technology needs that would help make their jobs easier (**Table 26**). Overall, participants requested changes with electronic health records (N=20/30), blood glucose monitoring (N=11/30), ways to have easier communication with patients (N=4/30), and one (N=1/30) endocrinologist requested a new technology that monitors food intake similar to how CGM monitors blood glucose values.

The requests for changes made to electronic health records were varied and many related to the participant's specific work tasks (e.g., a dietitian requesting specific terminology be implemented in documentation notes for nutrition therapy). However, nine (N=9/30) participants did request a universal health record, four (N=4/5) of which were pharmacists. Some participants (N=5/30) also requested ways for changes to patient electronic health records to be more salient to other members of the diabetes care team. One nurse suggested implementing a concept that was reminiscent of how they used to place a "sticky note" on a paper chart to alert a provider before, and translating this metaphor into the electronic sphere.

Several participants (N=8/30) also mentioned access to CGM technology for their patients would be their number one health IT need. A few (N=2/30) also said that testing without finger sticks would be beneficial for patient care. Some nurses (N=2/5) and dietitians (N=2/5) remarked on ways to make communication with their patients easier, such as through minimizing the log-in requirements to access messages in patient portals (N=2/30) and enabling ways to communicate with patients more naturally and securely, such as through their cell phones (N=1/30) or social media (N=1/30)

Table 26. Health Information Technology Needs Assessment.

These are the results from when participants were asked, "What is your health IT wish?" The results are listed in descending order by frequency that patients mentioned the item in the interview. All participants answered this question during the interviews (Total N=30), but some provided more than request. The overall summation in the last row of the table omits specific requests that were mentioned by only one participant and were unique to that role.

Role	Health Information Technology Needs Assessment
END	Electronic Health Records (N=3)

Table 26 continued

	<ul style="list-style-type: none"> • Universal EHR (N=2) • Universal note format (N=1) • Handheld EHR device (N=1) <p>Blood Glucose Monitoring (N=1)</p> <ul style="list-style-type: none"> • Prompts for patients to upload data before meeting with their providers (N=1) <p>New technology (N=1)</p> <ul style="list-style-type: none"> • Technology to monitor food intake similar to how CGM monitors blood glucose values (N=1)
PCP	<p>Electronic Health Records (N=5)</p> <ul style="list-style-type: none"> • Better design to help saliency of changes to patient records (N=3) • Universal EHR (N=2) • Automatic note forwarding to providers on the patient's team (N=1) • Improved accuracy of medication start dates (currently has renewal date) (N=1) <p>Blood Glucose Monitoring (N=1)</p> <ul style="list-style-type: none"> • Better education resources for patients testing their blood glucose values (N=1)
Pharm	<p>Electronic Health Records (N=4)</p> <ul style="list-style-type: none"> • Universal EHR (N=4) • Medication reconciliation software that compares records from across systems (N=1) • Incorporating check boxes for faster documentation (N=1) <p>Blood Glucose Monitoring (N=3)</p> <ul style="list-style-type: none"> • CGM for patients (N=2) • Software connecting patients and all providers to blood glucose data (N=1) • Blood glucose testing without finger sticks (N=1) • Real-time telehealth services for helping patients with hyper/hypoglycemia (N=1)
RD	<p>Electronic Health Records (N=3)</p> <ul style="list-style-type: none"> • Make EHR less impersonal and time consuming (N=2) • Incorporate international dietetics nutrition terminology in patient note documentation (N=1) <p>Blood Glucose Monitoring (N=1)</p> <ul style="list-style-type: none"> • CGM for patients (N=1) <p>Easier Communication (N=2)</p> <ul style="list-style-type: none"> • Minimizing the number of portals and logins to communicate securely with patients (N=1) • Allow use of social media portals to communicate with patients (N=1) • Method for allowing easier authorization of HIPAA information to avoid

Table 26 continued

	slowing down care (N=1)
RN	<p>Electronic Health Records (N=2)</p> <ul style="list-style-type: none"> • Section in EHR like a “sticky note” where very important information about changes can be obvious to other providers on the patient care team (N=2) • Section in EHR for lifestyle data (N=1) • Section in EHR about normal patient ranges (e.g., for blood glucose values) (N=1) <p>Blood Glucose Monitoring (N=3)</p> <ul style="list-style-type: none"> • CGM for patients (N=3) • Automatic upload to EHR with blood glucose and pump data (N=1) • Blood glucose testing without finger sticks (N=1) <p>Easier Communication (N=1)</p> <ul style="list-style-type: none"> • Minimizing the number of portals and logins to communicate securely with patients (N=1) • Communicate to patient phones more securely (N=1)
SW	<p>Electronic Health Records (N=3)</p> <ul style="list-style-type: none"> • Universal EHR (N=1) • Flags for previous mental health issues (N=1) • Ways to link family member records within an EHR (N=1) <p>Blood Glucose Monitoring (N=2)</p> <ul style="list-style-type: none"> • CGM for patients (N=2) <p>Easier Communication (N=1)</p> <ul style="list-style-type: none"> • Drug coverage chart to share with patients so they don’t have to contact insurance company (N=1)
Total	<p>Electronic Health Records (N=20)</p> <ul style="list-style-type: none"> • Universal EHR (N=9) • Better design to help saliency of changes to patient records (e.g., “sticky note” concept) (N=5) <p>Blood Glucose Monitoring (N=11)</p> <ul style="list-style-type: none"> • CGM for patients (N=8) • Blood glucose testing without finger sticks (N=2) <p>Easier Communication (N=4)</p> <ul style="list-style-type: none"> • Minimizing the number of portals and logins to communicate securely with patients (N=2) • Communicate to patient phones more securely (N=2)

In addition to asking about their health IT requests, participants were probed about their knowledge and use of CGM technology. Nearly half of the participants (N=14/30) had some experience working with CGM technology, a third (N=10/30) knew of CGM but did not have significant experience, and a fifth (N=6/30) were not familiar with the technology. Those who were experienced or familiar with the technology shared their perspectives on the experienced benefits or potential benefits of CGM technology and the barriers to CGM technology usage (**Table 27**).

Table 27. CGM Benefits and Barriers.

These are the results from when participants were asked about ways CGM facilitated diabetes care and barriers to CGM usage. The results are listed in descending order by frequency that patients mentioned the item in the interview. Not all study participants had a working knowledge of CGM, therefore the total number of participants for this question was N=24 and the number per role is indicated in the first column. The overall summation in the last row of the table omits specific requests that were mentioned by only one participant and were unique to that role.

Role	Benefits of CGM	Barriers to CGM
END (N=5)	General Patient Benefits (N=4) <ul style="list-style-type: none"> • Increased safety (N=2) • Improved quality of life (N=2) • Provides a sense of security (N=1) • Can be part of a closed loop system • Increases compliance for patients (N=1) Improved Patient Situation Awareness (N=3) <ul style="list-style-type: none"> • Provide blood glucose trends (N=3) • Real-time data (N=3) • Alerts for hypoglycemia prevention (N=1) • Draw connections between actions and blood glucose outcomes (N=1) • Connectivity with other technologies (e.g., smart watch) to increase awareness (N=1) Improved Provider Situation Awareness (N=2) <ul style="list-style-type: none"> • Provide blood glucose trends (N=1) • Provide statistics (N=1) • Report print outs (N=1) • Can be used as an investigative tool to verify accuracy of patient history (N=1) • Can be used to help assess medication 	Access (N=2) <ul style="list-style-type: none"> • Cost (N=2) • Insurance coverage (N=1) • Insurance coverage for people with type II diabetes (N=1) • Distance patients have to travel to have assistance with the technology (N=1) Patient Preferences (N=2) <ul style="list-style-type: none"> • Patients dislike having to wear another device (N=2)

Table 27 continued

	<p>requirements (N=1)</p> <ul style="list-style-type: none"> • Use to help assess nutrition requirements (N=1) • Electronic connectivity facilitates patient-provider communication (N=1) 	
PCP (N=3)	<p>Improved Patient Situation Awareness (N=1)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=1) <p>Improved Provider Situation Awareness (N=2)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=1) • Can results in less labs (e.g., A1c) ordered (N=1) • Can be used as an investigative tool to verify accuracy of patient history (N=1) • Help more accurate decisions about medications and care (N=1) 	<p>Access (N=1)</p> <ul style="list-style-type: none"> • Cost (N=1) • Insurance coverage (N=1) <p>CGM Software Issues (N=1)</p> <ul style="list-style-type: none"> • Alerts were over sensitive in previous versions of CGM technology (N=1)
Pharm (N=5)	<p>General Patient Benefits (N=1)</p> <ul style="list-style-type: none"> • Less finger pricks (N=1) • Opportunities for telehealth care and increased patient access to care (N=1) <p>Improved Patient Situation Awareness (N=4)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=4) • Real-time blood glucose data (N=4) <p>Improved Provider Situation Awareness (N=4)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=4) • Real-time blood glucose data (N=3) • Help providers make more accurate decisions (N=3) • Electronic connectivity facilitates patient-provider communication (N=3) • Provides statistics (e.g., variability) and reports that can help with patient management (N=2) • Can be used as an investigative tool to verify accuracy of patient history (N=1) • System provides suggestions for patient care (N=1) • Allows more response time for providers to 	<p>Access (N=3)</p> <ul style="list-style-type: none"> • Insurance coverage for people with type II diabetes (N=3) • Insurance coverage (N=2) • Cost (N=2) <p>Lack of Clinical Trials Showing Effectiveness for People with Type II Diabetes (N=2)</p>

Table 27 continued

	intervene and make adjustments (N=1)	
RD (N=3)	<p>General Patient Benefits (N=1)</p> <ul style="list-style-type: none"> • Safety (N=1) <p>Improve Patient Situation Awareness (N=3)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=2) • Alerts for hypoglycemia prevention (N=1) <p>Improve Provider Situation Awareness (N=2)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=1) • Alerts for hypoglycemia prevention, particularly for pediatric populations (N=1) 	<p>CGM Software Issues (N=2)</p> <ul style="list-style-type: none"> • Not always accurate (N=2) • Difficulty downloading reports (N=1) <p>Provider / Administration Buy-In & Acceptance of New Technology (N=2)</p> <p>Access (N=1)</p> <ul style="list-style-type: none"> • Cost (N=1) • Insurance coverage for people with type II diabetes (N=1) <p>Patient Motivation (N=1)</p>
RN (N=5)	<p>General Patient Benefits (N=2)</p> <ul style="list-style-type: none"> • Save money over time (N=1) • Reduce hospitalizations (N=1) • Less finger sticks (N=1) • Less time spent thinking about the disease (N=1) • Improve disease control (N=1) <p>Improve Patient Situation Awareness (N=3)</p> <ul style="list-style-type: none"> • Draw connections between actions and blood glucose outcomes (N=3) • Alerts for hypoglycemia prevention (N=2) <p>Improve Provider Situation Awareness (N=4)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=4) • Real-time blood glucose data (N=2) • Allows more response time for providers to intervene and make adjustments (N=2) • Draw connections between actions and blood glucose outcomes (N=1) • Help providers make more accurate decisions (N=1) • Provides reports that can help with patient management (N=1) 	<p>Access (N=4)</p> <ul style="list-style-type: none"> • Cost (N=3) • Insurance coverage (N=3) • Insurance coverage for people with type II diabetes (N=1) <p>Lack of infrastructure for inpatient hospital staff to monitor CGM alerts—could be a liability risk (N=1)</p>

Table 27 continued

<p>SW (N=3)</p>	<p>Improve Patient Situation Awareness (N=1)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=1) <p>Improve Provider Situation Awareness (N=3)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=2) • Help providers make more accurate decisions about medications (N=1) • Draw connections between actions and blood glucose outcomes (N=1) 	<p>Access (N=2)</p> <ul style="list-style-type: none"> • Cost (N=2) • Insurance coverage (N=2) <p>Patient Preferences (N=1)</p> <ul style="list-style-type: none"> • Patients dislike having to wear another device (N=1)
<p>Total (N=24)</p>	<p>General Patient Benefits (N=8)</p> <ul style="list-style-type: none"> • Increased safety (N=3) • Improved quality of life (N=3) • Less finger pricks (N=2) <p>Improve Patient Situation Awareness (N=15)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=11) • Real-time data (N=7) • Alerts for hypoglycemia prevention (N=4) • Draw connections between actions and blood glucose outcomes (N=4) <p>Improve Provider Situation Awareness (N=17)</p> <ul style="list-style-type: none"> • Provide blood glucose trends (N=14) • Help providers make more accurate decisions about medications and care (N=8) • Provides statistics (e.g., variability) and reports that can help with patient management (N=5) • Real-time blood glucose data (N=5) • Electronic connectivity facilitates patient-provider communication (N=4) • Can be used as an investigative tool to verify accuracy of patient history (N=3) • Allows more response time for providers to intervene and make adjustments (N=3) • Draw connections between actions and blood glucose outcomes (N=2) 	<p>Access (N=13)</p> <ul style="list-style-type: none"> • Cost (N=11) • Insurance coverage (N=9) • Insurance coverage for people with type II diabetes (N=6) <p>CGM Software Issues (N=3)</p> <ul style="list-style-type: none"> • Not always accurate (N=3) <p>Patient Preferences (N=3)</p> <ul style="list-style-type: none"> • Patients dislike having to wear another device (N=3) <p>Lack of Clinical Trials Showing Effectiveness for People with Type II Diabetes (N=2)</p> <p>Provider / Administration Buy-In & Acceptance of New Technology (N=2)</p>

Participants listed many benefits to CGM, which were organized around the following key themes: improving patient (N=15/24) and provider (N=17/24) situation awareness, and general

patient benefits (N=8/24). The most commonly referenced benefits for improving situation awareness was with the ability of CGM to provide glucose trends (N=11/24 patients, N=14/24 providers), real-time data (N=7/24 patients, N=5/24 providers), and provide data to assist providers with making more accurate decisions about patient care (N=8). Alerts for hypoglycemia prevention (N=4/24) and helping patients draw connections between their actions and their blood glucose levels (N=4/24) were also referenced as benefits for patients and CGM usage. Of the six roles interviewed, the pharmacists and endocrinologists had the most experience working with CGM technology and outlined the majority of the findings for the CGM benefits, while the primary care provider and social worker roles had the least interaction and knowledge of benefits of CGM usage.

There were a few barriers mentioned to implementing CGM technology, and these were mostly focused around patient access to the technology (N=13/24), patient preferences (N=3/24), and software issues (N=3/24). Patient access issues were related to the intersections of cost of the technology (N=11/24) and insurance coverage (N=9/24), with a few participants (N=6/24) specifically mentioning that people with type II diabetes struggle to obtain insurance coverage for CGM technology, with two (N=2/5) pharmacists sharing that a lack of clinical evidence showing support could be the culprit. A few participants (N=3/24) said that a barrier to CGM adoption could be through the willingness of patients to agree to wearing another device, which could interfere with their sense of mobility and freedom, as one social worker shared. Three participants (N=3/24) mentioned that software accuracy was a barrier.

Participants who mentioned using CGM software reports were probed further to share additional information about these experiences. Nine (N=9) participants shared specific details about their interactions with CGM reports: four (N=4) endocrinologists, two (N=2) pharmacists, one (N=1) dietitian, and one (N=1) nurse. All participants shared that they used the CGM reports to look at historical patient data and patterns. Providers tended to focus on patterns per different days of the week and times of the day because they are “*easy places to start to fix*” –*endocrinologist*. After assessing issues with daily patterns and postprandial responses, providers tend to focus on adjusting unusual lows or highs to minimize the risk of hypo- or hyperglycemia. Additional statistics about patient status, such as variability, time in range, mean glucose, and percentages

are often included on CGM reports, and they can be useful for providers who would not “*otherwise spend the time calculating these statistics*”-pharmacist. However, these values are more for understanding an overall state and not as useful for problem solving, as one endocrinologist explained:

“For some reason, the software companies think that providing you the averages in these pretty curves and stuff is the most useful, but I don't find it useful at all. I mean, you can start with that, again, to look at patterns, but I'm always ... diabetes is always about details. It doesn't matter what is happening in general. It only matters what's happening right now and why this happened because that's where all the understanding comes from [...] So that's what those overviews are like. “Oh, the blood sugars are sort of high.” It means absolutely nothing. So the details are what I need.”

-Endocrinologist

Nearly half of the participants with experience with CGM reports (N=4/9; N=2 endocrinologists and N=2 nurses), mentioned a dire need for standardization between CGM reports across the software companies involved. One provider requested that looking at a CGM report should be akin to “*reading an EKG*”- endocrinologist. Some difficulties with the different reports include the varying order of information on reports (even within different software versions from the same companies), balance of graphical information and text, and the lack of options to visually overlay data from different graphs to one combined graph. A nurse also mentioned that it can be difficult to balance the requests of providers for more information without the CGM reports turning into a catch-all for information and then it taking too long for providers to assess (“*Nobody, anybody, not a diabetes educator or a physician or a provider has 20 minutes to look at everybody's CGM per patient. That's just not realistic*”-Nurse).

In addition to improving the standardization of the reports, healthcare providers requested that there be “*8-10 things on the first page, max*”-endocrinologist, “*make it fast and easy to assess*”-nurse, and use “*big red flags for things like hypoglycemia*”-nurse to improve CGM reports for future use.

5.2.8 Methodology Deviations & Unexpected Events

Part way through data collection, it became apparent that the one-hour time commitment was quite burdensome for healthcare professionals, many who already had severe time limitations with their regular work requirements. Participants, contacts at healthcare facilities, and participants that declined to participate all recommended shortening the study to 30 minutes to increase the potential participation pool. **Appendix D** contains the original moderator guide for the 1-hour interview, and **Appendix E** is a revised moderator guide for a shortened 30-minute interview. The main difference between the two moderator guides is that participants were asked to fill out the worksheets (**Appendices F & G**) on their own time at the completion of the interview instead of during the interview. This significantly reduced the amount of time necessary to complete the interviews, although it did result in a few participants not fully completing the worksheets, as seen in the results above.

5.2.9 Summary of Key Findings from Study II

Study II aimed to answer the following overarching research question and sub-questions:

Research Question 1 (RQ1): what opportunities exist for spatially and temporally distributed pharmacists to participate effectively in diabetes care teams?

Study II:

- **RQ1.2** What are the specific tasks for diabetes care team members?
- **RQ1.3** What are the required information flow attributes for effective diabetes care team coordination?

To answer these research questions, thirty (30) participants with N=5 for each role were interviewed via phone. The typical study participant was a female healthcare provider working in an outpatient setting for about 13 years; the mean length of interview was 48 minutes. The roles mentioned in Study I were also confirmed in Study II.

To answer research question 1.2, task and information content analyses were used to define the overarching goal of the diabetes care team and distinct tasks for each role. These analyses found that the primary care provider and endocrinologist roles tend to be very similar, with the primary

care provider acting as the main hub or “gatekeeper” of patient care and working with less complex patients, while the endocrinologist is more specialized and focused on complex and/or noncompliant patients. The nurse and dietitian roles also were found to be relatively similar, with many participants referring to both interchangeably as certified diabetes educators. Differences in these roles besides their training are minor differences in emphasizing nutrition education (dietitian role) vs. technology and overall disease education (nurse role). The pharmacist role varied slightly due to some pharmacist participants operating as certified diabetes educators as well, while participants were still describing pharmacist tasks more conceptually of that of a dispensing pharmacist role. Nevertheless, there was still consensus on the pharmacist helping mostly with medication management and insurance navigation tasks. Some participants also mentioned the ability of pharmacists to help offload some patient management tasks from primary care providers via collaborative practice agreements. The social work role had the least amount of overlap of tasks compared to the other roles, yet it was still deemed important for patients that require social work services. Social workers were deemed predominantly responsible for helping connect patients to resources to help minimize barriers to care (e.g., financial, housing, transportation, etc.).

Information flow attributes related to frequency of communication, communication mode, and information content were examined to answer RQ 1.3. The results revealed that patients interact with nurses, primary care providers, and dietitians the most, while pharmacists and endocrinologists were on a monthly basis, or annually/as needed for social workers. The higher interaction with nurses and dietitians could be skewed slightly due to the higher interactions of these providers with inpatient care. Providers interacted with nurses, dietitians, and pharmacists the most often (weekly), and all other roles on a monthly basis. Face-to-face communication was strongly preferred for all roles communicating with each other, except for participants preferred sticking with phone communication to communicate with pharmacists. Pharmacists, however, preferred talking face-to-face with team members. The information content for each role reinforced findings from the task analysis: the nurse, dietitian, and social worker roles share and receive more information related to lifestyle barriers, whereas primary care providers, pharmacist, and endocrinologists share and receive more information related to medications, diagnoses, and treatment plan information. Providers share information with their patients

predominantly via face-to-face appointments, but phone calls are used for follow-ups as needed, as well as using secure messaging and patient portals to share blood glucose record information.

