

Confronting complexity: toward equitable healthcare technology design and evaluation for socioeconomically marginalized patients

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Abstract

Objectives: Investigate how patients at a Federally-Qualified Health Center (FQHC) perform with, and perceive, complex telehealth tasks. Determine which complexity dimensions most affect patients' performance and perceptions, and compare this to researcher-evaluators' complexity walkthrough results.

Materials and Methods: A novel complexity walkthrough inspection method was implemented by researcher-evaluators ($n=8$) to identify theory-informed complexity dimensions in 6 FQHC-required telehealth tasks. Remote user testing ($n=24$) where FQHC patients were observed performing tasks, then completed newly-developed complexity-focused interviews and surveys. Descriptive statistics regarding complexity dimension presence, task performance, cognitive load, and perceived difficulty were integrated with qualitative data analyzed using inductive and deductive coding.

Results: Patients completed 33.9% of the required subtasks without issues. Cognitive load and perceived difficulty were high for 2 tasks. Complexity dimensions of *ambiguity* (*unclear inputs/processes*; *new concepts/words*) and *relationship* (*context switching*; *deep navigational hierarchies*) most affected patient-perceived difficulty. Patients spent twice as long as walkthrough evaluators on tasks, and encountered broader complexity dimensions: *new concepts/words*, and *errors*. Many patients ended tasks early, asserting that they would abandon them outside of a study or had previously done so.

Discussion: Technology-mediated task complexity may explain some telehealth uptake inequities. The complexity dimensions that challenge patients extend known usability heuristics by enhancing their equity sensitivity. Complexity walkthroughs surface design patterns that challenge patients, but complexity-focused user testing with patients reveals additional difficulties. Findings support *complexity reduction* of tasks via structuring, familiar concepts/words, feature integration, and shallow/broad navigation.

Conclusion: This paper's novel, theoretically-grounded complexity-focused methods and findings may inform future equitable design and evaluation of technology-mediated tasks for socioeconomically marginalized patients.

Key words: telehealth, healthcare equity, access to primary care, human factors, usability

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Lay Summary

People can get healthcare by using telehealth tools like patient portals and video visit platforms. But many patients have trouble using them. We studied how patients at a Federally-Qualified Health Center completed 6 steps for a video visit: requesting a visit, completing a consent form, checking in, getting a reminder, joining the visit, and following up after.

We introduced 2 methods. First, 8 research team members (“evaluators”) used a *complexity walkthrough inspection method*. They tried each step and wrote down what made the work harder, like unclear labels, too many clicks, or having to switch between applications. Second, we used *complexity-focused user testing*: 24 patients completed the same steps while we watched what happened and asked what made each step easier or harder.

Patients completed 33.9% of steps without problems and did not try 42.3% of steps. Two steps felt especially hard: telehealth consent and follow-up after a visit. The biggest problems were unclear directions and having to move between apps or click through deep menus. Patients took twice as long as evaluators and ran into more unfamiliar words and errors.

To help more people get care, telehealth steps should be clearer, kept in “one place,” and easier to navigate.

Background and significance

Expanded access to technology-mediated healthcare is a policy goal in the United States (US). Federal Meaningful Use incentives¹ prompted widespread healthcare provider adoption of patient portals (henceforth, “portals”). Furthermore, 25 US states passed legislation supporting long-term video visit use.² Hence, US healthcare organizations have increasingly transitioned to telehealth using patient-facing technologies like portals and video visit platforms (henceforth, “telehealth technologies”). These transitions can result in differential access for socioeconomically marginalized patients—those with low incomes or educational attainment,^{3,4} lower-status occupations^{3,4} or unemployment,⁵ and/or public or no health insurance.⁶ Such patients often receive healthcare at safety net providers like Federally-Qualified Health Centers (FQHCs).

Differential uptake of telehealth technologies among socioeconomically marginalized people is consistently observed across the US,^{6–13} and in groups with high rates of socioeconomic marginalization: Black or Hispanic/Latino,^{14–16} non-English-speaking,^{6,8} disabled,⁶ and rural people.¹⁵ There is a similar inequity in the *usage* of telehealth technologies.¹⁷ Yet, little research *explains* socioeconomic differences. Explanation is critical because portals can improve preventive health care and treatment adherence¹¹ and video visits are often more clinically effective than phone visits.^{18,19}

Additionally, prior research has not sufficiently considered the *design* of telehealth technologies as a potential explanation of differential uptake and usage.¹¹ Usability challenges with commercial portals and telehealth technologies have been documented^{11,20–22} for first-time users²³ and patients with low literacy.^{22,24} However, this work has sparsely analyzed *design patterns* that contribute to usability challenges. Moreover, the general standards (“heuristics”) operationalized in commonly used usability inspection methods may fail to meet the needs of marginalized groups.²⁵ Consequently, researchers lack a systematic understanding of *what matters* for designing patient-facing healthcare tasks using telehealth technologies (henceforth, “technology-mediated tasks”) to foster equitable adoption,

usage, and healthcare access for socioeconomically marginalized patients. New, equity-focused heuristics and methods for evaluating patient-facing technology-mediated tasks are needed to assess current technology-mediated tasks and to inform future design. This also addresses field-wide calls for new methods of assessing patients’ healthcare technology use.²⁶

Therefore, this study investigated the *complexity of technology-mediated tasks as a potential design-related equity issue* for telehealth access (Appendix A for definitions). Complexity is the focus for 3 theoretical reasons derived from learning theory, economics, and sociology. First, complex tasks produce *higher cognitive load*. Cognitive load is reduced when a person can draw from prior knowledge of completing similar tasks. Because technology experience may be constrained by differential educational experiences, occupations, and device/Internet access, socioeconomically marginalized people may experience higher cognitive load when encountering complex technology-mediated tasks. This can impede learning²⁷ and task completion. Second, more complex tasks typically *take more time*. Because socioeconomically advantaged people spend more time on health-related tasks, economic literature shows that they typically benefit more when tasks are more complex.²⁸ This may be linked to time scarcity and control studied in sociology: lower-income people typically have less control over their time than higher-income people.²⁹ Yet, technologies that *simplify* healthcare tasks have equitable benefits across socioeconomic positions.²⁸ Third, socioeconomically marginalized people are often under greater *psychological stress* than people who are more socioeconomically advantaged (see Appendix A for a definition). Due to stress, poverty in particular can tax cognitive and emotional resources^{30–32} and negatively affect executive cognitive functions such as working memory and attention.^{33,34} Notably, these functions are employed when interacting with digital systems (eg,^{32,35}), and even more so when complex tasks increase the cognitive load required to use them.²⁷ Nevertheless, there is a lack of empirical evidence regarding how socioeconomically marginalized patients may perform with, and experience, complex, technology-mediated tasks for telehealth.

While complexity is sometimes acknowledged, research has not simultaneously considered the *multiple dimensions of complexity* interrogated in multiple fields. For instance, in human-computer interaction (HCI), complexity is investigated as an obstacle to usability.^{36–38} HCI and health informatics research studies single complexity-related problems, recommending removal of unnecessary features, automating tasks, creating templates,³⁹ and interface design consistency.⁴⁰ Organizational studies research assesses the complexity of work tasks^{41–43} and its relationship to performance.^{41,42,44,45} Engineering research centers *process complexity* (ie, a series of tasks and subtasks) encountered when configuring software.^{46,47}

To enrich the treatment of complexity in health informatics and investigate its posited equity implications, the simultaneous assessment of multiple complexity dimensions from these fields is needed. Therefore, we synthesized complexity dimensions and related measurements from these literatures⁴³ by comparing definitions and mapping similar concepts and measures to create a “Task Complexity Dimensions Theoretical Framework” (Box 1). This theoretical framework incorporates both subjective and objective complexity dimensions and intentionally brings different disciplines into conversation. For instance, the likelihood of completing a task without error (mentioned in engineering⁴⁶) is linked in the framework to *task reliability* from organizational behavior⁴² and measured by the occurrence of errors during task completion. The result is the set of integrated complexity-related concepts and measures shown in Box 1. Here, each complexity dimension is classified into a high-level category drawn from extant theoretical literature⁴³: action complexity, task ambiguity, task relationship, task reliability, task variety, task size, and temporal demands. This framework permits identification and probing of complexity dimensions through our novel, sequential task-focused inspection and user testing methods: a “complexity walkthrough” and “complexity-focused user testing.”

