Discordant Chronic Comorbidities: Final Paper Outline

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ABSTRACT
Abstract goes here.

Categories and Subject Descriptors
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General Terms
Theory

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ACM proceedings, LaTeX, text tagging

1. ABSTRACT
Discordant Chronic Comorbidities (DCCs), or the presence of two or more chronic illnesses with opposing treatment instructions in a patient, can make it difficult for patients and healthcare providers to prioritize and manage the treatment of each individual disease. Some difficulties that arise from having DCCs include seeing multiple health care providers, medication conflicts, social and familial dependencies, etc. This research seeks to understand the hardships that patients with DCCs face in managing their health. Furthermore, this research aims to create an intervention that will effectively support these patients to manage their health. This study focused on 16 patients with DCCs, all of whom had Type 2 Diabetes: 1 from South Indiana, 1 from Illinois, and 14 from Bloomington, IN. During the interview, the patients answered a structured questionnaire and were engaged in a photo elicitation task where they described objects and aspects of their lives that either support or stifle their health management. This study used mixed methods to investigate how these patients manage their health. A qualitative analysis of the content from the patients' interviews revealed themes that will be used to create an appropriate intervention.

- Add results, conclusions, and implications to abstract

2. INTRODUCTION
Chronic conditions, or conditions lasting five or more months, are becoming increasingly common in patients. These conditions typically require patients to play an active role in managing their own conditions due to the length of time patients are living with a condition. Due to the difficult nature of many conditions, this often leads to poor management of the disease, which in turn can often lead to patients developing other chronic diseases. The development of discordant chronic comorbidities, or multiple chronic conditions with unique and often opposing treatment instructions has become increasingly common, with XXX percent of patients with Type 2 Diabetes having one or more additional chronic conditions. Despite the increased numbers of patients with discordant chronic comorbidities, there is a lack of studies on these patients as well as a lack of tools to aid individuals with comorbidities in managing their conditions. In this study we aim to develop a tool to help individuals with discordant chronic comorbidities better manage their overall health and well being.

The challenge in studying patients with comorbidities often arises from their compounding health issues, which often leaves these patients sicker and spending more time in hospital and clinical environments. This presents a unique challenge in understanding the barriers to successful self-management of their diseases as well as discovering what tools would potentially be useful in improving their self-management skills. As there are few papers on patients or tools for patients with chronic comorbidities, we looked for papers focusing on patients with Type 2 Diabetes, multimorbidities, self-management, medication management, and apps to help manage diseases. These papers allowed us to identify the need for studies focusing on patients with chronic comorbidities, as well as the need to look at designing technology to effectively support patients with chronic comorbidities in managing their diseases. We also identified the need to develop technology that aids with other aspects of self-management in addition to medication management, as most mobile applications on the market focus exclusively on medication management while ignoring other aspects of chronic disease treatment management.

By studying patients with discordant chronic comorbidities, and specifically focusing on patients with Type 2 Diabetes and other chronic conditions, we were able to develop a tool

to help patients better manage their chronic conditions. We also discovered the primary barriers these patients face when it comes to managing their treatment, and the solutions they have developed to address the needs of their conditions. In this paper, we make three primary contributions, the first of which is the study and collection of data from patients with discordant chronic comorbidities. Our second contribution is identifying the barriers faced by patients with chronic comorbidities in successfully managing their conditions. Our third contribution is represented by the tool we have developed to help patients manage their conditions.

3. RELATED WORK

As chronic conditions become increasingly prevalent among patients, a plethora of studies have been done examining the impact of chronic conditions, how patients manage a chronic condition, and focusing on technology developed for patients with a single chronic condition. However, few studies [w4:recommended to reword 'have been done']have focused on patients with multimorbidities or comorbidities, which are two or more chronic conditions, and almost no studies have looked at patients with discordant comorbidities, which are chronic conditions with opposing treatment instructions. Due to the inadequate amount of research on discordant comorbidities, we pulled information focusing on a variety of similar topics including diabetes, multimorbidities, self-management, medication management and adherence, and mobile applications. [w4:recommended to explain relevance of related work]By studying these areas, the researchers were able to identify ideas and processes used in the treatment of single chronic conditions, which can serve as the basis for developing technology designed to suit the more complex need of patients with discordant chronic comorbidities .