The results from answering research questions 1.2 and 1.3 were used to create a new systems engineering analytical framework, *DRIFT*, which visualizes the differences in time scales, granularity of care, type of care provided, and mode of care. The results depicted with *DRIFT* reinforce the finding that the majority of diabetes care is handled in the outpatient settings. Furthermore, *DRIFT* highlights that patients may only have quarterly appointments with their primary care provider or endocrinologist, so the monthly interactions with pharmacists can be a potential opportunity for providing an update on patient status. Strong connections between spatially distributed pharmacists can be an avenue for improving information freshness in diabetes care teams. *DRIFT* also demonstrates the significant overlap and onslaught of information that patients receive after an event trigger; it is essential for care teams to coordinate messages and patient education endeavors during these transition times.

To ensure that all potential opportunities were explored for improving diabetes care team coordination, additional barriers, information gaps, and health IT requests were reviewed. Participants cited key barriers to diabetes care were incomplete information during team coordination and patient access to care with high costs and/or lack of insurance coverage. Gaps in information flows were often related to issues with patient honesty about how they were taking their medications and provider access to blood glucose records. Many participants requested wanting to know fix these information gaps via universal electronic health records and/or continuous glucose monitoring systems. Participants with extensive experience with CGM reported a dire need for standardization of report forms to facilitate more efficient care.

6. STUDY III METHODOLOGY

Results from Studies I & II were synthesized to determine the initial designs for a novel healthcare prototype developed by the author as part of this dissertation work and tested for feasibility of concept in Study III. Specifically, this study aims to answer the following research question and sub-questions:

Research Question 2 (RQ2): How can health information technology better support pharmacist information coordination for diabetes care?

- **Study III:**
 - **RQ2.1.** What are the data requirements for pharmacists monitoring people with diabetes?
 - **RQ2.2** What are the benefits and barriers of a universal patient appointment tracking feature?
 - **RQ2.3** What are the benefits and barriers of a universal messaging portal?
 - **RQ2.4** What are the benefits and barriers of the proposed DRIFT analytical framework for HCPs providing diabetes care?

6.1 Study III Design

To answer RQ2, established usability testing methods (Jakob Nielsen, 1994; Janni Nielsen, Clemmensen, & Yssing, 2002; Wiklund, Kendler, & Strohlic, 2015) and semi-structured interview questions (Harrell & Bradley, 2009) were used (**Appendix M**) to assess a new health IT analytical framework that the author created based on the findings from Studies I & II. The author developed the prototype (see **Appendix P** for links to prototypes) using Axure RP 8 © (2018) for a patient-facing mobile application and a provider-facing desktop software. Minor usability issues that were uncovered during testing sessions were iteratively fixed throughout the formative testing sessions.

Prior to each testing session, participants were asked to complete a participant screener form via email to determine eligibility (**Appendix L**). Once the participant was deemed eligible, a time

slot was scheduled for a thirty-minute video-conference. Each session started with a recap of the study goals, verbal confirmation of interest in participation from the participant, and a confirmation of the participant screener data accuracy. The session started out with general confirmatory questions related to the participant's experience working with diabetes care teams, and then quickly flowed into formative usability testing of a mobile application and software prototype (see **Appendix P** for links to the prototypes). Participants were asked exploratory questions related to their understanding of the overall purpose of the mobile application and software, and were encouraged to think aloud (Janni Nielsen et al., 2002) while exploring the health IT prototypes independently. Each session concluded with Likert scale questions about the usefulness and feasibility of the health IT as well as open-ended questions related to its potential for future integration within existing health IT systems. After each participant session, the data were de-identified and participants were given a number (e.g., Participant #1). Each session was audio-recorded to facilitate transcription for qualitative data analysis.

6.2 Participant Sampling & Recruitment

After receiving IRB approval from Purdue University (protocol #1809021021), participants were recruited to participate in the research study. Although the applications for the health IT tested in Study III can have a variety of end-users, the scope of this study focused on pharmacy professionals who were currently interacting with people with diabetes at least monthly as part of their work tasks. Pharmacy professionals could work at any type of location (e.g., inpatient, outpatient, community, etc.) but the participants were limited to people with the PharmD and RPh degrees. Participants had to be currently licensed and practicing in the United States and over 18 years of age, and had to have video conferencing capabilities and computer access during the testing session. A preliminary screener was sent via email to all interested participants to verify eligibility prior to scheduling their participation. A combination of convenience and snowball sampling methods were used (Ferber, 1977; Goodman, 1961): participants were contacted via social media and email platforms, with initial contacts at Midwestern healthcare facilities and from Study I & Study II participants who indicated interest in participating in future studies. Participants were not compensated for their participation. Participant recruitment occurred from October to December 2018.

To reduce excessive email communication with potential participants, efforts were made to reduce, as much as possible, contacting participants multiple times via different methods. A detailed list of known list-servers that the study recruitment information was shared with was logged. Furthermore, participants that indicated interest in participating were contacted via follow-up reminders a maximum of three times, with one to two weeks between each email reminder. Participants were always reminded that they could opt out of the study at any time.

The minimum participant number was set at five (n=5) pharmacy professionals, with an ideal goal of ten (n=10) participants (Faulkner, 2003; Hwang & Salvendy, 2010; Macefield, 2009). Recruitment stopped when the minimum goal was reached and no additional recruitment emails or postings yielded new potential research participants for 30 days.

6.3 Data Coding, Processing, & Analysis

Participants were assigned a number to de-identify the participant from their demographic data. The worksheets and interview audio records were each coded with the participant number. Once the interviews were transcribed, any remaining identifying information (e.g., names, employment locations, etc.) were removed from the transcription to protect participant anonymity. The participant interview transcripts were imported into a qualitative data analysis tool, NVivo 12 for Mac (© QSR International), where the data were then qualitatively coded using process and thematic, open coding methods (Saldaña, 2015). The codes were predefined and iteratively refined in a code key (**Appendices Q & R**) that aligned with RQ2. After data were coded, the codes were verified with the code key for accuracy. Usability issues that occurred during the testing sessions were also captured and organized based on usability heuristics (Jakob Nielsen, 1995; Zhang, Johnson, Patel, Paige, & Kubose, 2003) and risk (FDA, 2016).

7. STUDY III RESULTS

7.1 Participant Demographics

Six (n=6) pharmacists participated in interviews for Study III from October to December 2018 (Table 28). The recruitment goal of a minimum of 5 participants was reached, but the ideal goal of 10 participants was not achieved. Data collection was terminated when snowball and convenience sampling methods yielded no additional participants for three weeks. The mean interview time was 38 minutes (median 38.5 minutes) and was conducted over the phone while the participant shared their screen via video-conferencing technology. The typical participant was a female pharmacist working in an ambulatory care setting with about 4.5 years' work experience, and interacting with diabetes patients as part of their job every day.

Table 28. Study III Participant Demographics.

Category	Number of Participants
Gender	Male (N=1) Female (N=5)
Years in Role	Average: 4.5 years; Median: 2.5 years 0-5 years (N=4) 6-10 years (N=2)
Work Environment	Outpatient (N=5) <ul style="list-style-type: none"> • Ambulatory Care (N=4) • Primary Care (N=2) • Federally Qualified Health Clinic (N=1) • Endocrinology Clinic (N=1) Independent Community Pharmacy (N=1)
Frequency of Interaction with People with Diabetes	Every Day (N=5) Few Times a Week (N=1)
Additional Certifications Related to Diabetes Care	Total Having Additional Certifications (N=5/6) BCACP (N=3) CDE (N=2) APhA Diabetes Certificate (N=1)

Table 28 continued

Health IT Experience	Meters (N=5) CGM (N=4) Software (N=2) Insulin Pumps (N=2) None (N=1)
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Participants were contacted via snowball and convenience sampling methods in-person, via email, and via social media. Many participants responded to the call for participation but did not ultimately participate due to schedule demands, time commitment of study, or lack of payment for participants. Seven (N=7) participants completed the screener, but only six (N=6) completed the interview.

7.2 Diabetes Care Team Structure Confirmation

Participants were asked a series of background questions prior to providing feedback on the software prototypes. Participants were asked to briefly describe the areas of expertise or team member roles that would be present on a diabetes care team. All participants (N=6) indicated that a provider (MD, NP, or PA) and pharmacist exist on a diabetes care team. Nearly all participants (N=5) indicated that a dietitian would also be included on a diabetes care team, but two (N=2) participants qualified that the dietitian is as necessary if the pharmacist is also a CDE. Nurses (N=3) and medical assistants (N=1), and an as-needed endocrinologist (N=1) were also mentioned as members of the diabetes care team. These results confirm the findings from Study II regarding diabetes care team composition.

7.3 eVincio Prototype Development

Results from throughout Study II (Chapter 5) were used as foundational components of the eVincio mobile application and desktop software prototypes, which were created by the author using *Axure RP 8* ©(2018). eVincio aims to help support information coordination for diabetes care teams via a patient-facing mobile application and provider-facing desktop software. The overall purpose of the mobile application is to help patients track their healthcare interactions (e.g., appointments, visits, phone calls, etc.) and provide a centralized tool for healthcare

communication. The mobile application syncs with the desktop software to inform healthcare professionals about patients' overall care processes and activities. The purpose of the desktop software is to help HCPs with care coordination and reviewing patients care activity. The following sections review the key features developed in both the mobile application and desktop software that were assessed during the formative usability testing of Study III. Links to prototypes used throughout the study are included in **Appendix P**.

7.3.1 eVincio Mobile Application

The eVincio mobile application was developed out of an expressed need for having better patient information regarding their care within various healthcare systems that do not all communicate seamlessly with one another. In efforts to promote patient-centered care (Bates & Bitton, 2010), the mobile application aims to encourage patients to be engaged in their care activities with three main features: 1) tracking their HCP interactions/visits and making notes, 2) authorizing HCPs to talk to one another about their care, and 3) communicating with HCPs via a universal messaging system.

Upon opening the mobile applications, users first see a barcode for patients to be able to be scanned in for their healthcare appointments, or patients may manually enter the data if the healthcare organization does not have the desktop software available to scan them in. Below the barcode scanner, is a list of past and upcoming visits or appointments. The logging of patient appointments is designed to be a high-level tracking of the time of patient-provider interactions, provider contact information, and the reason for the interaction/appointment (**Figure 29**). The high-level tracking is not designed to be detailed or to be able to replace patient EHR records, but rather to serve as a brief note on why the patient saw that particular provider that day. Another goal for the mobile application is for patients to have a list of their appointments in one central place, and to authorize the healthcare professionals on that list to talk to one other as per HIPAA regulations. This feature was requested in Study II as a means to reduce the administrative work and workarounds to obtain patient data necessary to provide care. Patients may also message all healthcare professionals via one universal messaging portal through the application instead of using individual portals to talk to their providers.

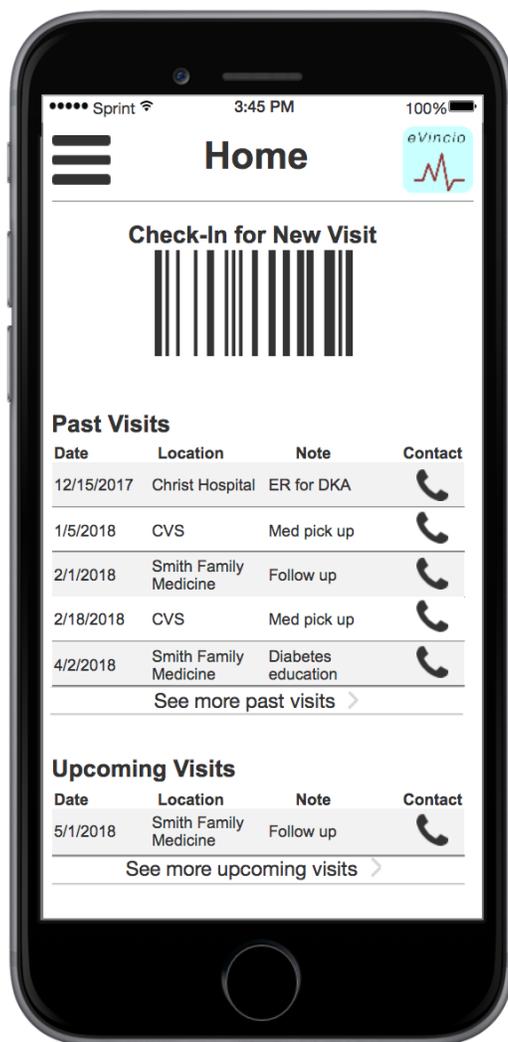


Figure 29. eVincio Mobile Application for Patients, home page.

7.3.2 eVincio Desktop Software

The eVincio desktop software is designed to synchronize with data added by patients via the mobile application. The purpose of the software is to provide HCPs with an overview of patient care activities and processes inside and outside of their healthcare system. The features in the provider-facing desktop software include the universal visit list, universal secure messaging system, care coordination tool, and alerts.

The universal visit list (**Figure 30**) and universal secure messaging features (**Figure 31**) are the provider-facing counterparts to the same features offered in the patient-facing mobile

application. These features were a result of requests from HCPs in Study II for desired features to help them better care for their patients.

	Date	Location	Provider	Note	Contact Info
Visit List	8/15/2017	Dr. Lacy Therapist	Dr. Sue Lacy (PhD)	Initial meeting	📞
Care Coordination	9/5/2017	CVS	Dr. Pete Lane (PharmD)	Med pick up	📞
Messages	9/10/2017	Dr. Lacy Therapist	Dr. Sue Lacy (PhD)	Follow up for depression	📞
Alerts	10/1/2017	CVS	Dr. Pete Lane (PharmD)	Med pick up	📞
	11/1/2017	Smith Family Medicine	Dr. Kate Smith (MD)	Annual Checkup	📞
	12/15/2017	Christ Hospital	Dr. Lisa Jones (MD)	ER for DKA	📞
	1/5/2018	CVS	Dr. Pete Lane (PharmD)	Med pick up	📞
	2/1/2018	Smith Family Medicine	Dr. Kate Smith (MD)	Follow up	📞
	2/18/2018	CVS	Dr. Pete Lane (PharmD)	Med pick up	📞
	4/2/2018	Smith Family Medicine	Dr. Kate Smith (MD)	Diabetes education	📞

Figure 30. eVincio Desktop Software, Universal Visit List, Prototype Version 1

It is intended for HCPs to use the software to scan patients quickly into their respective systems at the start of an interaction for the universal visit list (**Figure 30**). The barcode scan tracks the date, time, patient information, provider name, provider contact information and these data are all auto-populated. In some cases, the reason for the patient visit could be auto-populated as well (e.g., check box for medication refill at a community pharmacy, natural language processing from text data in an EHR, etc.). If a provider does not have the system installed, the patients may be able to manually input the data themselves via the mobile application.

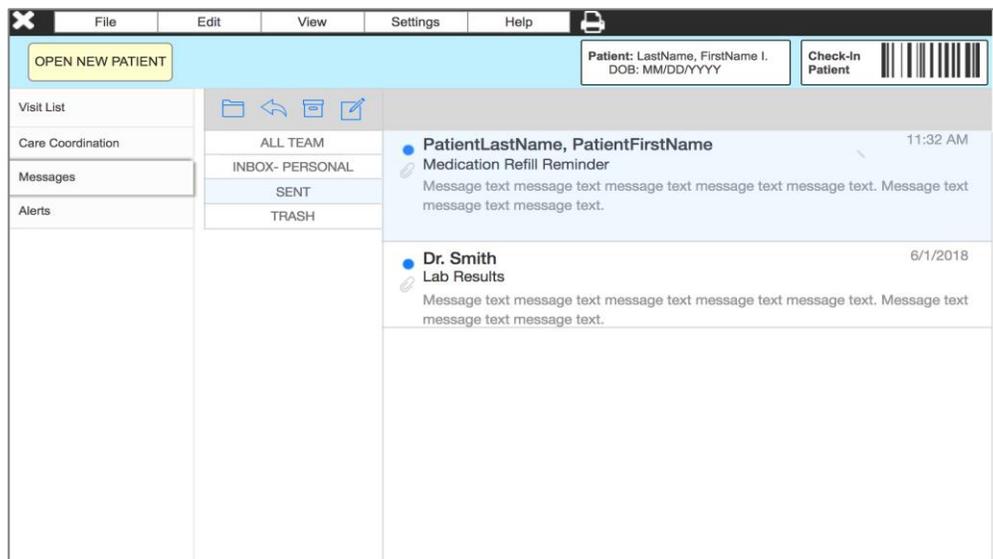


Figure 31. eVincio Desktop Software, Universal Secure Messaging, Prototype Version 1

The universal secure messaging system (**Figure 31**) is designed to mimic common secure messaging functions and recommendations from the literature (Jahn, Porter, et al., 2018). The key difference for this feature is that it aims to aggregate messages from multiple secure messaging platforms and sync based on a universal patient number. The goal of this feature is to have all patient-provider exchanges in one location, irrespective of healthcare system or electronic health record portal. Individual users will be able to see their private inbox as well as a team inbox for an individual patient.

The care coordination feature (**Figures 32-33**) in the provider-facing desktop software is the most novel aspect of both of the eVincio prototypes. This feature is a modified version of the visualizations presented as part of the DRIFT analytical framework (introduced in section 5.2.6.2.3). The care coordination feature was developed from the team task analysis from Study II, which included mapping of frequencies of interactions, tasks, and roles based on time and location. These areas were selected for developing the care coordination feature because granularity, temporal data, and sociotechnical factors were deemed critical aspects for chronic care systems engineering tools for improving patient care (Michelle A. Chui et al., 2017; Furniss et al., 2015; Heiden, 2018; Holden et al., 2013; Jahn & Caldwell, 2017; Karsh, 2004).



Figure 32. eVincio Desktop Software, Care Coordination Over Time, Prototype Version 1

The care coordination feature displays the overall plot of patient care over time by care location (**Figure 32**), as well as plots based upon the areas of expertise (**Figure 33**). Users can also drill down by location to view the areas of expertise and type of care provided.

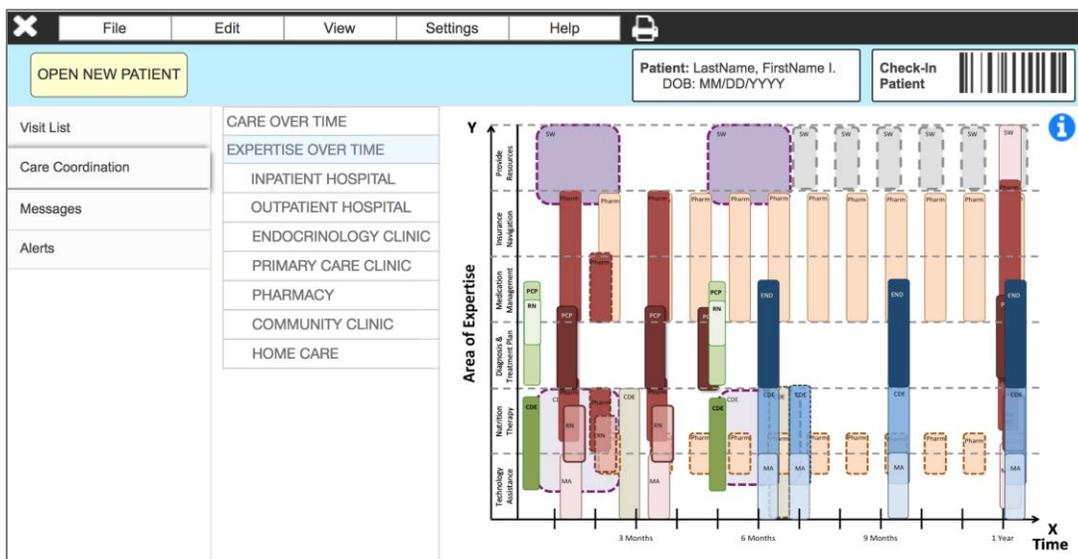


Figure 33. eVincio Desktop Software, Care Coordination by Area of Expertise, Prototype Version 1

The alerts feature (**Figure 34**) is not fully defined in the software prototype, as it depends on the evidence-based trends that are recommended for the setting and/or users' needs. It is anticipated

that alerts could gain insight on common trends or when there are gaps in care coordination. For example, if a patient has a history of having diabetic ketoacidosis after an extended amount of time away from a primary care doctor or endocrinologist, the system could alert a member of the care team could check in with the patient and see how their blood glucose levels are tracking.

