

Translating a DC³ Model into a Conceptual Tool (DCCs Ecosystem): A case Study with a Design Team

Tom Ongwere¹, Erik Stolterman², Patrick. C Shih², Clawson, James², and Kay Connelly²

¹ University of Dayton

² Indiana University Bloomington

tongwere1@udayton.edu

{estolter, patshih, clawson, connelly }@udayton.edu

Abstract. In this paper, we draw inspiration from the Discordant Chronic Comorbidity Care (DC³) model. The model recognizes the complexities of DCCs and incorporates key strategies for assessing and addressing the complexities of DCCs care. We worked with user experience design experts over several design sprints to come up with a conceptual design. It became clear early on that because of the changing DCCs care needs, there is no one-size-fits-all solution for DCCs needs. Thus, the effective care of DCCs requires a holistic approach. The holistic approach involves designers collecting multiple individual tools and mapping those tools to specific needs for DCC care and treatment, which ultimately results in the creation of an ecosystem. We discussed how this ecosystem may be optimized and personalized using machine learning to address individual DCCs needs. Furthermore, putting together these multiple sets of tools could introduce an engineering challenge. We provide strategies and recommendations for future work to address these engineering challenges and how to make a theoretical concept adaptable to technology.

Keywords: Discordant chronic comorbidities · Designing with experts · Design sprints.

1 Introduction

Patients with complex needs face many challenges, such as Discordant Chronic Condition (DCCs). DCCs have unrelated or contradicting care and treatment plans, for example, depression, arthritis, or end-stage renal disease is discordant to type-2 diabetes [23]. Type-2 diabetes is often co-occurring with DCCs [22]. Thus, the effective DCCs treatment involves treating the primary condition (Type-2 diabetes) plus varied concurrent conditions (i.e., arthritis, depression, or both) and mitigating the risks of developing additional conditions or severe symptoms [10, 22, 2]. In this situation, every new development in a patient's health, a new disease, treatment, or procedure often leads to new conflicts. Like single chronic diseases, effective treatment of DCCs may require prioritizing and

making trade-offs. However, these treatment plans are more complex for patients with type-2 diabetes and DCCs. There may be single chronic conditions that portray characteristics similar to DCCs, (i.e., cancer or Parkinson’s) by requiring individualized treatment plans, coordination of multiple providers, and consultation of multiple resources, however, these conditions often have a defined disease trajectory and may present fewer challenges than the DCCs.

Recently, a plethora of models, systems, mobile apps, and linked devices have become available to help individuals manage comorbidities [29, 7, 13, 8]. However, these tools, theories, and models are targeted to a specific goal or disease and are therefore unable to adapt as a user’s disease needs evolve over time or alter with context [20].

In this study, we worked with a design team over several design sprints (sessions) to design for complex and dynamic patient needs, especially for the patient who has DCCs. To do this, we draw inspiration from the Discordant Chronic Comorbidity Care (DC³) model [redacted for anonymity] that recognizes the complexities of DCCs care and incorporates key strategies for i) assessing and addressing DCCs care, ii) adapting to an individual’s varying goals and needs, and iii) working closely with healthcare providers who understand the disease and the patients who are living with DCCs.

We provide three main contributions in this paper: i) we show a case study of how to use design sprints in a complex design context (the case study can be a model for future studies), ii) we propose an ecosystem that seeks to address the challenges of managing DCCs, and iii) we discuss strategies to further optimize and standardize the proposed ecosystem to better address the complexities of DCCs care.

2 Background

In this section, we discuss theories and models relevant to multiple chronic conditions care. We also, present an overview of tools suggested by DC³ model for DCCs care and support.

2.1 Theories and models in multiple chronic disease care

In Human-Computer Interaction, Personal Informatics, and healthcare, models and theories are being used to guide people in i) deciding what information to gather, ii) deciding what tools to use, iii) discerning what needs are pertinent, and iv) participating in shared decisions. For example, Hayes et al. [5] show how cancer patients’ physical and emotional needs evolve as cancer progresses over time. The journey care framework depicts the responsibilities, challenges, and personal impacts that patients face while transitioning from diagnosis through post-treatment survivorship [8]. These models have consequently informed the design of decision aids to assist patients in difficult decisions [7, 8], and support clinicians in including patient preferences into illness management [7, 14].

Further, theories and their applications are used in interventions targeting behavioral risk factors (e.g. smoking, [24]), encouraging health-protective behaviors (e.g., health screening, [3]), and improving adaptation to chronic and acute illness (e.g., adherence to medical advice, [17]), addressing clinical problems including depression [1], diabetes management [13], and other behaviors). These models and theories, and interventions that implement these models and theories show that specific strategies or constructs may work for one group of people while another strategy works for other populations. However, these studies do not account for patients with DCCs who have multiple and interacting experiences. These multiple and interacting experiences is the topic of this paper.

There are systems looking to address multiple needs. For instance, Health-Kits are being used to help people with multiple conditions to use different tools to navigate their situation. Health-Kits can interface with many care systems, however, they are unable to resolve conflicts that you often find in DCCs and it is usually static configuration and does not evolve over time as DCCs would require. The second consideration is a multi-component application for comorbidity support [27]. However, a multi-component system is limited to specific integrated interventions, which limits the ability of the patient with DCCs to choose tools appropriate for their care needs.