3.1 Diabetes

Several studies have explored the process of managing Type 2 Diabetes, and the different aspects of managing the condition. An [w4:add an apostrophe]individual's ability to successfully manage diabetes has several components at play, including their ability to adhere to treatment regiments, their attitudes and beliefs towards their disease and treatment regiment, their knowledge of the condition, their ethnicity and culture, their language ability, their financial resources, other comorbidities they may have, and their social support system [21]. These factors are similar to many of the challenges faced by patients with other chronic conditions, and can be used to determine the likelihood of an individual being able to successfully manage a single chronic condition.

Another explored field is the use of mobile applications in managing Type 2 Diabetes. While overall patients found diabetes management applications to be useful tools, the vast majority stopped using the app after a few weeks. Common reasons for stopping were that the app produced negative emotions, especially after entering what was perceived to be a negative value, and that the app was too much work and not worth the amount of time required to properly use it [14].

3.2 Multimorbidities

Multimorbidity, the presence of two or more chronic illnesses in an individual, can create difficulties in managing and treating these illnesses. Bayliss et al. [1] found 15 primary challenges faced by individuals with multimorbidities which were the compound effect of multiple conditions, physical limitations, the compound effect of medications, the challenge of coordinating multiple medications, the burden of taking multiple medications, side effects of medications, lack of knowledge about their conditions, financial constraints, low self-efficacy, the burden of the dominant effect of one condition, the emotional impact of having chronic conditions, inadequate communication with health care providers, the need for social support, logistical issues, and the need to better understand their conditions. This combination of challenges makes the management of multiple conditions more difficult, but also leads to patients with multimorbidities being more willing to learn self-management strategies to aid them in successfully managing their conditions, and being more willing to see non-physician medical professionals such as nurses, chiropractors, nutritionists, physicians assistants, or others to supplement their care [24]. Multimorbidities can make other aspects of managing care more difficult than if a patient only had one chronic condition, such as managing medications. Doyle et al. [6] found that in order to encourage patients with multimorbidities to use a long-term medication management application, the app had to have the ability to create medication lists, educate users about their different medications, manage changing medications, and support individuals in scheduling and taking medications as prescribed.

Multimorbidity is increasingly prevalent in patients with diabetes, with several studies looking at the frequency of patients with diabetes and other multimorbidities. Teljeur et al. [29] found that 90% of patients with diabetes had at least one additional chronic condition, and more than one-fourth had more than 4 additional chronic conditions. Studies have also found that the number of chronic conditions an individual has increases with their age [10], and that these patients with multiple other chronic conditions in addition to diabetes typically placed a lower priority on their diabetes, as other conditions were more intensive, resulting in these patients often being unsuccessful in managing their diabetes [15]. This leads to patients with diabetes receiving lower quality medical care for discordant conditions, due in part to the limited amount of time during visits with health care providers to address all concerns they may have. However, in situations where patients are able to maintain e-mail or phone correspondence with providers in between regular appointments, patients with and without multimorbidities experienced the same standard of care as these alternative communication channels with health care providers were able to fill in the care gaps and circumvent time constraints during appointments [27].

3.3 Self-Management

Self-management is the process of empowering patients with the knowledge, skills, and tools to facilitate self-care, and to encourage them to be an active participant in the treatment of their conditions. For patients with chronic conditions, self-management is a necessary aspect of their care to ensure that they are taken care of, even when not frequently seeing a doctor. Self-management relies on the needs, goals,

and life experiences of patients with chronic conditions to improve clinical outcomes, health statistics, and their quality of life [8]. Self-management often involves the collaborative health care model, where patients work with their health care providers to manage and treat their diseases. It also often focuses on holistic outcomes, including a [w4:add an apostrophe]patient's physiology, symptoms, physical and emotional functions, their personal health perceptions, and their quality of life [17]. Self-management can be broken into three main components - medical management of the condition(s), creating and maintaining new behaviors or routines, and dealing with the emotional impact of having a chronic condition. In order to successfully manage each of these components, patients need to learn skills such as problem solving, decision making, how to find and utilize resources, how to form partnerships with their health care providers, and how to take action to improve their health [18].