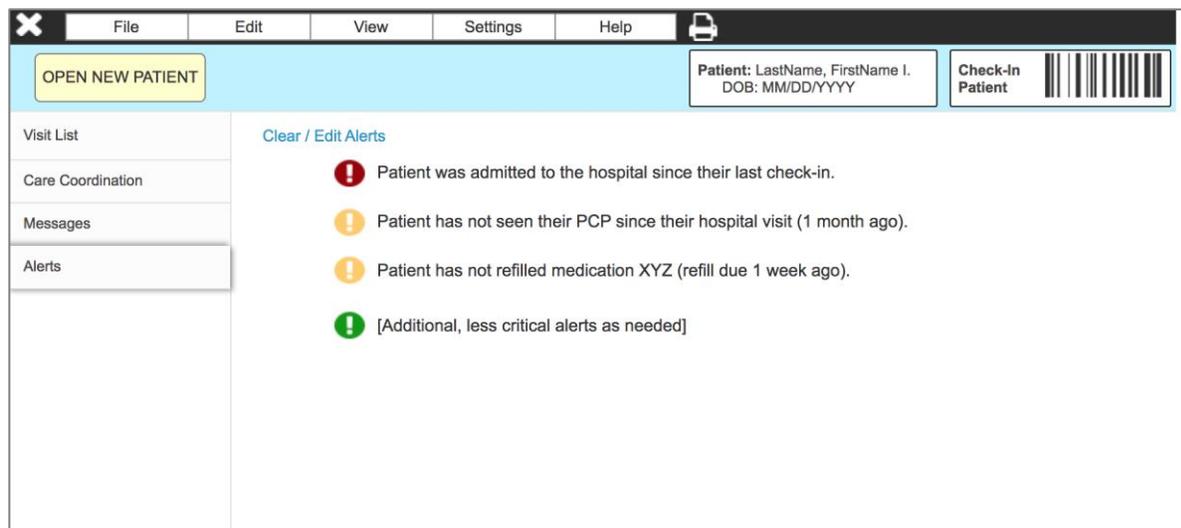


Figure 34. eVincio Desktop Software, Alerts feature, Prototype Version 1

The subsequent sections review the Study III findings of a formative usability study of both the patient-facing mobile application and provider-facing software, which includes participants' reviews of key features, observed usability benefits and barriers, and Likert scale ratings for perceived likelihood of adoption.

7.4 Pilot Testing & Prototype Adjustments

There were two (n=2) pharmacists who participated in pilot testing the moderator guide and prototypes. The participants participated prior to IRB approval to help provide feedback on the structure, flow, wording, and timing of the interview. A few usability suggestions were also suggested during testing. These changes included the following recommendations:

- Enlarge the graphics on the interface to fill more of the visual space
- Synchronize the events on the mobile application with the events in the desktop prototype
- Care coordination feature (**Figure 35**)
 - Adjust the graphs to better be able to pinpoint the dates / times for events

- Include a legend
- Change x-axis to be specific dates in time instead of “3 months”, “6 months”, etc.
- Change “visits over time” label to “care over time” to represent care that is not always a visit (i.e., over the phone)
- Change “expertise over time” label to “type of care provided” to better mesh with typical HCP jargon

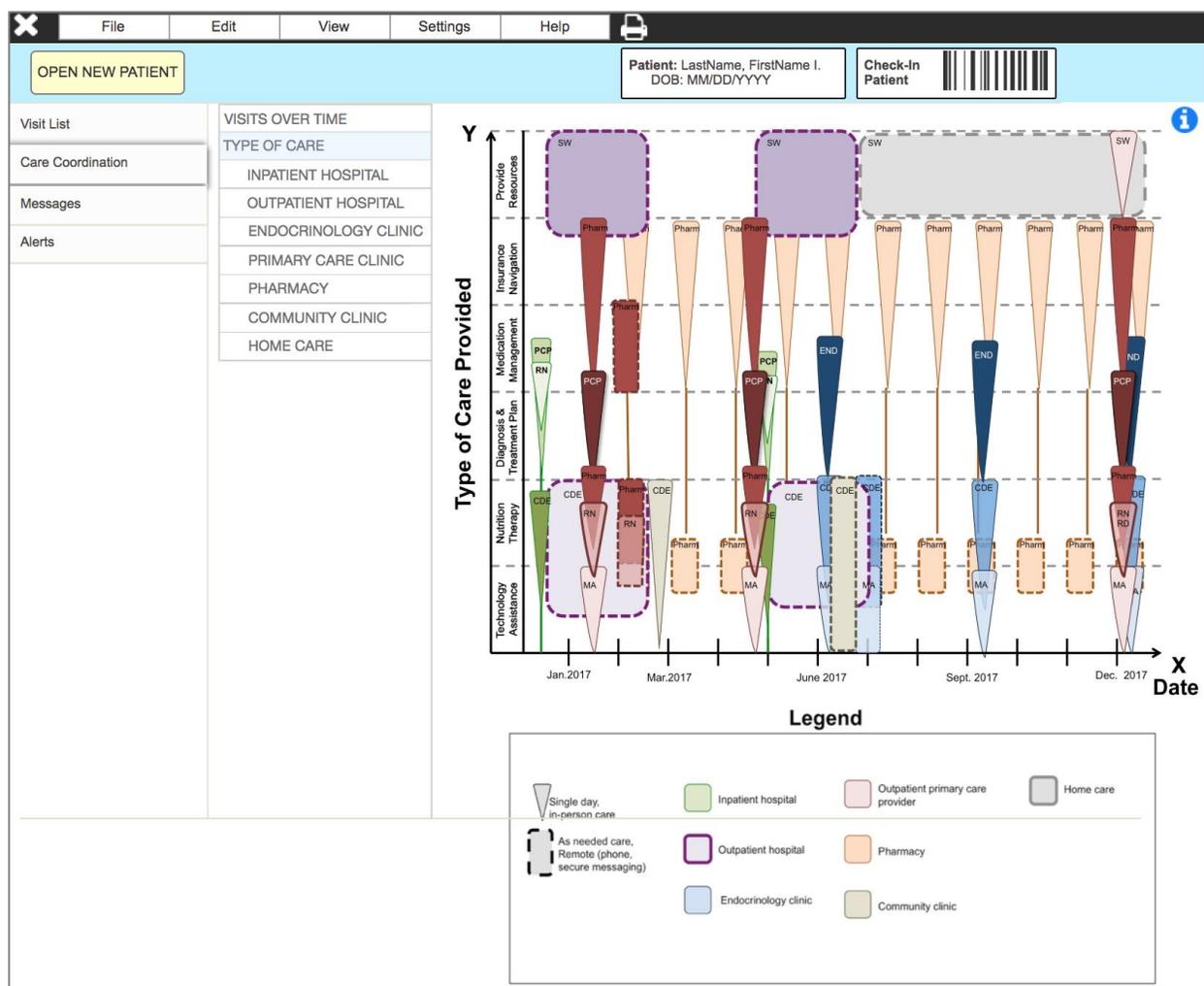


Figure 35. eVincio Desktop Software, care coordination tool, Prototype Version 2

These changes were all incorporated into version 2 of the mobile application and software prototypes, which were tested with participants 1-4. A few additional changes were made in version 3 (tested with participants 5-6), which are highlighted in section 7.5.5 below.

7.5 Formative Usability Testing Results

During the formative usability testing of the eVincio mobile application and software prototypes, several features were assessed: the universal patient visit list, universal messaging system, HIPAA authorization (mobile only), care coordination tool (software only), and alerts (software only). Participants shared their opinions on benefits and barriers to each feature, as well as the overall purpose of each prototype and a Likert scale rating on perceived likelihood of adoption.

7.5.1 Overall Perception of Prototypes

Participants were asked to think-aloud during an initial exploration for both the mobile application and desktop software prototypes. No instructions or clues were given during the exploration phases beyond the moderator identifying if the prototype was patient-facing or provider-facing. After the participants finished reviewing the prototypes, they were asked to explain their interpretation of the prototypes' purposes. For the mobile application, participants described its purpose as an application for patients to track their visits (N=5) and communicate with their providers (N=3) all in one location (N=4). One participant described it as a "*transitions of care*" application that could be helpful for taking notes on where they've been.

For the software prototype, only 5 of the 6 participants shared their perspective on the purpose of the prototype. Participants described the software as a tool to help coordinate care outside of their organization with other members of the patient's care team (N=5). Two participants (N=2) mentioned being able to communicate with other providers and patients, while another said the software seems designed to help ensure that providers are giving "*comprehensive and compliant care*" or "*are we doing the right job?*" Participants may have been primed on the purpose of the software due to their initial interactions with the mobile application.

7.5.2 Universal Patient Visit List

Participants were asked, "*What are the benefits and barriers of a universal patient visit list?*" (RQ 2.2) for the patient visit list feature presented in both the mobile application and desktop software. The results were organized by general feedback and feedback specific to the mobile application and desktop software in **Table 29** below. The most frequently cited benefit was the ability for both patients and providers to keep track of patient activity across care systems (N=5).

Barriers mentioned include concerns about compatibility with other healthcare systems (N=3), lack of patient adoption (N=3), and a lack of details in the notes section of the provider desktop software (N=4).

Table 29. Benefits and Barriers of Universal Patient Visit List Feature.

	Benefits	Barriers
General	<ul style="list-style-type: none"> • Keep track of all visits across care systems (N=5) <ul style="list-style-type: none"> ○ Upcoming visits (N=2) ○ Provider names (N=2) • Easy to use (N=3) • Helps with transitions of care (N=2) 	<ul style="list-style-type: none"> • Compatibility with all healthcare systems (N=3) • Accuracy of list information (N=3) <ul style="list-style-type: none"> ○ Notes (N=2) ○ Names of providers (N=1) ○ Contact information (N=1)
Mobile Application	<ul style="list-style-type: none"> • Potential to speed up check in process (N=1) • Most patients have smart phones already (N=1) 	<ul style="list-style-type: none"> • Many older patients do not have smart phones and/or willingness to adopt mobile apps (N=3) • Manual check-in issues (N=2) <ul style="list-style-type: none"> ○ Issues with data validation (N=2) ○ Time consuming (N=1) • Need differentiation between patient notes and provider notes (N=1) • Phone number and title are not very informative (N=1) • Patient incentives for tracking are not as obvious (N=1)
Desktop Software	<ul style="list-style-type: none"> • Can obtaining patient records in a central location (N=1) • Information regarding patient compliance with keeping appointments and filling medications (N=1) • Safety check for ensuring correct patient (N=1) 	<ul style="list-style-type: none"> • Notes section do not have enough details (N=4) • Additional steps for staff during check-in would be cumbersome and difficult (N=2) • Would like vaccination records and labs (N=2)

A few participants (N=2) also mentioned concerns with validating data between the manual entry in the mobile application and the desktop software. For example, one participant mentioned the following scenario:

“On manual check in, if the patient doesn’t put them in the same way that [the application] would auto-populate during check-in, then the patient wouldn’t have the ability to correlate this visit with other visits at that same place. For example, here on the past visit on December 11, 2016 it said, ‘Christ Outpatient hospital’. Let’s say they go back to Christ Outpatient Hospital for another visit on sometime after that December visit, then for whatever reason this bar code is not scanned and they have to do this manual check-in option. Under location, they might just write ‘hospital’.”

Another participant mentioned data validation issues related to the phone number and provider name. For example, a patient could primarily interact with a nurse practitioner or a resident, but the main contact could be the attending physician or main provider associated with the visit. The contact information could result in a discrepancy and distrust in the accuracy of the system from the patient perspective.

7.5.3 Universal Messaging Portal

Similar to the universal visit list, the universal messaging portal feature is available in both the mobile application and desktop software. Participants were asked to share their views on the benefits and barriers of this feature (RQ 2.3) (**Table 30**).

Table 30. Benefits and Barriers of Universal Messaging Portal.

	Benefits	Barriers
General	<ul style="list-style-type: none"> • One central messaging location for people in different healthcare systems (N=4) • Messaging can be easier than calling providers; could reduce phone calls (N=2) • Visually pleasing (N=1) 	<ul style="list-style-type: none"> • Some healthcare systems may not have a messaging system (N=3) • Cannot easily track phone communication or messages over the phone (N=1)
Mobile Application	<ul style="list-style-type: none"> • Easier for patients to contact providers (N=3) • Nice for patients to have messaging available in an app form (N=1) • Can reduce the number of communication methods that patients need to access (N=1) 	<ul style="list-style-type: none"> • Not all patients are technologically savvy or willing to use mobile applications (N=3) • Some patients may overuse the communication features (N=1)

Table 30 continued

Desktop Software	<ul style="list-style-type: none"> • Providers can see who patients are talking to and compliance information (N=3) • Nice to have both personal inbox and team (N=1) 	<ul style="list-style-type: none"> • If a provider is outside of the system, they most likely are going to call them anyway instead of message them (N=1)
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Potential benefits for the universal messaging portal include: a central messaging location for people in different healthcare systems (N=4); ease of use for patients to contact providers (N=3) and the ability to decrease phone calls (N=2); and the ability for providers to see other communication patients have with providers to keep up to date on their care (N=3). Some of the key barriers to implementing this feature are integration issues with other systems (N=3) and patients not being technologically literate and/or engaged in using the technology (N=3).

7.5.4 HIPAA Authorization

The HIPAA authorization feature exists solely in the mobile application and was incorporated due to Study II requests for an easier way to access patient information to provide better care. The goal of this feature is to allow patients to authorize the healthcare providers on their visit list to talk with one another and reduce the volume of paperwork required for HIPAA requirements. This feature is in a very formative state; further legal research is needed to assess the specific language and functionality requirements, however, participants still provided their initial insights on the concept of a feature of this type (**Table 31**).

Table 31. Benefits and Barriers of HIPAA Authorization within Mobile Application.

Benefits	Barriers
<ul style="list-style-type: none"> • Easy to use (N=2) • Could be used to help with caregivers getting access to patient records (N=1) • Help encourage continuity of care (N=1) • Can reduce need to have to send requests for information (ROIs) (N=1) • Make patients feel more in control of their care (N=1) 	<ul style="list-style-type: none"> • The feature does not facilitate the actual communication of patient information (N=4) • Patients may not understand the necessity of the feature or language used (N=4) • Providers would need to somehow be alerted of a patient authorizing them (N=1) • Some providers may not accept this form of HIPAA authorization (N=1) • Not necessary for people in same system (N=1)

Participants were not as optimistic about the potential benefits of this feature. A few participants mentioned that it seemed easy to use (N=2) since the feature existed of a simple toggle switch for authorization. Another participant (N=1) mentioned that it could be useful for authorizing family members and/or care providers as well. Nearly all (N=4) participants mentioned that the feature does not actually support the transmission of patient information so it is not actual very useful. One participant said, *“Unfortunately this doesn't help facilitate that communication which is where the difficulty tends to be and actually sharing records from one place to the next. But at least the authorization to share is easier.”* Several participants (N=4) also echoed concerns about patients understanding the feature and the language related to HIPAA.

Two (N=2) participants were from the same Midwestern state and mentioned that they had access to a state-wide health information exchange system that can help with these issues. One participant said that they had a link through their EHR that connected to the information exchange system, and they could proceed to look up records for their patients. There are issues with the data from an EHR “crosswalk” in that not all healthcare systems submit their information nor do they all use the same formats.

7.5.5 Care Coordination Feature

RQ 2.4 aims to address the benefits and barriers of the proposed DRIFT analytical framework for HCPs providing diabetes care. The DRIFT analytical framework was incorporated into the eVincio provider-facing desktop software in a series of information visualizations named, “Care Coordination”. A few simple changes were made between the pilot testing (version 1) and the first version iteratively tested in Study III (version 2, see **Figure 35** and section 7.4 above). The benefits and barriers noted by participants 1-4 for prototype version 2 are noted in **Table 32** below.

Table 32. Benefits and Barriers of Care Coordination Feature, Prototype Version 2

	Benefits	Barriers
Prototype Version 2 (N=4 participants)	<ul style="list-style-type: none"> • Visualization of Care (N=4) <ul style="list-style-type: none"> ○ Gaps in care (N=4) ○ Outside care (N=2) ○ Frequency of care (N=2) ○ Utilization of roles and organizations (N=2) ○ Shows trends (N=2) ○ Shows type of care provided (N=1) • Useful feature for people interested in quality, compliance, and care transitions (N=2) • Can use tool to determine appropriate interventions or follow-ups (N=1) 	<ul style="list-style-type: none"> • Physicians will not use this feature (N=4) • Information presented is already available in list form in EHR, especially in closed looped systems (N=3) • Visualization Usability Issues (N=3) <ul style="list-style-type: none"> ○ Unsure how to interpret graph (N=3) ○ ‘Type of care provided’ graph is very visually overwhelming (N=3) ○ Triangles are confusing (N=2) ○ Difficult to discern phone versus in-person care (N=2) ○ Type of care provided labels are not intuitive (N=1) • Needs to be integrated with EHR to be useful (N=2) • Do not have a reason to look back up to a year in a patient’s history (N=1) • Concern about how this data is populated and extra tasks required of providers (N=1)

Participants mentioned that the care coordination feature was helpful for visualizing gaps in care (N=4), as well as showing activity outside of the care system (N=2) and frequency of care (N=2). One participant mentioned that the feature could perhaps be used to show the utilization of specific roles or levels of care to help demonstrate the usefulness of these HCPs to the diabetes care system, especially for roles that do not get reimbursed from insurance companies as often for their services provided. There were several barriers listed by participants: participants were most concerned that PCPs would not use the tool (N=4) and that the majority of the

information shared already existed in their nearly closed healthcare systems (N=3) in the EHR notes section of patient records.

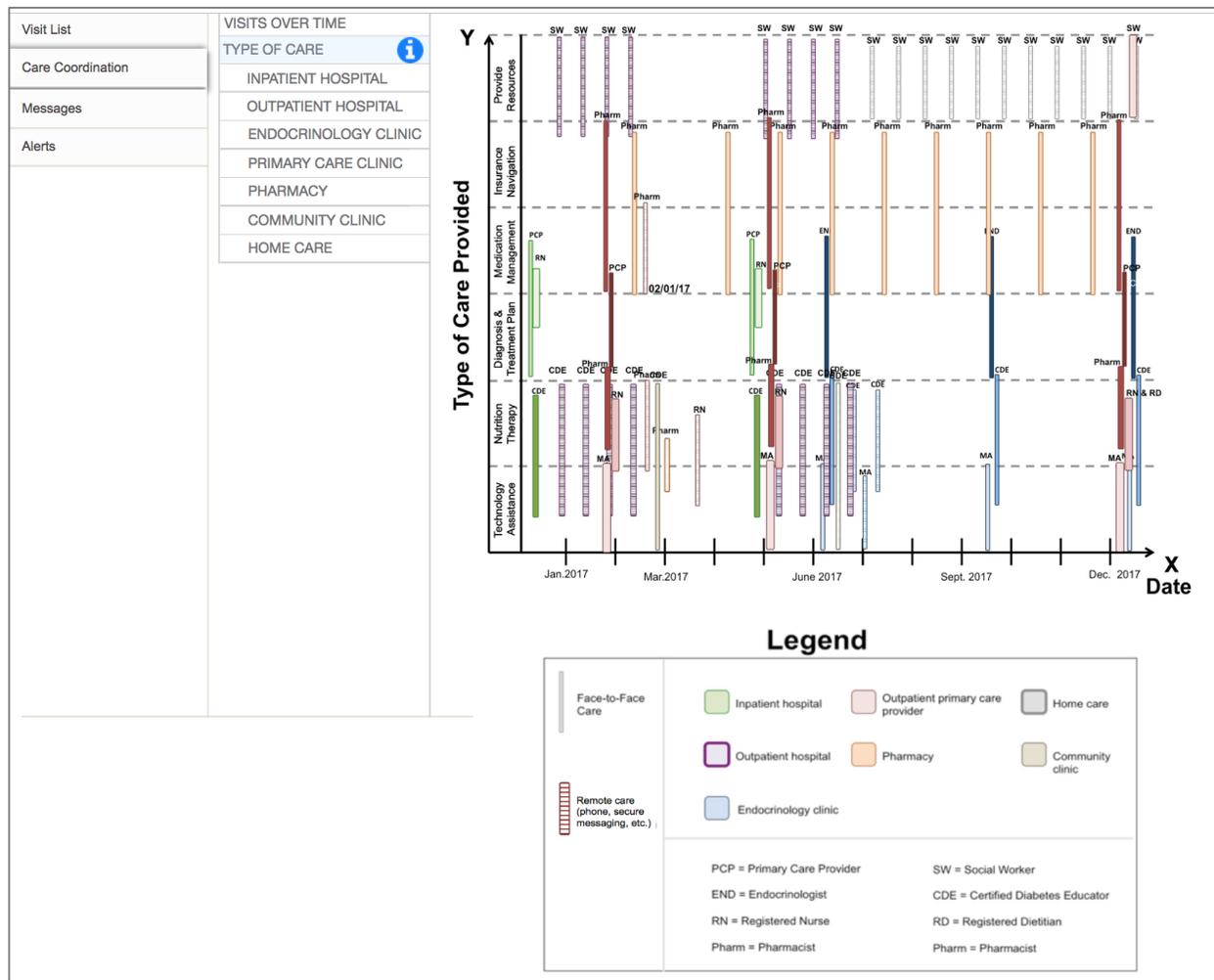


Figure 36. eVincio Care Coordination Feature, Type of Care Provided, Prototype Version 3

There were also several issues with the usability of the care coordination tool mentioned by several participants (N=3) that were addressed in a third version of the prototype. No other changes were made to version 3 prototype beyond the following changes to the care coordination feature. Participants incorrectly interpreted triangles on the Type of Care page as more care provided in the wider width part of the triangles and less of the care provided in the narrower part of the triangle. These were shifted to be skinny rectangles in prototype version 3 (**Figure 36**). The Type of Care page was often cited as “visually overwhelming”. The changes to the size

and shape of the markers to depict patient interactions were also incorporated to help reduce the overall visual impact.