Research aims and objectives

Investigate how patients at a FQHC perform with, and perceive, complex telehealth tasks. Determine which complexity dimensions most affect patients’ performance and perceptions, and compare this to researcher-evaluators’ (henceforth, “walkthrough evaluators”) complexity walkthrough results.

Methods

Research setting

The FQHC had 5 clinical sites in a Midwestern state, providing care for over 20 000 patients primarily insured through public insurance (Medicaid/Medicare) (57%). The FQHC had implemented a new electronic health record (EHR) and portal 5 months before the COVID-19 pandemic, with only 4.5% of patients having used the portal by March 2020. Video visits were unavailable via the portal vendor; hence, the FQHC adopted a standalone platform that did not require software installation in March 2020.

Data collection

This study involved 2 stages informed by the “Task Complexity Dimensions Theoretical Framework”: (1) complexity walkthrough evaluations completed by the research team ($n=8$) followed by (2) complexity-focused user testing conducted remotely with randomly selected FQHC patients ($n=24$) (Figure 1).

Stage-1 involved 2 steps. First, with FQHC staff advice and following a task analysis approach,⁵⁴ we identified 6 tasks and related subtasks required for a telehealth visit (Figure 2). Then, we extended existing technology evaluation inspection methods⁵⁵ to create a novel “complexity walkthrough” approach guided by the theoretical framework (henceforth, “walkthrough”). In the walkthrough, research team members with no prior portal or telehealth platform experience served as walkthrough evaluators. They performed the 6 tasks while completing Qualtrics forms to capture complexity dimensions using the measures in Box 1.

Stage-2 involved complexity-focused user testing (henceforth, “tests”) conducted remotely in which adult, English-speaking, active FQHC patients (defined as patients who had a visit in the previous year) participated. Randomly-selected patients were contacted by telephone and then emailed invitations to participate. Of 101 patients reached, 24 participated (23.7% acceptance rate). Tests were conducted using FQHC-provided accounts and data (eg, upcoming appointments). Participants received mailed “technology kits” containing: (1) a printed participant guide and visual survey response scales; (2) an Internet hotspot; (3) a cell phone with Zoom and a mount; and (4) an Android tablet pre-loaded with screen-recording software and the portal and telehealth platform. Researchers provided remote help with setting up the provided technology, and gave participants time to familiarize themselves with the technology. The tests were conducted and recorded over Zoom, transcribed, and verified.

Participants were instructed to complete the 6 tasks (Figure 2) and were assisted or redirected by the researcher when done. Participants shared their actions on the screen and verbalized their thoughts.⁵⁶ Researchers completed a structured form while observing participant performance (Appendix B). Following each task, researchers asked participants to answer 5 questions from the NASA Task Load Index (NASA-TLX)⁵⁷ plus one perceived difficulty³⁸ using a visual paper scale given to participants. When participants’ responses were greater than 10 (midpoint), the researcher asked follow-up questions about which complexity dimensions, if any, made the task more difficult, and why. These task-based questions were selected based on the Stage-1 walkthrough results, establishing whether a given complexity dimension was present or not in the task. Finally, researchers asked semi-structured questions to gather perspectives on areas of difficulty (Appendix B).

Participants completed a demographic and technology experience survey. They were also asked to report their self-appraised levels of stress based on situations in their lives through the 10-item Perceived Stress Scale (PSS-10).⁵⁸ The instrument asks how often participants had experienced feeling overloaded, or that events were unpredictable or uncontrollable in the past month (0 = Never, 1 = Almost Never, 2 = Sometimes, 3 = Fairly Often, and 4 = Very Often). The PSS-10 has high internal

Box 1. Complexity dimensions framework: definitions and measures.

Complexity dimensions	Definitions	Subjective or objective	Measures
Action complexity	The physical demands of performing a task. ⁴³		
Navigational interactions	Actions that users must perform with their bodies.	Objective	Number of navigational interactions (ie, clicking, dragging, typing, and scrolling) recorded through screen recordings.
Task ambiguity	Lack of clarity or specificity in the cues given to users about information that they should enter, or how to complete a process. ⁴³		
Input/process clarity and unstructured guidance	How clear and specific information cues are for entering information into a system to complete a task, and for taking the next subtasks in a task. When inputs and processes are ambiguous, more prior knowledge is required to infer meaning. ⁴⁸	Subjective	Question posed after performing the task: Did you always know what to do when completing this task? (yes/no) <u>Follow-up questions for patients only:</u> When did you feel confused? How did you figure out what to do?
New concepts/words	"Background information on a specific topic that the user needs to understand ... to perform a step, and that the user has encountered for the first time in the context of their current task(s)." ³⁶	Subjective	<u>Question posed after performing the task:</u> Did you encounter any new words or ideas while completing this task? (yes/no) <u>Follow-up questions for patients only:</u> If so, did you figure out what it meant? If so, how?
Task relationship	Interdependencies between tasks. ⁴³		
Context switching	Task completion involves moving between distinct components of computing systems within a task. ^{36,49}	Objective	Whether the task required moving to a new user interface, window, tool, view, container, or product. ^{36,49} (yes/no).
Hierarchy level	Hierarchy level is linked to the system's information architecture. ⁵⁰ Hierarchical organizational structures within systems involve parent/child relationships and mutually exclusive categories. ⁵⁰ The hierarchy level is how deep in the hierarchy one must go to locate content, often measured as number of clicks. Deeper organizational hierarchies, accessed through more clicks, are associated with greater task complexity. ^{51,52}	Objective	Number of parent/child pages accessed to complete the task (ie, first page followed by the number of clicks needed to perform the task).
Task reliability	Congruity or incongruity between parts of the task; incongruity involves errors, mismatches, or incompatibilities ⁴³ that tax cognitive resources.		

(continued)

Box 1. (continued)

Complexity dimensions	Definitions	Subjective or objective	Measures
Errors	Incorrect or unanticipated system behavior, which may be produced by user behavior. These may or may not be highlighted by error messages produced by the system; a lack of a message to explain errors is more difficult to resolve.	Both	Count of errors encountered while performing the task. ^{46,47} <u>Follow-up questions for patients only:</u> Do you feel like you understood why you got an error? If yes, how did you figure out why you got the error?
Task size Number of subtasks	The number of subtasks in a task ⁴³ and the interdependence of the pathways that must be followed to complete a task. ^{43,53}	Objective	Count of subtasks within a task.
Task variety Diversity of inputs	The number of dissimilar and distinguishable elements in a task. ⁴³ Count of the types of information users must enter to complete a task (eg, free text, check boxes, drop-down lists, and radio buttons). This is taxing due to the attentional cognitive resources that dissimilar elements may require. ⁴⁸	Objective	Count of number of types of information (eg, free text, check boxes, drop-down lists, and radio buttons) which users must enter different types of information to complete a task. <u>Follow-up questions for patients only:</u> Do you think the number of different things you needed to do to request a telehealth visit (eg, text inputs, radio buttons, check-boxes, and drop-down menus) made the task more difficult? Why or why not?
Temporal demands Amount of time taken	The time-based requirements of a task. Time on task for each task in a process. ^{46,47} More time taken adds to task complexity by increasing stress and taxing cognitive resources. ⁴³	Objective	The time taken for each task in a process is based on screen recordings. ^{46,47}

consistency and test-retest reliability,⁵⁹ and is associated with depression and anxiety.⁵⁹ It is also positively associated with measures of socioeconomic marginalization including lower income,^{30,60} educational attainment,^{30,32,60} unemployment,³⁰ and neighborhood disadvantage.³²

Data analysis

For Stage-1, counts, means, and proportions for evaluators' assessment of complexity dimensions for each task were calculated. Given a lack of objective, validated complexity standards, they were then classified by distributions as no, low, moderate, and high complexity for each task/dimension pairing.

