IMPROVING PATIENT FLOW FOR THE SUITE 2100 CLINICS IN THE UVA HEALTH SYSTEM

HUMAN-CENTERED DESIGN FOR DEMENTIA CARE

A Research Paper submitted to the Department of Engineering Systems and Environment
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Systems Engineering

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Healthcare settings need to operate smoothly and efficiently to provide its unique set of patients with prompt, quality care to ensure positive health outcomes. For example, dementia-care spaces must meet the distinctive needs of dementia patients, with complex symptoms such as "impaired communication, disorientation, confusion, poor judgment, [and] behavioral changes" (Alzheimer's Association, 2021, p. 6). Alternatively, out-patient hospital clinics must adapt their logistical operations to fluctuating COVID-19 protocols to meet the health and safety needs of the many patients entering and leaving the clinic each day (Korte et al., 2021, p. 1). Despite COVID-19 adjustments to hospital clinics, such as UVA Health, problems including long wait times for patients, healthcare worker burnout, difficulty managing bottlenecks in patient care, and more issues, continue to persist (Norman et al., 2021, p. 1008). These healthcare settings have the challenge and opportunity to optimize their design and operation to better support the complex needs of patients, healthcare professionals, family members, and other relevant social groups.

Therefore, the technical paper will collaborate with UVA Health to observe current patient arrivals, provide recommendations to maximize patient throughput, and analyze the effectiveness of solutions to support an efficient patient admission process. Professor Robert Riggs in the Engineering Systems & Environment department at UVA will mentor the technical project in collaboration with Dr. Kim Dowdell, an MD and physician in the UVA Fontaine Research Park Primary Care clinic. As demonstrated in Figure 1 on page 2, observations and data for the technical project will be collected in fall of 2021, while the recommendations and paper will be finalized in spring of 2022, culminating in the Institute of Electrical and Electronics Engineers Systems and Information Engineering Design Symposium conference in April 2022.

TASK NAME	START DATE	END DATE	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Statement of Topics	1-Sep-21	21-Sep-21								
Annotated Bibliography	21-Sep-21	12-Oct-21								
Fontaine Suite 2100 Clinic Observation	1-Oct-21	1-Feb-21								
Analyze Cadence and Observational Data	1-Oct-21	15-Feb-21								
Prospectus	12-Oct-21	1-Nov-21								
Oral Presentation	4-Nov-21	4-Nov-21								
Develop Recommendations	1-Nov-21	1-Jan-21								
Implement Recommendations	15-Dec-21	15-Feb-21								
STS Thesis	17-Jan-21	1-Apr-21								
Technical Thesis	17-Jan-21	1-Apr-21								
IEEE SIEDS Conference	1-Apr-21	1-May-21								

Figure 1: STS and technical paper timeline. This Gantt chart displays the approximate time frames for various tasks related to the STS and technical papers (Schmid, 2021).

The STS paper will apply the idea of healthcare design improvements to the environment of dementia patients. As the aging population increases around the world, and particularly in the United States, there is a rising urgency to develop quality care spaces for the unique needs and symptoms of dementia patients (Alzheimer's Association, 2021, p. 27). The STS paper will use the Social Construction of Technology framework to explore how human-centered design can be applied to create dementia-care spaces that support patients, while also accommodating the needs of family members, caregivers, and other relevant social groups (Pinch & Bijker, 1984, p. 401). As displayed in Figure 1, the beginning stages of the STS paper will be completed in fall of 2021 and the paper will be written and finalized in spring of 2022. The technical and STS papers are closely coupled as they aim to better understand how healthcare settings can be improved from both a logistical, efficiency perspective and a human-centered design thinking perspective.

