



# An exploration of facilitators and barriers to patient navigator core functions with breast cancer patients: Implications for the development of a human-centered mHealth app

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## ARTICLE INFO

### Keywords:

Breast neoplasms  
Humans  
Mobile applications  
Needs assessment  
Patient navigation  
Smartphone  
User-computer Interface  
Workflows

## ABSTRACT

**Objectives:** To understand the barriers to core functions and workflow among patient navigators (PN) who navigate people diagnosed with breast cancer (BC). To identify how a mobile health (mHealth) app could assist PNs in providing care to BC patients.

**Methods:** This qualitative research study used purposive sampling to recruit stakeholders ( $N = 33$ ) from January to August 2021. We conducted individual semi-structured interviews with PNs ( $n = 11$ ), oncology care providers ( $n = 12$ ), and BC patients ( $n = 10$ ). We used conventional content analysis to analyze the interview data.

**Results:** Participants identified the following sociotechnical systems barriers in PN workflows that negatively impact BC patient care: 1) resources, 2) insurance coverage, 3) communication challenges, and 4) impact of logistical tasks. Participants identified the user experience, app features, and interoperability customizations to enhance PNs' provision of patient care as important design elements to include in a mHealth app.

**Conclusion:** Feedback from stakeholders provided valuable insights into key design considerations, functions, and content areas for developing a mHealth app for PN use in BC care delivery.

**Innovation:** This is one of the first studies to incorporate the human-centered design and sociotechnical systems frameworks to understand barriers to PN workflow and provision of BC patient care across the cancer care continuum.

## 1. Introduction

Breast cancer (BC) is the most commonly diagnosed cancer, with 2.3 million new cases per year, and is the fifth leading cause of death globally [1,2]. Advancements in BC screening, early detection, and treatments have reduced the BC mortality rate [1,3-5], with a 5-year relative survival rate of 90.8% in the U.S. [5]. However, persistent health disparities remain for specific populations, including BC patients who identify as Black, African American, and Hispanic/Latino. Worse BC outcomes in these populations are due, in part, to later stage of diagnosis and treatment delays from barriers to healthcare access and lack of timely care [6-8]. There is a need for improving BC care pathways across the cancer care continuum – from screening to end of life - to address healthcare access barriers and improve the coordination of

timely care for BC patients [4].

One cost-effective approach to reducing these care barriers is patient navigation, which is a patient-centered intervention model designed to reduce healthcare access barriers [3,6,9-11] and prevent delays in care [11-14]. Patient navigators (PNs) provide a critical role in BC care delivery by guiding individuals diagnosed with BC through the complex health system [12,15,16]. The PN role and level of professional training vary and include lay navigators, nurse navigators, registered nurses, advanced practice nurses, or social workers [14,17]. Substantial evidence and national reports document the significant benefits of patient navigation for breast, cervical, colorectal, and prostate cancer patient outcomes [18]. Patients who receive patient navigation have improved outcomes across the cancer continuum, including timely access to cancer care [16,19] and greater patient adherence to cancer screening

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<https://doi.org/10.1016/j.pecinn.2023.100226>

Received 24 March 2023; Received in revised form 1 October 2023; Accepted 2 October 2023

Available online 4 October 2023

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[12,20] and diagnostic follow-up care [16,19,21-25], reduced hospital readmission [26], and improved decision-making and treatment knowledge [26] when compared to patients who do not receive navigation. In addition to these improved access, adherence and clinical outcomes, non-clinical and nurse-driven patient navigation programs are cost-effective, yielding financial benefits to health systems, practices, and patients by reducing emergency department visits, hospitalizations, and intensive care unit admissions [11,23].