Several studies have explored the benefits of self-management, specifically for patients with one or more chronic conditions. When studying diabetes patients in an intensive treatment and education program, Polonsky et al. [28] found that compared with individuals in a standard diabetes treatment program, those in the intensive treatment and education program experienced a greater drop in their A1c, monitored their blood-glucose levels more frequently, paid more attention to the carbohydrate and fat-contents of food, and overall had better glycemic control. Patients in intensive self-management educational programs typically had increased levels of exercise and fewer uses of health services such as extra doctors visits or hospital stays, which contributes to lowered health care costs and higher quality of life for patients [19]. In addition, patients with self-management skills are more likely to know how to research and find information, which leads to a better understanding of their disease and treatment options, which can be especially helpful for patients who are unable to treat their conditions using the standard treatment options [20].

There are several barriers to successful self-management which are preventing patients from successfully managing their conditions. Bodenheimer et al. [3] found that the lack of trained personnel, the lack of funds for self-management education, and the current medical model, which leaves patients dependent on physicians, prevents many individuals from learning to self-manage their conditions. Financial worries, lack of awareness to self-management education programs, lack of physician or family support, and pain also prevent many patients from being able to successfully self-manage their conditions [13].

3.4 Medication Management and Adherence

For many patients with multimorbidities, managing multiple medications is a crucial part of successful self-management of their disease. When it comes to managing medications, the biggest concerns of patients are the ability to obtain reliable information on medications, maintaining autonomy when it comes to medication and treatment decisions, concerns about polypharmacy, discrepancies between traditional and alternative medical therapies and treatments, and the challenge of coordinating medications lists and health records between multiple health care providers [11].

For patients with Diabetes, medication adherence is an important aspect of treatment. Nkansah et al. [23] found that diabetes patients who managed their medications with the assistance of a pharmacist had improved glycemic control, were more likely to maintain their desired weights, and were more likely to reach their blood pressure goals. Electronic monitoring systems, such as those used to monitor insulin use in diabetics, have been shown to improve medication adherence as they can help patients easily monitor blood sugar levels and identify when they need to take more insulin, as well as aid health care providers in identifying patients who need more support [5]. In studying various methods to find the best medication management system, Granger et al. [9] found that the integration of in-person contacts with electronic monitoring systems, technology based medication reminders, and pharmaceutical database monitoring improved medication adherence and resulted in a positive impact on overall patient outcomes.

3.5 Mobile Applications and Technology

Recent studies have looked extensively at mobile applications as a tool to aid with the management of chronic diseases. Apps are useful for many individuals to aid them with tracking medications and numbers such as glucose scores, but Owen et al. [25] found that apps were more helpful for individuals who were changing their routines or experienced high fluctuations in glucose scores than for stable individuals as the ability to correlate glucose scores to daily activities was useful in understanding their scores and developing healthy habits. This often leads users to use only the features of the app that they find useful, especially if they have other monitoring methods that they don't want to change, which leads patients to interpret data in a non-clinical manner as they don't store all their data in the same place [12]. In studying ways to encourage consistent interpretation of data, Pernencar et al. [26] found that wearable sensors with connected mobile apps captured clearer statistics which encouraged the user to take an active role in managing their health by providing them the tools to consistently interpret and evaluate different aspects of their health.

4. METHODS

This study was aimed at unveiling the needs, resources, support measures and health care goals required to effectively support DCCs patients manage their health. This section describes the aim of the study and research questions, participants recruitment, study design, data collection and data analysis procedures used.