Stage-2 quantitative analysis involved compiling descriptive statistics of the structured observations, perceived difficulty, and NASA-TLX questions for each task. Two proportions were

calculated. One in which the "number of all subtasks completed without issues" was divided by "total subtasks" and one in which "number of all subtasks completed without issues" was divided by "total subtasks attempted." An "abandonment rate" was calculated using the "number of subtasks not attempted," divided by the "total subtasks." We compiled the total time for each task using screen recording timestamps and prepared graphs to compare the time taken by walkthrough evaluators and participants. Participants completed the five NASA-TLX items and one additional perceived-difficulty item. Each item was rated on a 21-point scale ranging from 1 to 21. Aligned with widespread practice,^{61–64} we averaged the NASA-TLX and related perceived difficulty scale items with equal weights. We then transformed scores to a 0–100 scale for comparability. Following prior work,^{65–68} we treated NASA-TLX scores as cognitive load measures.

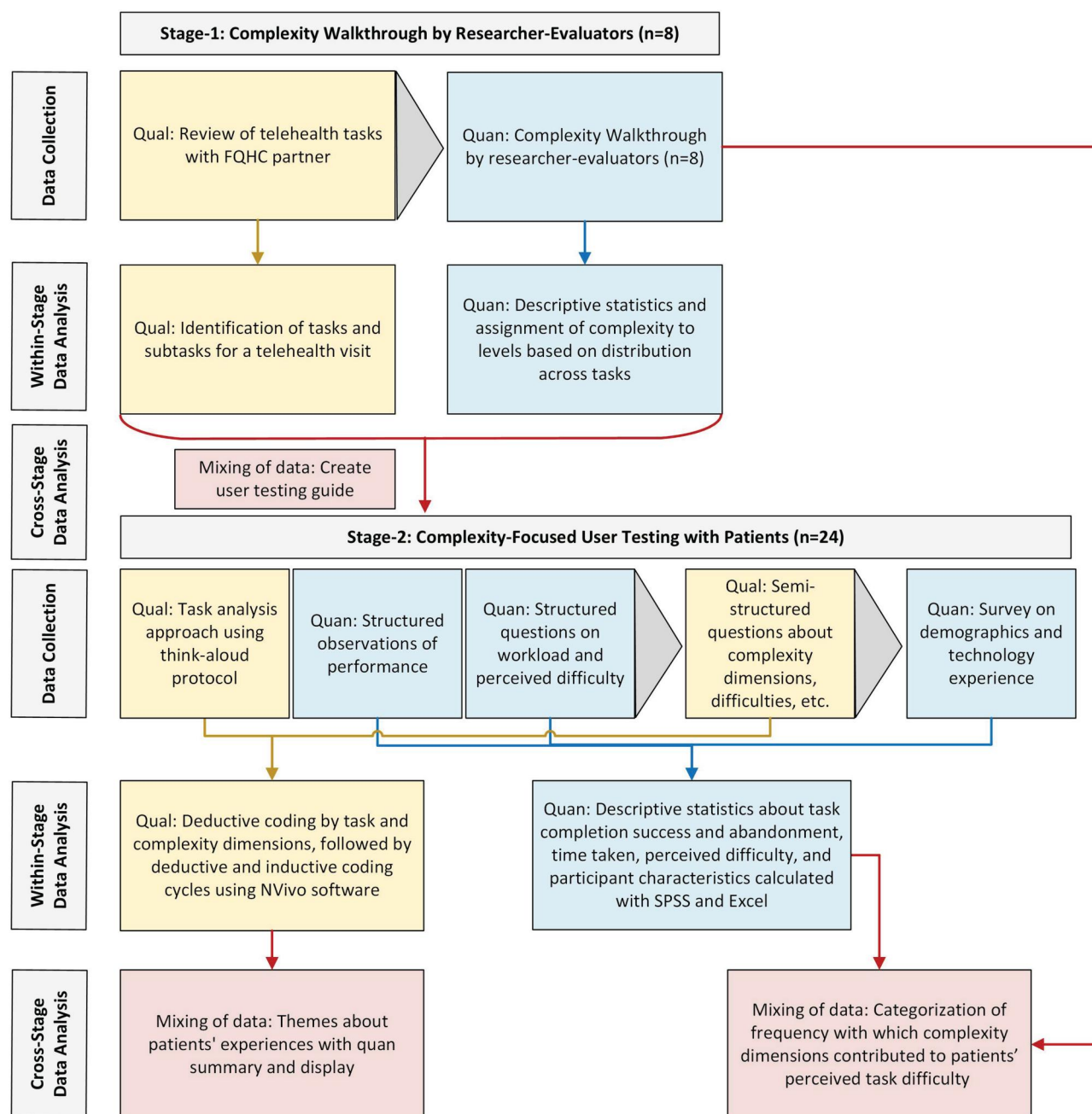


Figure 1. Study design.

Adhering to published guidance,⁵⁸ we also created a measure of perceived stress that sums the total of responses to the PSS-10. Although there is no official cutoff for the PSS-10,⁶⁰ this study adopted the ordinal categorization of perceived stress often found in studies using this measure: low (0–13), moderate (14–26), and high (27–40).^{69–71} Stage-2 qualitative analysis began with deductive structural coding of user test transcripts by task and complexity dimension (Figure 1). In a second inductive coding cycle using structural codes, themes were produced (eg, *it should be “right there,” wasting time*).⁷²

Data from all stages were integrated to illustrate the relationship between complexity types and difficulty. First, the frequency with which complexity dimensions contributed to patients' perceived

task difficulty was categorized. Next, Stage-2 themes about patients' experiences with each complexity dimension were compared to this issue-frequency categorization (Figure 1).

Ethical considerations

The study was exempted from oversight by the University of Michigan's Institutional Review Board. To protect participant confidentiality, participants were assigned a pseudonymous code, and this pseudonymization process was used for all participant data. Data were also de-identified and are stored on a password-protected server and will be retained for a 7-year period as set out in the informed consent materials. Test

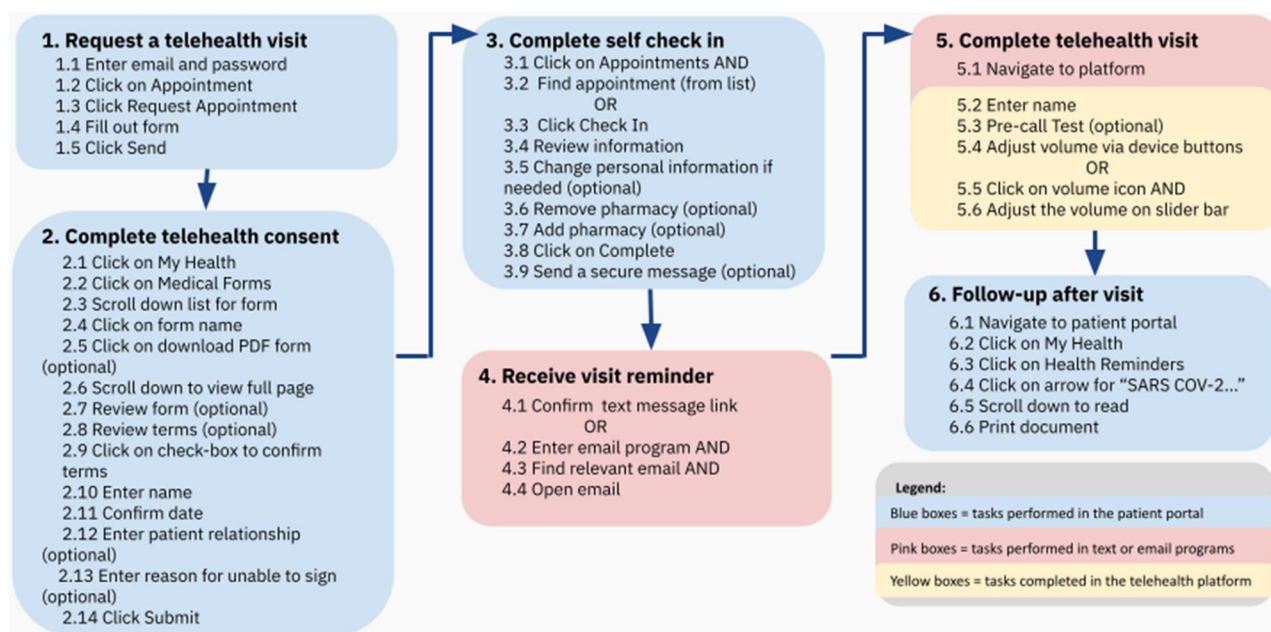


Figure 2. Tasks for a telehealth visit.

accounts were also used to avoid video recording patients' portal data through screen sharing. Participants were instructed to use the label "USER" rather than entering their own name when prompted to join the video call for the test. Patient study participants gave informed consent and received \$75 for test participation.

