

Personalized Clinical Decision Support to Improve Participation in Hospital at Home

Final Report

Principal Investigators:

Marc Kowalkowski, PhD
Andrew McWilliams, MD, MPH

Team Members:

Shih-Hsiung Chou, PhD
Tara Eaton, PhD
Justin Kramer, PhD, MAT
Kelly Reeves, MSN, RN, UXC
Stephanie Murphy, DO
Colleen Hole, BSN, MHA
Asha Ganesan, PhD
Amanda Aneralla, MPH

Organization:

Atrium Health

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Federal Project Officer:

Mario Terán, MD, MS

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STRUCTURED ABSTRACT

Purpose: To develop a technology-enabled shared decision making solution, called 4PACS (Partnering Patients and Providers for Personalized Acute Care Selection), to inform and enhance the complex decisions patients and providers make when considering Hospital at Home (HaH) as a viable care option.

Scope: Patients with pneumonia who are admitted to a brick-and-mortar hospital and low risk for death or ICU stay.

Methods: We leveraged mixed methods to iteratively design and test 4PACS. First, we conducted semi-structured interviews with patients, caregivers, and providers (n=12) to define user needs for 4PACS. Second, we conducted a participatory design session and usability tests with end users (n=7 and 19, respectively) to ideate and refine 4PACS. Third, we conducted a feasibility study with 20 patients approached to use 4PACS, and 3 providers who collaborated in presenting 4PACS. The primary outcome was HaH admission. We also assessed usability and acceptability of 4PACS and practicality of integrating the app into HaH workflows.

Results: After iteratively designing 4PACS, 16 of 20 patients approached during feasibility testing agreed to use 4PACS (80%; 95%CI, 60%-100%). Median age of 4PACS users was 65, 10 (60%) were female, 8 (50%) were Black, 6 (38%) were single, median Charlson Comorbidity Index score was 2, and median Pneumonia Severity Index score at hospital presentation was 74. Twelve patients who used 4PACS were admitted to HaH (75%; 95%CI, 52%-100%). Patients reported excellent usability (median System Usability Scale=89, IQR=85-95). Patients qualitatively reported 4PACS to be accessible and informative and HaH providers indicated 4PACS improved workflow efficiency.

Key Words: Health IT, Shared decision making, clinical decision support, hospital at home, usability, iterative design, real-world, pragmatic evaluation.

PURPOSE

This study was conducted under Health Information Technology (IT) to Improve Health Care Quality and Outcomes with Funding Opportunity Announcement Number PA-17-246. The purpose of the study was to engage end users in the development of an interactive app (called 4PACS –Partnering Patients and Providers for Personalized Acute Care Selection) that helps guide patients and caregivers through the complex decision of whether to pursue hospital at home as a location for their hospital care.

Objective 1. Characterize patient, caregiver, and provider perceptions of the risk tradeoffs, needs, and care preferences for Hospital at Home.

Objective 2. Design 4PACS iteratively with patients, caregivers and providers to integrate risk-model probabilities and patient and caregiver preferences.

Objective 3. Evaluate the feasibility of implementing 4PACS in acute care and establish the rate of patient and provider acceptance of Hospital at Home as a potential care option.

SCOPE

Background and Context

Traditional hospitalization is expensive and resource intensive, accounting for over \$1 trillion in annual U.S. health care spending.¹ Additionally, being hospitalized is associated with risks to patients, some of which are inherent to the acute setting like hospital acquired infections and development of delirium.^{2,3} For these reasons, the concept of shifting some aspects of care from the hospital to home has been present for decades, though its implementation gained momentum during the COVID-19 pandemic.⁴ Coined Hospital at Home, this care model provides hospital level services in a patient's home.^{5,6} Despite growing evidence of improved outcomes for select populations, Hospital at Home has struggled to scale and sustain. One challenge driving low Hospital at Home participation is the complexity of decision making that providers and patients must navigate to consider Hospital at Home at the time of hospital admission.^{7,8} This decision making typically: occurs during a time of stress for patients in a fast-paced, high-acuity environment; relies on assimilating data from multiple sources to ensure the patient meets appropriate criteria (electronic health record, patient reported, and care team); and requires detailed discussions to explain the program, its potential benefits, as well as risks. Prior research suggests that difficult decisions like this should: 1) rely on Clinical Decision Support (CDS) ideally informed by validated models to help identify appropriate populations and 2) be guided by a framework supporting Shared Decision Making (SDM) between providers and patients.⁹⁻¹¹

Creating a useful CDS system is challenged by the inherent complexities in meeting the unique needs of its different user groups (e.g., expectations, information quality, format and features, and cultural considerations), which are best overcome by engaging users throughout the development lifecycle.^{12,13} In this study, we adopted a user-centered design process to develop a technology-

enabled solution, named 4PACS (Partnering Patients and Providers for Personalized Acute Care Selection), to address the gap in CDS and SDM tools for Hospital at Home. We initially focused on patients with pneumonia given its high prevalence and the availability of validated condition-specific decision support tools tailored to acute hospital settings.^{14,15}

Settings and Participants

This study was conducted at Atrium Health, a large integrated health system headquartered in Charlotte, North Carolina between June 2021 and May 2023. The Atrium Health system supports over 14 million patient encounters yearly and generates more than 400,000 discharges annually. Within Atrium Health, the patient population is diverse; 30% of patients are African American and 12% are Hispanic. Practice and hospital settings range from rural to urban.