Despite the benefits of patient-centered navigation programs, heterogeneity in the design and delivery of these programs persist [7] and leads to incongruencies across PN roles, services, and models of care delivery [6,7,12,20,22]. The absence of standardization in the operational design of patient navigation programs can make multidisciplinary care coordination difficult and unintentionally create PN-specific challenges in an already complex healthcare system. Understanding the sociotechnical aspects of these challenges in existing technologies and PN workflows [27,28] from the perspectives of BC patients, PNs, and oncology care providers (OCPs) is needed. The human-centered design (HCD) framework [29], which emphasizes understanding people and their needs, engaging stakeholders early on and throughout the design process and designing a solution for their needs, can provide insights into these complex care challenges from patient and provider perspectives and offer design solutions to respond to these needs [30-32].

Mobile health (mHealth) applications offer a design solution with the potential to optimize BC care delivery for patients [2] and care communication among PN and other BC healthcare providers. mHealth is a method to deliver accessible health information, care, or services through mobile phones and other wireless technology at minimal cost [33,34]. Preliminary evidence shows that mHealth apps may increase PN efficiency, especially in the communication and performance of time-consuming, repetitive tasks [35,36]. For example, prior efforts described the integration of mHealth apps for patient monitoring into standard cancer care with PNs [37,38], and provided real-time alerts for increasing symptom severity [38,39]. Recent reviews on mHealth apps for BC managed care showed positive effects of mHealth interventions on health-related quality of life, promoting weight loss, and reducing stress [4,34,40]. Leveraging mHealth tools in PN clinical settings could promote efficiency within different types of PNs role and workflow, reduce care fragmentation, and enhance the coordination of BC care throughout the cancer continuum. mHealth apps can potentially improve healthcare delivery and cancer patient outcomes [35,41]. The 2022 American Society of Clinical Oncology (ASCO) presidential address recognized that digital health technologies offer the potential to improve the delivery of equitable healthcare across the cancer continuum [42]. However, prior studies have focused mHealth app development on a singular point of care in the cancer continuum and none, to our knowledge, have developed a mHealth app with PNs as the central user or [43-45]. Thus, there may be utility in developing mHealth apps that support the PN role in delivering care coordination throughout the cancer trajectory.

Engaging BC patients, OCPs, and PNs throughout the mHealth app design and development process is needed to identify and address real-world needs and priorities [46] to optimize healthcare delivery for BC patients at the health system level [4,30]. Drawing upon the HCD framework [31] in mHealth development, the present study sought to elicit PN stakeholder perspectives on the daily activities, workflows, and processes to identify currently unmet needs of the existing technology and services within their practice settings. PN perspectives, in addition to other end-users affected by operational efficiencies, such as BC patient and OCPs stakeholder perspectives, can provide insight into key features most salient to the infrastructure in which PNs provide care and key factors influencing the potential uptake of a prospective mHealth app [29,47,48].

The purpose of this study was to conduct a needs assessment among PNs, OCPs, and BC patient stakeholders to 1) identify barriers to PN core functions and workflow and 2) identify how a smartphone mHealth app

could assist PNs in their provision of care to BC patients at the individual and health-system level.

## 2. Methods

### 2.1. Study design

This study used a qualitative, cross-sectional design. A purposive sampling strategy was used to recruit 33 stakeholders (i.e., 11 PNs, 12 OCPs, and 10 BC patients) across community-based organizations and local healthcare facilities in the DC area.

### 2.2. Ethical considerations

This study was approved by the Georgetown University Institutional Review Board (IRB; #00003175). Procedures were followed in accordance with the Helsinki Declaration of 1975 and the ethical standards of the Georgetown University IRB.

### 2.3. Participant recruitment

Recruitment of participants took place at three hospitals of a Mid-Atlantic regional hospital system and through outreach to PN groups and list serves in the Washington DC metropolitan area between January 2021 and August 2021. Potential participants were referred to the study by PNs and nurse colleagues and through postings on PN listservs and prior lists of BC participants who agreed to be re-contacted for prospective studies. Eligibility criteria included: 1) self-identified as a PN, an individual diagnosed with BC, or an OCP; 2) ability to understand and speak English; and 3) willingness and ability to provide written informed consent. Exclusion criteria included not providing care to BC patients or working in a setting outside our geographic region. Trained study staff screened the potential participants for study eligibility and obtained written informed consent from all participants before data collection.