To ensure accessibility, the research team members ran multiple pilot tests to refine the study materials shipped to patients. For literacy-related accommodations, patient-facing materials underwent plain language review using the Flesch-Kincaid readability tests to ensure that materials were at no more than an eighth-grade reading level. The materials also deliberately included photos to assist with set-up and participation. When starting the user test, researchers verbally walked individuals through the setup while on the phone with them. Researchers repeatedly emphasized that the research was testing the system and not the participant. To reduce participant burden, the researchers encouraged them to take breaks, and they were given the opportunity to split the user test across 2 sessions if desired (though none did so). Additionally, if participants were becoming frustrated with a task, the researcher offered them the ability to stop that task and move on.

Results

Characteristics of participants

Table 1 shows that most participants had multiple indicators of socioeconomic marginalization. In addition to receiving safety net health care at an FQHC, 16 participants (66.7%) had less than a bachelor's degree. Seven participants (29.2%) had individual incomes below \$12 000 per year. The poverty level in 2020 was \$12 760 annually for a single-person household and \$26 200

annually for a 4-person household.⁷³ An additional 3 (12.5%) were at or below the 133% poverty level based on Medicaid eligibility. Three participants (12.5%) disclosed limited reading ability. User test participants felt moderately stressed on average across the PSS-10 questions (mean: 20.9; $SD=6.4$; minimum = 9.0-maximum = 37.0; see Table 1 for distribution). Most used the Internet daily, but 66.7% (16/24) had low technology experience, primarily due to never having used the patient portal or video visit platform (Table 1).

Task complexity dimensions found in the walkthrough

The walkthrough revealed 1–5 high complexity dimensions per task, of 9 dimensions assessed (Figure 3). Rarely discovered complexity dimensions were *new concepts/words* in one task (*task ambiguity*; Task 1); and *errors*, found by most evaluators for just one task (*task reliability*; Task 6). Appendix C illustrates tasks using wireframes.

Performance with, and perceptions of, technology-mediated telehealth tasks from user tests

Patient test participants (henceforth, "participants") completed 33.9% of subtasks without issues, and did not attempt 42.3% of them during the user testing (Table 2). Perceptions of task-specific cognitive load as measured by the NASA-TLX were 24.0 on average (Table 3), with perceived difficulty scoring 30.6. Two tasks scored highly for both cognitive load and perceived difficulty: Task 2 (Complete telehealth consent form) and Task 6 (Follow-up after visit).

	1	2	3	4	5	6
Complexity Dimension Type	Request a telehealth visit	Complete telehealth consent	Complete self check-in	Receive visit reminder	Complete telehealth visit	Follow-up after visit
Action Complexity						
Number of Navigational Interactions ¹	4 (0) ^{2,3}	5 (6)	2 (0)	1-2 (0)	2 (0)	7
Task Ambiguity						
Input/Process Clarity and Unstructured Guidance ⁴	5 (62.5%)	6 (75.0 %)	6 (75.0%)	8 (100.0 %)	6 (75.0 %)	5 (62.5%)
New Concepts or Words ⁵	Yes	No	No	No	No	No
Task Relationship						
Context Switches ⁵	No	No	No	Yes	Yes	Yes
Hierarchy Level ⁶	3	4 (1)	3	n/a	n/a	4
Task Reliability						
Errors ⁷	3 (37.5%)	1 (12.5%)	3 (37.5%)	2 (25.0%)	2 (25.0%)	5 (62.5%)
Task Size						
Number of Subtasks ⁸	5	9 (5)	3-4 (4)	1-3	3-4 (1)	6 (0)
Task Variety						
Diversity of Inputs ⁹	4	3 (1)	2 (4)	1	2-3 (1)	1 (1)
Temporal Demands						
Amount of Time Taken ¹⁰	1:49	1:16	1:59	1:30	0:31	0:52
Total Moderate Complexity	4	2	4	1	2	0
Total High Complexity	3	4	1	2	1	5

Figure 3. Heatmap of complexity walkthrough results ($n = 8$ evaluators). ¹White = no complexity; Light blue = low complexity; Royal blue = moderate complexity; Dark blue = high complexity. Categories determined by the distribution of findings, with levels assigned by creating either 2 groups or quartiles based on variable type and values for each dimension. ²Bracketed numbers represent optional subtasks. ³0 = no complexity; 1–2 = low complexity; 3–4 = moderate complexity; ≥ 5 = high complexity. ⁴0 = no complexity; 1–5 = low complexity; 6–7 = moderate complexity; ≥ 8 = high complexity. ⁵no = no complexity; yes = high complexity. ⁶n/a = no complexity; 3 = moderate complexity; 4 = high complexity. ⁷Found by number of evaluators: 1–2 = low complexity; 3 = moderate complexity; 4–6 = high complexity. ⁸0 = no complexity; 1–4 = low complexity; 5 = moderate complexity; ≥ 6 = high complexity. ⁹1 = low complexity; 2–2.99 = moderate complexity; 3–4 = high complexity. ¹⁰0–1:07 = low complexity; 1:08–1:36 = moderate complexity; 1:37–1:59 = high complexity.

Task complexity dimensions and patients' performance and perceptions of technology-mediated telehealth tasks from user tests

Action complexity

Participants believed that a higher number of navigational interactions made the task more difficult frequently (Table 4). High numbers of navigational interactions often co-occurred with subtasks not attempted. Qualitatively, such results may be explained by participants' difficulties with seeing everything on the screen. For instance, P30 said that the most difficult part of Task 2, completing the telehealth consent, was "I had to make sure I scrolled all the way down and looked at all the forms." (Subtask 2.6, Figure 2).

Task ambiguity

Input/Process Clarity and Unstructured Guidance

Both walkthrough evaluators and participants experienced high rates of uncertainty about what to do across all tasks. For

participants, this complexity dimension contributed to difficulty very frequently (Table 4). P8 said, "Not knowing what you're doing is a problem ... it makes it difficult."

Clarity challenges were linked to the portal's unclear labeling systems. Some participants could not align their task-related goals with the topical labels provided. For example, in Task 2, the consent form was located under the second-level label "Medical Forms" (Subtask 2.2, Figure 2). But as P21 complained, "I feel confused ... it shouldn't be in medical forms." For 6 participants, another input/process clarity issue arose from the requirement to enter free text into the "subject" line and "message" boxes, neither of which included structured guidance. P14 said, "... I might have had a hard time explaining [why I want to see the doctor] ..."

Lack of clarity concerning information to be input by participants was not only difficult but could also lead to errors. For example, lacking the telehealth visit option in Task 1 (Request telehealth visit), 6 participants chose a site name that included the word "Mobile" from a dropdown list. P17 explained, "I figured that would be the mobile, since it's going

Table 1. Participant demographics, perceived stress, technology use (*N* = 24).

