MEDINFO 2021: One World, One Health – Global Partnership for Digital Innovation
P. Otero et al. (Eds.)

doi:10.3233/SHTI220122

Digital Methodology for Mobile Clinical Decision Support Development in Long-Term Care

Malaika R. Gallimore, RN, MPH[a], Chelsea Howland, MSN[a], Jo-Ana D. Chase, PhD, APRN-BC[a], Amy Grimsley, MSN, RN, CCRN-K[a], Chuka Emezue, PhD, MPH, MPA[a], Katrina Boles, MS[b], Allison B. Anbari, PhD, RN[a], LeeAnne B. Sherwin, PhD, MS, FNP-BC[a], Amy Vogelsmeier, PhD, RN, FAAN[a], Lori Popejoy, PhD, RN, FAAN[a], Marilyn J. Rantz, PhD, RN, FAAN[a], Blaine Reeder, PhD[a,b]

[a]Sinclair School of Nursing, University of Missouri, Columbia, Missouri, USA
[b]MU Institute for Data Science and Informatics, University of Missouri, Columbia, Missouri, USA

Abstract

The global COVID-19 pandemic has driven innovations in methods to sustain initiatives for the design, development, evaluation, and implementation of clinical support technology in long-term care settings while removing risk of infection for residents, family members, health care workers, researchers and technical professionals. We adapted traditional design and evaluation methodology for a mobile clinical decision support app - designated Mobile Application Information System for Integrated Evidence ("MAISIE") - to a completely digital design methodology that removes in-person contacts between the research team, developer, and nursing home staff and residents. We have successfully maintained project continuity for MAISIE app development with only minor challenges while working remotely. This digital design methodology can be implemented in projects where software can be installed without in-person technical support and remote work is feasible. Team skills, experience, and relationships are key considerations for adapting to digital environments and maintaining project momentum.

Keywords:

Mobile Applications, Clinical Decision Support, Technology Development

Introduction

The global COVID-19 pandemic has challenged post-acute care facilities to protect vulnerable patients and staff from infection while maintaining normal operations and sustaining initiatives that improve care delivery[3]. One important improvement area is information technology sophistication, specifically with regard to clinical support technology, which is particularly lacking in nursing homes[1]. Given that long-term care residents are at high risk for morbidity and mortality[3], infection control protocols will dictate restrictions on entry to long-term care facilities for an indeterminant time period. Accordingly, status quo research and quality improvement methods for the design, development, evaluation, and implementation of clinical support technology that require in-person contacts between essential and non-essential staff will also be restricted. Therefore, innovative methods are needed to comply with infection control protocols that reduce infection risk and, at the same time, sustain clinical technology support initiatives that can improve care delivery.

The objective of this report is to describe our adaptation of traditional design and evaluation methodology for a mobile clinical decision support app for use in long-term care - designated Mobile Application Information System for Integrated Evidence (MAISIE) – to maintain project continuity during the COVID-19 global pandemic. We revised our approach as a completely digital design methodology to eliminate infection risk during app development and testing by removing all in-person contacts for anyone involved in the project. Figure 1 illustrates the MAISIE digital design methodology.

MAISIE is a mobile clinical decision support smart phone app designed to bring evidence-based guidelines to nurses for assessment of symptom concordance for suspected clinical syndromes in long-term care settings. The app is intended to support clinical practice and communication by simplifying use of guidelines for suspected clinical syndromes via symptom checklists, verification of symptom concordance or non-concordance with suspected clinical syndromes based on user inputs, and generating Situation, Background, Assessment and Recommendation (SBAR) scripts based on outputs. MAISIE expands our prior work developing a dedicated mobile clinical decision support app for evidence-based urinary tract infection (UTI) symptom concordance for anti-microbial stewardship in long-term care [4; 9; 10]. In the prior work, nurse users of the UTI mobile app requested expanded feature support for other clinical syndromes, including respiratory infection. Based on this request and our current team expertise, a long-term goal of the MAISIE project is to support features for the six most common clinical syndromes that result in avoidable hospitalization for nursing home residents. These six clinical syndromes are: UTI, pneumonia, dehydration, congestive heart failure, skin ulcers/cellulitis, and chronic obstructive pulmonary disease/asthma [15].