2.2 DC³ model and tools

In our prior work, we explored the patients' perspectives [18, 20] and providers' perspectives [19] and proposed a conceptual care model (DC³) [21]. The DC³ model suggested tools to support patients with DCCs in every stage of management (i.e., information comprehension, treatment plan decision making, and treatment plan implementation). They include tools: for a single-stage, to transition between care stages, to simplify complexities, and to coordinate multiple healthcare providers.

– *Tools for a single stage*

We suggested tools to be used in a single stage to help patients organize information across multiple conditions instead of focusing on a single condition or type of data. For example, tools that help patients collect all of the different treatment recommendations made by their various providers and evaluate them simultaneously and tools to help patients track their progress for the entire plan and not just individual components.

– *Tools for transitions between stages*

We suggested tools that help patients transition from one stage to the next, including tools that help patients quickly communicate with all providers and adjust the plan, without a patient having to wait days or weeks to see their various providers. We also included tools to support patients in recording any potentially relevant information and to support providers in filtering that information into the most urgent and relevant items of information.

- *Tools to simplify the complexity.*

We suggested tools to simplify complexity in care, such as, tools that help patients break down larger treatment goals into smaller, achievable tasks reflecting the patient’s capabilities. We also suggested tools that support patients and providers in recording, reviewing, and starting/stopping treatment plans.

- *Tools for coordinating with multiple providers.*

We suggested tools for supporting multiple healthcare providers and patients to collaboratively digest and process new information, as well as seek professional verification of the new information. Additionally, we suggested tools that can help patients navigate conflicting advice and prioritize different aspects of their treatment plans. Finally, we also suggested tools that provide an overview of the patient’s severe symptoms resulting from multiple interacting chronic conditions as well as progressive symptoms that may become problematic at a later time.

In this paper, we take these suggestions and engage a team of professional designers/design experts through design sprints to design for the multiple and interacting experiences of DCCs.

3 Methods

This section describes three design sprints to produce ideas and a conceptual tool to support patients with DCCs in prioritizing their care and communicating with multiple providers. These design sprints were guided by the following two design questions(DQs):

- **(DQ 1)** How might a patient use this conceptual design idea to set goals and navigate their situation during the time of crisis, during times of change, and when symptoms are stable? and
- **(DQ 2)** If implemented, will this design help a patient prioritize their treatment and communicate with their multiple healthcare providers?

In our prior research [18, 20, 19], we explored the following: i) how technology might help patients with DCCs to prioritize their treatment and communicate with multiple healthcare providers, ii) how designs might help patients with DCCs set goals and navigate their situation during the time of crisis and change, and when their symptoms are stable, and iii) how we might present and foster interaction with a tool that allows patients with DCCs to do this prioritization and goal setting, and iv) what patients’ experiences with a tool may be like.

We are using these findings to explore the DCCs design space and to supplement these research questions, we are introducing two specific design questions **(DQ 1 and DQ 2)**.

3.1 A case Study

To answer our research question and design questions, we used the Design Sprint technique to engage the design experts. The idea of design sprints was first introduced by "Google Ventures" to tackle critical business problems and design viable solutions within five days [16]. A Design Sprint often consists of five stages, which include: i) understand, ii) diverge, iii) decide, iv) prototype and v) validate. [26]. Because of limited resources in this study (we did not have full time engineers to build prototypes), we set out to complete the first three stages. In the first Design Sprint (understand), we focused on introducing participants to the care needs of patients with DCCs and creating a journey map of patients' actions. A journey map is a visualization of the process that a person goes through in order to accomplish a goal [6]. In the second Design Sprint (diverge), we explored several potential design strategies and tools for DCCs care and support. We then narrowed our focus and explored a conceptual ecosystem in the third Design Sprint (decide). Each subsequent Design Sprint was dependent on the activities of the previous Design Sprint. Below we discuss these activities in further detail.

Design Sprint 1, has two parts, part A and part B. The purpose of the Design Sprint 1, part A, was to introduce the participants to the challenges of supporting and caring for patients with DCCs. The session started with an ice breaker, where participants briefly introduced themselves and talked about what their day in life is like. This was followed by the researcher giving a brief presentation about the DCCs challenges that need to be addressed through design. In the presentation, the researcher also presented the design opportunities that included tools that support patients with DCCs in every stage of their care (**see Background section for details**). After the presentation, the researcher asked the participants to read through the patient scenario that demonstrates the daily life of a patient with DCCs (**see below**).

In the Sprint 1, Part B, the researcher began the session by reviewing themes from Design Sprint 1, Part A. The researcher used the patient's scenario to reflect and solicit comments from participants. The participants then created a journey map showing how the patient and providers interacted in the study scenario. The researcher led a discussion about the features of the journey maps that stood out.