Characteristic	Number	Percent
Age		
Mean/median	46.8/44.0	—
Standard deviation	11.0	—
Minimum-maximum	28-68	—
Missing	3	12.5
Gender		
Female	15	62.5
Male	9	37.5
Non-binary	0	0.0
Missing	0	0.0
Race/Ethnicity		
Black non-Hispanic	16	66.7
White non-Hispanic	6	25.0
Hispanic/Latino	1	4.2
American Indian/Alaska Native	1	4.2
Asian	0	0.0
Native Hawaiian/Pacific Islander	0	0.0
Missing	0	0.0
Education		
Grade 8 or less	0	0.0
Grades 9 to 12, no diploma	3	12.5
High school graduate or GED	5	20.8
Some college	6	25.0
Associate degree (eg, AA, AS)	2	8.3
Bachelor's degree (eg, BA, BS)	4	16.7
Graduate degree (eg, MA, MS)	2	8.3
Professional degree (eg, MD, JD)	0	0.0
Doctoral degree	0	0.0
Missing	2	8.3
Employment		
Working full-time	12	50.0
Working part-time	2	8.3
Unemployed	2	8.3
Disability	2	8.3
Retired	1	4.2
Student (full/part-time)	0	0.0
Other (incl. self-employed)	3	12.5
Missing	2	8.3
Individual monthly income		
\$0–1000 per month	7	29.2
\$1001–2000 per month	7	29.2
\$2001–3000 per month	2	8.3
\$3001–4000 per month	3	12.5
\$4001–5000 per month	1	4.2
\$5001+ per month	1	4.2
Missing	3	12.5
Health insurance type		
Public (eg, Medicaid, Medicare)	13	54.2
Private	8	33.3
No health insurance	1	4.2
Other	0	0.0
Missing	2	8.3

(continued)

Table 1. (continued)

Characteristic	Number	Percent
Difficulties with reading written health information		
Never	11	45.8
Rarely	4	16.7
Sometimes	4	16.7
Often	3	12.5
Always	0	0.0
Missing	2	8.3
Perceived stress (PSS-10)		
Low (0–13)	4	16.7
Moderate (14–26)	15	62.5
High (27–40)	3	12.5
Missing	2	8.3
Device access*		
Smart phone	21	87.5
Laptop computer	11	45.8
Desktop computer	11	45.8
Tablet computer	10	41.7
Missing	3	12.5
Typical device(s) used for connecting to the Internet*		
Smart phone	14	58.3
Basic cell phone	9	37.5
Laptop computer	7	29.2
Desktop computer	5	20.8
Tablet computer	2	8.3
Game console	1	4.2
Missing	3	12.5
Years of Internet experience		
Mean/median	17.8/17.5	—
Standard deviation	9.1	—
Minimum-maximum	2-35	—
Missing	6	25.0
Frequency of Internet Use		
Several times a day	17	70.8
About once a day	2	8.3
Less often or never	2	8.3
Missing	3	12.5
Low technology experience*	16	66.7
≤15 years of Internet experience	7	29.2
Internet use less than daily	2	8.3
Never used patient portal	9	37.5
Never used video visit platform	9	37.5

* More than one response was possible.

to be a mobile phone call.” However, this option designated a health team serving unhoused patients, making it a system-facilitated error.

New concepts/words.

Participants encountered *new concepts/words* in Tasks 1, 2, 3, and 6, while walkthrough evaluators only found new concepts/words in Task 1. Specifically, almost two-thirds of participants identified new concepts/words that walkthrough evaluators

Table 2. Participants' task performance ($N = 24$).

Task	Percentage of <i>attempted</i> subtasks without issues (mean (SD)) ^a	Percentage of <i>all</i> subtasks completed without issues (mean (SD)) ^a	Percentage of subtasks not attempted (mean (SD)) ^b
1: Request a telehealth visit	57.3% (30.8%)	44.8% (28.5%)	25.0% (25.5%)
2: Complete telehealth consent	31.3% (41.9%)	19.8% (29.5%)	63.0% (28.9%)
3: Complete self check-in	79.9% (33.6%)	65.3% (38.4%)	21.9% (31.6%)
4: Receive visit reminder	62.5% (49.5%)	62.5% (49.5%)	0% (0%)
5: Complete telehealth visit	56.5% (37.9%)	45.8% (32.7%)	12.5% (26.6%)
6: Follow-up after visit	50.2% (34.6%)	24.4% (21.7%)	50.0 % (28.9%)
All tasks (mean)^c	56.9% (18.5%)	33.9% (19.0%)	42.3% (20.1%)

^aWithout issues was defined as participants being able to complete without encountering challenges or requiring assistance.

^bSubtasks were not attempted due to: (1) participant apprehension/frustration; (2) participants erroneously thinking that they had successfully completed the full task and indicating that they were done; or (3) running out of time.

^c"All tasks" values were calculated at the participant level across all applicable subtasks from the six tasks and summarized as mean (SD); they are not the arithmetic mean of the task-level means.

Table 3. Participants' perceptions of tasks ($N = 24$).

Task	Cognitive load (NASA task load index) (mean (SD)) (1–100)	Perceived difficulty (mean (SD)) (1–100)
1: Request a telehealth visit	26.5 (20.2)	23.3 (25.5)
2: Complete telehealth consent	50.3 (31.2)	43.9 (39.2)
3: Complete self check-in	16.6 (16.1)	15.5 (24.6)
4: Receive visit reminder	20.3 (25.4)	27.0 (37.0)
5: Complete telehealth visit	17.3 (17.4)	21.4 (23.6)
6: Follow-up after visit	42.5 (30.5)	62.7 (44.8)
All tasks (mean)^a	24.0 (9.8)	30.6 (15.1)

^a"All tasks" values were calculated at the participant level across all applicable subtasks from the six tasks and summarized as mean (SD); they are not the arithmetic mean of the task-level means.

knew. At the participant level, new concepts/words made tasks more difficult frequently (Table 4).

To illustrate, most patients had phoned the health center to schedule an appointment. However, the portal's process conceptually divided "requesting" from "scheduling" when it had previously all occurred together on a call. Thus, P24 erroneously thought that, "Instead of when you on the phone, they be like, 'Hold on. Let me see what we've got available.' They tell you what [appointment times] they got available." Alternatively, a unitary "visit" metaphor resonated with participants, and multiple participants wanted all subtasks associated with a visit combined into one task process.

Furthermore, because the portal organization was based on healthcare concepts and workflows that were unfamiliar, participants found it difficult to *recognize* appropriate actions. For example, during Task 6, P10 looked in the forms section, which was the right place to locate a laboratory requisition for a COVID-19 test, but was confused because nothing looked like a request form. Visiting a lab to obtain the COVID-19 test also confused some participants: P11 found herself browsing information about COVID-19 vaccine locations after following a link out of the portal. When participants could not recognize the right

content, they resorted to time-consuming searches. P21 said, "I just clicking on a lot of different things."

Task relationship

Context switches made tasks more difficult very frequently (Table 4). One explanation for this was the *violation of expectations*. For instance, for Task 5 (Complete telehealth visit), many participants expected to start the video visit from the portal, despite having received a visit reminder via text with an embedded link (Task 4). P17 explained, "Because you're going through the patient portal, you're thinking that it's just going to be on there, you're not really thinking that the text is going to be your check-in."

Three to four *hierarchy levels* alongside *insufficient navigation guidance* contributed to difficulty frequently (Table 4). When asked what made a task difficult or confusing, participants often discussed hard-to-find features, nested within deep hierarchies. Qualitatively, participants preferred features to be immediately evident, and a recurrent phrase was having something "right there." This meant the presence of prominent cues that made it possible to find features with little searching. For example, P18

Table 4. Summary of complexity dimensions' contributions to perceived task difficulty.