4.1 Related Work

As a first step to understand type 2 diabetes patients with discordant chronic comorbidities, a collection of about 40 papers about previous research done in the area were read. In order find the right materials, key words such as diabetes, medication management, self management, multimorbidity, and comorbidity were used for a search in Google Scholars. These searches resulted in finding some useful articles. After finding some useful articles, we also created citation trees. Making use of backward and forward references from Doyle et al. [6], for example, lead to finding more useful articles.

4.2 Aim of Study and Research Questions

The presence of discordant chronic comorbidities (DCCs) with a higher symptom burden than an index disease (Type 2 diabetes) is likely to have a negative impact on the management of both index disease and other conditions a patient may have. Patients with DCCs face many challenges when trying to meet the recommended treatment goals. Thus, in order to support and empower them, we seek to understand appropriate design intervention based on their needs, experiences and their health care providers' recommendations. The purpose of this study was, therefore, to understand patients' perspectives on how DCCs impact the management of type 2 diabetes and was guided and supported by the following investigative major and specific research questions: RQ1; How do discordant chronic comorbidities impact the management of type 2 diabetes? RQ2; How do patients prioritize the management of type 2 diabetes and other DCCs that they may have? RQ3; How can technology be used to support and/or empower DCCs patients to effectively manage their conditions?

4.3 Participant Selection

Participants were recruited for this study through our contacts, by face-to-face interaction, use of flyers and local connections. We used purposive sampling strategy to recruit patients who met the following criterion: i) were between the ages of 25-65-we chose this age group in order to eliminate young participants who are still depending on their parents for medical decision or older adults who may be assisted living facilities; ii) expressed an interest in the study and were willing to take photographs and participate in interviews and iii) self-reported to being type 2 diabetic and had at least one additional chronic condition such as arthritis, body joint pain, or depression. Patients who had limited consent capabilities and major communication problems were excluded from the study. Participants were provided with an overview of the study and assurance of confidentiality. Written consent was obtained from participants prior to the commencement of the study; participants received compensation of 15 dollars for participating in the study. All participants had the option of reading the consent form or having it read and explained to them; our study was approved by institutional review board (IRB). A total of 16 patients were invited to participate in the study. Five of them identified themselves as males, and nine as females. One participant identified as gender-fluid, and another participant identified as agender. Ages broke down as 25-34 years old: N=5, 35-44: N=1, 45-54=7, 55-59: N=2 and 60-65: N=1. 15 participants completed the study, and 1 was unable to continue with the photo taking activity after filling out the questionnaire due to medical complications.

4.4 Study Design

In this study, we met with participants two times. In the first meeting, we met participants for approximately one hour to obtain their consent, fill out a questionnaire and give directions for the photo elicitation activity. The participants were also briefed on how to use cameras and safety tips on taking photographs in the community. Participants without smartphones were given disposable cameras in this meeting. Participants were asked to take at least 20 photographs over a 2-week period, of which some should reflect positive aspects of their lives, some negative or challenging aspects and others items that they normally use to manage their conditions including resources they usually consult. We provided minimal instructions to ensure that participants exercise control over what to shoot and what to narrate about the photographs in a manner representative of their experience. As to the participants who did not have their own smartphone, we met with them to collect the disposable camera that we provided approximately 24-48 hours before the second meeting.

In a second meeting, we met for 60-90 minutes to review a participant photos and asked participants questions about the photos and debrief them and brainstormed ideas not covered in the photos. The meeting was conducted in a quiet and safe place most convenient for participants, with participants presenting the photos and narrating their meaning to the interviewer. We asked general questions such as "Why did you take that picture?" or "Can you tell me more about this picture?" or "How does the item in this picture help you or discourage you from managing your condition?" All interviews were audio recorded and verbally transcribed for analysis.