IMPROVING PATIENT FLOW FOR THE SUITE 2100 CLINIC AT UVA HEALTH

The technical paper aims to observe and analyze the patient flow of Suite 2100 at UVA Health Fontaine Research Park to provide operational recommendations that increase patient throughput and optimize patient care. Suite 2100 accommodates the operations of three different clinics, Primary Care, Rheumatology, and Endocrinology, that all share a registration desk,

check-in desk, waiting room, nurses, and other resources. The suite suffers from inefficiencies regarding patient arrival in the form of long wait times, bottlenecks in patient appointments, and healthcare worker burnout, which all pose concerns to the patient care process. (R. Riggs, personal communication, September 1, 2021)

The project is related to a previous UVA capstone mentored by Robert Riggs and titled "A systems approach to optimizing patient flow during the COVID-19 pandemic", which aimed to analyze patient arrivals and focused on implementing appointment pre-registration improvements (Korte et al., 2021, p. 4). The goal of this technical project is to assuage Suite 2100's issues regarding patient registration, check-in, clinic signage, provider scheduling and pre-appointment communication, by suggesting and implementing solutions that will optimize the patient arrival process. Professor Robert Riggs mentors the project and Aram Bahrini, a graduate systems engineering student at UVA, supports him. The project team will work closely with Dr. Kim Dowdell, an MD and physician in the UVA Primary Care Clinic, and Karen Measells, a management engineer at UVA Health. Other members of the undergraduate systems engineering project team are Maggie Cusack, Claire Dozier, Noor Drissi, Bryce Huffman, Sarah Saas, and Wei Wu.

CURRENT CLINIC OPERATIONS: INEFFICIENT AND DISJOINTED

The suite's current operations are disconnected and not using the full potential of available resources. Starting with the appointment creation process, when patients make an appointment at any of the three clinics, they may receive a text or email reminder about the appointment location and time. However, they do not receive a reminder to complete a pre-registration form, called E-update, where they can input insurance and other information despite the health system's ability to send these registration reminders. Pre-appointment notifications are

variable and the notification system does not use all the capabilities available. Upon arriving at the suite's building, patients must register at the first-floor general registration; provide insurance, demographic, and other information; proceed up the elevator to Suite 2100 where they must check-in and then wait for their appointment. Unclear signage, redundant processes, confusing floor layouts, and efficiency issues result in bottlenecks throughout the patient admission process. (R. Riggs, personal communication, September 1, 2021)

The central registration desk tends to be congested prior to peak appointment times, which often induces long patient wait times and compounds to make patients late for appointments, thus putting doctors behind schedule (R. Riggs, personal communication, September 1, 2021). Kulkarni et al. (2021) conducted an outpatient study that simulated patient flow and found that the billing section, like Suite 2100's central registration desk, had high resource utilization and resulted in bottlenecks because an "imbalance in resource utilization leads to uneven distribution of queue lengths and variation in patient waiting time" (p. 9). After completing central registration, patients take the elevator up to the second floor and see the entrance to Suite 2100 displayed in Figure 2 on page 5. This figure demonstrates the overwhelming nature and inconsistency of signage throughout the patient arrival process. Additionally, patients are supposed to checkout upon completion of their appointment, however, many fail to checkout and are unable to schedule follow-up appointments or pay copays (R. Riggs, personal communication, September 1, 2021). Overall, the current patient arrival process is inefficient and thus can benefit from data-informed recommendations to improve patient flow and throughput.

Figure 2: Entrance to suite 2100 UVA fontaine research park. The entrance to Suite 2100 after exiting the second-floor elevators. There are many signs placed in haphazard locations with many stop signs, inconsistent fonts, and confusing messages that do not provide clear, concise, legible instructions for patients entering the suite (Dozier, 2021).

PROJECT METHODS: OBSERVATION AND DATA ANALYSIS

The technical project will observe and collect data regarding the suite's processes. Student observers will take notes about patient arrival processes and collect data about the number of people arriving, registering, entering the elevator, checking in, and being seen by a nurse during peak times of busy days at the clinic. A study conducted at an oncology clinic in Jordan used "a lean thinking concept, … including value-stream mapping and VA/NVA analysis … to describe the pre-intervention pain clinic workflow," which may be a beneficial approach to describing the patient flow processes at Suite 2100 (Alloubani et al., 2019, p. 383). The observational focus will be on the periods of 9 am to 11 am and 1 pm to 3 pm from Tuesday

through Thursday because these timeframes have the largest number of doctors seeing patients, and thus are more susceptible to bottlenecks and inefficiencies.