The MAISIE project began in March 2020 just before we began working from home to maintain social distancing in response to COVID-19. Our digital design methodology implements methods translated from our experience with applied technology and research projects in nursing homes and other contexts [4; 8-13]. The core team comprises members of the Precision Smart Technologies and Applications for Rapid Translation (Precision START) laboratory at the University of Missouri Sinclair School of Nursing and the MU Institute for Data Science and Informatics with input from senior nursing faculty and advisors from the Missouri Quality Initiative (MOQI). MOQI is a Center for Medicare and Medicaid Innovation Initiative to reduce avoidable hospitalizations for long-stay nursing home residents through early illness detection and improved management of chronic conditions and has an 8-year history of funding [2; 6; 7; 16].

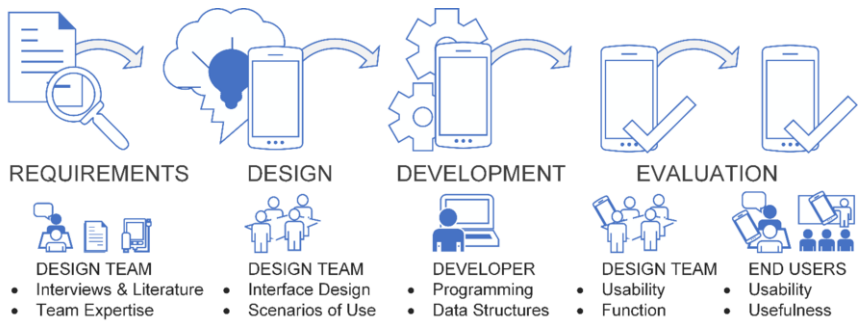

Figure 1. Overview of MAISIE digital design methodology

Methods

To maintain MAISIE project continuity, we innovated to eliminate risk of infection for everyone involved in the project. Prior work with design, development, and evaluation of the UTI app in nursing homes was conducted mainly through in-person team meetings, stakeholder interviews, app installations, and usability tests. We note that different aspects of "traditional" methodology have been implemented digitally in our pre-pandemic work because many design projects naturally involve a mix of in-person and remote contacts. However, the COVID-19 pandemic has served as a driver to bring the entire process into a digital state that allows for social distancing between all team members and stakeholders impacted by development of the MAISIE app. Table 1 compares digital and traditional activities of the design process.

MAISIE app features for UTI and COVID-19 features were developed and formatively tested by the lab team through three iterations with distinct foci using the digital methodology. The three foci were: content, usability, and function. The MAISIE remote usability protocol was pilot-tested and refined during two run-throughs with three research team members consisting of two nurses and a human-centered design methodologist in preparation for testing with nurses in long-term care. Protocol pilot tests were conducted via Zoom and browser-based simulations running fully-interactive MAISIE app code. In the first session, one nurse played the role of the test participant while

Table 1 – Comparison of design activities in digital and traditional approaches

Design Activity	Digital	Traditional
Weekly team meetings to: • Document information needs based on prior app research in nursing homes, stakeholder input, and literature review • Develop case scenarios for feature requirements and testing • Design interfaces	Video meetings	In-person meetings
Stakeholder meetings as needed with post-acute care experts, nursing home advisory board members, and MOQI team members to solicit requirements and implementation guidance	Video meetings, e-mail, messaging tools	Mix of in-person and video meetings and e-mail
Project management meetings as needed between design team and developer	Video meetings	Mix of in-person meetings and video meetings
Requirement communication and iterative delivery of MAISIE app versions	E-mail attachments, web pages, file sharing tools	E-mail attachments, web pages, and file sharing tools
Design team meetings as needed for usability and function testing for new MAISIE app versions	Video meetings	Mix of in-person meetings and video meetings
Accessing the MAISIE app	Download and installation of the app or remote access of browser-based app simulation	In-person installation by the design team
Usability and function testing with nursing home clinical end users	Video meetings with interactive online trainings and electronic surveys	In-person meetings and a mix of paper-based and electronic surveys
Member-checking of evaluation results	E-mail, file sharing tools, and video meetings	E-mail, in-person meetings, and phone calls

the other two team members served as primary and secondary interviewers who administered cognitive walk-through test procedures[5] and conducted a post-test interview. In the second session, the nurse team members switched interviewer and test participant roles.