Design Sprint 2 started by the researcher reminding participants of the ideas generated in the Design Sprint 1 and ensuring everyone had a common understanding and focus of the study. The participants then brainstormed design ideas for a conceptual tool, filtered those ideas, and mapped the ideas and tools to meet the needs and pain points they identified. In Design Sprint 3, the participants combined multiple tools together to form an ecosystem and discussed how this ecosystem may work to address needs of patients with DCCs.

The first author facilitated each Design Sprint, which lasted 60-90 minutes. Each Design Sprint was initiated by an ice breaker, followed by a presentation (sprint 1 part A) or reflection (for sprint 1 part B, sprint 2, and sprint 3), and then the probe.

Probe: Jeff, is dealing with type-2 diabetes, arthritis, and severe depression. All of which present continuously changing disease episodes and drug interactions. Jeff needs to set and monitor his treatment goals and to learn about other activities to improve his health. Jeff also needs to monitor and communicate his current level of function. To do these activities effectively, Jeff will need to consult and coordinate his care with multiple providers.

This probe was followed by leading question:

"How might designs help Jeff set goals and navigate their situation during the time of crisis and change, and when their symptoms are stable?"

In addition, as the participants started each Design Sprint, the researcher used the suggested tools for DCCs care (which are described in Background section) to narrow the scope of the participants' ideation and design focus. The participants used the shared miro-board (an online visual collaboration platform for teamwork [11]) to record, share, brainstorm, and sketch conceptual ideas/designs with each other.

All the materials (including the zoom recordings and miro-board sketches) for each Design Sprint was collected for analysis by the researcher and for preparation for the next Design Sprint. The researcher's analysis process was guided by DQ4 and DQ5

3.2 Scenario

Here we provide, a summary of the scenario, a full summary is one and a half pages and is available in our website (<http://tongwere.com/category/project/>). The scenario describes the life experience of Jeff (patient with DCCs). Jeff is restless, experiences sad moods and fatigue such that his mobility and independence are affected. When symptoms come up (or interactions), Jeff gets a recommendation from his provider (Dr. Zoo) to see a psychiatrist, Dr. Depreux. Jeff calls Dr. Depreux, who gives him some directions, but Jeff is also dealing with type-2 diabetes symptoms. And he ends seeing another provider, Dr. Beetis-his diabetes doctor who gives him another directive. Dr. Beetis didn't have a full understanding of Jeff's arthritis and refers Jeff to Dr. Arthur. So, Jeff calls Dr. Arthur and gets additional directions. And slowly, Jeff's care process becomes complicated and expensive.

3.3 Participants

We recruited a total of five (N=5) user experience (UX) designers. Three (N=3) work with health-related firms, one (N=1) works with a top non-profit IT corporation, and the remaining participant is a freelance user experience designer. One of the five designers leads a large team of designers and engineers, another is a senior user experience designer, and the remaining three participants are UX designers researchers.

This study was approved by our University's Institutional Review Board (IRB).

Participant	Experience	Job title
P1	5+ years	UX Designer
P2	5+ years	UX Designer
P3	5+ years	UX Designer
P4	8+ years	Senior UX Designer
P5	10 + years	leads a large team of designers and engineers

Table 1. Participants

3.4 Analysis

The first author did the thematic analysis after each design sprint and then met with the research team to decide what results we are going to use in the next design sprint. The analysis process began as soon as each design sprint concluded and continued up to when all design sprints were completed. The analysis and design process was iterative, the result of the one sprint informed the results of the succeeding sprint. For sprint one, parts A and B, we extracted all the answers and evaluated those answers. In part B, we started by leading experts in reflecting on items they have suggested in part A. Six(6) sub-themes emerged out of that analysis. We iterated on these themes to create two(2) major themes (problems and pain points, and interactive solutions for DCCs care and support). After Design Sprint 2, we analyzed the data collected and four major themes emerged and were further iterated. This iteration resulted in a focus on an ecosystem in Sprint 3. When the three design sprints concluded, we analyzed the data and extracted four (4) sub-themes. We further iterated on these themes and came up with two main themes: i) critical components of an ecosystem for DCCs support, and ii) considerations for an ecosystem for DCCs support.

4 Findings

In this section, we highlight the findings of the three design sprints and talk about how these findings influenced our design iterations. Because of limited space and page limits, we are not discussing them in detail. We will discuss the process of design sprints (case study) in the discussion section.

4.1 Design sprint 1: (Understand)

In design sprint 1, part A, the researcher, and participants highlighted problems and pain points they found to be prominent and that should be addressed. In part B, we reviewed and reflected on the identified pain points, the participants then created a journey map showing how the patient and providers interacted in the study scenario. The participants used the journey map to emphasize the pain points in the patient care process and to ensure there is some continuity in their view of DCCs care needs. They also discussed technologies and other design ideas that could support patients in navigating their care process. We show some of those pain points in (**figure: 1**) and the journey map in (**figure: 2**).