In addition to this observational data, Karen Measells, management engineer at UVA Health, provided the team with Cadence data containing anonymous information about patient appointment dates, times, providers, cancellations, and timestamps for different stages in the patient arrival process. She also contributed spreadsheets about provider scheduling patterns and room assignments in the suite for analysis. Current work in this scheduling domain that may be beneficial to the project uses integer programming as a technique to determine clinician schedules that balance "patient access while taking into account other provider responsibilities" (Lobo et al., 2020, p. 340). The technical project will use a broad range of qualitative and quantitative data sources available to holistically analyze the current system's problems. The project group will meet and collaborate with Dr. Dowdell, Karen Measells and other UVA Health professionals to ask questions and understand the system from firsthand experiences and managerial perspectives.

POTENTIAL OUTCOMES AND RECOMMENDATIONS

The technical project hopes to provide actionable recommendations, in collaboration with UVA Health doctors and staff, that will optimize the patient arrival process from synthesizing this broad base of knowledge. If recommendations are implemented during the project, on the condition that UVA Health approves the recommendations and there is sufficient time to implement them, then the goal is for patient throughput to increase, patient wait times to decrease, and healthcare worker and patient satisfaction to increase. Potential recommendations may address a variety of areas including pre-appointment actions, such as establishing that patients arrive a certain amount of time before their appointment or sending consistent pre-

registration notifications; provider scheduling, such as adjusting when providers schedule appointment blocks; or design layout such as adding or removing signage, moving locations of queues or check-ins, or changing waiting room layouts. Despite the project's enthusiasm to adjust hospital operations, it is important to account for how new modifications and recommendations "affect care team members, particularly in view of growing dissatisfaction and burnout among healthcare professionals" (Hung et al., 2018, p. 1). Ultimately, the technical project analysis and its recommendations that optimize the patient admission process will be presented in an Institute of Electrical and Electronics Engineers Systems and Information Engineering Design Symposium paper in April of 2022.

HUMAN-CENTERED DESIGN FOR DEMENTIA CARE

The prevalence of dementia is rapidly increasing from the approximately 35.6 million dementia patients worldwide in 2010 "to 65.7 million in 2030 and 115.4 million in 2050" (Marquardt et al., 2015, p. 128). Specifically in the United States, the *baby boomer* demographic comprises a large portion of the population. According to the Alzheimer's Association (2021), by 2030 "the projected 74 million [age 65 and] older Americans will make up over 20% of the total population (up from 17% in 2021)" which is displayed in Figure 3 on page 8 (p. 27). With an increasing proportion of aging Americans, more individuals will be susceptible to developing Alzheimer's or other forms of dementia and more stress will be placed on the remainder of the population to provide quality dementia care. Though some dementia patients live in long-term specialized care facilities many family members must take on the role of caregiver, as it is estimated that "over 11 million Americans provide unpaid care for people with Alzheimer's or other dementias" which adds up to "an estimated 15.3 billion hours valued at nearly $257