4.5 Qualitative Methodologies

In this study, a mixed method approach was adopted to investigate how DCCs patients prioritize the treatment and management of their health. Structured questionnaire/survey and photo elicitation interviews were used to gain a deeper understanding of patients' needs, support measures, health care goals and resources required to effectively support DCCs patients to manage their health. Surveys helped foster descriptions and insights of participants' perspectives, views and behaviours towards the treatment and management of type 2 diabetes and other DCCs [22]. Photo Elicitation Interviews (PEI) was used as an interview process in which the participants and researchers discussed participants' photographs together; the participants' photographs acted as "conduits to narratives" which elicit significant experience from the participants' point of view [16]. PEI gave the researchers an opportunity to uncover underlying aspects from participants' lives through interviews and their expressions when using photos. PEI also gave participants an opportunity to elaborate on their responses and share further their experiences.

4.6 Data Coding and Analysis

Exploratory data analysis alongside ranking and scoring [4] was used to analyze the surveys' data. Sets of patients' options, strategies, and/or opinions were categorized and ranked in groups and clusters for easy interpretation and coding. Qualitative content analysis was also used in order to guide the description of both verbal and visual data from photo elicitation interviews [7]. Data codes were identified and categories were created as they emerged. This method helped capture the patients' needs, treatment practices, behaviours, and resources they normally use to manage their health. The analysis process involved reviewing interview questions with photographs to understand the data in context and coding alongside the respective transcripts. **[w4:Reviewer recommended to explain better the citations] Benjamin et al. [2] adopted a similar strategy when he used open coding to extract themes from the participants' transcribed interviews.**

For each interview with participants, the researchers listened to the audio recording to review the session, including the photographs discussed with each participant, field notes, and reflection of brainstorming session. Each photograph was numbered and marked based on the order it was discussed and its relevance to participants. Both typed transcription of individual interviews and associated photographs were used as the raw data for creating standard themes using affinity diagrams. The themes were iterated on several times through discussion and exchanges of analytical notes between researchers until the themes reached a point of saturation.**[w4:Reviewer recommended to explain better the citations] Benjamin et al. [2] took a similar approach by reanalyzing the data and revisiting the themes until there were no more emergent themes.**

5. FINDINGS

After a thorough qualitative analysis of the DCC's patients' interviews, the major themes that emerged can be organized into barriers that these patients have, and strategies they used to cope with such barriers.

One major concern faced by DCC's patients is the lack of communication among the medical providers whom they see and the resulting problems such as contradicting medications, diets, etc. DCC's patients feel that their medical providers prescribe them medications and treatments without considering other medication and treatments prescribed by the other providers. In the words of a patient *"Okay, so I'm talking to my kidney doctor, and he sees... he goes, 'Why are you taking B-vitamin? And cinnamon?' And I go, 'Well, my diabetic... He suggested that I take this.' 'Oh, you don't need that,' you know? He's going based on what his labs say, you know? 'You don't need that. That's not going to help.' And then you go, 'Oh... okay!'"* DCCs13?. Many of the patients interviewed mentioned lack of communication among medical providers as a concern in one way or another. As the same patient pointed out *"You know? But your diabetic doctor's not going to prescribe insulin based on your kidney schedule..."* -DCCs13?. One strategy used by some patients is carrying a list of the medications they take every time they go to the doctor, that way the provider is aware and can prescribe a new medication, if needed, that does not conflict with the ones the patient is currently taking. However, other patient do not take such initiative. There is not an emergent solution that solves this problem, but a suggestion for future work is an online portal for synced records between all medical providers that patients see.

Another major issue that emerged is polypharmacy and drugs impacting other conditions. Some DCC's patients do not get all their medications from the same pharmacy, and thus, pharmacists are not always aware of other medications the patients are currently taking, which results in the pharmacists not been able to flag possible drug conflicts. Patients often rely on pharmacists to know if they are giving the right medication, as a patient explains *"but I do trust the pharmacists, because they caught it. And so, that's why we have those 2 levels, we have doctors who prescribe and pharmacists who make sure what the doctor's prescribing is good."* -DCCs9?. Thus patients who use multiple pharmacies often end up having more complications that they already have because the new drugs conflict the old ones. A strategy that patients use to cope with this issue is reading medication reviews, which inform them of possible conflicts. Again, not all patients take the initiative of finding helpful medication reviews. The solution mentioned about synced records, if extended to pharmacies patients use, can solve the issues that arise from polypharmacy such as conflicting drugs.