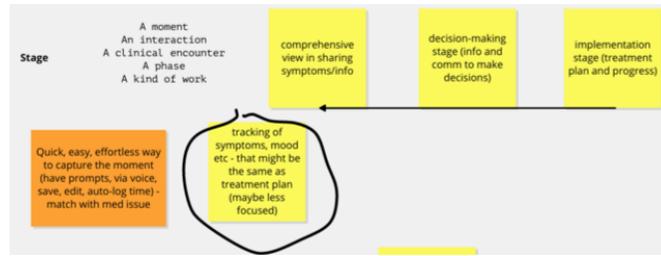


Fig. 1. Narrowing the design problems and design insights

Figure showing the needs of the patients with DCCs that experts believe to be prevalent. These needs occur during patients’ clinical encounters, data collection and sharing, treatment decision making, and implementation of those treatment plans. The figure emphasizes the moments of the patient’s life and barriers they face and solutions to those barriers, for example, communication, mood swings/depression, conflicting and overwhelming treatment plans medications.

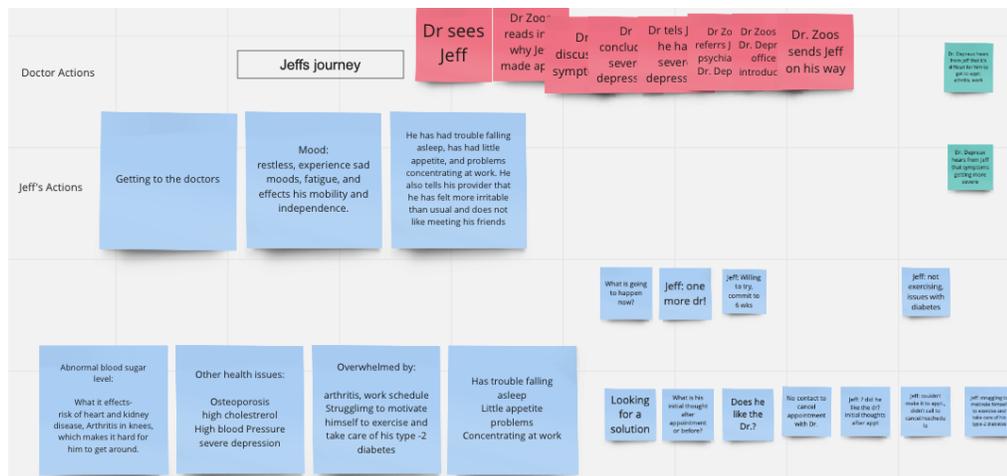


Fig. 2. DCCs Journey Map [6]

Showing a visual presentation of the process that a patient with DCCs goes through in order to get help. This process includes i) a patient’s symptoms, ii) a patient’s treatment plan, iii) a patient’s interactions with health care systems, iv) barriers affecting those interactions, and vi) support strategies and tools to help a patient navigate their care

4.2 Design sprint 2: (Diverge)

In Design Sprint 2, participants expanded and reflected on the problems and pain points, and interactive solutions for DCCs care and support themes they

identified in Sprint 1 part A and part B. Participants discussed how addressing DCCs issues requires engaging patients in multiple different ways and patients need to be proactive for it to be effective. Some strategies may work for one patient but not work for other patients. We show in (figure: 3) some of those DCCs support resources.

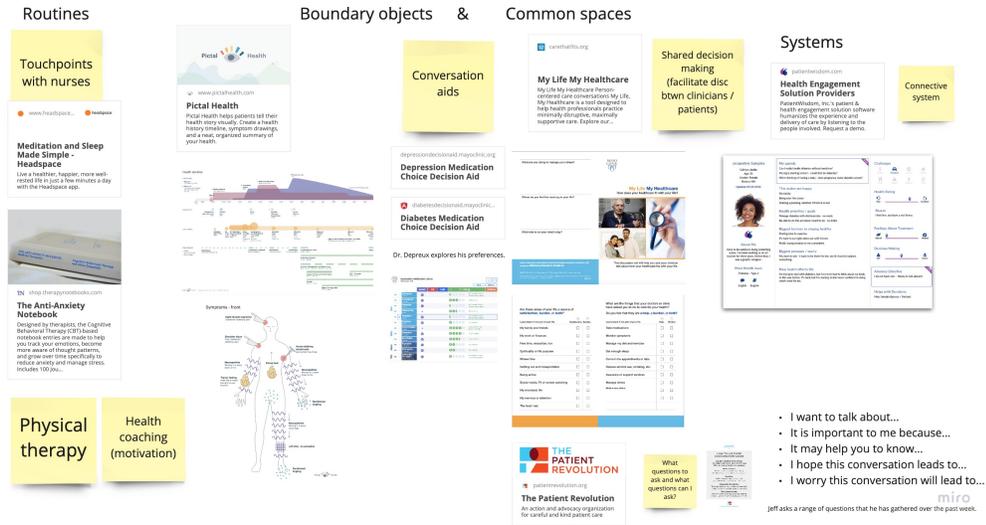


Fig. 3. DCCs Support resources, projects and tools

A figure showing DCCs support resources and tools that the participants discussed, including i) tools to visualize and communicate patients' symptoms, ii) shared decision aids, iii) tools to flag conflicts and treatment plan interactions, and iv) models to combine and moderate the operation of the care tools

4.3 Design sprint 3: (Decide)

In Design Sprint 3, the participants considered two ways to design for DCCs needs. One way was to focus on a single stage of DCCs care and build a tool for that stage. The second way consisted of mapping out an ecosystem to address the care of patients with DCCs. Because multiple things need to be considered when caring for DCCs, all participants agreed to focus on designing an ecosystem. Designing an ecosystem for DCCs involved participants taking different tools and learning how to put them together to address the individual needs of patients with DCCs. (figure: 4) shows components that make up the DCCs ecosystem. Here we briefly present i) critical components of an ecosystem for DCCs support, and ii) considerations for an ecosystem for DCCs support.