Specific aim 1: Characterize preferences for Hospital at Home

The study team recruited patients (n=3) who received treatment for pneumonia within our existing Hospital at Home and their caregivers (n=2). For provider recruitment, we enrolled Emergency Department and Hospitalist providers (6 physicians and 1 nurse), who had previously been involved in admitting patients to Hospital at Home. The study team interviewed participants to inform the development of user personas that helped guide early prototyping of the 4PACS decision support app.

Specific aim 2: Design session and usability testing

This aim included two parts. First, we held a design session with two patients, one caregiver, and four providers who collaboratively helped create a wireframe of the 4PACS app. After the research team created version one of the 4PACS app, we conducted in person usability testing. Feedback from this phase was applied to iteratively improve version two of 4PACS, which then also underwent usability testing. During this phase of usability testing, 19 patients, caregivers and providers participated. All patients and their caregivers were recruited for the study during an admission at a traditional brick and mortar hospital located in Charlotte, NC, where they were being treated for pneumonia.

Specific aim 3: Real-world evaluation

The research team partnered with the existing Hospital at Home team to evaluate 4PACS in the real-world setting. For the aim 3 evaluation, the research team worked alongside the patient navigator and 20 admitted patients who were treated for pneumonia participated in the evaluation. The 4PACS app was integrated into the routine workflow of Hospital at Home navigators, who approach potentially eligible patients after confirming eligibility with the patient's attending provider. For the evaluation, patients were provided the opportunity to use the 4PACS app prior to their first discussion with the Hospital at Home navigator.

METHODS

Study Design

This mixed-methods study had three complementary aims that were designed to test the hypothesis that shared decision making for Hospital at Home is feasible to implement and improves patient and provider participation in Hospital at Home. First, we conducted key informant interviews to define user personas and the requirements for 4PACS as a technology-enabled shared decision making solution for Hospital at Home. Second, we applied user-centered design principles to iteratively develop and usability test 4PACS. Finally, we conducted a pilot to test the feasibility of implementing 4PACS and assess perceptions of 4PACS and Hospital at Home participation decisions. We focused our initial investigation and design activities around Hospital at Home as a care option for patients hospitalized with pneumonia. We included eligible patients, caregivers, and providers to ensure diverse representation from different roles involved in the decision to admit patients to Hospital at Home. All study activities were approved by the Advarra Institutional Review Board (#Pro00054146) and conducted with a waiver of signed informed consent.

Data collection

In Aim 1, we conducted key informant interviews to define user personas and initial requirements for development of our 4PACS technology-enabled solution to improve Hospital at Home admission decision making. We conducted semi-structured interviews with patients and caregivers recruited from our Hospital at Home program and physicians and a nurse with experience referring patients to the program via the emergency department (ED) and inpatient care settings. Interview questions were informed by implementation science theory and user-centered design principles. Specifically, the interview guides explored perceptions of: 1) risks and benefits of Hospital at Home; 2) challenges patients and caregivers face when making decisions about their hospital care; 3) barriers and facilitators to meet needs for making informed decision about Hospital at Home participation; 4) attitudes toward shared decision making tools; and 5) ability of a technology-enabled shared decision making tool to satisfy patient, caregiver and provider needs. Interviews lasted approximately 30 minutes. Upon completion, study participants were offered a \$50 debit card as reimbursement for their time. Qualitative data was transcribed and analyzed to identify themes pertaining to user needs in Hospital at Home decision making and to map user needs to design elements for early prototyping.

In Aim 2, we conducted a participatory design session to engage end users (patients, caregivers, and providers) early in app ideation and development processes, followed by usability testing to iteratively reach consensus on app design specifications for a hi-fidelity prototype. The design session was conducted virtually using Microsoft Teams, due to COVID-19 pandemic-related precautions. During the 90 minute design session, patients, caregivers, and providers who agreed to participate reviewed user personas created in Aim 1, the current state of Hospital at Home admission decision making, and examples of healthcare related and unrelated shared decision making tools. Participants were then presented with the following challenge question, “When a patient with pneumonia visits the hospital for care, how might an app help the patient and doctor choose the best hospital care option?”. The remainder of the session was used to ideate and select design recommendations for an initial solution. The study team then translated findings from the design session into an initial wireframe built using R/Shiny (<https://shiny.posit.co/>). Subsequently, we led two rounds of usability testing with stakeholder groups, enrolling eligible patients admitted to the hospital with pneumonia and their caregivers. In each round of testing, we solicited feedback from end users about their experience with 4PACS. We used ‘Think Aloud’ to gather participant insights about 4PACS, the System Usability Scale¹⁶ to collect overall perceptions of usability, and the Net Promoter Score¹⁷ to capture participants’ likelihood to recommend 4PACS to others. Usability tests lasted up to 20 minutes. Upon completion, study participants were offered a \$25 debit card as reimbursement for

their time. Usability problems and corresponding contextual details were catalogued. Each problem was ranked by frequency and severity to characterize adaptation targets and redesign solutions. After each phase of testing, iterative modifications were made to the 4PACS prototype based on the redesign solutions identified through the data.