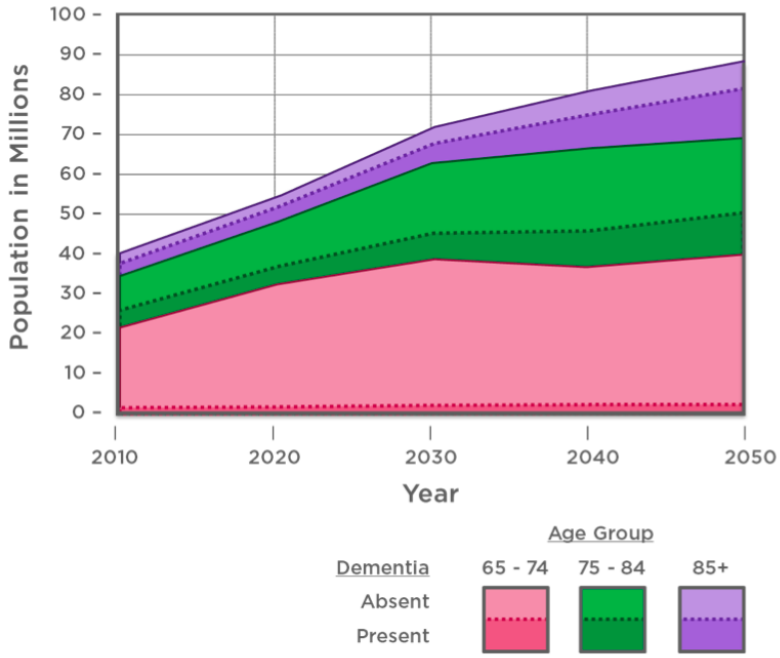

Figure 3: US population forecast: People 65+ with dementia. This figure demonstrates the projected increases in population specifically for ages 65-74, 75-84, and 85+ (Abushusheh & Taylor, 2020, p. 16).

billion" (Alzheimer's Association, 2021, p. 36). The expansiveness of dementia care poses a large challenge to creating spaces at-home and in long-term facilities that reduce stressors and support, not only patients, but family members and caregivers as well. In the face of an aging population, there is a need to develop innovative, creative, and effective solutions for designing environments that are conducive to the daily activities of dementia patients and their caregivers. Therefore, the STS paper will use the Social Construction of Technology framework to explore how human-centered design can be implemented to create spaces that provide quality care to dementia patients while accommodating the needs of all relevant social groups.

SETTING THE STAGE: DEMENTIA, PATIENT CARE, AND SOCIAL GROUPS

In the STS paper, the terms dementia and Alzheimer's will be used according to the Alzheimer's Association (2021) where dementia is an overarching term for a set of symptoms characterized by "difficulties with memory, language, problem-solving and other thinking skills

that affect a person's ability to perform everyday activities" and Alzheimer's disease is a progressive brain disease that results in dementia (p. 5). As the symptoms of dementia differ greatly from how normal aging individuals function, dementia care is more reliant on memory care to support patients' potential "disruptive memory loss; impaired judgment and recall; confusion over time and place; misunderstanding imagery/spatial relationships; challenges in planning, problem solving, and completing familiar tasks; social withdrawal; language difficulties; and changes in mood and personality" (Abushusheh & Taylor, 2020, p. 6). These extensive challenges in daily life place a burden on family members who must decide how to care for their loved one.

Some family members choose to pay for a long-term specialized dementia-care unit, while some choose to provide care themselves as "eighty-three percent of the help provided to older adults in the United States comes from family members, friends or other unpaid caregivers," half of which is "for someone with Alzheimer's or another dementia" (Alzheimer's Association, 2021, p. 36). These caregivers are vital to the wellbeing of dementia patients and provide the intense care required, which can make caregivers "vulnerable … to social isolation, physical exhaustion, stress, and loss of income from missed work" (Weigel, 2019, p. 74). Family members and caregivers are important social groups relevant to the design and use of dementia-care spaces, along with patients, nurses, healthcare regulators, physicians' assistants, long-term care staff, and healthcare providers as displayed in Figure 4 on page 10. This broad array of individuals has relevant needs and desires that are impacted by how dementia-care spaces are designed and conversely, these groups can impact designs to accommodate their needs. The nature of these relationships lends itself well to the Social Construction of Technology developed by Pinch and Bjiker (1984), which will serve as the primary framework for the STS paper (p.

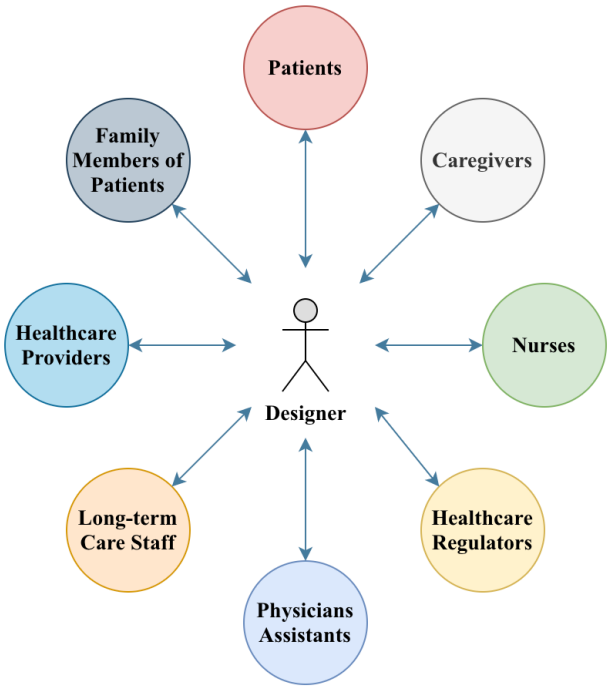

Figure 4: Social construction of technology for the design of dementia-care spaces. There are a variety of relevant social groups that impact and are impacted by the designer of dementia-care spaces (Schmid, 2021).