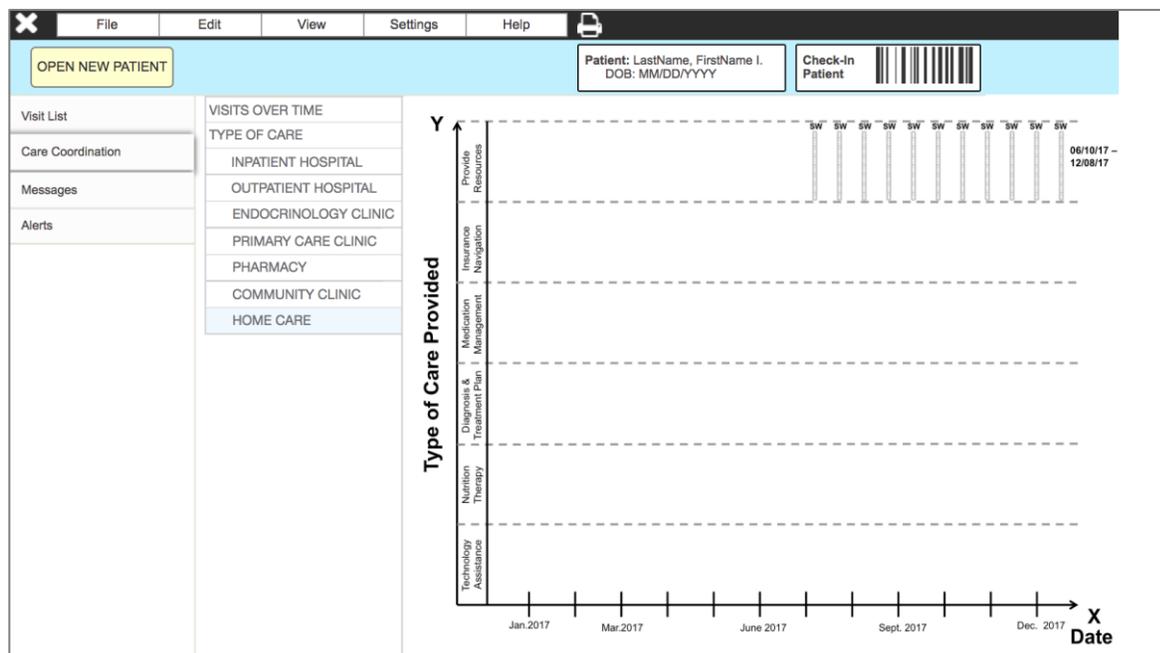


Figure 37. eVincio Care Coordination, Changes for On-going Care, Prototype Version 3

Dashed boxes with as needed care were interpreted incorrectly as patients receiving on-going in-person care during the entire time frame colored in. These were transformed to a bunch of tiny rectangular boxes to show each individual care interaction. The dashed lines indicate that the care was over-the-phone instead of in-person (**Figure 37**).

The labels for the types of care providers (SW, RD, etc.) were included in the legend to help clarify their meaning to users who were not sure what they represented (**Figure 38**). The information / help button (a blue “i” icon) was shifted to the care coordination sub menu tab to help encourage confused users to seek help (**Figure 39**).

Legend



Figure 38. eVincio Care Coordination Feature, Legend Changes, Prototype Version 3

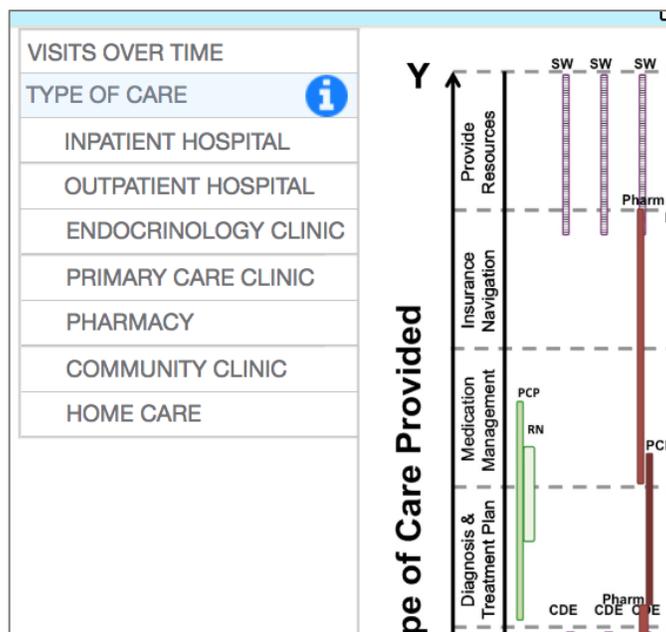


Figure 39. eVincio Care Coordination Feature, information help tool change in location, Prototype Version 3

Table 33 highlights the benefits and barriers mentioned by two participants during their review of the care coordination feature of prototype version 3.

Table 33. Benefits and Barriers of Care Coordination Feature, Prototype Version 3

	Benefits	Barriers
Prototype Version 3 (N=2 participants)	<ul style="list-style-type: none"> • Visualization of Care (N=2) <ul style="list-style-type: none"> ○ Type of care provided (N=2) ○ Frequency of care (N=2) ○ Gaps in care (N=2) ○ Non face-to-face time (N=1) • Visually pleasing (N=2) • Legend is helpful (N=2) • Helpful tool for people involved in quality (N=1) 	<ul style="list-style-type: none"> • PCPs may not have time for using this feature (N=2)

Benefits of the care coordination feature (version 3) included helping HCPs visualize patient care (N=2), and it was noted as having a helpful legend (N=2) and being visually pleasing (N=2), which were improvements from the previous prototype version. Participants still mentioned that PCPs may not have enough time to fully use the care coordination feature (N=2). One participant (N=1) mentioned that it might be a helpful tool for people, such as pharmacists, who have an aspect of quality involved in their job tasks. This participant said, *“It gives us more worth within the company to look more at quality measures since we're an FQHC and there's quality tied to the federal funding. So I can see someone looking at quality overall when they use this [feature].”*

7.5.6 Alerts Feature

The alerts feature in the eVincio desktop software prototype aims to use algorithms from patient data to alert users to useful information about their patients with diabetes. These alerts are not fully formulated; therefore participants were probed about the data requirements necessary for monitoring people with diabetes (RQ 2.1). The benefits and barriers of the alerts feature, as well as data requirements for diabetes care, are outlined in **Table 34** below.

Table 34. Benefits and Barriers of Alerts Feature.

Benefits	Barriers
<ul style="list-style-type: none"> • Alerts can help people who assess quality measures (e.g., population health coordinator, MA, pharmacist) (N=5) • General snapshot of patient state (N=4) <hr/> <ul style="list-style-type: none"> • Data requirements for monitoring diabetes patients (included in prototype) <ul style="list-style-type: none"> ○ Refill compliance (N=4) ○ Patient admittance notifications (N=3) ○ Stop light model for quickly and easily interpreting severity of alert (N=2) ○ Ability to modify alerts based on population and role (N=1) 	<ul style="list-style-type: none"> • PCPs not pay attention to alerts (N=4) • Lack of integration with EHR (N=4) • Concerns about alert fatigue (N=3) • Concerns about false alarms (e.g., fill prescription outside of system) (N=1) • Data requirements for monitoring diabetes patients (NOT currently included in prototype) <ul style="list-style-type: none"> ○ Details on medication information (N=4) ○ Lab results data (N=3) ○ A1c and blood glucose data (N=2) ○ Patient compliance with appointments (N=1) ○ Missed appointment alerts (N=1) ○ Patient reported symptoms list (N=1)

Participants mentioned that the alerts feature is beneficial in that it can help HCPs with quality-oriented roles (N=5) and provide a general snapshot of patient care with the levels of alerts (N=4). The alerts feature also has several features that are requested for monitoring diabetes patients from a pharmacist role, such as refill compliance alerts (N=4) and patient admittance alerts (N=3). Participants requested that the alerts feature and system as a whole include more details on medication information (N=4), lab results data (N=3), and diabetes specific data (e.g., A1c and blood glucose values) (N=2). Some barriers to the alerts feature were mentioned in other areas of the software prototype as well: concerns about PCPs not using the alerts feature (N=4), lack of integration with EHRs (N=4), and concerns about alert fatigue (N=3). One participant said, *“Unless it's integrated now within our current EMR, I'm not sure of the utility of it, because especially with how busy we are, it's unlikely that we would log into a separate system just to see this.”*

7.5.7 Participant Ratings

Participants were asked to rate the mobile application on a Likert scale of 1 to 5, where 1 is the likelihood that patients would not use the application at all, and 5 is where they think their

patients would use the application fully as intended. The median and average rating were both 2 (patients would be unlikely to use the application). Some participants did divide their patient populations into different categories and give different ratings and justifications. Five (N=5) participants said they had a patient population that was typically older, less engaged with technology, and a lower socioeconomic status and all of these factors contributed to their lower perception of potential adoption. Two of the five participants mentioned also working at a different location with different patient demographics that were younger and more engaged in their care, and they gave those patients an average rating of 4 for their likelihood of adoption.

Participants were asked to rate their likelihood of adopting the software and using it as intended on a scale of 1 to 5, where 1 is not at all and 5 is using it fully as intended. Participants gave a range from 1 to 5 (median 3.8, average 3.1), with a variety of justifications. Some participants only rated the software higher (>4) if it would be fully integrated with their EHR systems and cost was not an issue. The lower ratings (N=3, <3) were because the participants felt that the software did not provide added benefit beyond their EHR and it was not integrated with their system. Participants were asked the same question except for their perception of likelihood of other members of the diabetes care team adopting the software. Participants rated others from 0 to 5 depending on role and if the system is integrated with the EHRs (median=2, average=3.1). Two participants (N=2) rated doctors as an average of 1.5 to adopt the software, while people with a quality-focused role were rated as a 3.5. Three participants (N=3) rated the system without EHR integration as an average and median rating of 1; with EHR integration the likelihood other providers would adopt it rose to a median rating of 4.5 (mean 4).

7.6 Opportunities for Future Prototypes

For the eVincio system to better support pharmacists with diabetes care processes, there are several outstanding issues to address for improvements to the prototypes (**Table 35**). The categories of issues can be summarized as simple interface adjustments, health IT integration, alerts, data validation, and labeling.

Table 35. Outstanding Issues to Address for Future Prototypes

Category	Issue
Simple interface adjustments	<ul style="list-style-type: none"> • The mobile application should have a bigger area for patients to be able to take notes and enter information about their visits • The visit lists should have an easier way to differentiate the different types of visits (phone, in-person) beyond text-input
Health IT integration	<ul style="list-style-type: none"> • The software should be integrated with the EHR to have more information regarding notes, lab and vaccination records, medication information, blood glucose levels, vital signs, etc. for providers to access when they see across different healthcare systems • The software should be integrated with the EHR to reduce duplicitous efforts by the check-in staff • The software should be integrated with the EHR to reduce the number of places users have to look during patient appointments • Multiple EHR systems will need to be evaluated extensively for compatibility and integration for both the mobile application and software systems
Alerts	<ul style="list-style-type: none"> • Alerts in the system should be evidence-based and reviewed with FDA compliance documentation for medical devices • Less critical alerts for quality control algorithms (e.g., patient compliance with appointments) need to be determined with future research. • The HIPAA authorization feature needs to consider how to incorporate providers so that they are notified when a patient authorizes them in the mobile application.
Data Validation	<ul style="list-style-type: none"> • Need to determine the optimal way to enter the data into the system to reduce burden on users and data entry processes. Claims data, check boxes from visit, and natural-language processing of notes data are all options to consider from participants. • Need to determine data validation methods to reduce duplicitous information from manual and automated data entry sources. • Need to determine data cleaning methods for errors made by patients when inputting data manually
Labeling	<ul style="list-style-type: none"> • The labeling on the type of care for care coordination should be reviewed further to determine that the categories are evidence-based and match with the natural language and phrasing of the diabetes care team. • Diagnosis and treatment plans happen at every visit based on the HCPs role, therefore the PCP should not have sole responsibility for this task on the type of care graph for the care coordination feature.

7.7 Methodology Deviations & Unexpected Events

Participants spent between 26 and 52 minutes on participating in Study III (median 38.5 minutes), and the study was advertised as taking 30-45 minutes to complete. Therefore, the

majority of the questions were focused on completing the assessments with the two prototypes and participants were not probed as deeply with other secondary questions in the moderator guide (**Appendix M**) to save time.

7.8 Summary of Key Findings from Study III

Study III aimed to answer the following research questions:

Research Question 2 (RQ2): How can health information technology better support pharmacist information coordination for diabetes care?

- **RQ2.1.** What are the data requirements for pharmacists monitoring people with diabetes?
- **RQ2.2** What are the benefits and barriers of a universal patient visit list feature?
- **RQ2.3** What are the benefits and barriers of a universal messaging portal?
- **RQ2.4** What are the benefits and barriers of the proposed DRIFT analytical framework (i.e., care coordination feature) for HCPs providing diabetes care?

To answer research question 2, a patient-facing mobile application prototype and provider-facing desktop software prototype were developed by the author from empirical findings from Study II. These prototypes were named *eVincio*, originating from the Latin verb root “*vincio*” which means, “*to link, bind, or encircle*”. Three different iterations were created for Study III. The first version was used in pilot testing with two pharmacists; the second version was used for participants 1-4, and the third version was used for participants 5-6. The changes in each version were focused on the care coordination feature. The typical participant was a female pharmacist working in an ambulatory care setting with about 4.5 years work experience, and interacting with diabetes patients as part of their job every day. Participants confirmed the Study II results with the diabetes care team structure consisting of PCPs and/or endocrinologists, pharmacists, nurses, and dietitians, where pharmacists and dietitians often have diabetes-related certifications.

Participants correctly inferred the purpose of both prototypes, suggesting that the overall intuitiveness and ease of use was acceptable for the *eVincio* system. To answer research sub-questions RQ2.1-2.4, participants listed the following key benefits from the new health IT system: easy to use, helpful for transitions of care, can help coordinate across healthcare systems,

help shift away from phone calls and more towards technology, universal/central location for tracking patient care activities. Areas for the eVincio system to improve include: ensuring compatibility with outside healthcare systems and across EHRs; validating data entry to ensure data can be appropriately tracked and correlated over time; include mechanisms to facilitate the sharing of HIPAA information across systems; manage alert fatigue in the design of alerts; and review labeling to match provider care areas and language used. Other non-technology barriers include some patients not being as engaged or interested in adopting technology, and some PCPs not having time or interest in adopting a new health IT system. Many participants did recommend the future of the provider-facing eVincio system to be used predominantly by HCPs and administration with an interest in quality related measurements (e.g., care manager, population health coordinators, pharmacists, medical assistants).

Participants did not rate the system very highly based on their concerns of a lack of integration into existing EHR systems; a few participants mentioned that if it was fully integrated into their system they would use the features, particularly the care coordination features, which were new and an added benefit to their existing tools.

8. DISCUSSION

The following chapter reviews the results from studies I-III and discusses the findings in relation to similar studies, with identification of novel contributions and generalizations for future work. A discussion of the theoretical contributions within the intersection of human factors, systems engineering, and chronic care research is also discussed and directions for future work are proposed. The chapter concludes with a review of limitations and assumptions made throughout this dissertation work.

8.1 Study I Discussion

8.1.1 Study I: Key Findings

Study I aimed to address the sub-research question (RQ 1.1), “*What are the specific roles on a diabetes care team?*” To answer these research questions, snowball and convenience sampling methods were used to disseminate an electronic questionnaire that asked healthcare professionals to list the members they considered core members of a diabetes care team. The results were analyzed using social network analysis methods.

The in-strength summations and percentage measurements indicated that the primary care provider, nurse, dietitian, pharmacist, social worker, and endocrinologist roles were considered core members of the diabetes care team. Several participants indicated that a nurse, dietitian, or pharmacist could fill the certified diabetes educator (CDE) role, but participants were not able to select multiple roles to define their roles (e.g., nurse and CDE). Therefore, the diabetes care team did not include the CDE role, but it is recommended that as many members of the team receive CDE certification as possible.

8.1.2 Study I: Review of Related Work & Contributions

Diabetes care teams are comprised of healthcare professionals with differing certifications, approaches, and areas of expertise to patient care activities (Manser, 2009), thus necessitating the identification of key team members, structure, and processes involved (Garrett & Caldwell, 2009; Wagner, 2000). This research confirms findings from related work that nurses, primary

care providers, and endocrinologists are core members of diabetes care teams (Clement et al., 2013; Peimani et al., 2010; Rodgers et al., 2014; Willens et al., 2011).

Study I expands the definition of core diabetes care teams to include social workers and dietitians, suggesting that healthcare professionals recognize the importance of preventive, proactive, and holistic care provided by these roles. For example, social workers examine macroergonomic factors, such as a patient's support network, insurance, education, or transportation, that could influence a patient's ability to access care. Dietitians also provide preventative services by helping patients learn how to monitor their activity levels and nutritional intake so that they can manage their blood glucose levels over time. The inclusion of social workers and dietitians also may be indicative of an overarching shift in chronic care, with the patient at the center of their care and healthcare and community organizations providing people and resources to help facilitate preventative, proactive, patient-centered care (Clement, Harvey, Rabi, Roscoe, & Sherifali, 2013).

Typically, endocrinologists are used as key stakeholders for diabetes related health IT studies for determining product requirements. Therefore, it was anticipated that the endocrinologist would be a role with higher rankings compared to the other members of the diabetes care team, but this role was not mentioned by more than half of the study participants. This suggests that the endocrinologist may not be the most critical member of the team and diabetes health IT companies should consider expanding their user testing and key stakeholders to include other members of the diabetes care team.

The total degree measurement for Study I social network analysis found that the pharmacist role had the highest number of connections and the third highest in-degree measurement. Although this finding could be biased due to the skewed large sample of pharmacist participants, it could also suggest that the pharmacist role has the potential to ask as a "hub" of care coordination activity. The percentage of people listing a pharmacist as a key member of the diabetes care team also dropped significantly (from 59%, n=34, to 43%, n=18) when removing self-citations, suggesting that other healthcare professionals may not recognize the added value or scope of abilities of pharmacists to contribute to diabetes care teams.

Pharmacist roles are changing as a response to increasing numbers of people with diabetes, as well as collaborative practice agreements, shifts in reimbursement, and educational opportunities for advanced certifications (Dietz, 2016; Fazel et al., 2017). Healthcare professionals outside of pharmacy may not be as aware of these changes to the classical pharmacy role, thus neglecting to recognize the ability of pharmacists to contribute to diabetes care teams in such an expanded capacity. The systemic changes to the pharmacy profession have the potential to have positive impacts on both pharmacist-patient interactions and pharmacist-provider interactions. For example, studies show that patients may meet with their pharmacist up to seven times more often than with their primary care provider due to geographical and temporal constraints that favor the patient-pharmacist interactions (Shane-McWhorter et al., 2009). During these interactions, pharmacists may discuss a patient's medication and disease state, and could interact with other members of the care team to update on changes to the patient's care and disease management plan, especially in collaborative practice agreement situations. The Study I findings provide preliminary evidence towards a pharmacist-centric model (as opposed to a PCP-central model) for diabetes care coordination processes.

From a methodology perspective, this work also expands the application of social network analysis tools to the diabetes care team. No other studies have utilized these methods for identification of team members for a diabetes care team.

8.1.3 Study I: Limitations & Assumptions

At the start of the study, it was assumed that the core members of the diabetes care team would represent about 4 or 5 areas of expertise. This was based on existing literature on team member roles in diabetes care teams (Rodgers et al., 2014). Therefore, the questionnaire asked participants to list "at least 5" core members of diabetes care teams.

A key limitation of this study was that participants were not from the same institution, and diabetes care teams can vary significantly depending on the setting. In addition, participants could not select multiple roles for their demographic self-identification (e.g., nurse and CDE). The questionnaire free text response also contributed to unanticipated ambiguity, where participants listed "MD" and did not specify as primary care provider or specialist (e.g.,

endocrinologist) roles. Future work will need to better capture differences in workplace environments and clarification of participant roles and responses.

8.1.4 Study I: Future Work

This research provided a starting point for answering the overarching RQ1 by first defining the key members of diabetes care teams. Additional work aims to identify how the diabetes care team composition may differ based on clinical setting and patient population demographics.

8.2 Study II Discussion

8.2.1 Study II: Key Findings

Study II aimed to answer the overarching research question RQ 1, “*What opportunities exist for spatially and temporally distributed pharmacists to participate effectively in diabetes care teams?*”, and the sub- research questions RQ 1.2, “*What are the specific tasks for diabetes care team members?*”, and RQ 1.3, “*What are the required information flow attributes for effective diabetes care team coordination?*” Convenience and snowball sampling methods were used to recruit N=30 participants (N=5 per category on the diabetes care team, as identified in Study I) to participate in semi-structured interviews and worksheets with Likert scale and multiple-choice questions.

The data from Study II was used to answer the research questions and provide a systems engineering definition of the diabetes care team. The overall goals of the diabetes care team are to provide optimal care, support, and education while coordinating and collaborating with team members with other areas of expertise. The responses from Study II confirmed the key members of the diabetes care team found in Study I. The specific tasks for diabetes care team members (RQ 1.2) were defined as follows:

- The primary care provider is the hub of the diabetes care team, and most involved in assessment, diagnosis, referrals, and coordinating care to other members of the care team.
- The endocrinologist is more involved in the nuances of diabetes care, such as the detailed laboratory testing and technologies involved in treating people with diabetes.