Results

MAISIE feature results

The current version of MAISIE developed using our digital design methodology re-implements a UTI feature from prior work [4; 9; 10] and includes support for a COVID-19 feature within a clinical decision support framework that can be expanded based on user-driven needs in post-acute care contexts. MAISIE implements an interface that follows a head-to-toe assessment sequence to solicit resident symptom self-reports followed by clinician symptom assessments. The COVID-19 menu feature uses symptom checklists based on WHO and CDC guidance and is updated as evidence evolves[14; 17]. Figure 2 shows MAISIE app interfaces for the UTI menu feature that illustrate workflow using expandable checklist controls resulting from application of the digital methodology. The five additional feature options for pneumonia, dehydration, congestive heart failure, skin ulcers/cellulitis, and chronic obstructive pulmonary disease/asthma suggested by nursing home stakeholders will be implemented as features are prioritized during design engagements.

App development and evaluation is iterative and informed by our applied research experience with participatory and user-centered design methods [4; 8-13]. Based on requirements generated from our prior app research [4; 9; 10] and with input from current team members and stakeholders, the developer digitally delivered a prototype of the MAISIE app that implements the UTI and COVID-19 symptom cluster features. The first iteration within-team evaluation of MAISIE was content-based and focused on sequence of symptom data entry for COVID-19. The primary result of the first iteration evaluation was to reorder data input as a head-to-toe assessment starting with resident self-report and moving to objective measures. The next MAISIE app version implemented these changes with updated symptom guidance based on rapidly changing COVID-19 evidence[14; 17]. The second iteration evaluation focused on usability and the primary result was to reduce the number of data entry screens by presenting checklists in expandable menus (See Figure 2). The third iteration evaluation focused on function testing to verify correct identification of symptom concordance with clinical syndrome definitions using cases generated by the design team. This version of MAISIE is ready for review and testing via digital means by senior nursing advisors and advanced practice registered nurses embedded fulltime in Missouri nursing homes as part of the MOQI initiative.

Remote protocol pilot test results

Pilot tests of the remote protocol identified the need for changes in usability test procedures that were based on assumptions from our past in-person usability testing experiences and our daily work meeting experiences with video conferencing. Specifically, we refined the protocol with regard to when, how and by whom screens should be shared during usability testing, and when, how and in what format information about test scenarios should be shared with participants during usability test sessions. Remote testing requires verbal or digital consent of participants using online tools. Demonstration and explanation of the app requires screen sharing by the researchers. During cognitive walk-throughs, participants must share their screens via Zoom to allow researchers to observe and record app interactions. This also required us to develop explicit instructions to guide participants in the sharing of their screens. For example, our usability test protocol calls for participants to step through four scenarios of UTI patient cases: two cases with concordant symptoms and two with non-concordant symptoms. We learned that the researchers reading the patient case scenarios triggered an urge in the nurses playing the participant role to take notes as if they were taking a report from another nurse. However, simply copying and sending the text of the patient case via the chat feature in Zoom created a sense of time pressure and also the perception that we were testing the reader's comprehension