4.4 Critical components of an ecosystem for DCCs support

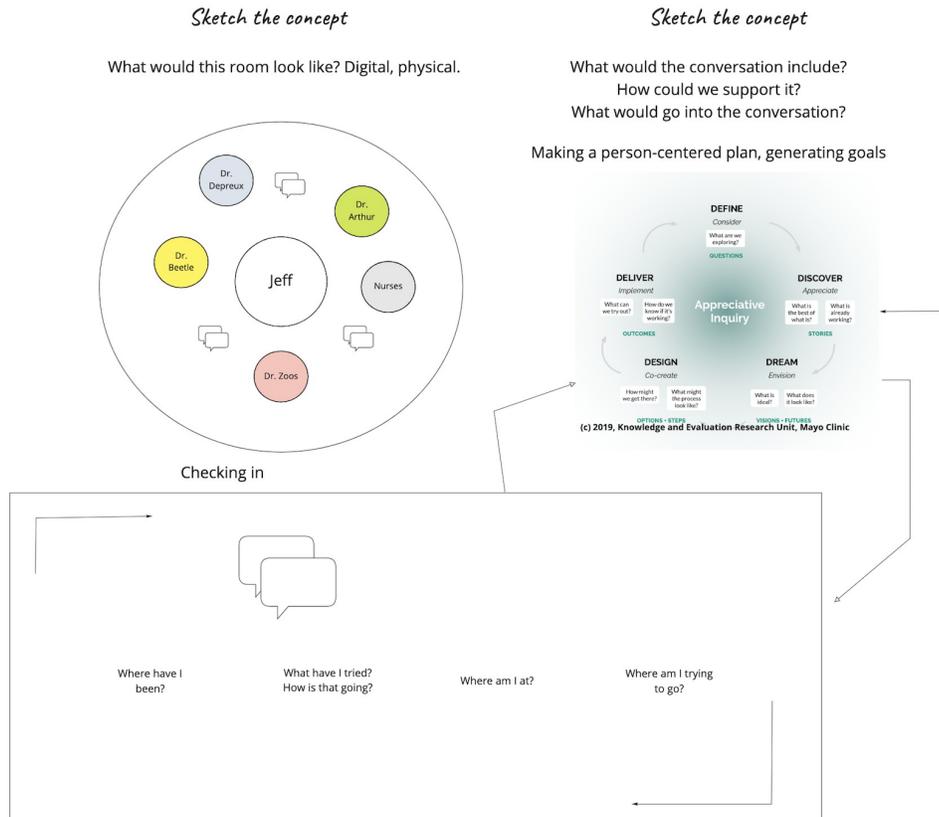


Fig. 4. Critical components of DCCs ecosystem

A figure showing some components that make an ecosystem, including i) patients at the center of their support network, ii) a tool that helps a patient set goals and prepare for doctors office visits, iii) a model to guide doctor-patient discussion and goal-setting process, and iv) a tool to evaluate a patient’s progress

Participants discussed how each of these parts fit together to address the needs of patients with DCCs. For examples, P1 explains that:

”In case of when [patient] had a range of questions that he has gathered over the past week . . . So that to [participant] is kind of attaches to that

moment of conversation . . . a boundary object or a conversation tools can support that conversation.”

Another tool that relates to similar needs is a shared decision aid, P2 explained how

”[A doctor] can like invite a patient and think through, like what they want to talk about what’s important to them what they want the clinician to know and their hopes and worries for the conversation”

4.5 Considerations for an ecosystem for DCCs support

Our experience engaging experts shows that the process of designing for the DCCs ecosystem is a complicated one. Here we provide a sample of the participants’ concerns. For example, the participants found that there are a lot of parts to be moved around.

”we have to bring things all together, one part should focus on helping a patient self-reflect . . . This one part should deal with their emotions, another [part] enables patient [to] get answers from other people”.- P2

Nonetheless, the participants discussed about introducing models to tie all these items together. One of the participants suggested using the Appreciative Inquiry Model, saying

”And then you have to do, your conceptual kind of thing . . . and use the Appreciative Inquiry to guide that thinking” - P5

In this situation, patients may end up using multiple tools a day. There is a need for a tool to help patients choose the tools appropriate for a given context. For example, one participant explained

”If you have to describe the daily life scenario of [patient], from the morning when he gets up, to the night [when] he goes to bed, interacting with this in . . . different kind of scenarios.” - P4

5 Discussion

The Design Sprint participants (n=5) generated a diverse range of ideas for supporting patients with DCCs. Here we discuss the using design sprints in research and the design space for DCCs.