- The pharmacist role is responsible for medication management, insurance navigation, and providing counseling and patient education services.
- The dietitian role focuses on patient education for nutrition and exercise.
- Nurses provide patient assessments to the diabetes care team and also provide education services to patients (more emphasis on disease and technology education than nutrition).
- Social workers assist the team via obtaining necessary resources (e.g., financial, community, housing, etc.) and helping with mental health counseling for their patients.

To answer RQ 1.3 (“*What are the required information flow attributes for effective diabetes care team coordination?*”), participants were asked their preferences for frequency, mode, and importance for communication and information coordination other members of the team. The primary care provider had the highest importance rating and was considered the hub for the diabetes care team. The nurse and dietitian roles were tied for team relatedness and these roles assist with information coordination and communicate with other members of the care team daily or weekly. These roles also focused more heavily on the social and environmental information acquisition from patients. The nurse role was considered the second most likely to be the hub of the diabetes care team. The social worker role was also rated highly, but several participants mentioned that it is not utilized as frequently due to patients not needing their services and they are not as integrated into the care team. The endocrinologist role was not rated as highly because not all people with diabetes see an endocrinologist for their care; endocrinologists are used primarily when patients are not managing their disease well and/or if they have type I diabetes. Pharmacists and endocrinologists interact with members of the care team on a monthly basis. Pharmacists interact with patients most frequently (typically on a monthly basis), while other roles tend to be as-needed and/or quarterly.

For every role, participants preferred face-to-face communication, except for participants preferred communicating with pharmacists via phone. Conversely, pharmacists had a stronger desire for face-to-face communication or technology-mediated communication modes (e.g., via secure messaging or EHR). Technology-mediated communication modes were utilized more for detailed patient notes and laboratory results for team members with geographical or temporal constraints that prohibited face-to-face communication.

Key barriers and opportunities for effective diabetes care were also captured. Key barriers included: a need for better team coordination of patient data, particularly with less bottleneck from the primary care role; better patient access to care; and ways to assist HCPs with decreasing documentation time and/or demonstration to insurance companies that these activities have added benefits for patients. Participants also mentioned key gaps in information for diabetes care processes, which included: medical history, medication records, lifestyle information, and a lack of patient honesty. Participants mentioned opportunities for technology interventions to help alleviate some of the barriers to care, such as: universal EHRs, blood glucose monitoring, and easier communication with patients.

To address the overarching RQ 1 (*What opportunities exist for spatially and temporally distributed pharmacists to participate effectively in diabetes care teams?*), the findings from Study II were synthesized using systems engineering tools to demonstrate overall system flows of activity. A new systems engineering analytical framework, DRIFT, was introduced to help visualize the diabetes care team system. The DRIFT analytical framework reinforced the finding that the majority of diabetes care occurs in outpatient settings, and that the majority of patient interactions are with pharmacists. The pharmacist role also has the potential to help alleviate some of the barriers mentioned, such as assisting with gaps in information, offloading documentation from PCPs, and providing data to assist with quality measures. Strong connections between spatially distributed pharmacists can be an avenue for improving information freshness in diabetes care teams.

The combination of the DRIFT model with findings from the opportunities and barriers to care resulted in the development of a new health IT tool that was assessed in Study III.

8.2.2 Study II: Review of Related Work & Contributions

The most significant contributions from Study II are mentioned in the sections below related to diabetes care team goals, care coordination during patient handoffs, clinical inertia and opportunities for pharmacist involvement, and diabetes care team attributes for designing and implementing health IT systems.

8.2.2.1 Diabetes Care Team Goals

Related work confirms the goals of diabetes care teams as providing care, education, disease monitoring, and coordination from members of the care team (Clement et al., 2013; Pimouguet et al., 2011). Chronic care literature also heavily emphasizes patient-centered care and organizing all care processes around the patient, but this theme was not emphasized by the participants in the study, suggesting that there could be a disconnect between what is recommended and what occurs in practice.

8.2.2.2 Care Coordination During Patient Handoffs

From a methodological perspective, the results from Study II were unique in that they were captured using a team task analysis method and contained data from practicing HCPs perspectives on the actual tasks that are performed. Results from related research in the literature tend to outline diabetes care team tasks from evidence-based practices and guidelines from professional societies, instead of tasks that are occurring in practice. When comparing the results of the team task analysis to the recommendations for team tasks, the main tasks for each role are in agreement with task guidelines found in the literature (Aron & Pogach, 2007; Ball, Goolsby, & Nicholas, 2011; Bodenheimer et al., 2002b; Cabana & Jee, 2004; Clement et al., 2013; Davidson, Blanco-Castellanos, & Duran, 2010; Early & Stanley, 2018; Zgibor, Songer, Kelsey, Drash, & Orchard, 2002).

One novel finding from the team task analysis results found that there is a lack of ongoing coordination between the primary care provider and endocrinologist led teams, even though it is recommended that endocrinologists are involved in care for people with type I diabetes (Aron & Pogach, 2007) and during transitions of care (Borgermans et al., 2009; Clement et al., 2013). This finding suggests that there are opportunities for better facilitating these transitions of care and helping coordinate care continuously for endocrinologists and primary care providers.

8.2.2.3 Clinical Inertia & Opportunities for Pharmacist Involvement

Study II results found that members of diabetes care teams view PCPs as the hub of the care team, which is also echoed in the literature (Clement et al., 2013). However, despite the ubiquitous PCP-hub philosophy, research shows that this is detrimental to patient care in that it

can contribute bottlenecks and inertia in patient care (Ball et al., 2011; Clement et al., 2013; Ghorob & Bodenheimer, 2012; Handelsman et al., 2011; Pimouguet et al., 2011; So & Chan, 2010). Clinical inertia, particularly from PCPs, was also a finding that was listed as a key barrier to diabetes care by Study II participants. This suggests that although there are recommendations for “sharing the care” and offloading some PCP tasks to other members of care teams (e.g., increasing team role flexibility, nurse interventions and proactive screening, pharmacist information coordination, pharmacist monitoring of A1c values, etc.) to improve care outcomes at reduced costs, this recommendation is not followed as often in practice and HCPs still subscribe to the PCP-hub mental model (Ball et al., 2011; Clement et al., 2013; Ghorob & Bodenheimer, 2012; So & Chan, 2010). Barriers to adopting this paradigm shift may include: PCP desired control over care, buy-in to the patient-centered medical home philosophy, and upfront costs for training and/or hiring HCPs with advanced certifications related to diabetes care (Ghorob & Bodenheimer, 2012; So & Chan, 2010; Willens et al., 2011).

The paradoxical finding of the PCP-hub / clinical inertia supports the central thesis of this work: pharmacists have the potential for increasing their involvement in diabetes care teams and contributing towards improved outcomes for people with diabetes. Team care, or sharing care among empowered team members, is a critical aspect of reforming healthcare and quality improvement initiatives for patient-centered care and chronic disease prevention and management (Ball et al., 2011). Clinical pharmacists are one solution for helping assist with sharing care responsibilities for reasonable costs (Ghorob & Bodenheimer, 2012; So & Chan, 2010; Willens et al., 2011). The team task analysis results from Study II indicate that many HCPs are not cognizant of the wide range of skills that pharmacists can provide to diabetes care teams, and that many are not using these team members to their full potential. For example, a pharmacist could assist in a clinic setting by providing comprehensive medication reviews, individualized therapy based on cognitive and medical status, education, screening for other health issues, patient reminders, continuity of care and communication to other HCPs, and develop patient-specific goals to help increase medication effectiveness while decreasing the potential for adverse drug events (Grossman, 2011). A barrier to integrating pharmacists in diabetes care teams is that many tasks beyond medication dispensing and medication therapy are not reimbursed as often by insurance, despite the evidence that shows these activities improve

patient outcomes (Armor et al., 2010; Clement et al., 2013; Fazel et al., 2017; Munger, Sundwall, & Feehan, 2018). As a result, a key contribution of this work is the identification of a need for technology assistance with documenting care activities to help provide evidence towards quality metrics that affect reimbursement within diabetes care.

Another barrier to more effectively using pharmacy professionals in the diabetes care team is that many pharmacists in community settings are not clinical pharmacists and do not have additional certifications (e.g., BC-ADP, BC-ADM, CDE) to help with diabetes care processes, and their tasks are more focused on medication dispensing activities. Participants also mentioned that these pharmacists were more disjointed from the team and less involved in the patient care processes. The pharmacists that were considered members of the diabetes care team tended to be clinical pharmacists working with team members in the same geographical location and functioning as a hybrid CDE / pharmacist role. The future of diabetes care could involve more pharmacy professionals with this level of clinical expertise to practice in the community pharmacy setting with collaborative practice agreements, thus helping increase access to care for patients.

8.2.2.4 Diabetes Care Team Attributes for Designing and Implementing Health IT Systems

The synthesis of findings for roles on the diabetes care team, with their related task requirements, frequency attributes, communication modes and preferences, and geospatial definitions for care activities were a novel contribution to this area of research. These results could be used to help health IT companies involved in diabetes care better define the users and system attributes prior to building their systems. These data could also be beneficial from a healthcare organizational perspective for understanding how to integrate different teams and health IT to support provider workflows and preferences.

Participants also requested health IT interventions to make their jobs easier and patient care more effective, such as a universal EHR, blood glucose monitoring technology, and increased information freshness with patient history, medications, and activity. These requests all suggest an underlying desire by HCPs to participate in a patient-centered medical home (PCMH), where the health IT systems support comprehensive, coordinated care (Bates & Bitton, 2010; Chiauzzi,

Rodarte, & DasMahapatra, 2015; Clarke et al., 2015). A PCMH philosophy with health IT interventions will also help facilitate the shared-care model and reducing the potential for clinical inertia (Handelsman et al., 2011).

8.2.3 Study II: Theoretical Contributions

8.2.3.1 Systems Engineering Model Requirements for Chronic Care

Systems engineering models have demonstrated effectiveness for improving health IT implementation and the overall quality of care (Chui et al., 2017; Furniss et al., 2015; Heiden, 2018; Holden et al., 2013; Jahn & Caldwell, 2017; Karsh, 2004). However, when applying these systems engineering models to chronic care contexts, it is necessary for the model to capture the system granularity, temporal dynamics, and sociotechnical factors (Jahn, Heiden, et al., 2018), and there currently is a lack of a systems engineering model that incorporates these necessary attributes for chronic disease management.

Due to the many levels of care for chronic disease management and multiple environments for care, it is critical to have a model that can capture system granularity. Some models demonstrate system granularity as a grain size (e.g., individual-team-system) (Jahn & Caldwell, 2017; Karsh, Holden, Alper, & Or, 2006), while others combine the grain size (e.g., individual-unit-floor-hospital) through macroergonomics lenses (e.g., resources, operations, policy, economics) (Boustany & Caldwell, 2007). A commonality between these models is that they are all presented in two dimensions, thus making it difficult to demonstrate layers of a system and to apply them to complex chronic care processes. Furthermore, adding in temporal components increases the visual intricacy and it can be difficult to model the system processes and granularity. These models, while still useful for some less involved context, can serve as a reminder to consider granularity in engineering systems analysis but they are not as practical for trying to map specific flows.

Temporal dynamics are a crucial component of systems engineering models for chronic care disease management, as the temporal requirements for chronic care are one of the significant differences between it and acute care processes. Some systems engineering models include very specific time flows and event triggers to help map processes (Garrett & Caldwell, 2006; Heiden,

2018; Kurke, 1961), while others include more general indications that time is something to consider as working through the system (Furniss et al., 2015; Jahn & Caldwell, 2017). When combining temporal dynamics and system granularity, it is essential to recognize that not all operations occur at the same time scales and to capture this as appropriate. For example, a chronic care patient may receive acute care after an event trigger (e.g., low blood glucose resulting in hospitalization), which occurs very rapidly, but then they may interact with their other healthcare providers at a significantly slower time scale after discharge from the hospital. The time data is necessary to track for chronic care patients to ensure that there are not gaps in care over time.

Further, sociotechnical factors, such as the team member roles, processes, tools, and organizational factors, are all essential to include within chronic care systems engineering models. Chronic care patients see a vast number of health care professionals: Medicare patients with only one condition typically see four physicians per year, while those with multiple conditions see upwards of fourteen physicians annually (Vogeli et al., 2007). Furthermore, these numbers do not include the other members of the care team with whom patients interact, such as nurses, dietitians, pharmacists, social workers, etc. The varying environments, areas of expertise, processes, and communication tools at each location can impact patient care over time.

8.2.3.2 DRIFT Analytical Framework

The results from Study II were synthesized based upon the six pre-identified roles and their relative work environments (ordered based on criticality of the level of care) to map the diabetes care system processes, tasks, and area of expertise over time. The resulting Diabetes care Roles, Information Flows, and Team coordination (DRIFT) analytical framework, was a key theoretical contribution from Study II.

The DRIFT analytical framework is unique as a systems engineering tool to combine the levels of systems granularity, temporal data, and sociotechnical factors in a model that focuses on chronic care processes. This model is beneficial in that it helps visualize system components by identifying gaps and overlaps in care processes. DRIFT could be used by healthcare organizations to determine areas where interventions are necessary to prevent readmissions or

adverse events, as well as identifying redundant processes that could be eliminated to reduce costs. Furthermore, this model encourages systems engineers towards thinking of systems beyond the typical flat, two-dimensional space. The future of mapping complex systems will require multi-dimensional mapping of processes,

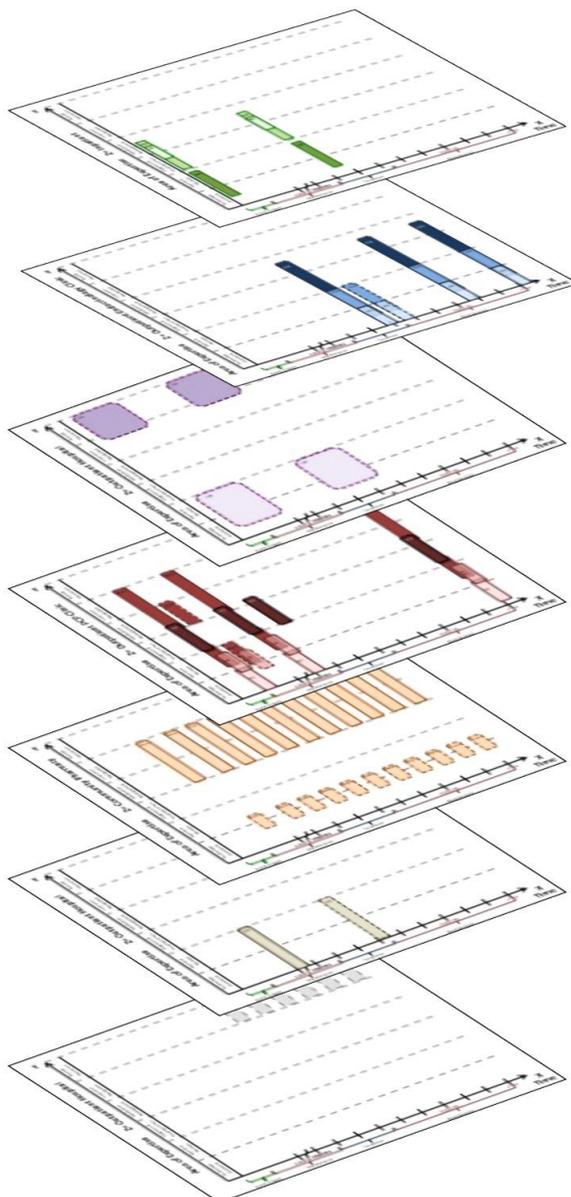


Figure 40. DRIFT Overall Systems Engineering Tool.

Depicting Time (X), Area of Expertise (Y), and Granularity of Care (Z) for each level of the diabetes care system.

Although DRIFT was developed with diabetes care in mind, the methods used to develop DRIFT can be applied to other chronic care applications to map healthcare processes. The mapping of

these processes can help healthcare systems define critical flows for care coordination between HCPs and design health IT to support these processes and flows. Future work can explore adaptations of DRIFT for chronic care visualization management with a variety of HCPs and settings (e.g., traumatic brain injuries, cancer, cardiovascular disease).

The DRIFT analytical framework is limited in that the levels of granularity within DRIFT occur at static planes on the Y-axis, as the majority of participants listed one work environment and did not float between environments. Future versions of DRIFT could better capture transient team members that shift between work environments (e.g., diabetes educator that provides consults in both inpatient and outpatient settings). The interactions between layers of DRIFT could also be further refined. Currently, the mode of communication is captured for individuals in the system, but communication modes between layers as well as interactions between layers could yield information about the system that could lead to better information coordination. Future work will continue to explore these interactions and methods for visually displaying chronic care coordination.

8.2.4 Study II: Limitations & Assumptions

Study II had an initial assumption that the diabetes care team was comprised of the roles identified in Study I. The study was limited in that the participants were not restricted based on their location in the care system. For example, participants could participate if they were a part of a large health care organization, a federally qualified health clinic, an independent private practice, or a closed-loop healthcare system. These variations provided a variety of responses that helped define various attributes of diabetes care teams, but it does limit the strength of the generalizations that can be made due to decreased samples from the various locations. Future research could refine the attributes presented in this research by focusing on one type of location (e.g., outpatient primary care).

The strength of the generalizations, particularly for frequency counts, was also limited in that there were only 5 participants per role category. Future work can confirm the quantifiable aspects of diabetes care information flows with larger participant populations. Another study limitation is the lack of patient input on the diabetes care team members, tasks, and information

flows. Patients are central to their care, and additional research is necessary to ensure patient experiences are in alignment with provider perspectives.

The study methods limited data collection in that participants only had so much time for participation, and participants may have been less likely to be detailed in their responses due to time constraints and/or their perception of the moderator's baseline knowledge with their existing system. Providing participants with incentives could have increased the amount of time participants would be willing to participate and the number of participants overall.

8.2.5 Study II: Future Work

The results from Study II were expansive and detailed due to the qualitative nature of nearly 30 hours of interview data. Future work can confirm the system attributes of diabetes care teams (e.g., frequencies, locations, content of information, communication modalities, preferences for communication, etc.) with larger sample sizes. With a larger data set, comparisons could be made that compare the system attributes based on different location attributes (e.g., patient population, type of care facility, presence of particular roles).

Several questions also arose from the Study II findings in a few distinct categories: patient / caregiver perspectives, patient-centered medical homes, opportunities for pharmacists on diabetes care teams, and DRIFT Analytical Framework. These research questions are listed below:

Patient / Caregiver Perspectives

- How does the patient perspective compare to the HCP perspective on diabetes care team composition and tasks?
- How do caregivers and home healthcare providers fit within the diabetes care team?

Patient-Centered Medical Homes

- Is the concept of patient-centered care prevalent for diabetes care teams?
- What does a PCMH look like in practice? What are the attributes of a well-functioning PCMH? How can we test for effectiveness of PCMHs?

- How can HCPs and healthcare administrators be encouraged to adopt a PCMH philosophy for their healthcare system?

Opportunities for Pharmacists on Diabetes Care Teams

- What are the barriers for insurance reimbursement for pharmacist activities?
- *How can health IT better support pharmacist information coordination for diabetes care processes?*
- *How can the health IT requests from Study II be incorporated into existing health IT systems to better facilitate shared care processes?*

DRIFT Analytical Framework

- *What are the benefits and barriers of using DRIFT for HCPs providing diabetes care?*
- Is DRIFT useful for HCPs involved in care coordination or quality metrics?
- How can DRIFT better capture transient team members that shift work environments?
- How can DRIFT better capture modes of communication and coordination within the framework visualization?

The third research study for this dissertation focuses on questions from both opportunities for pharmacist involvement in diabetes care teams and the DRIFT analytical framework that are indicated by italics and underline in the list above. These questions were selected for Study III due to their focus on engineering problems and the potential for innovative solutions.

8.3 Study III Discussion

8.3.1 Study III: Key Findings

The health IT requests and opportunities for pharmacists mentioned by participants in Study II were the starting point for the author developing a new health IT tool, eVincio, for assessment in Study III. eVincio aimed to fulfill some of the health IT requests while also supporting pharmacist information coordination processes in diabetes care (RQ 2). The sub research questions for Study III assessed the data requirements for pharmacists monitoring people with diabetes (RQ 2.1), and the benefits and barriers of several features: universal patient appointment

tracking (RQ 2.2), universal messaging portal (RQ 2.3), and a care coordination feature (aka DRIFT analytical tool) (RQ 2.4). Six (N=6) pharmacists participated in iterative usability testing of both patient-facing mobile application and provider-facing desktop software for the eVincio prototypes.

The data requirements for pharmacists monitoring people with diabetes (RQ 2.1) include refill compliance data, patient admittance information, medication history, lab results, A1c and blood glucose data, patient appointment compliance data, patient reported symptoms, and features that facilitate quick interpretation and modification of data and alerts. For the universal appointment tracking feature (RQ 2.2) and universal messaging feature (2.3), there was significant overlap in the benefits and barriers. Participants liked that these features were helpful for transitions of care, can help coordinate across healthcare systems, help shift away from phone calls and more towards technology, universal/central location for tracking patient care activities. Barriers to implementing these features included ensuring compatibility with outside healthcare systems and across EHRs, data validation, and lack of patient and/or provider interest in adopting new technology.