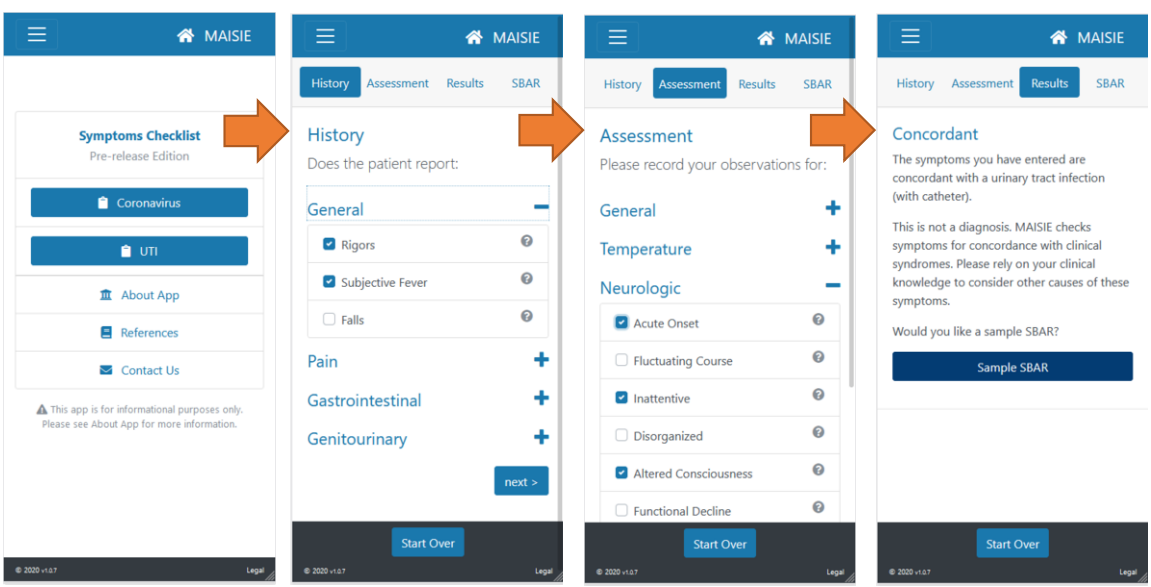

Figure 2. MAISIE app interfaces illustrating workflow refinements with expandable checklists developed with digital methodology

of the patient case. We discovered that the best solution was to send the text of the patient case via the chat feature to the participant side and then have the researcher read the patient case aloud while the participant follows along. In addition, to reduce participant cognitive load, we learned we needed to extract vital signs and symptoms from the patient case and send them via the Zoom chat feature as an itemized list when the participant indicates they are ready to begin the test scenario. Our pilot test of procedures revealed the need for changes to the previously approved institutional review board study protocol.

Discussion

We have demonstrated a digital design methodology for mobile clinical decision support apps that removes infection risk for all research team members, participants and stakeholders. Based on accepted design methods, and incorporating evidence from our previous app project, this effort has been successful with minor challenges. Notable challenges have been delays in communicating feature change summaries and revised app interfaces to the developer by the design team leader due to scheduling constraints at the beginning of the global COVID-19 pandemic. While these bottlenecks existed before the pandemic, they were revealed by the move to remote work. We have begun to address these challenges by adopting messaging platforms that mimic real-time communications afforded by in-person interactions and moving to greater decentralization of tasks.

Important considerations for successful adoption of this digital design methodology throughout the app development life cycle are the need for buy-in and active participation from the design team, development team, content experts, nurses, and administrators in nursing homes. We benefited from the in-house informatics, clinical, and nursing home expertise in the Precision START Lab, MU Sinclair School of Nursing, MU Institute for Data Science and Informatics, and the Missouri Quality Initiative (MOQI). Indeed, the next phase to fully implement our digital design methodology will rely on long-standing relationships in long-term care that will enable us to recruit nurse participants for remote testing and deployment of the MAISIE app. For other projects, stakeholder participation needs will vary by project, focus, requirements and context.

Another key consideration in successful translation from in-person or hybrid design and evaluation methodologies to a digital methodology is to test all assumptions of the translation process, regardless of experience of the team. While we acknowledge the limitation that nurse scientists on the research team are not the target audience of nurses practicing in long-term care, the formative test of our procedures was invaluable. Even with the deep experience of our team with design studies, nursing and long-term care settings, without a run-through of the test protocol, we may have encountered potential embarrassing or failed outcomes during remote usability test sessions with nurse participants.

Conclusions

We have described our experiences in adapting traditional design and evaluation methodology for a mobile clinical decision support app for use in long-term care. In doing so, we highlighted two aspects of the project by describing the app produced by the methodology (the product) and the digital design methodology itself (the process).

This digital design methodology is appropriate for projects where software can be installed without in-person technical support and the context allows for remote work. Evaluation of the digital method is ongoing and adaptive based on emergent project needs, resources, and team availability. Special care should be taken to consider and test all assumptions when translating the complex process of app design, development, and evaluation to a wholly digital research process. In addition, explicit procedures to support varying levels of participant technical knowledge should be prepared in advance. Team skills, experience, and relationships are key considerations for adapting to wholly digital research.

Acknowledgements

The MU Sinclair School of Nursing provides funding for the Precision START lab. Malaika R. Gallimore and Chelsea Howland are funded as pre-doctoral fellows by the National Institutes of Health T32 Health Behavior Science Research Training Grant 5T32NR015426 at the MU Sinclair School of Nursing.

Lori Popejoy, Amy Vogelsmeier, and Marilyn Rantz report conflicts of interest for New Path Health Solutions. Blaine Reeder is co-founder and Chair of the Board of Directors for Hekademeia Research Solutions, a non-profit organization whose mission is to support technology-based academic research. He receives no direct financial benefit from this relationship. The remaining authors report no conflicts of interest.