5.1 A case study of using design sprints in research

This work was a case study on how to engage the design team in design for a complicated situation. We show how we engaged designers, who are less familiar with the DCCs population, in the design process for identifying pain points. We

provided a conceptual map on how to think about processes of designing for a complicated situation. First, every designer must understand the problems associated with a complex situation. Secondly, in our case study, we originally wanted the experts to design tools, but then experts wanted to create an ecosystem. This changed our conceptualization of what a good solution was. Future researchers should be open to the direction of the research changing slightly because you might find something really surprising that might be beneficial. However, it is challenging to keep participants on task without suppressing their creativity. In our case study, some of discussions that went off track ended up leading to very positive, creative outcome, while other discussions did not. **Future researchers need to explore how to master the balance of being open to something while not allowing discussion to go too far off course.** We recommend the following strategies, First, nudge the discussions within the sessions, this might be harder to manage within the session. The time between design sprints (which are normally 90 minutes), gives researchers the flexibility to reflect where discussions went off course and time to figure-out how to bring the discussion back on task. This same break also gives researchers time to reevaluate whether participants came up with something creative that should be further pursued and explored more fully. It is also good practice to ensure researchers have time to discuss the Design Sprint session with their fellow researchers before they make decisions about the next session. The second recommendation is to refer to focus group management techniques, where there are people who dominate and people are more quiet. Researchers should be careful to engage everyone and not make anyone feel left out. However, if some participants are in really productive conversation, engaging a participant who has been quiet at that moment might derail the conversation. Researchers need to allow those discussions to finish before they try to bring the quiet people into the discussion. Finally, avoid asking participants open ended questions. Instead, focus on re-engaging participants by asking more targeted questions to direct the discussion. For example, *“do you know how you might improve this solution?”*

5.2 Design space for DCCs

Here we recommend three design directions, tools to empower patients make and implement treatment goals, tools to record and communicate the DCCs needs, and the DCC Ecosystem.

Tools to empower patients to make and implement treatment goals

In DCCs care, we need to understand that there is no generic, one-size-fits-all solution for DCCs patients. Machine learning algorithms can be used to observe the interaction and learn the patient’s preferences. To do this, we need to first identify the baseline to i) understand what patients care about and why, ii) observe the behavior of patients and understand their needs with data, and iii) be able to prompt patients at the right time. Thus, a feedback

loop between patients and the system needs to be created and this loop needs to evolve. A second consideration is the use of human input. For example, we should allow a patient to decide what information is valuable enough to record and prompt the patient to record the information at the appropriate times. We understand, there is a lot of literature justifying why some patients don't take medication when they should. With that said, reminders alone may not solve the problem and some patients will not record or take medications even when they are reminded. **We need to explore systems that address all types of patients (patients who respond to reminders and patients that do not respond reminders).**

For example, designers should focus on helping patients understand what is good for them. Such tools must; i) be empathetic, ii) provide the evidence necessary for the patient to make effective decisions or show patients what happened in the past when a similar situation occurred, iii) explain to patients why they are not feeling well and the benefits of the choices available to a patient, and iv) prepare patients to pose questions to their providers and understand interactions coming from multiple treatment plans. A patient should be placed at the center of every design and designers have to understand that every time the system generates a recommended action – a patient's needs must come first.

Tools to record and communicate the DCCs needs

Patients with DCCs experience severe symptoms and multiple issues. To the best of our knowledge, there is no system robust enough for these patients to record and communicate their issues to multiple providers. The current health-care system is relying upon the patient to personally communicate their issues, and that is not fair, efficient, or accurate. Current studies confirm this argument. For example, the Jacobs et al. [8] study on breast cancer patients showed that oncologists and surgeons were interested in understanding the emotional health of their patients, however, these patients hesitated to share this information. Ongwere et al., showed that patients did not share all of their information because they assumed that providers may not be interested in some aspects of their life, some patients were fearful of judgment and other patients forgot terms that were used by their various providers [20]. Tools are being used to help patients record and share their information. For example, online journals are used to track patients' information. However, the challenges associated with this type of tool are the challenges of recording, filtering, and communicating that information across multiple providers. There are health video blogs that allow individuals with chronic illnesses to share their stories, experiences, and knowledge with the general public [12]. There are also web-based personal health records that can be used by patients to collect and manage their health information (e.g., medical history, past surgeries, medications, and allergies), request self-referrals, and store a record of their consultations [28]. However, these systems employed data entry methods that limit the range and content of patient-entered information related to medical history, medications, laboratory tests, diagnostic studies, and

immunizations [9]. The findings of this case study raise new questions about the modalities of recording and sharing DCCs information with multiple providers.

First, because of their DCCs, we must understand that not every patient is the same and may not relate similarly to the modality. Some patients with DCCs may be visual, some may prefer writing or text, and others may want a voice. Researchers should recognize that patients with DCCs are diverse and should be provided with diverse modalities to record and share their information. Further, these modalities may also be impacted by the events in a patient's life. **Future research could explore how to provide a suitable tool for a patient to record and share their information when in crisis/overwhelmed and when they are stable.** For example, i) the research could explore the design of smart systems that can switch the modality based on the situation of an individual patient with DCCs, and ii) research could also identify ways to help patients emotionally prepare for interaction when in crisis and also when stable.