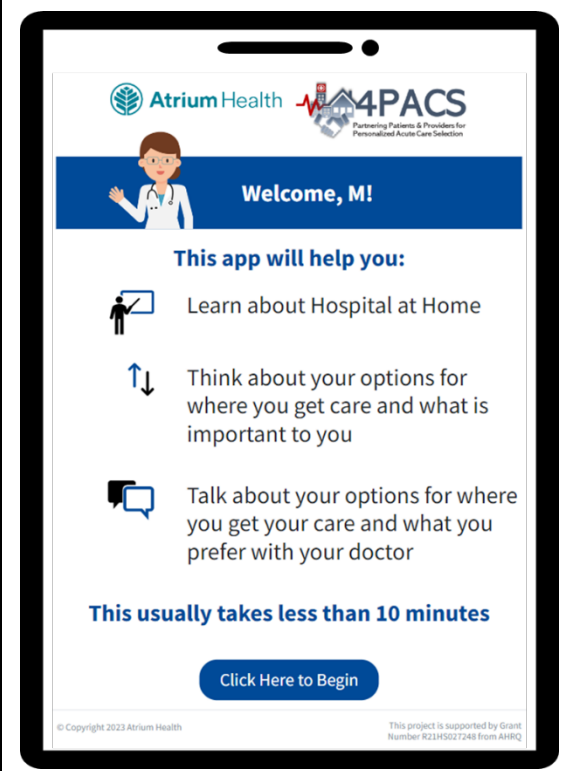
In Aim 3, we conducted quantitative surveys and semi-structured interviews to assess patients' and providers' perspectives on feasibility, acceptability, and usability of implementing 4PACS for shared Hospital at Home admission decision making. Potential study participants were approached in the hospital and presented with the option of using 4PACS. All patients who agreed to participate completed surveys after using 4PACS, and a subset also agreed to take part in an additional semi-structured interview regarding their experience. Surveys included eleven multiple-choice questions, comprised of the System Usability Scale and Net Promoter Score. Semi-structured interviews were designed to capture more detailed understanding of patients' experiences using 4PACS and their suggestions for additional modifications to improve its acceptability to patients. Demographic characteristics were abstracted directly from the health system's electronic health record system and enterprise data warehouse to provide additional descriptive information about participants (e.g., age, sex, race, insurance status) and their hospital encounter (e.g., admission to Hospital at Home). Participants were offered a \$25 debit card for completing each data collection activity. After data collection was completed with patient participants, we also conducted semi-structured interviews with three providers who collaborated to enroll patient participants in Aim 3. Interview questions were designed to assess their perceptions of the 4PACS app's practicality and clinical utility, elicit suggestions for change, and recommendations to integrate 4PACS into existing clinical workflows.

Intervention

Our study developed and tested 4PACS, which was designed to help patients, caregivers, and providers better share in the decision-making process for admission to Hospital at Home. 4PACS is a web-based application that was developed using R/Shiny to run on a tablet computer, but it can also be viewed on a smartphone or desktop computer. Our user-centered design process consisted of initially collecting user needs and identifying user personas to guide early development, followed by design ideation and usability testing with end users, and testing the feasibility of implementing 4PACS in the decision-making process of choosing between hospital-level care options.

The 4PACS app that was ultimately deployed during feasibility testing was comprised of interactive features to promote increased knowledge of Hospital at Home as a care option for patients with pneumonia. These included 1) initial assessment of home-based eligibility factors (e.g., access to a working phone, food availability, ability to perform daily activities or someone to help); 2) goals of the app (e.g., increase understanding about care options, elicit care preferences); 3) video to learn about Hospital at Home; 4) presentation of similarities between Hospital at Home and traditional in-hospital care; 5) side-by-side presentation of differences between Hospital at Home and traditional in-hospital care and interactive feature selection to discern preferences and values; 6) answers to frequently asked questions; 7) presentation of clinical risk information;

Figure 1. Introduction screen for 4PACS



and 8) response summary in preparation for discussion with care team (see 4PACS screenshot, **Figure 1**).

At the time of enrollment, patients who participated in either usability testing or feasibility testing were offered to use 4PACS and provided with an iPad device pre-loaded with the most recent version of 4PACS. Participants were instructed to use this tablet to access 4PACS during their one-time study visit. Additionally, during the feasibility study, participant responses regarding individual care preferences and questions about Hospital at Home were captured and stored in an app-based database. After completion of using 4PACS, a summary of user responses including preferences and questions was shared with the care team to facilitate follow-up discussion of care options. There was no comparison condition in this study.

Measures

In Aim 1, twelve study participants completed qualitative interviews comprised of questions regarding participant characteristics and targeting four domains: 1) attitudes about Hospital at Home; 2) information needs regarding Hospital at Home decision making; 3) perceived barriers to implementing 4PACS; and 4) perceived facilitators to implementing 4PACS. Inductive coding was performed to identify initial overarching themes regarding patient experience and user needs for Hospital at Home shared decision making. Deductive coding was performed to identify user characteristics for user persona development goals.


In Aim 2, individuals were eligible to participate in one of two phases: 1) a participatory design session; or 2) usability testing. Seven patients, caregivers, and providers participated in the design session with the study team. Observation notes were collected from design session participants, thematically analyzed, summarized by the study team and translated into an initial 4PACS wireframe design. Nineteen patients, caregivers, and providers completed usability testing. In each round of testing, we employed Think Aloud to gather participant responses about 4PACS, the System Usability Scale to evaluate perceptions of usability, and the Net Promoter Score to assess likelihood to recommend 4PACS to others. The System Usability Scale included ten, Likert-type questions. Responses were converted to a numeric value and scored (0 to 100) using established criteria.^{18,19} The Net Promoter Score included a single question, rated 0-10. Overall scores were calculated as the proportion of “promoters” (respondents very likely to recommend 4PACS; i.e., scores of 9-10) minus the proportion of “detractors” (respondents unlikely to recommend 4PACS; i.e., scores of 0-6).¹⁷