401). The discussion will pay particular attention to patients, family members and caregivers who are the most prominent individuals in the dementia-care space and are heavily impacted by its daily use.

ORGANIZING SPACES: DEMENTIA PATIENTS' NEEDS

The design of dementia care has become more heavily researched around the world to better understand the idea of how spaces can be designed for patients and other social groups. Addie Abushousheh and Ellen Taylor (2020) with the Center for Health Design developed a set of "programming considerations for memory care" using design-based evidence, which includes ideas such as "destination-based amenities and services" to promote consistent movement and social interaction with patients and community members, as well as "regulation of contextual sensory stimulation" to accommodate vision and acoustic needs (p.11). These design ideas can

be integrated into current dementia patient care to assuage dementia symptoms and improve activities of daily life. Marquardt et al. (2014) conducted an evidence-based systematic literature review of 169 studies exploring "the impact [that] design of the built environment [has] on people with dementia in long-term care settings" (p. 127). The review delineates environmental design decisions that promote the wellbeing of dementia patients in areas such as behavior, cognition, function, social abilities, orientation, and care outcomes (Marquardt et al., 2014, p. 131). For example, regarding a building's spatial layout, the study states that "direct visual access to relevant places, the integration of reference points, and the implementation of several zones with a unique character were identified as helpful for resident's wayfinding abilities" (Marquardt et al., 2014, p. 137). This extensive review provides valuable insight into specific designs regarding building layout, wayfinding, and more that support the activities and health outcomes of people with dementia. These studies and reviews highlight the valuable research being done in the dementia-care space that will be evaluated in the STS paper.

ORGANIZING SPACES: THE WORKER'S PERSPECTIVE

A study by Lee et al. (2016) in Vancouver, Canada incorporated the vital perspective of dementia-care staff on how the built environment impacts patient outcomes (p. 743). The study reported that staff believe "poor environmental factors, including stimulation overload, safety risks, wayfinding challenge, and rushed care" negatively impacted patients while "comfort, familiarity, and an organized space were important therapeutic resources" (Lee et al., 2016, p. 743). As this study demonstrates, caregivers and staff have everyday intimate interactions with patients and can therefore provide valuable input about patient environments, which is supported by their deep knowledge of patient symptoms and needs. These workers serve as the primary

support for the extensive care of dementia patients, engaging in difficult emotional, mental, and physical tasks, and are therefore an important social group to incorporate in the design process.

POTENTIAL OUTCOMES: EXPLORATION AND FIRST-HAND PERSPECTIVES

The paper aims to use the Social Construction of Technology framework to explore innovative design work with a thorough consideration of all relevant perspectives and social groups in the care process. As previously discussed, patients, caregivers, and family members are the primary users of dementia-care spaces, and any design improvements should consider all groups' needs and desires. A study by Toubø et al. (2020) comprising focused interviews with these stakeholders in dementia care compiled a thematic representation of how to ethically preserve the quality of life and ideals of patients as displayed in Figure 5 (p. 1507). These