Complexity dimension	Number ^a (percentage) of user test participants indicating that this dimension made a task more difficult	How frequently did this dimension make tasks more difficult? ^b (very frequently/frequently/occasionally/rarely) ^c
Action complexity		
Number of navigational interactions	13/22 (59.1%)	Frequently
Task ambiguity		
Input/process clarity and unstructured guidance	24/24 (100.0%)	Very frequently
New concepts or words (task ambiguity)	15/24 (62.5%)	Frequently
Task relationship		
Context switches	17/18 (94.4%)	Very frequently
Hierarchy level	17/24 (70.8%)	Frequently
Task reliability		
Errors	13/24 (54.2%)	Frequently
Task size		
Number of subtasks	9/19 (47.4%)	Occasionally
Task variety		
Diversity of inputs	6/20 (30.0%)	Occasionally
Temporal demands		
Amount of time taken	12/21 (57.1%)	Frequently

^aFrequency with which patients indicated that each complexity dimension contributed to their perceived task difficulty, based on patient responses to task follow-up questions. Each count is a participant who has ever said that this complexity dimension made any task more difficult. Differences in denominators reflect the number of participants who were actually asked whether this dimension made a task more difficult. Participants who were not asked questions about this complexity dimension did not have issues with any task that was high in this complexity dimension. Participants' issues with tasks were identified by their responses to the NASA-TLX index questions after completing those tasks.

^bCategories based on the proportion of participants who reported that the dimension made at least one task more difficult.

^cVery frequently = 76.0%–100.0% of participants said that this complexity dimension made a task more difficult; Frequently: 51.0%–75.0% of participants said this complexity dimension made a task more difficult; Occasionally: 26.0%–50.0% of participants said this complexity dimension made a task more difficult; Rarely: 1.0%–25.0% of participants said this complexity dimension made a task more difficult.

said, “Right on that home screen it tells you you have a visit scheduled. There should... be a button that said, ‘Fill out a consent form.’” Similarly, this was difficult for P18 to find as it was on the fourth level of a hierarchy. P14 also suggested the following to make it easier to find the lab requisition that was also located at a fourth-level hierarchy, “... another tab saying follow-up... recent events...”

Task reliability

More than half of the participants encountered *errors*, a key form of task unreliability. Aside from Task 6 (Follow-up after visit), errors did not often emerge when the walkthrough evaluators performed tasks. Table 4 shows that errors contributed to difficulty frequently.

Participant-experienced errors occurred both during and outside of attempting a specific task. Participants made typos in researcher-provided passwords. Some participants also accidentally logged out of the platform and had trouble returning. For example, P17 logged out during Task 6 (Follow-up after visit): “I’m trying to go back. I backed out of the whole thing.”

Task size

Participants rated the *number of subtasks* as *occasionally* contributing to task difficulty. Participants indicated that it was a comparatively less common contributor to difficulty (Table 4).

For some, this view was linked to the belief that *any* task would involve subtasks. P31 explained: “I don’t think the [number of] steps would make it difficult you have to go through a procedure to do anything.”

Task variety

Participants felt that the *diversity of inputs* contributed to task difficulty *occasionally* (Table 4). Generally, participants focused on the ease of performing each action rather than the range in their assessments. P7 said, “... check boxes. So, like a date... that was good.” P25 said this was not difficult because “there was literally only one thing to do on each step.”

Temporal demands

Figure 4 compares the time taken for each task by walkthrough evaluators and patient participants. As shown, participants took longer than walkthrough evaluators for every task except Task 4, and longer for all six tasks together. In this context, participants saw the *amount of time* required for tasks as contributing to difficulty frequently (Table 4).

Several participants had a sense of how long a given task “*should*” take, and their assessment of task time length referred to it. Where duration was *less than* that level, time was not a problem. However, when the time taken *exceeded* that limit, the judgment of task duration was the opposite. P8 said of Task 1

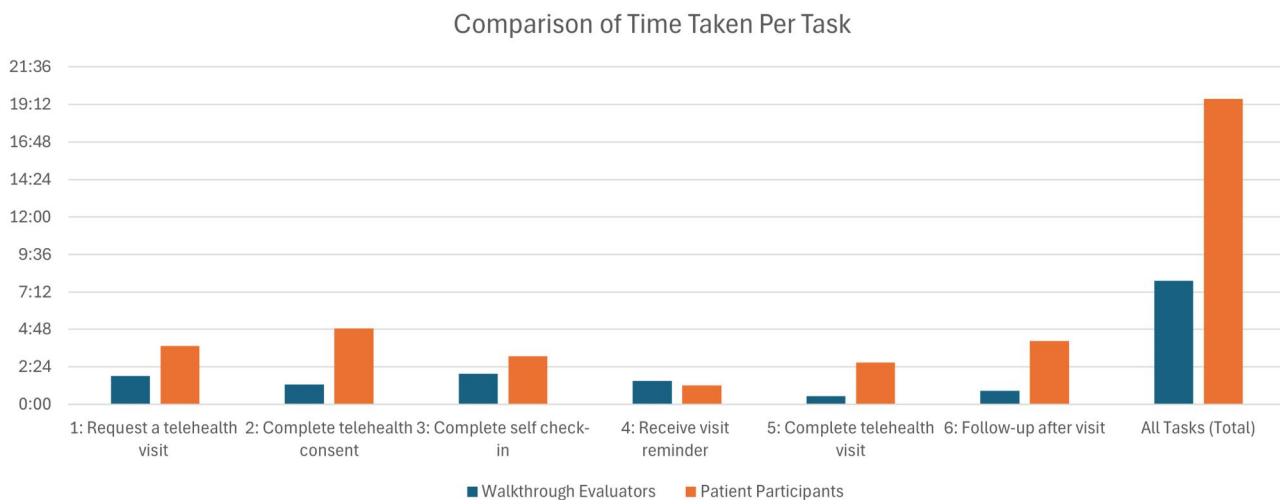


Figure 4. Comparison of the mean amount of time taken per task (in minutes:seconds) between walkthrough evaluators ($n=8$) and FQHC patient participants ($n=24$). All Tasks (Total) displays the sum of the mean time taken for each of the six tasks by walkthrough evaluators and patient participants, respectively.

(Request a telehealth visit), “It’s just too time-consuming ... I can make a phone call, two minutes, it’s over with. I got an appointment.”

Participants’ views about the amount of time to complete a task could not be separated from their strong views that their time was precious. As P6 asserted, “That’s some of the things that I have, my time ... So, I try to make the best of my time.” P16 similarly said, “That’s just my thing, I don’t waste time.”

With a lack of task-related progress and time spent accumulating, many participants expressed frustration while abandoning the task early or asking for help. P17 said, “instead of wasting my time because I’m not that good with electronics anyways ... if I ran into a problem and there’s a telephone number ... I’m ... going to call that and stop my aggravation.” Such patients also asserted that they would abandon the tasks outside of a study, or had previously done so. P30 said, “... you give up.”

Discussion

Study findings provide a foundation for *equitable healthcare technology design* for socioeconomically marginalized patients. This paper contributes a “Task Complexity Dimensions Theoretical Framework” motivated by learning,²⁷ economic²⁸ and sociological²⁹ theory and research, and which synthesizes task complexity dimensions from multiple fields. This grounds novel complexity-focused methods theoretically, increasing their analytic generalization potential.⁷⁴ Empirical results also validated these methods with a socioeconomically marginalized sample by showing that multiple complexity dimensions present in 6 technology-mediated telehealth tasks co-occurred with modest task performance success, high cognitive load, and perceived difficulty. Relatedly, 2 of 6 tasks had high cognitive load scores; these scores aligned with those found for demanding work tasks like control and operation of airplanes.⁷⁵

Participants reacted negatively to high cognitive and temporal demands alongside modest task performance success. Relatedly, frustration when using computer systems is

correlated with lost time.⁷⁶ Subsequently, some participants abandoned tasks, sought help, or stated that they would not continue telehealth tasks in everyday life. Similarly, research elsewhere has documented patient abandonment of technologies that they do not find easy to use.^{77,78} At the FQHC, patients may have been unable or unwilling to complete telehealth-related tasks. This may be linked to the perceived stress levels of participants, which, though moderate at 20.9 ($SD=6.4$), exceeded low perceived stress levels found in national probability samples of adults in the US⁶⁰ and Germany.⁷⁹ However, in line with the timing of this study, these PSS-10 scores are closer to the moderate North American average found in a survey conducted in the early COVID-19 pandemic ($M=16.8$, $SD=5.2$; March-May 2020).¹²³ Such patient stress levels alongside limited ability or willingness could have contributed to the number of video visits at the FQHC decreasing substantially when pandemic isolation waned, as reported by FQHC staff. This also aligns with national research showing inequitable adoption and ongoing usage.^{6-13,17} Further research is needed to determine whether the low adoption and usage of telehealth among socioeconomically marginalized patients at the study FQHC (and perhaps elsewhere) can be explained by *inappropriate design complexity*. Such future research should aim to establish whether task complexity is quantitatively associated with patient performance and uptake/usage differentials. Future research should also be conducted in other settings to facilitate wider generalization.