In Aim 3, twenty patients and caregivers among three providers were offered to use 4PACS during the process of choosing between Hospital at Home and traditional in-hospital care for pneumonia. All participants who used 4PACS completed an exit survey comprised of the System Usability Scale and Net Promoter Score. Demographic and clinical data was collected from the electronic health record system. Primary outcomes included the proportion of patients who were admitted to Hospital at Home after using 4PACS. Secondary outcomes included 1) proportion who used 4PACS among the number approached; 2) median 4PACS system usability scale score; and 3) proportion with high likelihood to recommend 4PACS to others. Descriptive analyses were completed to measure the proportion of patients who used 4PACS (out of total number approached) and the proportion admitted to Hospital at Home. A one-sided, one-proportion z-test was used to test if the observed proportion of patients admitted to Hospital at Home after using 4PACS was greater than the null hypothesis value of 50%. Twelve patient and provider participants completed semi-structured interviews. Qualitative methods were used to explore perceptions of 4PACS acceptability, practicality, and integration from the data.

RESULTS

Principal Findings and Outcomes

Co-design and iterative usability testing. In the initial phase of development, twelve stakeholders participated (three patients, two caregivers, seven providers [physicians/nurse]) in semi-structured interviews to assess user needs and multi-level barriers and facilitators to guide early prototyping and design decisions. We identified four primary themes: attitudes about Hospital at Home; 4PACS app content and information needs; barriers to 4PACS implementation; facilitators to 4PACS implementation. To support design decisions, we characterized three user personas (one for each stakeholder group; see example in **Table 1.**), which helped empathetically understand the end user's behaviors, needs, goals and challenges for decision making around choosing Hospital at Home.

Patient Persona	Description
 <p>Violet</p> <p>60 years old; works as CPA; adult daughter at home</p>	<p>Violet is a single female and works as a professional certified personal accountant (CPA). During the COVID-19 pandemic, her adult daughter moved back in with her. When Violet isn't working, she likes to do yoga to maintain a healthy lifestyle, enjoys wine tasting, and loves to travel.</p> <p>Violet uses technology daily. She relies on technology in many different aspects of her life and is likely to use a health app if it meets her expectations.</p> <p>Quotes: "I use technology frequently. I need it to work and not be compromised."</p> <p>Goals:</p> <ul style="list-style-type: none"> ▪ Likes detailed information that is in plain language ▪ Wants good communication with her health team ▪ Needs to have confidence in the care decision made <p>Pain points:</p> <ul style="list-style-type: none"> ▪ Lack of reliable information ▪ Concerned about healthcare costs and insurance coverage - is the program covered? What is my out-of-pocket cost?

User needs included patient selection criteria, clear program details, and descriptions of Hospital at Home components to inform care expectations. Participant responses, such as the following, exemplified these needs:

- *"I think they could better communicate, when you're released, what's going to happen when you get home... because when they made the decision to release me, I was like, "What? Okay, good. I want to go, but is everything set up?" I think patients leaving knowing exactly what to expect would help." ~ patient*
- *"It caused my mom to almost start to break down into tears to the point where I had to tell the nurse, "we need to be in contact with the people that are gonna be supplying her care going forward." I think, maybe, some better communication or better understanding of who to reach out to..." ~ caregiver*

Implementation barriers included conflict between app recommendations and clinical judgement, inability to adequately represent patient risk profile, and provider burden. Implementation facilitators included ease of use, auto-populating features, and appropriate health literacy. Example quotations from participants to support these determinants included the following:

- *Barrier: "I think that ...clinician judgment has to be first and foremost. I think that's probably the main reason I wouldn't use it, if I felt like my judgment trumped any risk score [in the app]." ~ provider*
- *Barrier: "there's so many different things they want us clicking and doing. So [it has to be] something easy in my workflow of the day" ~ provider*

- *Facilitator: “If it comes prepopulated in the sense, or if [the EHR] can pull all the data and just throw me a score into that app if I just put the patient’s name in—Yes, that would be really useful.” ~ provider*
- *Facilitator: “If the app had information that was clear to a non-doctor person that might help give a better understanding of what the situation is and why you might [choose] Hospital at Home...if it was really kind of easy for the nonmedical person to see the benefits.” ~ patient*

Findings were mapped to potential design elements and user interface features to guide subsequent phases of 4PACS development (see examples in **Table 2**).

Table 2. Example user needs mapped to proposed attribute descriptions and solution requirements