The DRIFT analytical framework showed some benefits for use for HCPs providing diabetes care to patients (RQ 2.4). Participants mentioned its potential usefulness for those with a more quality-focused role (e.g., care managers, public health researchers, pharmacists, medical assistants) and for visualizing patient care activities over time and across systems, a feature that does not currently exist in EHR systems. Some barriers to implementing the DRIFT analytical framework in practice are ensuring the accuracy of the patient data and integration with other pre-existing health IT so that information can be coordinated seamlessly across healthcare systems.

8.3.2 Study III: Review of Related Work & Contributions

8.3.2.1 Development of a Novel Health IT Solution for Diabetes Care

Diabetes is often used as a model in the chronic care management literature (Wagner, 2000) yet diabetes Health IT still faces many similar issues as other chronic diseases. For example, continuous glucose monitoring (CGM) technology is a recent advance that can help patients and

providers better track blood glucose levels and related health events in real-time. However, not all health events are captured within CGM systems (e.g., exercise, stress, food, medications), and not all providers have access to this data. In addition, patients may use some technology systems like CGM for one provider (e.g., endocrinologist), but their primary care provider or pharmacist may not have the technology available.

Electronic health records (EHRs) are the ubiquitous tool for tracking patient health changes over time, regardless of chronic or acute care needs. Although the general benefits and barriers of EHRs have been discussed at length (e.g., Carspecken, Sharek, Longhurst, & Pageler, 2013; Edwards, Moloney, Jacko, & Sainfort, 2008; Goldzweig et al., 2013; Kuo & Dang, 2016; Poissant, Pereira, Tamblyn, & Kawasumi, 2005), recent research has reviewed gaps and opportunities for leveraging EHRs specifically for chronic disease management (Gillingham & Fredriksson, 2015; Goldwater et al., 2013; Michigan Medicine, 2018), most of which focuses on designing better clinical decision support systems and integrated tools within EHRs (Dixon & Samarth, 2009).

Despite some advancements with health IT and chronic disease management, there are still significant opportunities for improvements. For example, work by Gillingham & Fredriksson (2015) highlighted key areas that contribute to limited information sharing for chronic disease prevention, which includes a lack of data standards, information plan, and interoperability, as well as poor interface designs and ill-defined procedures for general data collection and screening. Furthermore, several research studies indicate that better temporal displays and information visualization tools are necessary for better treating chronic diseases (de Lusignan & Poh, 2011; Kinch, 2017; Samal, Wright, Wong, Linder, & Bates, 2014).

The introduction of the eVincio mobile application and desktop software system is the first of its kind and is one of the key contributions of this dissertation work. There are some health IT solutions that have some similar features, but they are significantly different than the eVincio mobile application and desktop software. For example, many EHR portals offer secure messaging and appointment tracking features, but they do not integrate across healthcare systems seamlessly. There are a few new mobile applications that attempt interoperability across

healthcare systems to exchange patient data, store health data for families, and/or track appointments (Mandl, Mandel, & Kohane, 2015; Sullivan, 2018), but these solutions do not contain features like the DRIFT analytical framework that help track gaps in care coordination for patients.

There has been some related work that attempts to track healthcare workflows over time. This technology, *EventFlow*, extracts data from EHRs to present data in a guided user interface to analyze patterns and events (Monroe, Lan, Lee, Plaisant, & Shneiderman, 2013; Monroe, Lan, Morales del Olmo, et al., 2013). This software has been used in a variety of applications, ranging from point-based to interval events, such as: tracking patterns of activities for older adults (Chung, Ozkaynak, & Demiris, 2017), analyzing disease and treatment outcomes (Beer, Collier, Du, & Gargano, 2017), analyzing patient adherence with medications (Bjarnadóttir, Malik, Onukwugha, Gooden, & Plaisant, 2016), determining patient utilization rates of healthcare services (Onukwugha, Plaisant, & Shneiderman, 2016), and tracking workflows in various healthcare centers (E. Carter, Burd, Monroe, Plaisant, & Shneiderman, 2013; Ozkaynak et al., 2015). An advantage of the *EventFlow* software over eVincio is its exceptional flexibility for a variety of applications and filtering options—researchers have expanded its applications beyond healthcare to cybersecurity, sports analytics, learning analytics, and incident management industries. The software is designed to be easily adapted to the datasets that researchers wish to analyze. Due to these benefits, *EventFlow* is less practical for usage by clinicians in a clinical setting for identifying gaps in care in real-time. It also does not have integrated features beyond the historical data filtering options. Future work could involve the integration of *EventFlow* data management and filtering with principles and ideas presented in the eVincio software, and the layering of data sets as presented in the DRIFT analytical framework. These tools could work in tandem and be integrated within an EHR system to provide an optimal solution for care coordination activity tracking.

8.3.2.2 Pharmacists & Health IT Opportunities

There are a variety of health IT applications designed specifically for pharmacies, such as medication management tools, mobile applications designed to connect with patients, telemedicine technology, medication reconciliation tools, and many more (Aungst, 2014;

Goundrey-Smith, 2014; Hartzema et al., 2007; Kimber & Peterson, 2006; Paoletti et al., 2007; Poon et al., 2005; Siska & Tribble, 2011; Westerling, Haikala, & Airaksinen, 2011). However, with the advancing skillsets of pharmacy professionals, there are opportunities for pharmacists to use more than pharmacy specific tools when providing care for patients. These tools can range from EHRs and patient portals, to focused technologies for managing specific diseases (e.g., CGM for diabetes care) or chronic diseases (e.g., eVincio). When assessing technologies that can have a variety of end users and settings, health IT companies may not always consider including pharmacists into their user testing samples. The future development of health IT solutions should consider the pharmacist perspective to help design features that can assist with care coordination and quality. For example, Study III found that pharmacists would like to see health IT with features to help them track patient compliance, admittance, health history, and specific lab and blood glucose data. These feature requests may have been different if the end user testing the eVincio software was a different member of the diabetes care team. Including the pharmacist perspective can help health IT companies include features that help with tracking quality metrics and medication data so that pharmacists can have better insights on their patients' current health statuses.

8.3.3 Study III: Theoretical Contributions

Study III provides some preliminary evidence of the utility of the new DRIFT analytical framework for use by practicing HCPs. eVincio has features that follow key standards for patient-centered medical home guidelines, such as patient communication, patient tracking, care management, test tracking, referral tracking, and performance reporting and improvement (B. L. Carter et al., 2012). The eVincio system could help shift a healthcare system towards a patient-centered medical home model and improve chronic care outcomes (B. L. Carter et al., 2012). Additional refinement of the interface, interoperability, and testing with end users needs to occur to prepare eVincio for implementation (see section 7.5 for additional details).

8.3.4 Study III: Limitations & Assumptions

At the start of this dissertation work, it was anticipated that Study III would look at the pharmacist as an end user of CGM technology, as this is a new concept in the diabetes health IT space. Unfortunately, due to unforeseen limitations, CGM technology was unavailable for

assessment. Future work can explore pharmacists as end users with CGM, particularly in the community pharmacy setting based off of current research and predictions from experts on CGM trends (Davies, 2016; Dietz, 2016; Ellis, 2015).

Study III was also limited in that the patient perspective was not captured for the eVincio mobile application, which is designed to be patient-facing. Patients were omitted from the study due to the time and logistical restrictions with user testing with medical devices with patient participants. The formative study was intended to assess preliminary feasibility before assessing the nuances of the prototype from the patient perspective. Future work will involve iterative testing with patient participants. Also, the formative nature of the study precluded participants from offering as detailed feedback about the usability of the prototypes, so further development and refinement of the features is necessary before the next round of testing.

8.3.5 Study III: Future Work

The completion of this third study of the dissertation work spawns several new opportunities for expanding the design and direction of the eVincio mobile application and software system, as well as continuing to refine the DRIFT analytical framework. The eVincio mobile application and software needs to be improved with interface issues, health IT integration and interoperability, data validation, alerts, and evidence-based guidelines. This will necessitate the involvement of multiple disciplines, including industrial engineering, systems engineering, electrical and computer engineering, healthcare policy, medicine, and law. Multiple iterations of testing with a variety of end-users are also necessary.

Beyond the development of eVincio, the DRIFT analytical framework should continue to be tested and revised to improve its applicability and generalizability for other chronic care systems. Future work will look at its applicability for traumatic brain injury patients and their care teams.

9. CONCLUSION & SIGNIFICANCE OF WORK

To address the challenges of chronic care management for people with diabetes, it is recommended that healthcare organizations adopt a patient-centered medical home model and implement health IT solutions for information coordination. Furthermore, advanced certifications, collaborative-practice agreements, and a shifting model towards sharing care processes can allow other healthcare professionals, such as pharmacists, to participate in a more central role on diabetes care teams and improve outcomes.

This dissertation work aims to help healthcare professionals, healthcare organizations, and health IT vendors with bridging the gap to the patient-centered medical home concept by providing systems engineering definitions of diabetes care teams, a systems engineering analytical framework for defining care coordination processes, and introducing a new health IT tool for care coordination. Another objective of this dissertation is to provide evidence of the opportunities for pharmacist involvement on diabetes care teams.

The results from Studies I and II provide insight into how diabetes care teams are structured, including details on the specific roles, tasks, and information flows required for diabetes information coordination. These findings can be applied by healthcare organizations and health IT companies to understand the current flows of information for diabetes care processes prior to implementing new health IT, processes, policies, or other sociotechnical systems changes that could impact diabetes care coordination. Vendors who are considering expanding the applications of their technologies beyond the typical primary care provider or endocrinology settings can also use the identification of key members of the diabetes care team. By encouraging companies to support other end-users that are involved in diabetes care, this can help expand the patient-centered medical home concept. If technology can support a variety of healthcare professional mental models and tasks, there is a higher potential that tasks could be shared and/or offloaded and the patient-centered medical home will be more easily adopted.

The results from this research support and expand existing cognitive theories and frameworks related to care coordination, chronic care models, distributed cognition, systems engineering,

work systems, sociotechnical systems, and technology implementation and acceptance. The author's development of the DRIFT analytical framework expands existing chronic care and healthcare systems engineering frameworks through the inclusion of granularity, temporal, and sociotechnical factors in a three-dimensional systems model. Future systems engineering models should consider the inclusion of multiple dimensions to better depict temporal trends in addition to other aspects of the system. The author's development and assessment of the eVincio prototype with the integration of the DRIFT analytical framework also suggested that this framework could be used by practitioners in their own organizations to identify areas for process breakdowns in chronic care. The concepts behind the DRIFT model suggest a practical utility for health IT systems that involve tracking quality metrics or population health trends.

Finally, this dissertation provides confirmatory support towards the need for pharmacy professionals to increase their involvement in diabetes care team information coordination. The results of this work indicated that pharmacists could add value to diabetes care teams by providing medication management, disease monitoring, and diabetes education services. Other studies have found that pharmacists are a cost-effective solution for reducing the burden of care for primary care providers (Willens et al., 2011). Technology that supports pharmacist information coordination and patient monitoring, such as the eVincio prototype developed by the author for Study III, can help pharmacists shift into advanced roles and share the workload. Furthermore, technology should track all types of care activities to demonstrate the potential impact on health outcomes for patients and system constraints for providers. Including these quality metrics could lead to changes in healthcare policy and reimbursement practices, so that there is evidence-based support for pharmacist involvement and patient-centered medical home best practices.

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APPENDIX A: STUDY I QUESTIONNAIRE

1. Do you wish to participate in the 5-10 minute questionnaire on the following pages?
 - a. Yes [If yes, continue]
 - b. No [If no, thank and close]

2. Are you 18 years of age?
 - a. Yes [If yes, continue]
 - b. No [If no, thank and close]

3. Are you a healthcare professional who is currently practicing in the United States?
 - a. Yes [If yes, continue]
 - b. No [If no, thank and close]

4. Please select from the following list what most closely matches your job title
 - a. Certified Diabetes Educator
 - b. Dietician
 - c. Endocrinologist
 - d. Mental Health Counselor
 - e. Nurse Practitioner
 - f. Pharmacist- Community/Retail
 - g. Pharmacist- Hospital Inpatient
 - h. Pharmacist- Hospital Outpatient
 - i. Primary Care physician
 - j. Podiatrist
 - k. Registered Nurse
 - l. Social Worker
 - m. Specialist (e.g., nephrologist): _____
 - n. Other: _____

5. How frequently do you interact with diabetes patients as part of your job?
 - a. Every day

- b. A few times a week
- c. A few times a month
- d. A few times a year [If selected, thank and close]
- e. Never [If selected, thank and close]

6. What types of healthcare professionals would you include on a core diabetes care team?
“Core” can be defined as a function of the most common and critical health professionals to include to ensure safe and efficient care.

Please list **at least 5** different types of healthcare professionals in order of the most critical to include on a core diabetes care team to the least critical member.

Feel free to use the space to share any other thoughts you may have on core diabetes care team members. [Open ended question]

7. Are you interested in being contacted to participate in future studies related to diabetes care and software?
- Yes [If yes, provide hyperlink for email address sharing]
 - No [If no, thank and close]

APPENDIX B: STUDY I EMAIL RECRUITMENT SCRIPT

Hello,

My name is Michelle Jahn and I am a PhD Candidate at Purdue University in the School of Industrial Engineering. You are receiving this email because either you are a healthcare professional or you may know someone who is a **healthcare professional who works with people with diabetes.**

You are invited to participate in a **brief, 5-10 minute questionnaire**, which can be completed **online.** Participating in this questionnaire can inform my dissertation research, which addresses how healthcare professionals work together to provide care and treatment for people with diabetes.

Your participation in this study is completely voluntary. You must be over 18 years of age, and a certified healthcare professional currently practicing in the United States. If you choose to participate, no identifying demographics will be collected beyond your job title and yes/no responses to 1) over 18 years of age, and 2) U.S. citizenship status. Only the Principal Investigator (Dr. Barrett Caldwell, PhD, bscaldwell@purdue.edu) and myself will have access to the data.

If you are interested in participating and helping add to the research in this area, please use the following link to complete the Qualtrics survey:

https://purdue.qualtrics.com/jfe/form/SV_0IYObyb8EZ9rf13

Please feel free to forward this message and share with any one who may be interested.

Best,

Michelle A. Jahn

APPENDIX C: STUDY II PARTICIPANT SCREENER

1. Are you a certified healthcare professional?
2. Are you currently practicing in the United States?
3. Please select from the following list the answer that most closely matches your job title. You may pick more than one response.
 - a. Certified Diabetes Educator
 - b. Dietician
 - c. Endocrinologist
 - d. Mental Health Counselor
 - e. Pharmacist
 - f. Primary Care Provider (MD, NP, PA)
 - g. Podiatrist
 - h. Registered Nurse
 - i. Social Worker
 - j. Specialist (e.g., nephrologist):_____
 - k. Other:_____
4. Do you have any other credentials or certifications related to diabetes care (e.g., Certified Diabetes Educator)?
5. What environment are you currently practicing in? (e.g., inpatient, outpatient, clinic)
6. How many years have you been working in this role?

7. How frequently do you interact with pharmacists as part of your job?
- a. Every day
 - b. A few times a week
 - c. A few times a month
 - d. A few times a year
 - e. Never
8. How frequently do you interact with diabetes patients as part of your job?
- a. Every day
 - b. A few times a week
 - c. A few times a month
 - d. A few times a year
 - e. Never

APPENDIX D: STUDY II INITIAL INTERVIEW MODERATOR GUIDE

Study Supplies:

- Consent form, worksheets (**Appendices F & G**), blank paper
→ Send electronically if remote conferencing
- Voice recorder
- Moderator guide, clipboard folder
- Two pens

Introduction:

Thank you for agreeing to participate in this research study. Is now still a good time to talk?

First, do you have any questions about the research study? I have a copy of the waiver of consent I sent to you via email if you would like to review anything. Please remember that you can stop the study at any time for any reason.

Before I begin, I would like you to confirm that these responses to the recruitment screener are still accurate [reviews screener responses].

Thank you. I am going to be reading from a script today to maintain consistency across participants. I am going to start the recording device now.

[TURN ON AUDIO-RECORDING HERE. STATE 'PARTICIPANT CODE [#]']

Background Questions:

Now I am going to ask you a few general questions about your experiences working with diabetes care teams.

1. In your own words, what is the purpose or goal of a diabetes care team?

2. Please briefly list the members of a “core” diabetes care team from your perspective. Core can be viewed as the most critical members for achieving the goal you mentioned previously.
3. Please briefly describe how you interact with people with diabetes and/or the members of a diabetes care team as a part of your job.
4. Please describe how you interact with health information technology and/or computer systems as part of your job.
5. Please describe your knowledge of Continuous Glucose Monitoring Data Management Software, and any experience you may have interacting with this type of software. Some examples of this software include: Dexcom Studio, CoPilot Health Management System (for use with Freestyle Libre); Diabetes Partner, CliniPro, etc.

Section 1: Tasks and Processes

Now I am going to shift and ask you some questions about the tasks and processes that are typical for different diabetes care team members. First we will start with filling out a worksheet.

6. Please fill out the following worksheet with the tasks and responsibilities for each healthcare professional as it relates to a patient’s diabetes care team. The tasks and responsibilities are open to your interpretation. Please take about five to ten minutes to fill this out.
 - a. [Example if the participant needs help determining scope for tasks and responsibilities] For example, imagine the overarching goal was for a child to get to school on time, and the team members were the parent, the child, the school bus driver, and the teacher. The parent would be responsible for waking the child up and making sure they had all of the materials in their backpack and breakfast to eat. The child would be responsible for waking up, getting dressed, brushing their teeth, etc. The school bus driver would be responsible for following the bus route, picking up the children, obeying safe traffic laws, and reaching the school in time. Although it could be said that the school bus driver is responsible for applying appropriate pressure to breaks at every stop sign, using the turn signal, and not speeding, this is

too detailed and specific for the time frame. Keep things at a higher level (e.g., follow traffic laws) for the purpose of this exercise.

[HAND PARTICIPANT WORKSHEET 1 (APPENDIX F)]

7. Tell me a little bit about what you filled out in this worksheet and why.
8. How does your role differ from the other roles on the diabetes care team?
9. For the tasks you outlined in the worksheet, please rank them on a scale of importance of how it relates to your previously stated goals for the diabetes care team, where 1 is not at all important and 5 being very important. Please rank each item independent of each other. You can write this ranking directly on the chart in the column titled “I.” [Refer to page 3 of worksheet for a scale visual, if needed].
10. Can you talk me through some of your rationale for the ratings?
11. For the tasks you outlined in question 2, please rank them on a measure of team relatedness, where 1 is not required to work with other members of the team for optimal patient care performance and 5 is very much required to work with other team members for optimal patient care performance. If you are unfamiliar with a particular role, you may write “not available”. Please write your ranking directly on the chart in the column titled “T”
12. Can you talk me through some of your rationale for the ratings?

Section 2: Information content

Now we are going to put worksheet 1 away, and I am going to shift and ask you some questions about the content of the information you share with patients and other healthcare professionals.

13. What information do people with diabetes typically share with you related to their disease?

14. What information do you typically share with people with diabetes to help them manage their care?
15. As you are probably well aware, sometimes, healthcare professionals do not have complete information from patients. In an ideal world, what information would you want to be able to receive from patients about their health that would best help you provide care for their diabetes?
16. What are some of the barriers, in your opinion, for receiving this ideal information?
17. Similarly, in an ideal world, what information would you want to be able to communicate back to patients about their health to help provide care for their diabetes?
18. What are some of the barriers, in your opinion, for communicating this ideal information back to patients?

Now I am going to hand you another worksheet to help facilitate discussion for the next few questions. You can jot down your answers if you like, or you can just talk through it with me.

[HAND PARTICIPANT WORKSHEET 2 (APPENDIX G)]

19. Looking at the first row, please share what information you typically share with each of the members of a diabetes care team? [Row 1]
20. What information do each of the following members of a diabetes care team members share with you? [Row 1]
21. Similar to the previous questions, how would your responses change in an ideal situation?
22. What information would you want them to share with you?

23. What are the barriers for you receiving this information from them?
24. What information would you ideally want to be able to share with them?
25. What are the barriers that limit you from sharing this information with them?

Section 3: Information Flow Attributes

Now I am going to ask you some questions related to the frequency of communication and interaction, and the specific tools you use to communicate with healthcare professionals and patients. You can continue referring to the second worksheet I handed you [APPENDIX G].

26. How frequently do you communicate or interact with other healthcare professionals on a diabetes care team? Please circle your response [Row 2].
27. How does the frequency change depending on the type of information you are sharing?
28. How do you typically communicate with other healthcare professionals on a diabetes care team (e.g., face to face, telephone, technology, etc.) [Row 3]?
29. Do any of these healthcare professionals work in the same clinic or environment as you, so that you could interact with them face-to-face? Where do they typically work? [Probe spatial/temporal differences].
30. What is your ideal or preferred form of communication with different healthcare professionals? [Row 4]
31. How does this change for the different types of information you send or receive?
32. What barriers are there to achieving this ideal form of communication with other healthcare professionals?