The DCC ecosystem

The effective support and care for patients with DCCs should be consistent with the patient's values, desires, and goals. The DCCs care and support should be feasible and flexible to accommodate shifts in a patients' life and must be tailored so it makes intellectual, emotional, and practical sense to a patient. Studies are looking to help patients and healthcare providers set the care goals that are tailored to each patient's needs. For example, the use of decision aids help clinicians share information about the options and their consequences during the clinical encounter [4]. The decision aids help clinicians tailor care and reduce the burden of treatment on patients with DCCs and help patients reflect on their values and goals with their healthcare providers. Some tools such as motivational interviewing help create conversations about the options and their relative merits and downsides [25].

For DCCs, any modification to a patient's treatment plan often introduces new complications to patients' care [20]. If a patient wants to make a modification to their treatment, the research could explore how to bring into the forefront the issues that may matter to a patient in making that switch. More specially, research must visualize what it would be like to stop or introduce a new treatment plan. There are apps that are designed to help visualize patients' health histories and symptom maps, with a focus on people living with complex conditions [15]. Patients may visualize and communicate their histories and symptoms maps. However, communicating with a provider alone might not necessarily lead a patient to change their behavior or solve a problem. Sometimes a patient may be struggling to get around their mood and other patients may be scared of change. If there is a need to switch a treatment plan, a tool must show how that process would look like. Further, a tool must have an interactive interface where a patient could visualize how minimizing one behavior may affect their quality of life. Thus, identifying the pain points and making all potential issues tangible to a patient can help them in a crisis. Such a tool may take a real-time log of a patient's thoughts. Such a tool may also monitor whether a patient is not going

to relapse and should show a patient's current trajectory. There are systems that are already addressing such multiple needs. For example, Health-Kits and multi-components applications. However, patients need to be supported in identifying the combination of tools that work best for their involving and complex needs. **Future research should explore how DCCs can be addressed, by combining existing single condition tools and systems and how to guide patients with DCCs in identifying the combination of systems and tools that make an ecosystem that is appropriate for their situation.** Further, putting together multiple sets of tools could be a challenge. For example, some of the tools could be owned by private companies looking to make profits, others may be very difficult to integrate. **Future research could explore how to address this engineering challenge and how to make a theoretical concept adaptable to technology.**

6 Conclusion

In this study, we show how design experts explored the DCCs problems space, and discussed and refined strategies to address the problems they identified. The design experts focused on discussing the ideas for conceptual tools that make patients the center of the design. For example, they strongly suggested the need for i) tools that frame feedback around patients' experiences rather than framing feedback around statistical risks, ii) tools to visualize a patient's progression and motivate patients using gamification, and iii) tools that are capable of providing a view of all the patient's conditions, instead of individual conditions. When a patient reports a condition, the participants suggest that it should be placed in the context of their other conditions regardless of which condition caused the symptom. Experts decided that the best way to address the DCCs was to combine tools to form an ecosystem. When conducting design sprints, the following strategies worked for us; First, introducing participants to design space in the first meeting and laying a solid foundation. The second item was analyzing and reflecting on the design trajectory after every Design Sprint session. This allowed us to answer design questions (DQ 1 and DQ 2) and formulate discussion points to be used at the next Design Sprint session. Finally, having designers keep an open mind and allowing them the flexibility to explore fresh conceptual design ideas. However, this may result in experts diverging from designing for the original problem/need. There is a need for a high level of management to keep experts focused on the original problem.

7 Acknowledgement

It is with true pleasure that we acknowledge the contributions of our design experts Daria Loi, Kevin Shaw, Timothy Kelly, Janette Shew, and Ginny Hong. Thank you for generously sharing your time, experience, and other resources for this project.