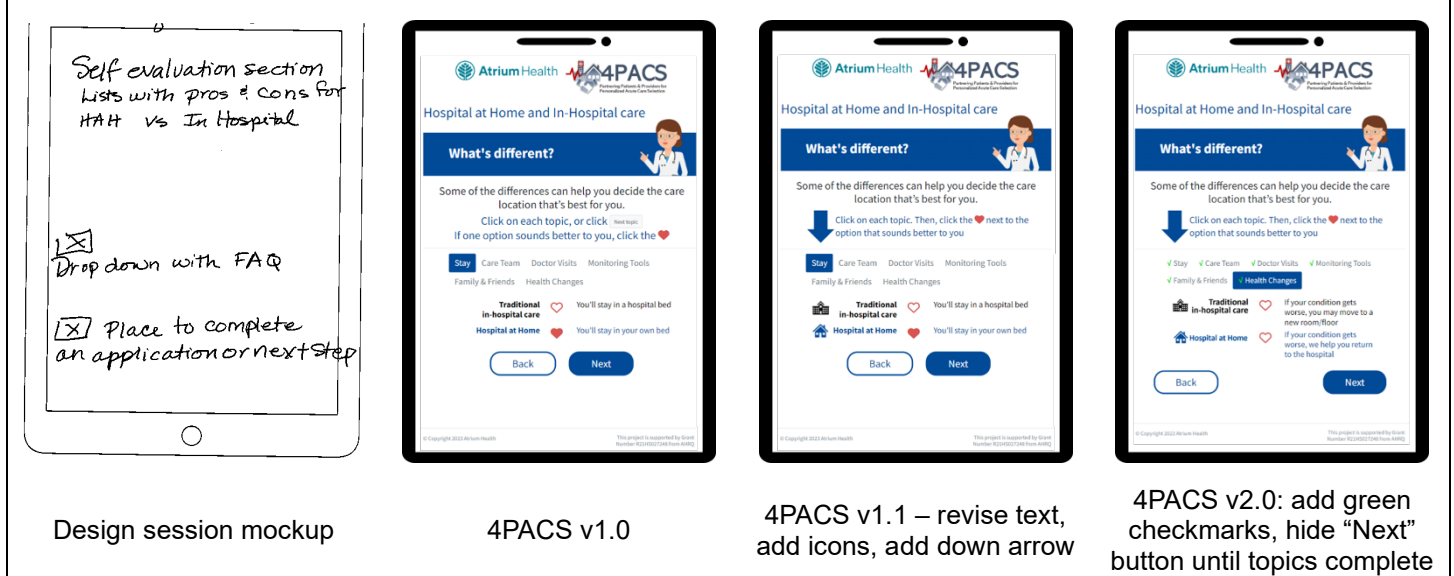
User Need	Design element
Hospital at Home program components/ description	Clear, simple language and visual aids, written at an 8 th grade level (reviewed and approved by health literacy experts)
Alternative means to increase information accessibility	Incorporate video or other media. Colors, numbers, pictographs to convey disease severity using previously validated risk scores.
Understand differences between care settings	Include side-by-side comparisons of key care model differences
Personal values clarification	Check boxes for user selection of preferred care features
Provider burden for data entry	Automated data upload for clinical risk data, other elements

Fourteen stakeholders (two patients, one caregiver, four providers, and seven research team members) participated in a design session to ideate and brainstorm around 4PACS design elements, using the findings from prior semi-structured interviews as background context. Stakeholder feedback collected during the session reiterated key design elements like the following:

- *“Personalized welcome message” ~ provider*
- *“Video sharing the benefits of Hospital at Home, including some doctors and patients” ~ patient*
- *“Self evaluation section with lists of pros and cons for Hospital at Home versus In hospital [care]” ~ patient*
- *Images of “someone at home with a paramedic from Hospital at Home” ~ patient*
- *Pictures “showing some of the equipment” ~ caregiver*
- *Links to a “typical schedule [of care in Hospital at Home]” and “explanation of [disease] risk calculation” ~ provider*

We leveraged this stakeholder feedback to develop an initial prototype (4PACS v1.0). We collected additional feedback from nineteen participants during two rounds of usability testing and iteratively revised app content, appearance, and functionality after each round. An example depiction of modifications applied during the course of 4PACS development is shown in **Figure 2**. These iterative revisions demonstrate the evolution of a screen designed to present the differences between Hospital at Home and traditional in-hospital care and promote interactive feature selection to discern preferences and values.

Figure 2. Co-design progress from initial 4PACS design ideation through iterative app versions.



Between usability testing of 4PACS v1.0 and v1.1, we conducted a literacy evaluation that revealed some content was above our target reading level (8th grade or less). We made text edits like the following to reduce the reading complexity to the 6th grade level.

Original text (reads at 10th grade level):

- Think about your care location options and what is important to you
- Discuss your care location options preferences with your doctor

Revised text (reads at 6th grade level):

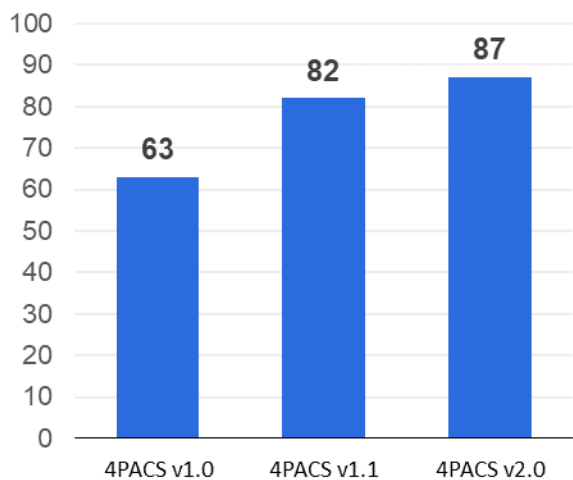
- Think about your options for where you get care and what is important to you.
- Talk about your options for where you get your care and what you prefer with your doctor.

Additional examples of key modifications made to the 4PACS app based on feedback collected during usability testing is shown in **Table 3**.

Table 3. Key modifications made during 4PACS app development

Example critique	Modification type	Modification description
Not intuitive how to access information on different care topics	Change to function	Updated how patients cycle through care-related topics to learn more about their care options
Smaller buttons and hyperlinks were difficult for participants to use	Change to function	Enlarged selection area for “heart” selector and enlarged buttons for those with hand mobility issues
Unclear what the Pneumonia Severity Index meant	Change to content	Integrated health literacy expertise into presentation of risk information to make more accessible to patients
Information about general Hospital at Home operations, home visits, and care team was not sufficient	Change to content	Expanded question and answer section to address common questions about the Hospital at Home program

Figure 3. System Usability Scale scores across versions of 4PACS app



Usability was assessed at each phase of testing with the System Usability Scale. 4PACS v1.0 and v1.1 were deployed during usability testing and 4PACS v2.0 was deployed during the feasibility pilot. Scores increased with each new version of 4PACS (**Figure 3**).