33. How frequently do you estimate patients interact with each of the healthcare professionals on a diabetes care team? Please circle the response. If you are unsure, you may write N/A.

[Row 5]

34. If you had to list one member of the diabetes care team as the “hub” of the patient’s care (meaning that they interact with the patient and other health care professionals the most often, tend to know the patients “current state”), who would you pick, and why? [If they pick their role, ask what role they would pick second].

Now please close the worksheet for the last few questions. These questions are related to your interactions with patients and frequency of communication.

35. How do patients typically communicate with you (e.g., face to face, telephone, technology, etc.)?

36. What is your ideal or preferred form of communication with patients?

37. How does this change for the different types of information you send or receive?

38. What barriers are there to achieving this ideal form of communication?

To wrap up, I have two final questions for you:

39. If you could ask people that create healthcare technology and software for one request to make your clinical work easier related to caring for people with diabetes, what would it be? (e.g., change to existing feature, new feature, new software system, etc.)

40. Do you have any other thoughts about diabetes care teams and the roles of different healthcare professionals that you would like to share?

APPENDIX E: STUDY II REVISED INTERVIEW MODERATOR GUIDE

Introduction:

Thank you for agreeing to participate in this research study. Is now still a good time to talk?

First, do you have any questions about the research study? I have a copy of the information sheet I sent to you via email if you would like to review anything. Please remember that you can stop the study at any time for any reason.

Before I begin, I would like you to confirm that these responses to the recruitment screener are still accurate [reviews screener responses].

Thank you. I am going to be reading from a script today to maintain consistency across participants. I am going to start the recording device now.

[TURN ON AUDIO-RECORDING HERE. STATE 'PARTICIPANT CODE [#]']

Background Questions:

Now I am going to ask you a few general questions about your experiences working with diabetes care teams.

1. In your own words, what is the purpose or goal of a diabetes care team?
2. Please briefly list the members of a “core” diabetes care team from your perspective. Core can be viewed as the most critical members for achieving the goal you mentioned previously.
3. Please briefly describe how you interact with the members of a diabetes care team as a part of your job.
4. How does your role differ from the other roles on the diabetes care team?

5. At a high level, can you walk me through from your perspective in the care process of where the patient goes and to whom to receive care from the different members of the diabetes care team?
 - a. Do any of these healthcare professionals work in the same clinic or environment as you, so that you could interact with them face-to-face? Where do they typically work? [Probe spatial/temporal differences for Endo, PCP, RN, RD, PharmD, and SW roles].
 - b. When you think about communicating with other members of the diabetes care team, what barriers do you have with communicating with them?
6. From your perspective, how does the nurse practitioner role fit into the diabetes care team?
7. Diabetes patients can vary (type, age, socioeconomic status, etc.). Please describe your diabetes patient population.
8. Please briefly describe how you interact with people with diabetes as a part of your job.
 - a. What information do people with diabetes typically share with you related to their disease?
 - b. What information do you typically share with people with diabetes to help them manage their care?
 - c. As you are probably well aware, sometimes, healthcare professionals do not have complete information from patients. In an ideal world, what information would you want to be able to receive from patients about their health that would best help you provide care for their diabetes?
 - d. How do patients typically communicate with you (e.g., face to face, telephone, technology, etc.)?
 - e. What is your ideal or preferred form of communication with patients?
 - f. How does this change for the different types of information you send or receive?
 - g. What barriers are there to achieving this ideal form of communication?

9. Please describe how you interact with health information technology and/or computer systems as part of your job.

10. Please describe your knowledge of Continuous Glucose Monitoring Data Management Software, and any experience you may have interacting with this type of software. Some examples of this software include: Dexcom Studio, CoPilot Health Management System (for use with Freestyle Libre); Diabetes Partner, CliniPro, etc.

11. [Probe if knowledgeable:] How do you or would you use CGM in your role?
 - a. [If using] What do you like about CGM?
 - b. What are potential barriers for using CGM?

To wrap up, I have two final questions for you:

12. If you had to list one member of the diabetes care team as the “hub” of the patient’s care (meaning that they interact with the patient and other health care professionals the most often, tend to know the patients “current state”), who would you pick, and why? [If they pick their role, ask what role they would pick second].

13. If you could ask people that create healthcare technology and software for one request to make your clinical work easier related to caring for people with diabetes, what would it be? (e.g., change to existing feature, new feature, new software system, etc.)

14. Do you have any other thoughts about diabetes care teams and the roles of different healthcare professionals that you would like to share?

Thank you so much for your participation in this interview today. There is one other part that to my research, if you wouldn’t mind completing, which involves filling out two worksheets. I can send them to you via email and they have instructions attached to them. They should take approximately 15 minutes to fill out both of them (10 minutes for the first worksheet and 5 minutes for the second worksheet). I can go ahead and send those to you and please just let me know if you have any questions. If you could return them to me within one weeks time, that would be very helpful.

APPENDIX F: STUDY II WORKSHEET 1

Instructions for Worksheet 1

Thank you for your participation in this research study. Please fill out the worksheet below with the following instructions.

1. You may print the worksheet (pages 2-3 of this document) or fill it out electronically.
2. Please fill out the worksheet on the following pages with the tasks and responsibilities for each healthcare professional as it relates to their role on a patient's diabetes care team. The tasks and responsibilities are open to your interpretation, and can be at a high level. Please add any details for your rationale if you feel that it is necessary
3. After you fill out the tasks and responsibilities, please use the following rating scales to rank EACH task/responsibility you listed in the worksheet. Please list the importance rankings in the "I" column and the Team Relatedness rankings in the "T" column. You do not need to rank the tasks against each other or the roles against each other (i.e., meaning that you may rank all tasks with a score of "5" if you feel that it is appropriate for the importance and team relatedness)
4. If you have any notes regarding your rationale for your importance and team relatedness rankings, you may share them in the document via the comment feature.

IMPORTANCE

- ① = Not at all important
- ② = Of little importance
- ③ = Somewhat important
- ④ = Very important
- ⑤ = Of highest importance

TEAM RELATEDNESS

- ① = Not required to work with team members at all for optimal performance
- ② = Required to work with team members very little for optimal performance
- ③ = Somewhat required to work with team members for optimal performance
- ④ = Required to work with team members quite a bit for optimal performance
- ⑤ = Very much required to work with team members for optimal performance

5. Once you have finished the above tasks, **please send a copy of your worksheet pages to Michelle Jahn at jahnm@purdue.edu**. Scans or pictures of printouts are accepted.

Roles

Tasks & Responsibilities

Endocrinologist (END)			Primary Care Provider (MD/ NP /PA)			Nurse (RN, CDE)		
	I	T		I	T		I	T

Roles

Tasks & Responsibilities

Registered Dietician (RD, CDE)			Pharmacist (PharmD, RPh, CDE)			Social Work (MA or MSW, CDE)		
	I	T		I	T		I	T

APPENDIX G: STUDY II WORKSHEET 2

Instructions for Worksheet 2

Thank you for your participation in this research study. Please fill out the worksheet below with the following instructions.

1. You may print the worksheet (pages 2-3 of this document) or fill it out electronically.
2. Please fill out the worksheet on the following pages by answering the questions in the left-hand column for each of the roles on the diabetes care team.
 - a. For the first two rows, you may use bullet points to list the information you share and receive for each of the members of the diabetes care team. If your role is listed, you may put an 'X' in that column
 - b. For the remainder of the worksheet, please mark the multiple-choice answer that most accurately reflects your response (e.g., bold, highlight, or free text). If an option is not listed, feel free to add a note. You may select multiple options if necessary.
3. Once you have finished the above tasks, **please send a copy of your worksheet pages to Michelle Jahn at jahnm@purdue.edu**. Scans or pictures of printouts are accepted.

	Endocrinologist (END)	Primary Care Provider (MD/ NP /PA)	Nurse (RN, CDE)	Registered Dietician (RD, CDE)	Pharmacist (PharmD or RPh)	Social Work (MA or MSW)
What information do you typically share with each professional?						
What information does each professional share with you?						
How <u>frequently</u> do you interact?	A. Daily B. Weekly C. Monthly D. Yearly E. Never F. Other____					

How <u>do</u> you typically communicate?	A. Face-to-face B. Phone C. Email/secure message D. Other:_____					
What is your <u>ideal</u> communication form?	A. Face-to-face B. Phone C. Email/secure message D. Other:_____					
How <u>frequently</u> do patients interact?	A. Daily B. Weekly C. Monthly D. Yearly E. Never F. Other_____					

APPENDIX H: STUDY II QUALITATIVE DATA ATTRIBUTE CODE KEY

Name	Description	Inclusion / Exclusion Criteria
Role	Their response to which role most closely matches their job title/functions	Include roles that they mention on the screener and in the interview. Exclude roles if they do not have the full certification yet (e.g., RD in training to be a NP cannot be coded as an NP)
Gender	Participant Identified Gender	N/A
Certifications	Their response to other certifications related to diabetes care	Include specific certifications beyond their license (e.g., CDE but not RN).
Environment	Their response to the type of environment they work in.	Include details that describe the facility purpose and setting (e.g., inpatient, outpatient, pediatric). Include location information of other team members. Do not include details about the processes.
Experience	Their response to the number of years they have been working in that role.	Include residency, but do not include medical school or other years not in that particular role. If they have experience in diabetes care in a slightly different role (e.g., RN versus Charge RN) the experience in years
Patient Interaction	Their response to how frequently they interact with patients.	Include responses related to any type of patient interaction (phone, email, in person).
Patient Population	Their response to “how would you describe your patient population?”	Include details on the types of patients they see (age, socioeconomic status, type I/type II diabetes)
Health IT Usage	Their response to “how do you interact with health IT as part of your job”. Subcodes include EHR, apps, secure messaging, etc.	Do not include extra details from Health IT wish list or from CGM related questions. Include details if it helps determine the level of health IT comfort/frequency of use

APPENDIX I: STUDY II QUALITATIVE DATA PROCESS CODE KEY

Code Category	Name	Description	Inclusion / Exclusion Criteria
General DCT Team	Goal of DCT	Response to “in your own words, what is the purpose or goal of a diabetes care team?”	Include responses to this question. Include any other responses if the participant circles back to this goal.
	DCT members	Response to “Who are the members of a core diabetes care team”	Include other references to team members after this question as well
	Hub	Participant response to “who is the hub of the diabetes care team?”	
Tasks & Processes	Tasks (self- Role Name)	Tasks and processes they list for themselves as members of the diabetes care team.	Include responses to this question and any other details where they talk about their tasks.
	Tasks (others- Role Name)	Tasks and processes they list for themselves as members of the diabetes care team. Each code will be tagged with a subcode with the role name so that responses about one role can be aggregated.	Include details for when they are talking about each of the roles. Do not include frequency data as part of the code. May co-code with magnitudes (e.g., ranking of a task as important or frequent).
	Care Process	Description from participant about the flow / order of care processes	N/A
	Importance Ratings	Participant response to the importance (1-5 scale) for each team member and their tasks	N/A
	Team Relatedness Ratings	Participant response to the team relatedness rating (1-5 scale) for each team member and their tasks	N/A
Communication	Preferences (Role Name)	Preferred mode and frequency of	N/A

		communication with each HCP role	
	Mode (Role Name)	Mode of HCP-HCP communication with that particular role	N/A
	HCP Communication-Facilitators	Description about what works for HCP-HCP communication	N/A
	HCP Communication-Barriers	Description about barriers for HCP-HCP communication	N/A
	Perceived Patient Communication Frequency (Role Name)	Participant response to how often they think other HCPs interact with patients	N/A
	Patient Communication Preferences	Preferred mode and frequency of communication	N/A
	Patient Communication Mode	Mode of communication with patients	N/A
	Patient Communication Facilitators	Description about what works for HCP-patient communication	N/A
	Patient Communication Barriers	Description about barriers for HCP-patient communication	N/A
Information Flows	Information Flows To/From Others (Role Name)	This will be coded with the information needs and flows that the participant sends to / receives from others with the subcode of the role that it is going toward.	N/A
	Patient Information Flows (Role Name)	This will be coded with the information needs and flows that the participant sends to / receives from patients with the subcode of the role of the participant	N/A
	Frequency (Role Name)	Participant response to how frequently they interact with each team member	N/A

	Location (Role Name)	Participant response to the people the physical locations of the different team members	
Opportunities	Ideal information - Patient	Participant response to “what information would you ideally like to have from patients?”	N/A
	Ideal information - HCP	Participant response to “what information would you ideally like to have from HCPs?”	N/A
	CGM	Participant response to “knowledge of CGM” if they include details for future opportunities / learning, etc.	Include details related to opportunities for improving CGM. Do not include details on their use if they provide a lot of information. This code is specifically focused on areas for future work that are within my control (e.g., insurance industry issues are not within my control and would not be included).
	Health IT Wish	Participant response to “What is your health IT wish?”	Include other health IT wishes expressed during other parts of the interview as well. Do not include non-engineering health IT wishes (e.g., complaints related to the insurance industry). Information related to CGM will be included here if it is stated as their health IT wish, otherwise it will be coded separately within the CGM related codes.
	Barriers to Care	Items that participants' mention that are a	Does not include barriers to

		barrier to care, potentially with the opportunity for an engineering intervention to provide a solution.	communication or CGM barriers (coded separately).
CGM	Description	Description of participant knowledge of CGM	N/A
	Usage in Role	Description of how participant uses CGM	N/A
	Hypothetical Usage in Role	Description of how participant would use CGM if they had it	Only use if participant does not use CGM and this question was probed.
	Reports Comments	Participant comments regarding their usage of CGM and BG reports for diabetes situation awareness.	Includes details on usage, facilitators, barriers, opportunities for improvement, and important pieces of information. Does not include non- diabetes software based reports (e.g., EHR reports)
	Facilitators	Ways that the participant thinks CGM would facilitate diabetes care team processes	N/A
	Barriers	Areas to improve for CGM related products and the supporting healthcare system	Include all barriers details here. May overlap slightly with opportunities and CGM.

APPENDIX J: STUDY II EMAIL RECRUITMENT SCRIPT

Email Recruitment Script (Initial Contact):

Hello,

My name is Michelle Jahn and I am a PhD Candidate at Purdue University in the School of Industrial Engineering. You are receiving this email because either you are or you may know someone who is a **healthcare professional who works with people with diabetes.**

You are invited to participate in a **research interview.** Your participation can help researchers better understand how healthcare professionals work together to provide care and treatment for people with diabetes. Your participation may also help you consider ways that you might be able to help provide new types of treatment for people with diabetes.

- Interviews will be conducted **Online via Video-conferencing software** (e.g., Skype).
- Interviews are expected to take **20-30 minutes** and will be **audio-recorded.**
- Participants will also be asked to complete 2 worksheets after their interview
- Your participation in this study is completely voluntary.
- You must be over 18 years of age, and a certified healthcare professional currently practicing in the United States.
- Only the Principal Investigator (Dr. Barrett Caldwell, PhD, bscaldwell@purdue.edu) and myself will have access to the data, and we will maintain confidentiality to the extent of the law.

If you are interested in participating and helping add to the research in this area, please send an email to jahnm@purdue.edu to schedule a time slot.

Please feel free to forward this message and share with other healthcare professionals who may be interested.

Best,

Michelle A. Jahn

Social Media Recruitment Script (Initial Contact):

I am a PhD candidate at Purdue University in the School of Industrial Engineering, and I am seeking healthcare professionals to partake in a research study.

If you are a healthcare professional who works with diabetics, I would like to invite you to participate in a research interview. Your participation can help researchers better understand how healthcare professionals work together to provide care and treatment for people with diabetes. Your participation may also help you consider ways that you might be able to help provide new types of treatment for people with diabetes.

- Interviews will be conducted Online via Video-conferencing software (e.g., Skype).
- Interviews are expected take **20-30 minutes** and will be **audio-recorded**.
- Participants will also be asked to complete 2 worksheets after their interview
- Your participation in this study is completely voluntary.
- You must be over 18 years of age, and a certified healthcare professional currently practicing in the United States.
- Only the Principal Investigator (Dr. Barrett Caldwell, PhD, bscaldwell@purdue.edu) and myself will have access to the data, and we will maintain confidentiality to the extent of the law.

If you are interested in participating and helping add to the research in this area, please send an email to jahnm@purdue.edu to schedule a time slot.

Please feel free to share with other healthcare professionals who may be interested.

Email Script After Participant Has Indicated Interest:

[Participant Name],

Thank you so much for your interest in the research study. I have attached an information sheet to explain more about the study details and risks. Please let me know if you have any questions or concerns. If you would like to participate, please complete the steps below:

1. Please complete the participant form (attached)
2. Please indicate your preference for video-conferencing (e.g., Skype, WebEx, FaceTime, Google Handouts). If none of these options work, phone call will suffice.
3. Please list at least five 30-minute time slots that you are available during the next 1-3 weeks.

Again, thank you for your interest in supporting this research. You may reach out to Dr. Barrett Caldwell (PhD, Principal Investigator, bscaldwell@purdue.edu) or myself at any time.

Best,

Michelle Jahn

APPENDIX K: STUDY II PARTICIPANT INFORMATION SHEET

RESEARCH PARTICIPANT INFORMATION SHEET

Identifying Core Healthcare Professionals on Diabetes Care Teams

Michelle Jahn, M.S., & Barrett Caldwell, Ph.D.

School of Industrial Engineering

Purdue University, West Lafayette, IN

This form describes a research study, what you may expect if you decide to take part, and important information to help you make your decision. Please read this form carefully.

Being in this study is voluntary – it is your choice. If you join this study, you can change your mind and stop at any time. There are minimal risks from participating in this study

What is the purpose of this study?

The purpose of this study is to further our understanding of how core members of a diabetes care team communicate with one another, including the types of information they share and the frequency of communication. “Core” can be defined as a function of the most common and critical health professionals that interact with people with diabetes.

What will I do if I choose to be in this study?

If you do decide to participate in this study, you will be asked to participate in a 20-30 minute audio-recorded interview either in person or over video-conferencing software (e.g., Skype, FaceTime, WebEx). After the interview is completed, you will be asked to fill out two worksheets on your own time and send them back to the researchers.

How long will I be in the study?

The estimated time to complete the interview is 20-30 minutes. There are two worksheets you will be asked to complete after the interview, and it is expected that it will take 15-20 minutes to fill out these worksheets.

What are the possible risks or discomforts?

There are minimal risks associated with participation in this study. If you are uncomfortable for any reason and wish to discontinue the interview, you may do so. You are free to stop at any time for whatever reason, and will not be penalized for choosing to end your participation.

Are there any potential benefits?

There are no direct benefits to you beyond the possibility of feeling helpful for contributing to furthering the research in this field.

Will information about me and my participation be kept confidential?

We make every effort to maintain confidentiality to the extent of the law.

Participant demographic information will be hand recorded prior to the start of the audio recording of the interview. This information will be kept in a locked filing cabinet at Purdue University. The audio-recorded interviews will be transcribed after the session and destroyed.

The results of this research study may be presented at meetings or in publications, however, your identity will be kept private. The project's research records may be reviewed by departments at Purdue University responsible for regulatory and research oversight. The details of individual data will not be disclosed to any other people except the researchers (Michelle Jahn and Barrett Caldwell). In the future, the data will be only used for future subsequent studies on evaluation of diabetes care teams only by the authors (Michelle Jahn and Barrett Caldwell).

What are my rights if I take part in this study?

Your participation in this study is voluntary. You may choose not to participate or, if you agree to participate, you can withdraw your participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Who can I contact if I have questions about the study?

If you have questions, comments or concerns about this research project, you can talk to one of the researchers. Please contact the primary investigator, Barrett Caldwell

(bscaldwell@purdue.edu or 765-494-5412) or the graduate research assistant, Michelle Jahn (jahnm@purdue.edu or [Redacted]).

If you have questions about your rights while taking part in the study or have concerns about the treatment of research participants, please call the Human Research Protection Program at (765) 494-5942, email (irb@purdue.edu) or write to:

Human Research Protection Program - Purdue University
Ernest C. Young Hall, Room 1032
155 S. Grant St.,
West Lafayette, IN 47907-2114

APPENDIX L: STUDY III PARTICIPANT SCREENER

1. Are you a licensed pharmacist currently practicing in the United States?

2. Please list any credentials or certifications related to diabetes care (e.g., Certified Diabetes Educator):

3. Please describe the type of healthcare environment in which you are currently practicing:

4. How many years have you been working in this specific position/role? In your professional area of healthcare?

5. How frequently do you interact with diabetes patients as part of your job?
 - a. Every day
 - b. A few times a week
 - c. A few times a month
 - d. A few times a year
 - e. Never

6. Please check all that apply in the list below for the diabetes health information technology you use as part of your job:
 - Blood Glucose Diabetes Management Systems (provider software)
 - Blood Glucose Meters (helping patients with their personal devices)
 - Insulin Pumps (helping patients with their personal devices)
 - Continuous Glucose Monitoring Software (provider software)
 - Continuous Glucose Monitoring (helping patients with their personal devices)Other (please describe):

APPENDIX M: STUDY III MODERATOR GUIDE

Introduction:

Thank you for agreeing to participate in this research study. Is now still a good time to talk?