Study results further support the theoretically-derived²⁷⁻²⁹ claim that *complexity is an equitable technology design issue* via comparisons between the task complexity-related experiences of university-affiliated walkthrough evaluators and the patient sample. For instance, participants experienced difficulties with complexity dimensions that walkthrough evaluators encountered less often: *new concepts/words* and *errors*. Additionally, telehealth tasks took patients more than twice as long as walkthrough evaluators across all tasks; this was problematic given participants’ aversions to *wasting time*. These time-related

findings should be contextualized among socioeconomically marginalized people,^{29,80–82} for whom greater precarity in labor markets⁸³ may mean less time control due to irregular work schedules and working multiple jobs.⁸⁴ Socioeconomically marginalized people also frequently face “time penalties”⁸⁵ from filling out forms for public benefits⁸⁶ and from unreliable public transportation.^{87,88} Thus, equitable technology design might require *designing technologies to take as little time as possible while retaining effectiveness*. Relatedly, technologies that *simplify* health-related activities and thus take less time tend to narrow health outcome inequities.²⁸

The novel methods for assessing technology-mediated tasks presented here may facilitate future equity-focused technology evaluation. This is critical since findings showed that the complexity dimensions that mattered depart from traditional usability heuristics.⁸⁹ This could be linked to the fact that prevailing technology inspection methods of heuristic evaluation and cognitive walkthroughs were initially developed and/or validated with undescribed samples,^{90,91} “average adults”⁹² or technologically savvy subjects who were likely to be socioeconomically advantaged, like industrial engineers and usability specialists.^{93–96} Critically, recent work argues that the use of existing, general heuristics may produce “equity failures” because they cannot accommodate the needs of users with varied socioeconomic positions.²⁵ In contrast, the complexity walkthrough method introduced in this paper identified key difficulties for socioeconomically marginalized users. However, findings also suggest that complexity-focused user testing surfaces additional issues not found in the walkthrough. Consequently, socioeconomically marginalized patients themselves may need to identify *new concepts/words*, and perform tasks themselves to accurately assess *error occurrence*. Because many errors occurred *outside required tasks*, such testing should include all parts of task completion: the tasks, and all required actions *before, between, and after* tasks.

Furthermore, in the service of equitable healthcare technology design, this study tells us *what complexity dimensions mattered*. First, input/process clarity and unstructured guidance (*task ambiguity*) contributed very frequently to participants’ perceived difficulty. Notably, the importance of input/process clarity and unstructured guidance echoes prior HCI theory on “the Gulf of Execution” and the “Gulf of Evaluation.”⁹⁷ In this work, there are gaps between what patients want to do and the actions the systems make available (Execution) and between the system’s actual state and patients’ ability to perceive what the system is actually doing (Evaluation). We also noted usability heuristics aligning with Nielsen’s Visibility of System Status (Heuristic #1), which emphasizes timely, interpretable feedback about system state. However, study data go further by elaborating theoretically-grounded task characteristics that can contribute to those gaps specifically for socioeconomically marginalized patients. Second, *context switching (task relationship)* mattered very frequently. Such context switching was marked by a violation of expectations (ie, mismatches in patients’ mental models) that can widen the gulfs of execution and evaluation. Specifically, patients’ “mental models”⁹⁸ were that the entire telehealth process would occur in the portal. The present work, therefore, specifies some of the task flow expectations that were present among study participants. Third, *new concepts/words (task ambiguity)* mattered frequently.⁹⁷ This may

relate to socioeconomically marginalized people having fewer healthcare experiences than more advantaged people (for example, due to insurance gaps)^{99,100} and less access to primary care.¹⁰¹ This highlights the limits of the well-known technology design principle that “recognition is easier than recall”¹⁰² for patient-facing, technology-mediated healthcare tasks. Indeed, this heuristic assumes prior familiarity with relevant concepts, which may not be evenly distributed across socioeconomic groups. Fourth, *deep hierarchies (alongside insufficient navigation guidance) (task relationship)* contributed to difficulty frequently. A common approach to navigation guidance is to provide menus, which is typically rationalized with the same “recognition is easier than recall”¹⁰² design principle. This is more applicable to this case since the inability to find the appropriate menu item meant that participants needed to remember where it was located.

Other complexity dimensions that mattered frequently were: *amount of time (temporal demands)*; *errors (task reliability)*; and *number of navigational interactions (action complexity)*. Conversely, the following factors only *occasionally* had an influence on participants’ perceptions of difficulty: *task size* and *variety*. However, most telehealth tasks in this study were not particularly large (an average of 4.8 subtasks) or diverse (an average of 2.3 input types), and there were other major areas of difficulty that took precedence for participants. It is possible that size or variety could matter more if tasks have a larger size (following known working memory limits¹⁰³) or greater diversity, or in situations with fewer other complexities at play. Nevertheless, identifying (un)important factors is needed because consistently associating patient demographics with technology adoption and usage without assessing or improving the technologies risks inappropriately individualizing systemic technology design issues.^{24,104} Equity-focused design allows researchers and practitioners to focus upon *(re)designing technology-mediated tasks*, which is easier than changing the socioeconomic positions of individual patients. We now turn to concrete design recommendations based on study findings.

Technology design recommendations for complexity reduction

Several overall design recommendations emerge from study findings to reduce the complexity of technology-mediated tasks for socioeconomically marginalized patients (Box 2). While some scholarship articulates low complexity as a goal,¹⁰⁵ this goal is rarely unpacked to determine *when difficulty emerges from complexity*. Therefore, this section discusses design alternatives for the complexity dimensions that participants believed *mattered most* for task difficulty: *task ambiguity* and *task relationship*.

Recommendation 1: Provide an action-oriented task structure

Task ambiguity can be reduced if more *task structure* is provided^{37,106,107} by using task-focused conceptual models to guide user interface design (Recommendation 1a, Box 2). When task structure is provided, task performance requires less task knowledge,¹⁰⁷ and lowers cognitive load.¹⁰⁸ Similarly, since plain language guidelines advocate *action-oriented text* to make

Box 2. Summary of design recommendations to simplify patient-facing technology-mediated tasks.