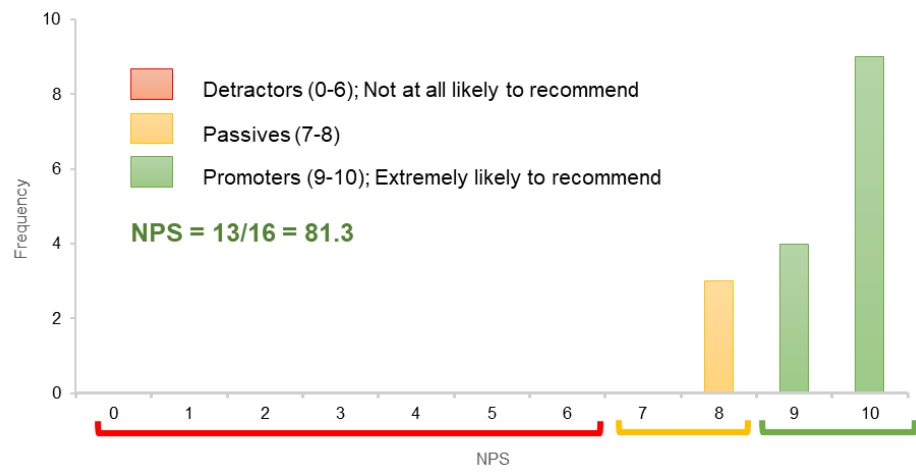
Feasibility pilot. Twenty patients were approached and 16 (80%; 95% confidence interval [CI], 60%-100%; $p < 0.01$) agreed to use 4PACS and complete the evaluation. Of patients who did not use the tool, one was found to have unstable housing after approach (male, unknown age), one was deemed to have mild cognitive impairment (88-year old male) and unable to complete the tool, and two others declined participation (59-year old male, 75-year old female). Of patients who agreed to use and evaluate 4PACS,

the median age at admission was 65 years, 10 (60%) were female, 8 (50%) were Black, 6 (38%) were single, and 7 (44%) had health insurance through either traditional Medicare or Medicare Advantage. The median Charlson Comorbidity Index score was 2 (IQR, 1-3), median Pneumonia Severity Index score at time of hospital presentation was 74 (IQR, 50-91) and 10 (62%) participants reported being able to independently complete activities of daily living prior to admission. Twelve (75%; 95% CI, 52%-100%; $p = 0.04$) patients who used 4PACS were transferred from an inpatient unit to Hospital at Home to complete their hospital stay.

During the feasibility pilot, the mean System Usability Scale score was 87 (SD, ± 12.4) and median System Usability Scale score was 89 (IQR, 85-95). The

calculated Net Promoter Score was 81.3 (**Figure 4**). Thirteen participants (81.3%) indicated they were extremely likely to recommend 4PACS to a friend or family member (i.e., responded 9 or 10 on the 0-10 scale; “promoters”). No participants indicated they were not at all likely to recommend 4PACS to a friend or family member (i.e., responded 0 to 6 on the 0-10 scale; “detractors”).

Figure 4. Net Promoter Score distribution for 4PACS app users



Nine patients and three providers completed semi-structured interviews after using 4PACS. Themes from qualitative data included: 1) ease of 4PACS use; 2) effectiveness of information about receiving care in Hospital at Home; and 3) improved provider efficiency. Illustrative quotes regarding these themes are shown in **Table 4**.

Table 4. Qualitative feedback on 4PACS from feasibility pilot study participants and their providers

Patients found 4PACS easy to use and informative
<ul style="list-style-type: none">• “I have not used any technology that was this easy to use. All I know is this one I seem to be able to use, and I like it.” ~ patient 1• “Listening to the man talk [informational video], and then going through the questions is exactly what I need because I’m by myself—I’m excited about it.” ~ patient 2• “It gave me the right information on top. It gives you a choice. So it’s up to the individual as far as choosing which one.” ~ patient 3
Hospital at Home providers found 4PACS increases efficiency in their workflow
<ul style="list-style-type: none">• “I really liked the fact that patients...get an idea of the program ahead of time. It makes my conversation with the patient more smooth and fast.” ~ provider 1• “I think it’s game-changing because...when a patient understands what to expect from a program...it’s just way, way easier for the patient to make a decision.” ~ provider 2• “If we get them the information generally about hospital at home, that’s where the navigators come in...[and] can customize the plan of care for the patient.” ~ provider 3

Discussion

Hospital at Home programs currently lack decision support tools to help efficiently navigate the complex decision-making process surrounding Hospital at Home as a care option. Our pilot study represents the first evidence demonstrating the feasibility of designing and implementing a web-based app for patients with pneumonia, their caregivers, and providers who are considering Hospital at Home as a choice for their care. Although the study sample was small, we achieved diverse representation and continual collaboration with the target stakeholder groups in our user-centered design process. This approach helped to promote our goal of creating a useful decision support app that fits in clinical workflows and improves efficiencies, while enabling shared decision making.

The 4PACS intervention described here provides a web-based app for patients with pneumonia and their caregivers to learn about Hospital at Home, elicit care preferences, and prepare for and facilitate discussion with providers about location options for their hospital care. 4PACS addresses the prominent challenge produced by the lack of decision support tools available to assist patient selection and enrollment into Hospital at Home, which has recently been identified as one of the most important research priorities for this emerging acute care delivery model.²⁰ Our findings advance this area of science in several key ways.