Another problem that emerged from the analysis is prioritizing illnesses and treatments. Patients with multiple chronic conditions often have to follow specific diets, exercise routines, regimes medications, and other treatment protocols. However, in many cases patients find themselves unable to follow a diabetes diet and a dialyses diet, for instance. In the words of a patient, *"But on a renal diet, you have to look at the vegetables and say, 'Oh. I cannot have raw spinach. You know, I have to limit raw spinach.' But, you know, diabetic doctors: 'Oh! Eat a big spinach!'"* -DCCsP13?. In many cases like this, patients are faced with a decision to make, a decision that results on favoring one condition while disfavoring others. A strategy that patients often use to help them make such decisions is finding reliable information. They seek advises from peers, medical sources. DCC's patients frequently also have medical support from case managers or health coaches who help them make decide how to prioritize their treatments. For example, *"My health coach handles swimming and exercising, and anything to do with my health. My case manager is there so for example my son wants to move out, well what's available to him or if I couldn't get to the grocery store I needed to get there my case manager take me. Or she could take me to the doctor."* -DCCsP3?. DCC's patients have access to reliable information, they just have to know where and how to find it.

An additional barrier that many patients with discordant chronic comorbidities faced was coping with their vulnerabilities and dealing with the mental implications of having multiple chronic conditions and the impact they have on an individual's life. For many patients each condition has its own set of difficulties to contend with, and varying mental and physical limitations which a patient must learn to overcome. Many patients discuss the need to come to terms with an altered life view, and the importance of realizing the impact that chronic conditions will have on one's life. Patient 9 discussed how *"...the sooner [patients] realize that it's a full time job and you are gonna have to dedicate so much time to controlling it. The faster you realize that, the faster you can do it and the faster you can take control of your health."* -DCCsP9. Once patients come to terms with their new lives, it it important that they find ways to reach a sense of normalcy within their new realities in order to be able to successfully manage their chronic conditions.

One thing patients often do to help them adjust and thrive in their new life styles is establishing and maintaining various support networks. For most patients, there support networks have multiple components and can include friends and family, social networks, other patients with similar conditions, online support groups, and the support of their medical network. Friends and family help to provide a patient with emotional support in understanding their conditions, physical support in maintaining their independence and ability to complete daily tasks, and support in adhering to a medication or treatment regimen. Social networks have

the ability to provide patients with a distraction from their conditions, and a way to focus on something else such as crafting or video games. For some this network can intersect with their network of other patients who they turn to for treatment advice and support in understanding the difficulties of living with chronic illnesses, such as Participant 11, who when discussing their knitting group said, *"So, a lot of the people I knit with, the vast majority of them are women. About half of them also do have other forms of anxiety or depression. So, I can kind of commiserate with them. We can talk about, you know, things that have been frustrating for us in the last week. Sometimes, I talk to them about some frustrations I've been having with schoolwork or just work, and they can kind of empathize with that. Sometimes, they rant and I listen."* -DCCsP11. Groups that intersect multiple types of support often allow patients to find support in others who can understand the challenges of their specific conditions, as well as help them to realize that they are not alone in facing the challenges associated with their conditions. It is also important for patients to develop a medical support network, which is often comprised of medical professionals other than their physicians, such as therapists, health coaches, pharmacists, and other who can help patients develop skills to manage the treatment of their chronic conditions. Developing this network is a crucial part of a patient being able to successfully manage and prioritize the treatment of their chronic conditions, as this network can help to provide advice, serve as a resource and source of reliable information, and help a patient to determine strategies that they can use to better manage their conditions. A strong medical support network, in combination with other networks of friends and family, social networks, and other patients can help to provide a patient with the emotional, physical, and informational support that they need to successfully manage their discordant chronic comorbidities.