Complexity reduction main recommendation	Sub-recommendations	Examples ^a
1. Provide an action-oriented task structure (Counters: Task ambiguity)	1a. Use task analysis and task-focused conceptual models for user interfaces. ¹⁰² 1b. Explicitly show the starting place, goal, and process for a task. ¹⁰⁷ 1c. Chunk tasks into subtasks and place them in a sequence. ^{50,110}	1a. Organize menus with task semantics, ¹²¹ and place action-oriented text on navigation labels ¹⁰⁹ (eg, “Request medications” and “Complete Forms” on main menu in Task 1, Appendix D). 1b. Provide cues for all the subtasks that patients need to complete and indicate which remain as they work through a task. 1c. Create supplemental navigation systems for tasks. ^{50,110}
2. Use familiar concepts and words (Counters: Task ambiguity)	2a. Avoid arranging patient-facing workflows using concepts and words that are primarily meaningful within the health-care organization. 2b. Prospectively collect data through design activities such as concept mapping (eg, ^{114–116}) and/or card sorting (eg, ^{117,118}) to identify patients’ known healthcare concepts and words.	2a. Use health care concepts and words that patients already know. 2b. Present and organize tasks according to known concepts and words as discovered through data collection (eg, “visit” in Appendix D).
3. Minimize and support context switching (Counters: Task relationship)	3a. Avoid shifting between applications and devices wherever possible. 3b. Facilitate automatically shifting between commonly-used applications (if necessary). 3c. Collect and associate resources across contexts and make it easier to stop and restart tasks (if necessary). ^{119,120}	3a. Integrate all tasks and subtasks within one application and device (see Task 3 mockup in Appendix D). 3b. Create links that automatically open the other application. 3c. Assist in re-accessing tasks or documents with “to do” lists or by highlighting task completion status ¹²² (see Tasks 2 and 3 in Appendix D).
4. Flatten hierarchies and provide shallow, task-driven navigation (Counters: Task relationship)	4a. Provide navigation guidance to elucidate task relationships. 4b. Create a broad and shallow navigational system. 4c. Make key documents visible (“right there”) when needed. 4d. Limit scrolling within tasks/subtasks even as navigation is made shallow.	4a. Provide the initial steps and subsequent paths to accomplish tasks. ¹⁰² 4b. Include no more than 2 menu hierarchy levels within a task completion workflow (see Task 2 in Appendix D). 4c. Embed critical documents within task processes (eg, “Get Ready for Your Next Visit” task flow in Task 3, Appendix D) and facilitate known-item searching or browsing). ⁵⁰ 4d. When a task/subtask requires multiple screens, divide it into short sequential screens with Back and Next controls.

^aSee [Appendix D](#) for overall redesigned tasks that embody these recommendations. Specific examples are mentioned only in this Box.

documents more widely accessible,¹⁰⁹ navigation labels (eg, menus and buttons) should use action-oriented text (Recommendation 1a). Task structure is also provided by making explicit the starting place, goal, and process (Recommendation 1b).¹⁰⁷ To facilitate this, overall tasks should be chunked into subtasks and placed into a sequence (Recommendation 1c).^{50,110}

This could be helpfully accompanied by supplemental task navigation systems, particularly those that involve clicking forward and backward. Likewise, although few participants disclosed literacy challenges, it is notable that people with low literacy perform better in assigned tasks using *linear (versus hierarchical) navigation*.^{111–113}

Recommendation 2: Use familiar concepts and words

New concepts and words make tasks more complex¹⁰² due to introduced ambiguity, an issue rarely faced by walkthrough evaluators but common among participants. Designers should avoid arranging patient-facing workflows using concepts and words that are primarily meaningful within healthcare organizations (Recommendation 2a, [Box 2](#)), and leverage what patients *do* already know and use those concepts. To understand what words and concepts *are* familiar, designers should prospectively collect data through design activities, such as concept mapping (eg, ^{114–116}) and/or card sorting (eg, ^{117,118}) (Recommendation 2b). They should then present and organize tasks according to known concepts and words as discovered through data collection. For instance, this study showed that “visits” are promising as a central concept for future telehealth task organization.

Recommendation 3: Minimize and support context switching

Task relationship-associated complexity may be addressed by avoiding shifting between applications and devices whenever possible (Recommendation 3a, [Box 2](#)). For telehealth, we posit that integration of all tasks within one application will go a long way toward supporting socioeconomically marginalized patients. Any unavoidable context switches should be facilitated through links that automatically open another application (Recommendation 3b), with task progress being tracked when moving away from an application. If neither is possible, designers can associate and collect resources across contexts and make it easier to pause and resume tasks (Recommendation 3c).¹¹⁹

Recommendation 4: Flatten hierarchies and provide shallow, task-driven navigation

Providing *navigation guidance* can help to elucidate task relationships (Recommendation 4a, [Box 2](#)). Many participants said they wanted the features “*right there*.” This aligns with the design principle that commonly-used features should be more visible and that it is vital to provide the initial steps and subsequent paths to accomplish tasks.¹⁰² Participants’ difficulties with navigating the portal’s narrow and deep hierarchical navigation system suggest a need for a *broad and shallow system* (Recommendation 4b).¹¹² The mockup for a redesigned Task 2, with only 2 hierarchy levels, is shown in [Appendix D](#). Given participants’ difficulties locating specific documents, special effort is needed to make documents visible (Recommendation 4c). Embedding them within a given healthcare organization’s customized task processes and/or facilitating known-item searching or browsing might also improve access.⁵⁰ Still, to reduce *action complexity*, it is important to minimize *navigational interactions* like scrolling within subtasks (Recommendation 4d).¹¹³ Thus, all necessary content should be visible on one screen.

Limitations

This study had limitations. It focused on one telehealth process using 2 platforms, at one US clinic, and during one historical period, after the lifting of COVID-19 isolation measures. This was a time in which US stress levels were higher than usual,¹²³ and

participants in our sample exhibited moderate stress on average. As expected given their socioeconomic status,^{30,32} participants’ moderate stress levels were still higher than the general US population during this time period. Since there is no clear threshold for stress causing difficulties with performing novel technology-mediated tasks, the generalizability of empirical findings across settings and time periods is unclear. However, a rich description of telehealth tasks and patients’ perspectives may facilitate transferability to similar settings.⁷⁴ Future research should continue to evaluate participants’ perceived stress levels (ie, using measures like PSS-10), to determine whether, and how, they affect findings. This was also an observational study; hence, it is impossible to assign causality to any observed relationships. Some aspects of the user tests may have made tasks more difficult than “in the wild” (ie, when performed on patients’ own devices during a real visit). Participants were not able to seek help from the researcher before trying tasks themselves, but healthcare staff often provide helpful instructions when patients seek care in daily life.¹²⁴ Participants were also given pre-configured devices and Internet hotspots. While this ensured access, they had less familiarity with the test device than with their own devices. Future research should investigate task complexity when telehealth tasks are “in the wild.” The NASA-TLX scale was originally developed for workplace tasks, and it is used less often with socioeconomically disadvantaged people in non-work contexts. To address this, researchers provided participants with a paper-based visual scale and explained the meaning of different numbers on the scale, as well as using clarifying words or questions to ensure understanding and accurate completion.

Conclusion

This study, through novel complexity-focused methods, revealed socioeconomically marginalized patients’ performance difficulties and negative perceptions when performing complex technology-mediated telehealth tasks. *Task ambiguity* and *task relationship* contributed the most to perceived task difficulty, suggesting novel design heuristics for evaluation. Structuring tasks, using familiar concepts, smoothing context switches, and making navigation task-oriented, broad, and shallow could address these difficulties. Taken together, this paper’s methods and findings may guide future equitable design and evaluation of technology-mediated tasks for FQHC patients.

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Author contributions

Tiffany C. Veinot (Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Visualization, Writing—original draft, Writing—review & editing), Alicia K. Stone (Data curation, Investigation, Project administration, Writing—review & editing), Sage Davis (Methodology, Resources, Writing—review & editing), Rupa S. Valdez (Conceptualization, Methodology, Writing—review & editing), Lorraine R. Buis (Funding acquisition, Methodology, Project administration, Resources, Writing—review & editing), Vaishnav Kameswaran (Investigation, Writing—review & editing), Marcy G. Antonio (Data curation, Formal analysis, Investigation, Validation, Visualization, Writing—review & editing), Graciela Lagraba (Visualization, Writing—review & editing), and Tawanna R. Dillahun (Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing—review & editing)

Supplementary material

[Supplementary material](#) is available at *JAMIA Open* online.

Conflicts of interest

Sage Davis was the clinical quality director at the study site, Covenant Community Care, during data collection.

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Data availability

The mixed-methods data gathered during this study are not publicly available and cannot be shared due to confidentiality, since participants are potentially identifiable from the information contained in the data. Furthermore, ethical restrictions imposed by the consent process used with participants prevent data sharing and data requests. Any questions about this can be directed to the corresponding author.

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