First, we observed high rates of 4PACS use among those approached to participate in the feasibility pilot, and a majority of those who used 4PACS went on to be admitted to Hospital at Home. Based on existing evidence demonstrating equivalent or better health outcomes for patients who receive care in Hospital at Home versus traditional inpatient care, this suggests that patients hospitalized with pneumonia may derive value from using 4PACS for Hospital at Home admission decision-making.²¹⁻²³ Additional large scale comparative effectiveness studies are needed to evaluate the effect of 4PACS use on patient-centered health outcomes.

Second, this small scale pilot reinforces the potential of using health information technology to link clinical data, accessible patient-centered information, and care preferences to enhance shared decision-making for admission to Hospital at Home. Prior research has shown that lack of knowledge about Hospital at Home is prevalent and deters patients from participating in Hospital at Home.²⁴ Developing tools like 4PACS to effectively overcome this information barrier, in the context of provider time constraints and under complex decision-making conditions, presents a key opportunity to extend access to preference-aligned hospital care options for appropriate patients.

Finally, our findings add further support to applying user-centered design strategies to enhance formative design and iterative improvements in developing useful technology-enabled decision support tools. Importantly, clinical decision support tools often fail to be utilized in practice because of added provider burden and workflow challenges that are not effectively addressed in the design phase.²⁵ By leveraging the feedback collected from end users to revise and enhance 4PACS throughout development, final 4PACS usability scores were high, the patient-facing information was deemed informative by patients, and app use was indicated to increase workflow efficiency for providers by fostering communication with patients who are better prepared. These factors are likely to support sustainability in future testing and dissemination of 4PACS.

Despite the robust mixed-methods approach and rigorous user-centered design process, our study has a few limitations. For example, we collected data on a small cohort of individuals across different study phases. Additionally, we focused our design and evaluation of 4PACS on patients with pneumonia as one of the most prevalent conditions in the inpatient and Hospital at Home settings; however, other conditions are commonly treated in Hospital at Home and should be considered targets for future expansion of 4PACS not represented here. Last, while fully integrating 4PACS with the electronic health record system was beyond the scope of this project, it is important to acknowledge that this will be a necessary future step to promote scalability and sustainability.

Conclusions

The 4PACS app was successfully designed with iterative feedback from end users and was associated with excellent usability. Our findings suggest that web-based, patient-centered decision support tools are feasible to implement to help patients and their caregivers navigate the complex decision-making process of choosing between discrete hospitalization options with their doctor. Future work should extend findings of this study to assess the efficacy of the 4PACS app intervention to improve hospital-level care decisions and health outcomes on a larger scale and in diverse contexts and settings.

Significance and Implications

To our knowledge, this is the first web-based app decision aid to support shared decision making about Hospital at Home admission. This technology was highly useful and acceptable to participants within our small study sample and addresses a gap in patient-centered clinical decision support for Hospital at Home. Given recent expansion of Hospital at Home as a care delivery model, we are optimistic that ongoing efforts to improve the app, extend to different disease conditions, and integrate 4PACS with the electronic health record system will provide patients and their caregivers with important information to enhance shared decision making with providers, access to preference-aligned hospital-level care options, and ultimately patient-centered health outcomes. Future studies will focus on these goals and will leverage our findings to improve the care delivered to patients hospitalized with pneumonia and other common acute illnesses.

PUBLICATIONS

Peer-reviewed Manuscripts

1. Kowalkowski M, Eaton T, Reeves K, Kramer J, Murphy S, Hole C, Chou SH, Aneralla A, McWilliams A. Incorporating patient, caregiver, and provider perspectives in the co design of an app to guide Hospital at Home admission decisions: A qualitative analysis (*under review*)
2. A web-based app intervention for Hospital at Home admission decisions: An iterative usability study with patients and providers (*in preparation*)
3. The feasibility and acceptability of implementing a web-based app intervention for Hospital at Home admission decisions (*in preparation*)

Presentations

1. Chou SH, McWilliams A, Murphy SE, Colleen H, Eaton T, Reeves K, Aneralla A, Graham, BP, Kowalkowski M. Preliminary Evaluation Of A Patient Selection Algorithm To Advance Clinical Decision Support For Hospital-at-home Eligibility Decisions. Presented at Society of Hospital Medicine Converge Conference; Nashville, TN, April 2022.
2. Murphy SE, Kowalkowski M, Chou SH, Hole C, Eaton T, Reeves K, Aneralla A, Baek S, Denault L, Kirkendall E, McWilliams A. Patient and Provider Decision Support to Facilitate Hospital at Home Delivery Model. Presented at Hospital Medicine Innovation Competition, Society of Hospital Medicine Converge Conference; Nashville, TN, April 2022. *Awarded First Prize in Innovation Competition.*
3. Eaton T, Reeves K, Kowalkowski M, Chou S-H, Murphy S, Aneralla A, Palmer P, Kramer J, McWilliams A. Rapid Design of a Clinical Decision Support Tool for Hospital at Home Admissions: Employing Qualitative Interviews and User Personas in the Identification of Stakeholder Needs and Preferences. Hospital at Home Users Group Virtual Annual Meeting. October 2022.
4. Chou S-H, Murphy S, Eaton T, Reeves K, Veerappanganesan A, Kramer J, McWilliams A, Kowalkowski M. Patient and Provider Decision Support for Hospital at Home: An update from Shark Tank 2022. Society for Hospital Medicine Annual Conference. March 26-29, 2023 in Austin, TX.
5. Eaton T, Reeves K, Kowalkowski M, Chou SH, Murphy S, Aneralla A, Palmer P, Kramer J, McWilliams A. Rapid Design of a Clinical Decision Support Tool for Hospital at Home Admissions: Identifying Stakeholder Needs and Preferences Using Qualitative Interviews and User Personas. Presented at AcademyHealth Annual Research Meeting, Seattle, WA; June 24-27, 2023