First, do you have any questions about the research study? I have a copy of the information sheet I sent to you via email if you would like to review anything. Please remember that you can stop the study at any time for any reason.

Before I begin, I would like you to confirm that these responses to the recruitment screener are still accurate [reviews screener responses].

Thank you. I am going to be reading from a script today to maintain consistency across participants. I am going to start the recording device now.

[TURN ON AUDIO-RECORDING HERE. STATE ‘PARTICIPANT CODE [#]’]

Background Questions:

Now I am going to ask you a few general questions about your experiences working with diabetes care teams and health IT.

1. Please briefly list the areas of expertise of a “core” diabetes care team from your perspective.
2. Please briefly describe how you coordinate tasks and exchange information with the members of a diabetes care team as a part of your job.
3. Please describe how you interact with health information technology and/or computer systems as part of your job.

Now I am going to switch gears and have you look at a prototype of a new analytical tool. First, we will look at the prototype of a mobile application intended to be used by patients, then we will look at the prototype for the related desktop software to be used by providers.

4. Please open the link for the mobile application and explore around for a few minutes. Since it is a prototype, some links may not work perfectly. To open the application, please click the “eVincio” icon and then click anywhere to login.
 - a. What do you think are the purpose or purposes of this app?
 - b. Please share your perspective on the usefulness of having a universal check-in feature for patient appointments. What benefits would there be for this? Barriers?
 - c. Please share your perspective on the usefulness of having a universal messaging system for patients. What benefits would there be for this? Barriers?

- d. Please share your perspective on the usefulness of having a HIPAA authorization list within a mobile application. What benefits would there be for this? Barriers?
- e. Please rate on a scale of 1-5 your perception of your patients adopting this application and using it as intended where 1 is not at all and 5 is using it fully as intended.

Now we will shift to the desktop software. This software is provider-facing software. There is an example patient opened in the software who was admitted to the hospital approximately one year ago, which resulted in a diabetes diagnosis.

5. Please open the link for the desktop application and explore around for a few minutes. Since it is a prototype, some links may not work perfectly.
 - a. What do you think the purpose or purposes are for this desktop software? How would you expect it to interact with the patient mobile application?
 - b. Please describe how you think the care coordination feature works. What do you think the benefits of this would be? What barriers are there?
 - c. Please share your perspective on the usefulness of having a universal patient visit list for tracking patient appointments. What benefits would there be for this? Barriers?
 - d. Please share your perspective on the usefulness of being able to view all messaging from patients. What benefits would there be for this? Barriers?
 - e. Please share your perspective on the usefulness of having alerts based on patterns from the care coordination results. What benefits would there be for this? Barriers?
 - f. Please rate on a scale of 1-5 your perception of your interest in adopting this application and using it as intended where 1 is not at all and 5 is using it fully as intended.
 - g. Please rate on a scale of 1-5 your perception of other healthcare provider's interest in adopting this application and using it as intended where 1 is not at all and 5 is using it fully as intended.
 - h. Are there any other features you would like to see added to this software prototype?
 - i. Could you see this software integrating with other software that you currently use? If so, which platforms? [Probes: CGM, EHR, Patient Management Portal, etc.]
 - i. Do you have experience using diabetes care information technology as part of your job?
 - ii. What items would you like to see tracked over time that are not currently present?
 1. Medications?

2. Appointment visits?
 3. Are you familiar with the different displays of blood glucose values over time? For your role, what items do you find the most useful on these graphs?
- j. Is there any other feedback you have regarding the software prototype of the mobile application for me today?

Those are all of the questions I have for you today. Is there anything else you would like to add?

Thank you so much for your participation in this interview today.

APPENDIX N: STUDY III EMAIL RECRUITMENT SCRIPT

Email Recruitment Script (Initial Contact):

Hello,

My name is Michelle Jahn and I am a PhD Candidate at Purdue University in the School of Industrial Engineering. You are receiving this recruitment message because either you are or you may know someone who is a **pharmacist who works with people with diabetes.**

You are invited to participate in a **research interview.** Your participation can help researchers evaluate health information technology for coordinating information for people with diabetes. Your participation may also help you consider ways that you might be able to use new types of technology for people with diabetes.

- Interviews will be conducted **online via video-conferencing software** (e.g., Skype).
- Interviews are expected to be **30-45 minutes** long and will be **audio-recorded.**
- Your participation in this study is completely voluntary.
- You must be over 18 years of age, and a pharmacist currently practicing in the United States.
- Only the Principal Investigator (Dr. Barrett Caldwell, PhD, bscaldwell@purdue.edu) and myself will have access to the data, and we will maintain confidentiality to the extent of the law.

If you are interested in participating and helping add to the research in this area, please send an email to jahnm@purdue.edu to schedule a time slot.

Please feel free to forward this message and share with other pharmacy professionals who may be interested.

Best,

Michelle A. Jahn

Social Media Recruitment Script (Initial Contact):

I am a PhD candidate at Purdue University in the School of Industrial Engineering, and I am seeking pharmacy professionals to partake in a research study. If you are a pharmacist who works with people with diabetes, I would like to invite you to participate in a 30-45 minute research interview that will evaluate a new health information technology tool.

Your participation can help researchers evaluate health information technology for coordinating information for people with diabetes. Your participation may also help you consider ways that you might be able to use new types of technology for people with diabetes.

- Interviews will be conducted online via Video-conferencing software (e.g., Skype, FaceTime, WebEx, Google Hangouts).
- Interviews are expected to be 30-45 minutes long and will be audio-recorded.
- Your participation in this study is completely voluntary.
- You must be over 18 years of age, and a pharmacy professional currently practicing in the United States.
- Only the Principal Investigator (Dr. Barrett Caldwell, PhD, bscaldwell@purdue.edu) and myself will have access to the data, and we will maintain confidentiality to the extent of the law.

If you are interested in participating and helping add to the research in this area, please send an email to jahnm@purdue.edu to schedule a time slot.

Please feel free to share with other pharmacy professionals who may be interested.

Email Script After Participant Has Indicated Interest:

[Participant Name],

Thank you so much for your interest in the research study. Please complete the steps below:

4. Please complete the participant form (attached)
5. Please indicate your preference for interview conferencing software:
 - a. Skype
 - b. Google Hangouts
 - c. WebEx
 - d. FaceTime
 - e. Other: _____
6. Please list at least three 30-minute time slots that you are available during the next 2-3 weeks.

Again, thank you for your interest in supporting this research. You may reach out to Dr. Barrett Caldwell (PhD, Principal Investigator, bscaldwell@purdue.edu) or myself at any time.

Best,

Michelle Jahn

Day of Email for Reminder [if remote]:**Dear [Participant name],**

Thank you for agreeing to participate in the research study today at [time]. I will be available at [username for their preferred method of video conferencing]; please start the videoconference when you are ready. If the video conferencing does not work, you may always call me at 513-368-8657.

We will also be accessing the following links during the call today:

Mobile Application: <https://oku9dh.axshare.com/#c=2>

Desktop Application: <https://vf8wnf.axshare.com/#c=2>

Talk to you soon,

Michelle

APPENDIX O: STUDY III PARTICIPANT INFORMATION SHEET

RESEARCH PARTICIPANT INFORMATION SHEET

Opportunities for Pharmacists on Diabetes Care Teams – Part 2

Michelle Jahn, M.S., & Barrett Caldwell, Ph.D.

School of Industrial Engineering

Purdue University, West Lafayette, IN

This form describes a research study, what you may expect if you decide to take part, and important information to help you make your decision. Please read this form carefully.

Being in this study is voluntary – it is your choice. If you join this study, you can change your mind and stop at any time. There are minimal risks from participating in this study

What is the purpose of this study?

The purpose of this study is to further improve the design of health information technology to help assist healthcare professionals coordinate information with one another about their patients.

What will I do if I choose to be in this study?

If you do decide to participate in this study, you will be asked to participate in a 30-minute audio-recorded interview over video-conferencing software (e.g., Skype, FaceTime, WebEx).

How long will I be in the study?

The estimated time to complete the interview is 30-45 minutes.

What are the possible risks or discomforts?

There are minimal risks associated with participation in this study. If you are uncomfortable for any reason and wish to discontinue the interview, you may do so. You are free to stop at any time for whatever reason, and will not be penalized for choosing to end your participation.

Are there any potential benefits?

There are no direct benefits to you beyond the possibility of feeling helpful for contributing to furthering the research in this field.

Will information about me and my participation be kept confidential?

We make every effort to maintain confidentiality to the extent of the law.

Participant demographic information will be hand recorded prior to the start of the audio recording of the interview. This information will be kept in a locked filing cabinet at Purdue University. The audio-recorded interviews will be transcribed after the session and destroyed.

The results of this research study may be presented at meetings or in publications, however, your identity will be kept private. The project's research records may be reviewed by departments at Purdue University responsible for regulatory and research oversight. The details of individual data will not be disclosed to any other people except the researchers (Michelle Jahn and Barrett Caldwell). In the future, the data will be only used for future subsequent studies on evaluation of diabetes care teams only by the authors (Michelle Jahn and Barrett Caldwell).

What are my rights if I take part in this study?

Your participation in this study is voluntary. You may choose not to participate or, if you agree to participate, you can withdraw your participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Who can I contact if I have questions about the study?

If you have questions, comments or concerns about this research project, you can talk to one of the researchers. Please contact the primary investigator, Barrett Caldwell (bscaldwell@purdue.edu or 765-494-5412) or the graduate research assistant, Michelle Jahn (jahnm@purdue.edu or 513-368-8657).

If you have questions about your rights while taking part in the study or have concerns about the treatment of research participants, please call the Human Research Protection Program at (765) 494-5942, email (irb@purdue.edu) or write to:

Human Research Protection Program - Purdue University

Ernest C. Young Hall, Room 1032

155 S. Grant St.,

West Lafayette, IN 47907-2114

APPENDIX P: STUDY III HEALTH IT PROTOTYPES

Version 1 (Used in Pilot Testing for two participants):

- Mobile Application: <https://oku9dh.axshare.com/#c=2>
- Desktop Application: <https://vf8wnf.axshare.com/#c=2>

Version 2 (Used for Participants 1-4):

- Mobile Application: <https://lpl7m0.axshare.com/#c=2>
- Desktop Application: <https://bbuy3v.axshare.com/#c=2>

Version 3 (Used for Participants 5-6):

- Mobile Application: <https://1nld4v.axshare.com/#c=2>
- Desktop Application: <https://bxvvzf.axshare.com/#c=2>

APPENDIX Q: STUDY III QUALITATIVE DATA ATTRIBUTE CODE KEY

Name	Description	Inclusion / Exclusion Criteria
Gender	Participant Identified Gender	N/A
Certifications	Their response to other certifications related to diabetes care	Include specific certifications beyond their license (e.g., CDE but not RN).
Environment	Their response to the type of environment they work in.	Include details that describe the facility purpose and setting (e.g., inpatient, outpatient, pediatric). Include location information of other team members. Do not include details about the processes.
Experience	Their response to the number of years they have been working in that role.	Include residency, but do not include medical school or other years not in that particular role. If they have experience in diabetes care in a slightly different role (e.g., RN versus Charge RN) the experience in years
Patient Interaction	Their response to how frequently they interact with patients.	Include responses related to any type of patient interaction (phone, email, in person).
Health IT Usage	Their response to question 6 on the screener where they are asked about the types of diabetes related health IT they use as well as their response to the background question “please describe how you interaction with health information technology as part of your job”	If participants share additional details in the interview, may include here for diabetes and non-diabetes related health IT Include details if it helps determine the level of health IT comfort/frequency of use

APPENDIX R: STUDY III QUALITATIVE DATA PROCESS CODE KEY

Code Category	Name	Description	Inclusion / Exclusion Criteria
Background	DCT members	Response to “Who are the members of a core diabetes care team”	Include other references to team members after this question as well
	Team coordination	Response to “how do you coordinate tasks and exchange information with members of the diabetes care team”	N/A
Mobile Application Review	Purpose	Participant’s view of the purpose of the app	This does not include comments made after the interviewer provides context and answers questions
	Universal check-in feature	Participant’s perspective of the usefulness of the feature. Organized by facilitators and barriers of implementing the feature	N/A
	Universal messaging feature	Participant’s perspective of the usefulness of the feature. Organized by facilitators and barriers of implementing the feature	N/A
	HIPAA authorization	Participant’s perspective of the usefulness of the feature. Organized by facilitators and barriers of implementing the feature	N/A
	Patient Adoption	Likert scale rating from 1-5 of patient adoption and any facilitators or barriers mentioned with respect to patients	Includes any justification or reasoning for their rating response
	Usability Facilitators	General comments and observations from participant interaction with application related to positive usability findings, using heuristics (Jakob Nielsen, 1995; Zhang et	Includes observations of participants demonstrating good usability through intuitively figuring out the interface and completing tasks.

		al., 2003)	
	Usability Barriers	General comments and observations from participant interaction with application related to negative usability findings, using heuristics (Jakob Nielsen, 1995; Zhang et al., 2003)	Includes observations of participants misunderstanding features of the application or demonstrating poor usability when navigating through the application
	Additional Features	Requests for additional features that are not included in the original software	These requests may be cross-coded with other codes if they relate to one of the features mentioned
Desktop Software	Purpose	Participant's view of the purpose of the software	This does not include comments made after the interviewer provides context and answers questions
	Care Coordination Feature – Overall visits	Participant's perspective of the usefulness of the feature. Organized by facilitators and barriers of implementing the feature	N/A
	Care Coordination Feature – Areas of Expertise	Participant's perspective of the usefulness of the feature. Organized by facilitators and barriers of implementing the feature	N/A
	Care Coordination Feature - Legend	Participant's perspective of the usefulness of the feature. Organized by facilitators and barriers of implementing the feature	N/A
	Universal visits list	Participant's perspective of the usefulness of the feature. Organized by facilitators and barriers of implementing the feature	N/A
	Universal messaging feature	Participant's perspective of the usefulness of the feature. Organized by facilitators and barriers of implementing the feature	N/A
	Alerts	Participant's perspective of the usefulness	N/A

		of the feature. Organized by facilitators and barriers of implementing the feature	
	Provider Acceptance	Likert scale rating from 1-5 of perceived adoption for themselves and other providers	Includes comments related to provider acceptance and adoption mentioned throughout interview, as well as justifications for their ratings responses
	Additional Features	Requests for additional features that are not included in the original software	These requests may be cross-coded with other codes if they relate to one of the features mentioned
	Health IT Integration	Discussion larger health care systems facilitators or barriers with respect to the hypothetical software integration.	N/A

PUBLICATIONS

Journal Publications (Refereed)

1. **Jahn, M.**, Caldwell, B. (2017). “Community Health Integration through Pharmacy Process and Ergonomics Redesign (CHIPPER)” *Ergonomics*, 1-13.
2. **Jahn, M.**, Porter, B.W., Patel, H., Zillich, A.J., Simon, S.R., Russ, A.L. “Usability Assessment of Secure Messaging for Clinical Document Sharing between Healthcare Providers and Patients,” *Applied Clinical Informatics*, (Accepted May, 2018).
3. Russ, A.L., **Jahn, M.**, Patel, H., Porter, B.W., Nguyen, K.A., Zillich, A.J., Linsky, A., Simon, S.R. “Usability Evaluation of a Medication Reconciliation Tool: Embedding Safety Probes to Assess Users' Detection of Medication Discrepancies,” *Journal of Biomedical Informatics*, 82:178-186, 2018.

Conference Publications (Refereed)

1. **Jahn, M.**, Caldwell, B. (2018). “Developing Distributed Expertise Coordination Models of Diabetes Care Teams”. In *Proceedings of the 2018 Human Factors and Ergonomics Society Annual Meeting*, Philadelphia, PA.
2. **Jahn, M.**, Heiden, S., Caldwell, B. (2018). “Identifying Improvement in Healthcare Systems Engineering Models for Chronic Care and Precision Medicine Applications”. In *Proceedings of the 2018 International Symposium on Human Factors and Ergonomics in Health Care*. Boston, MA.
3. Russ, A., **Jahn, M.**, Patel, H., Porter, B., Nguyen, K., Zillich, A., Linsky, A., Simon, S. (2017). “Formative Usability Evaluation of a Novel Tool for Medication Reconciliation”. In *Proceedings of the 2017 Human Factors and Ergonomics Society Annual Meeting*. Austin, TX.

4. Heiden, S., **Jahn, M.**, Caldwell, B. (2017). “Expanding Medication Decision Support in Community Pharmacies without Sacrificing Usability”. In *Proceedings of the 2017 Human Factors and Ergonomics Society Annual Meeting*. Austin, TX.
5. Chui, M., Holden, R., Russ, A., Abraham, O., Srinivas, P., Stone., J., **Jahn, M.**, Ozkaynak, M. (2017). “Panel on Human Factors in Pharmacy”. In *Proceedings of the 2017 Human Factors and Ergonomics Society Annual Meeting*. Austin, TX.
6. **Jahn, M.**, Cox, P., Du, W., Vorvoreanu, M (2015). “Enabling Graduate School Decision-making Through User-Centered Redesign of a Program Website”. In *Proceedings of the 2015 Human Factors and Ergonomics Society Annual Meeting*. Los Angeles, CA, 30 October 2015.
7. **Jahn, M.**, Caldwell, B., Hultgren, K. (2015). Developing Medication Safety Training Applications with Software Patients for Human Teams. In *Proceedings of the 19th Triennial Congress of the International Ergonomics Association*. Melbourne, Australia, 10 August 2015.
8. Balkin, E.A., Kumar, S., Mako, V., **Jahn, M.**, So, J. (2014). Robot-Assisted Surgery and the Nature of Remote Work: Lessons for Medicine From Other Fields. In *Proceedings of the 2014 International Symposium on Human Factors and Ergonomics in Health Care*. Chicago, IL, 17 March 2014.
9. **Jahn, M.**, Rivera-Rodriguez, A.J. (2013). Designing Patient Rooms to Facilitate Patient-Centered Care. In *Proceedings of the 2013 Industrial and Systems Engineering Research Conference*, A. Krishnamurthy and W.K.V. Chan, Eds.
10. **Jahn, M.**, Gombert, J., Rivera-Rodriguez, A.J. (2012). Is Teamwork *Really* that Beneficial in Health Care? In *Proceedings of the 2012 Industrial and Systems Engineering Research Conference*, G. Lim and J.W. Herrmann, Eds.

11. **Jahn, M.**, Lay, J. Walters, D., Gombert, J., Garland, A., Breenan, A., Rivera-Rodriguez, A.J. “Electronic Health Records: The Benefits and Consequences Experienced by Healthcare Providers at a University Health Clinic.” International Symposium on Human Factors and Ergonomics in Health Care. Baltimore, MD, 11 March 2013. Conference Presentation.

Conference Posters

1. **Jahn, M.**, Caldwell, B. (2018, April). Identifying Team Structures & Information Coordination Patterns for Diabetes Care Teams. Poster presented at Purdue University Industrial Engineering Graduate Student Poster Symposium. West Lafayette, IN.
2. **Jahn, M.**, Caldwell, B. (2018, February). Usability Evaluation of Continuous Glucose Monitoring Software. Poster presented at Health and Disease: Science, Technology, Culture, and Policy Research Poster Symposium. West Lafayette, IN.
3. **Jahn, M.**, Bradlau, M., Cheng, L., Caldwell, B. (2016, April). Reducing Gossypiboma: Lessons Learned from Human Factors Research. Poster presented at The International Symposium on Human Factors and Ergonomics in Health Care, San Diego, CA, 15 April 2015. Conference Poster Presentation.
4. **Jahn, M.**, Nguyen, K., Patel, H., Simon, S. Zillich, A., Caldwell, B., Russ, A. (2016, April). Improving Patient-Provider Communication for Medications via Health Information Technology. Poster presented at The Annual Industrial Engineering Graduate Student Organization Poster Symposium, West Lafayette, IN.
5. **Jahn, M.**, Caldwell, Barrett. (2015, April). Evaluation of ScripClip Technology in a University Pharmacy Setting. Poster presented at The Annual Industrial Engineering Graduate Student Organization Poster Symposium, West Lafayette, IN.

6. **Jahn, M.**, Caldwell, Barrett. (2015, April). Improving Patient Safety via Human Factors Engineering and Medication Delivery Simulation. Poster presented at The International Symposium on Human Factors and Ergonomics in Health Care, Baltimore, MD, 28 April 2015. Conference Poster Presentation.

7. **Jahn, M.**, Gombert, J., Jahn, M., Lay, J., Walters, D. & Rivera-Rodriguez, A. (2013, April). Electronic Health Records: The Benefits and Consequences Experienced by Healthcare Providers at a University Clinic. Poster presented at The Annual Focus on Creative Inquiry (FoCI) Poster Forum, Clemson, SC.

8. **Jahn, M.**, Hays, B., Michels, E., Roque, L., Jordan, K., Madathil, K. (2013, April). Nutra Manufacturing: Costing Model Improvement. Poster presented at The Annual Focus on Creative Inquiry (FoCI) Poster Forum, Clemson, SC.