References

[1] G.L. Alexander, R.W. Madsen, E.L. Miller, M.K. Schaumberg, A.E. Holm, R.L. Alexander, K.K. Wise, M.L. Dougherty, and B. Gugerty, A national report of nursing home information technology: year 1 results, *Journal of the American Medical Informatics Association* **24** (2016), 67-73.

[2] CMS Innovation Center, Initiative to Reduce Avoidable Hospitalizations Among Nursing Facility Residents, in, U.S. Centers for Medicare & Medicaid Services.

[3] D. Dosa, R.L.P. Jump, K. LaPlante, and S. Gravenstein, Long-Term Care Facilities and the Coronavirus Epidemic: Practical Guidelines for a Population at Highest Risk, *Journal of the American Medical Directors Association* (2020).

[4] W. Jones, C. Drake, D. Mack, B. Reeder, B. Trautner, and H.L. Wald, Developing Mobile Clinical Decision Support for Nursing Home Staff Assessment of Urinary Tract Infection using Goal-Directed Design, *Applied Clinical Informatics* **8** (2017), 632-650.

[5] D.R. Kaufman, V.L. Patel, C. Hilliman, P.C. Morin, J. Pevzner, R.S. Weinstock, R. Goland, S. Shea, and J. Starren, Usability in the real world: assessing medical information technologies in patients' homes, *Journal of Biomedical Informatics* **36** (2003).

[6] M.J. Rantz, G. Alexander, C. Galambos, A. Vogelsmeier, L. Popejoy, M. Flesner, A. Lueckenotte, C. Crecelius, M. Zwygart-Stauffacher, and R.J. Koopman, Initiative to test a multidisciplinary model with advanced practice nurses to reduce avoidable hospitalizations among nursing facility residents, *Journal of Nursing Care Quality* **29** (2014), 1-8.

[7] M.J. Rantz, L. Popejoy, A. Vogelsmeier, C. Galambos, G. Alexander, M. Flesner, C. Crecelius, B. Ge, and G. Petroski, Successfully reducing hospitalizations of nursing home residents: Results of the Missouri Quality Initiative, *Journal of the American Medical Directors Association* **18** (2017), 960-966.

[8] B. Reeder, J. Chung, T. Le, H.J. Thompson, and G. Demiris, Assessing Older Adults' Perceptions of Sensor Data and Designing Visual Displays for Ambient Environments. An Exploratory Study, *Methods of Information in Medicine* **53** (2014), 152-159.
[9] B. Reeder, C. Drake, M. Ozkaynak, W. Jones, D. Mack, A. David, R. Starr, B. Trautner, and H.L. Wald, Usability inspection of a mobile clinical decision support app and a short form heuristic evaluation checklist, in: *HCI International 2019*, Springer, Orlando, FL, 2019, pp. 1-14.
[10] B. Reeder, C. Drake, M. Ozkaynak, and H.L. Wald, Usability Testing a Mobile Clinical Decision Support App for UTI Diagnosis in Nursing Homes, *Journal of Gerontological Nursing* **45** (2019), 11-17.
[11] B. Reeder, R.A. Hills, A.M. Turner, and G. Demiris, Participatory design of an integrated information system design to support public health nurses and nurse managers, *Public Health Nursing* **31** (2014), 183-192.
[12] B. Reeder, D. Revere, D.R. Olson, and W.B. Lober, Perceived Usefulness of a Distributed Community-Based Syndromic Surveillance System: A Pilot Qualitative Evaluation Study, *BMC Research Notes* **4** (2011), 187.
[13] B. Reeder and A.M. Turner, Scenario-based design: A method for connecting information system design with public health operations and emergency management, *Journal of Biomedical Informatics* **44** (2011), 978-988.
[14] U.S. Centers for Disease Control and Prevention, Symptoms of Coronavirus, in, 2020.
[15] U.S. Centers for Medicare and Medicaid Services, Phase Two: Payment Reform, in, 2014.
[16] A. Vogelsmeier, L. Popejoy, S. Kist, S. Shumate, A. Pritchett, J. Mueller, and M. Rantz, Reducing Avoidable Hospitalizations for Nursing Home Residents: Role of the Missouri Quality Initiative Intervention Support Team, *Journal of Nursing Care Quality* **35** (2020).
[17] World Health Organization, Coronavirus, in, 2020.

Address for correspondence

Blaine Reeder, Associate Professor
Associate Professor
University of Missouri
blaine.reeder@missouri.edu