REFERENCES

1. Martin AB, Hartman M, Washington B, Catlin A. National Health Care Spending In 2017: Growth Slows To Post–Great Recession Rates; Share Of GDP Stabilizes. *Health Affairs*. 2019;38(1).
2. Schreiber PW, Sax H, Wolfensberger A, Clack L, Kuster SP. The preventable proportion of healthcare-associated infections 2005–2016: Systematic review and meta-analysis. *Infection Control & Hospital Epidemiology*. 2018;39(11):1277-1295.
3. Marcantonio ER, Solomon CG. Delirium in Hospitalized Older Adults. *New England Journal of Medicine*. 2017;377(15):1456-1466.
4. Jaklevic MC. Pandemic Boosts an Old Idea-Bringing Acute Care to the Patient. *JAMA*. 2021.
5. Leff B. Defining and disseminating the hospital-at-home model. *CMAJ*. 2009;180(2):156-157.
6. Leff B, Burton L, Mader SL, et al. Hospital at home: feasibility and outcomes of a program to provide hospital-level care at home for acutely ill older patients. *Ann Intern Med*. 2005;143(11):798-808.
7. Huntley AL, Chalder M, Shaw ARG, et al. A systematic review to identify and assess the effectiveness of alternatives for people over the age of 65 who are at risk of potentially avoidable hospital admission. *BMJ Open*. 2017;7(7).
8. Hammond CL, Pinnington LL, Phillips MF. A qualitative examination of inappropriate hospital admissions and lengths of stay. *BMC Health Services Research*. 2009;9(1).
9. Sutton RT, Pincock D, Baumgart DC, Sadowski DC, Fedorak RN, Kroeker KI. An overview of clinical decision support systems: benefits, risks, and strategies for success. *NPJ Digit Med*. 2020;3:17.
10. Fried TR. Shared Decision Making--Finding the Sweet Spot. *N Engl J Med*. 2016;374(2):104-106.
11. Kunneman M, Montori VM, Castaneda-Guarderas A, Hess EP. What Is Shared Decision Making? (and What It Is Not). *Acad Emerg Med*. 2016;23(12):1320-1324.
12. Westerbeek L, Ploegmakers KJ, de Bruijn GJ, et al. Barriers and facilitators influencing medication-related CDSS acceptance according to clinicians: A systematic review. *Int J Med Inform*. 2021;152:104506.
13. Chua CMS, Ko SQ, Lai YF, Lim YW, Shorey S. Perceptions of Hospital-at-Home Among Stakeholders: a Meta-synthesis. *J Gen Intern Med*. 2022;37(3):637-650.
14. James DC, Aran S, Ahsan RA, et al. Severity assessment tools for predicting mortality in hospitalised patients with community-acquired pneumonia. Systematic review and meta-analysis. *Thorax*. 2010;65(10):878.
15. Jones BE, Ying J, Nevers M, et al. Computerized Mortality Prediction for Community-acquired Pneumonia at 117 Veterans Affairs Medical Centers. *Ann Am Thorac Soc*. 2021;18(7):1175-1184.
16. Lewis JR. The System Usability Scale: Past, Present, and Future. *International Journal of Human–Computer Interaction*. 2018;34(7):577-590.
17. Reichheld FF. The one number you need to grow. *Harv Bus Rev*. 2003;81(12):46-54, 124.
18. Hyzy M, Bond R, Mulvenna M, et al. System Usability Scale Benchmarking for Digital Health Apps: Meta-analysis. *JMIR mHealth and uHealth*. 2022;10(8).
19. Lewis JR, Sauro J. Can I leave this one out? the effect of dropping an item from the SUS. *J Usability Studies*. 2017;13(1):38–46.
20. Leff B, DeCherrie LV, Montalto M, Levine DM. A research agenda for hospital at home. *J Am Geriatr Soc*. 2022;70(4):1060-1069.
21. Shepperd S, Iliffe S, Doll HA, et al. Admission avoidance hospital at home. *Cochrane Database Syst Rev*. 2016;9(9):CD007491.
22. Goncalves-Bradley DC, Iliffe S, Doll HA, et al. Early discharge hospital at home. *Cochrane Database Syst Rev*. 2017;6(6):CD000356.

23. Levine DM, Ouchi K, Blanchfield B, et al. Hospital-Level Care at Home for Acutely Ill Adults: A Randomized Controlled Trial. *Ann Intern Med.* 2020;172(2):77-85.
24. Paulson N, Paulson MP, Maniaci MJ, Rutledge RA, Inselman S, Zawada SJ. Why U.S. Patients Declined Hospital-at-Home during the COVID-19 Public Health Emergency: An Exploratory Mixed Methods Study. *Journal of Patient Experience.* 2023;10.
25. Stacey D, Suwalska V, Boland L, Lewis KB, Pesseau J, Thomson R. Are Patient Decision Aids Used in Clinical Practice after Rigorous Evaluation? A Survey of Trial Authors. *Medical Decision Making.* 2019;39(7):805-815.