References

1. Ancker, J.S., Witteman, H.O., Hafeez, B., Provencher, T., Van de Graaf, M., Wei, E.: "you get reminded you're a sick person": Personal data tracking and patients with multiple chronic conditions. *Journal of medical Internet research* **17**(8) (2015)
2. Ballegaard, S.A., Hansen, T.R., Kyng, M.: Healthcare in everyday life: designing healthcare services for daily life. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. pp. 1807–1816. ACM (2008)
3. Becker, M.H.: The health belief model and sick role behavior. *Health education monographs* **2**(4), 409–419 (1974)
4. Butler, M., Ratner, E., McCreedy, E., Shippee, N., Kane, R.L.: Decision aids for advance care planning: an overview of the state of the science. *Annals of internal medicine* **161**(6), 408–418 (2014)
5. Hayes, G.R., Abowd, G.D., Davis, J.S., Blount, M.L., Ebling, M., Mynatt, E.D.: Opportunities for pervasive computing in chronic cancer care. In: *International Conference on Pervasive Computing*. pp. 262–279. Springer (2008)
6. Howard, T.: Journey mapping: A brief overview. *Communication Design Quarterly Review* **2**(3), 10–13 (2014)
7. Huh, J., Ackerman, M.S.: Collaborative help in chronic disease management: supporting individualized problems. In: *Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work*. pp. 853–862. ACM (2012)
8. Jacobs, M., Clawson, J., Mynatt, E.D.: A cancer journey framework: guiding the design of holistic health technology. In: *Proceedings of the 10th EAI International Conference on Pervasive Computing Technologies for Healthcare*. pp. 114–121. ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering) (2016)
9. Kim, M.I., Johnson, K.B.: Personal health records: evaluation of functionality and utility. *Journal of the American Medical Informatics Association* **9**(2), 171–180 (2002)
10. Lagu, T., Weiner, M.G., Hollenbeak, C.S., Eachus, S., Roberts, C.S., Schwartz, J.S., Turner, B.J.: The impact of concordant and discordant conditions on the quality of care for hyperlipidemia. *Journal of general internal medicine* **23**(8), 1208 (2008)
11. Lee, L.J.: Tools: Miro real-time board, visual collaborations and tools, easy screen sharing and presentation (2020)
12. Liu, L.S., Huh, J., Neogi, T., Inkpen, K., Pratt, W.: Health vlogger-viewer interaction in chronic illness management. In: *Proceedings of the SIGCHI conference on Human factors in computing systems*. pp. 49–58 (2013)
13. Mamykina, L., Heitkemper, E.M., Smaldone, A.M., Kukafka, R., Cole-Lewis, H., Davidson, P.G., Mynatt, E.D., Tobin, J.N., Cassells, A., Goodman, C., et al.: Structured scaffolding for reflection and problem solving in diabetes self-management: qualitative study of mobile diabetes detective. *Journal of the American Medical Informatics Association* **23**(1), 129–136 (2016)
14. Mamykina, L., Nakikj, D., Elhadad, N.: Collective sensemaking in online health forums. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. pp. 3217–3226. ACM (2015)
15. McCurdy, K.: Visual storytelling in healthcare: Why we should help patients visualize their health. *Information Visualization* **15**(2), 173–178 (2016)
16. Nashrulloh, M., Setiawan, R., Heryanto, D., Elsen, R.: Designing software product with google ventures design sprint framework in startup. In: *Journal of Physics: Conference Series*. vol. 1402, p. 022084. IOP Publishing (2019)

17. Naylor, M.D., Van Cleave, J.: Transitional care model. *Transitions Theory: Middle-range and Situation-specific Theories in Nursing Research and Practice*. New York: Springer Publishing pp. 459–65 (2010)
18. Ongwere, T., Cantor, G., Martin, S.R., Shih, P.C., Clawson, J., Connelly, K.: Too many conditions, too little time: designing technological intervention for patients with type-2 diabetes and discordant chronic comorbidities. In: *Workshop on Interactive Systems in Health Care* (2017)
19. Ongwere, T., Cantor, G.S., Clawson, J., Shih, P.C., Connelly, K.: Design and care for discordant chronic comorbidities: A comparison of healthcare providers' perspectives (2020)
20. Ongwere, T., Cantor, G.S., Martin, S.R., Shih, P.C., Clawson, J., Connelly, K.: Design hotspots for care of discordant chronic comorbidities: patients' perspectives. In: *NordiCHI*. pp. 571–583 (2018)
21. Ongwere, T., Stolterman, E., Clawson, J., Shih, P.C., Connelly, K.: Design for discordant chronic comorbidities(dccs): a dc³ model (2021)
22. Pentakota, S.R., Rajan, M., Fincke, B.G., Tseng, C.L., Miller, D.R., Christiansen, C.L., Kerr, E.A., Pogach, L.M.: Does diabetes care differ by type of chronic comorbidity?: An evaluation of the piette and kerr framework. *Diabetes care* **35**(6), 1285–1292 (2012)
23. Piette, J.D., Kerr, E.A.: The impact of comorbid chronic conditions on diabetes care. *Diabetes care* **29**(3), 725–731 (2006)
24. Prochaska, J.O., Velicer, W.F.: The transtheoretical model of health behavior change. *American journal of health promotion* **12**(1), 38–48 (1997)
25. Rollnick, S., Miller, W.R., Butler, C.: *Motivational interviewing in health care: helping patients change behavior*. Guilford Press (2008)
26. Sari, E., Tedjasaputra, A.: Designing valuable products with design sprint. In: *IFIP Conference on Human-Computer Interaction*. pp. 391–394. Springer (2017)
27. Setiawan, I.M.A., Zhou, L., Alfikri, Z., Saptono, A., Fairman, A.D., Dicianno, B.E., Parmanto, B.: An adaptive mobile health system to support self-management for persons with chronic conditions and disabilities: usability and feasibility studies. *JMIR Formative Research* **3**(2), e12982 (2019)
28. Wang, M., Lau, C., Matsen, F.A., Kim, Y.: Personal health information management system and its application in referral management. *IEEE Transactions on Information Technology in Biomedicine* **8**(3), 287–297 (2004)
29. Zulman, D.M., Kerr, E.A., Hofer, T.P., Heisler, M., Zikmund-Fisher, B.J.: Patient-provider concordance in the prioritization of health conditions among hypertensive diabetes patients. *Journal of general internal medicine* **25**(5), 408–414 (2010)