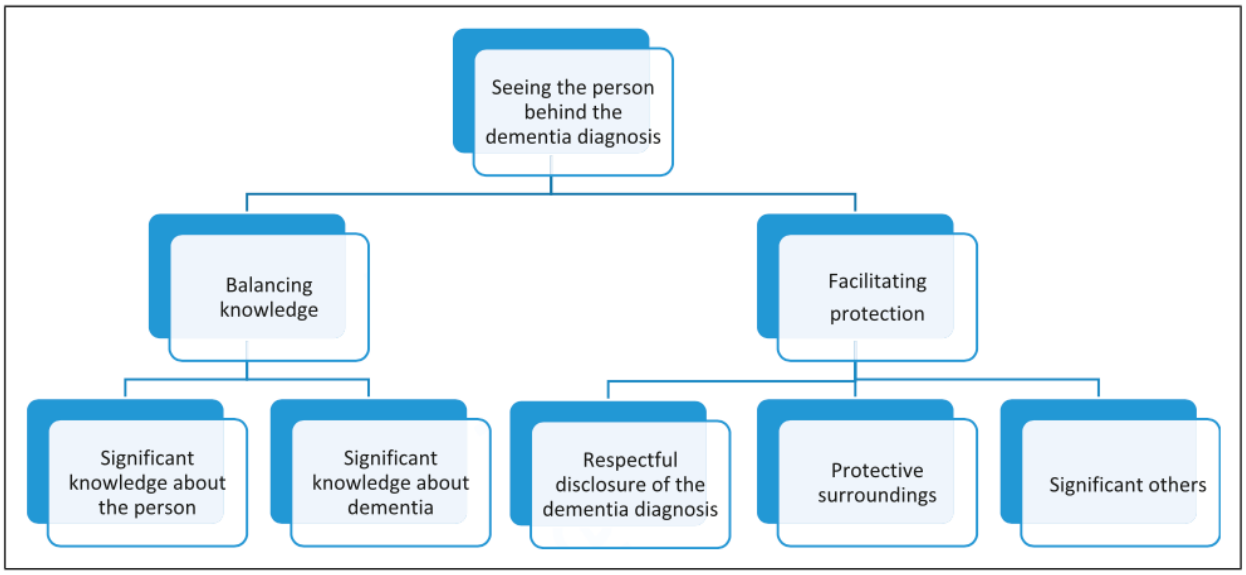

Figure 5: Thematic map of ethical dementia care considerations. The map in this figure displays the themes and corresponding sub-themes for evaluation in creating dementia-care environments (Toubø et al, 2020, p. 1507).

ethical considerations prompt a variety of questions about how designs can meet ethical criteria along with functionality needs in dementia care. The STS paper hopes to explore the following questions about designing spaces in the context of these users and the growing need for quality

dementia-care spaces: How can we use design and technology to reduce stress on caregivers and family members? What is being done or can be done to prepare for the increase in the aging population? How can we preserve the dignity and identity of Alzheimer's patients? What ethical considerations need to be taken into account when designing spaces and technologies for dementia patient care? Questions such as these, along with the Social Construction of Technology framework, will propel the discussion and exploration about how design innovation can improve dementia care.

To complement this STS research, I will visit a local Charlottesville nursing home, Our Lady of Peace, to incorporate the firsthand experiences of family members and potentially dementia patients and caregivers. I would specifically like to understand family members' thoughts and sentiments about the struggles of dementia care, their values in the decision-making process, and their hopes for the future of dementia care. These interviews will provide valuable insights into how this social group experiences dementia care and makes critical health and wellbeing decisions for their loved ones.

THE FUTURE OF INNOVATIVE HEALTHCARE

Healthcare settings have great potential for innovation in not only their logistics and efficient operations, but their promotion of patient wellbeing, to ultimately provide the best care and create a favorable environment for healthcare professionals, caregivers, and family members. Research should be conducted in the areas of efficiency, optimization, and design to provide healthcare workers at hospitals with positive work environments and to ultimately improve the efficiency and quality of patient care. The technical paper aims to address this issue of hospital design and efficiency to optimize patient flows at UVA Health and maximize patient throughput through data-informed recommendations. The STS paper will focus on the design of a different

healthcare setting: dementia-care spaces. The paper will explore how design innovations can be applied to the built environment of dementia patients in the context of not only patients, but caregivers, family members, and other prominent users of the space. With a future rise in the aging population, it is pertinent to design dementia-care spaces that fully meet the needs of patients while reducing stress and other potentially negative impacts on caregivers and family members who frequently interact with patients. The future of innovative healthcare is bright for hospital and dementia-care settings because it has the potential for improving patient care, quality of life, healthcare worker burnout, and so much more.

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