Another strategy that many patients use to help them adjust to their new lives is learning how to adhere to the non clinical aspects of their treatment, such as diet, exercise, or monitoring their conditions. Many chronic conditions require patients to change their diet and exercise in order to improve their overall health, such as Type 2 Diabetes. This can be a difficult transition for many patients, as it may require them to learn new skills such as limiting the amount of a type of food they eat or tracking the number of carbohydrates they eat in a day. Once patients area able to find the diet and type of exercise that they enjoy and that fits in their daily lives, they often begin to see health benefits such as weight loss, lower blood pressure, or a reduction in symptoms. While the rewards are high, it is often difficult for patients to make this transition and learn how to eat healthier and exercise. While doing this, patients also often have to become accustomed to monitoring their symptoms in order to help manage and understand their disease. For Type 2 Diabetics this often takes the form of monitoring one's blood sugar, which typically involves a patient sticking themselves in order to record their glucose levels. It can be difficult for some patients to get into the routine of watching what they eat, exercising, and monitoring their glucose levels. Once a patient is able to get into this routine, they are often able to better manage their conditions and better handle any medical situations that may arise. Incorporating non-clinical aspects of treatment such as diet and exercise are an important part of a patient adjusting to their new lives, and can help patients learn to manage and prioritize the treatment of their discordant chronic conditions.

An additional barrier that many patients face in successfully managing and prioritizing the treatment of their discordant chronic comorbidities is the financial difficulties that are associated to treating multiple chronic conditions. While clinical costs from seeing multiple health care providers or taking multiple medications are often at least partially covered by a patients insurance, many fear that if their insurance coverage is changed that they may no longer be able to afford all of the medications in the amount that they need. This can lead some worried patients to not take medication as prescribed, such as Participant 9, who cited concern that she may lose her insurance coverage as a reason for *"...trying to stockpile all of my supplies. I use infusion sets and cartridges longer than I should. I try to use less insulin, I refill my insulin as soon as possible."* -DCCsP9. This can often lead to complications, which can often lead to increased hospitalization and costs. In addition, patients also often have to worry about the costs of non-clinical aspects of their treatment, such as the cost of a gym membership, the higher prices of healthy food, or transportation to medical appointments. Concerns over the financial aspects of their treatment can often deter a patient from trying new treatments, and can prevent them from successfully managing their conditions. While patients were not able to provide any potential solutions for this challenge, it is important to recognize it and keep it in mind as a significant challenge patients with discordant chronic comorbidities must overcome.

6. DISCUSSION

At the conclusion of the qualitative analysis of the interviews with patients with discordant chronic comorbidities, a major point that emerged as intertwined with all of our themes was the compounding effect of multiple chronic conditions. Almost all patients interviewed discussed the impact one chronic condition had on other conditions, and how poor management of one condition can often lead to the development of another condition. Many patients also discussed the difficulties of managing one condition due to the impact of another, for example multiple patients with chronic pain sighted that condition as a reason they struggled to manage their diabetes, as the pain made it difficult or impossible to create exercise regimens as recommended by their providers. Having multiple chronic conditions also can make other aspects of managing the conditions more difficult. While many problems presented by patients with discordant chronic comorbidities, such as polypharmacy and adjusting ones lifestyle according to the impacts of a chronic disease, are also experienced by patients with a single chronic condition, the effects are often magnified by the presence of multiple chronic conditions. This magnification of impacts caused by the compounding effect of having multiple chronic conditions is important to keep in mind, as it serves as the driving force behind patients strategies for managing and prioritizing the treatment of their discordant chronic comorbidities.

In future work, it is important to keep the compounding effect of multiple conditions in mind when considering designing technologies to help patients manage and prioritize

the treatment of their discordant chronic comorbidities. Our next steps for this research are to conduct a participatory design study to begin developing technology for patients, with insight from health care providers. The population of patients with discordant chronic comorbidities is continuing to grow, and as it does it continues to be important to study this population and design technologies that allows them to manage their treatment, while keeping the compounding effects of their multiple conditions in mind.

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