### 2.4. Data collection

Participants completed the sociodemographic study questionnaire with the study staff via telephone or a HIPAA-compliant video platform. Trained study staff (NV and KL) then conducted the 60-min audio-recorded individual interviews with participants using a HIPAA-compliant video meeting platform (Zoom). The interviews were audio recorded, transcribed, and de-identified.

#### 2.4.1. Sociodemographic questionnaire

Sociodemographic data included age, race, ethnicity, education level, and a specific subset of questions based on participant type, including employment setting (PNs and OCPs), number of BC patients navigated per month (PNs), and time since diagnosis (BC patients).

#### 2.4.2. Semi-structured interview guide

The semi-structured interview guide was informed by the HCD [29,31] and the sociotechnical systems framework [27]. Experts in behavioral science (KDG), public health (KL), and medical oncology providers (MF) designed the semi-structured interview guide to elicit feedback on the information, resources, and tools that may be useful in helping PNs in their work to support BC patients (Supplementary Material). The PNs and OCPs specifically responded to questions about how they provide navigation support to BC patients, the role-specific tools they use in their jobs, and their perceived barriers to providing BC patient navigation. BC patients answered questions about their perceptions of what helped them feel supported in their cancer care at the time of diagnosis and during and after treatment. All participants provided feedback on the most impactful features to include in a prospective mHealth app designed to improve BC care across the care continuum.

Participants rated each feature's impact level (high, medium, or low), and responses were systematically organized into an SPSS v.29 database.

## 2.5. Statistical analysis

Descriptive analysis included means, standard deviations, and frequencies of sociodemographic data. We used a conventional content analysis [49] to generate themes from the interview transcript. Two study team members experienced in qualitative research (ALC and NV) independently coded transcripts using ATLAS.ti qualitative software. Data were initially coded using an inductive approach to allow initial categories to be directly derived from the text. The initial codes were then organized and grouped into broad or meaningful categories. The codes were further organized into major domains and subthemes with each subtheme defined by exemplar quotations from the transcripts. [49] The two coders independently analyzed all data and met to discuss any differences in coding, domains, and subthemes until a consensus was reached. The coauthors (ALC, KDG, NV, PF, and MJF) discussed and verified codes. Data saturation was achieved after no new domains, subthemes, or information emerged from the data, consistent with the definition of inductive thematic saturation by Saunders and colleagues [50].

Guided by Krippendorff's alpha coefficient where  $\alpha = 0.80$  is considered adequate [51], the inter-coder agreement  $\alpha = 0.86$  is indicative of adequate agreement for the semantic domains and subthemes across all transcripts.

Participant responses to the impact level of the features to be included in a mHealth app designed to improve BC care were analyzed using Fisher's exact test to identify differences between stakeholder subgroups.

## 3. Results

### 3.1. Participants

Following posting on PN listservs and outreach across three regional hospitals, study staff identified 45 potential participants. Of these 45, 12 of the approached potential participants did not respond to the study participation invitation (i.e., non-respondents), and 33 participants enrolled in the study and participated in the semi-structured individual interviews. Participant subgroups included 11 PNs, 12 oncology care providers (OCPs; oncologists, social workers, and nurses), and 10 BC patients. Among the PN subgroup, there were several differences noted between hospital and community-based navigators in the PN sample. Hospital-based PNs navigated more patients per month ( $n \geq 20$ ) compared to community-based navigators ( $n \leq 4$ ). Demographics and clinical characteristics of PNs, OCPs, and BC patients are presented in Tables A.1–A.3.

### 3.2. Content analysis results

Two domains emerged from qualitative data analysis: 1) PN socio-technical system barriers; and 2) Prospective mHealth app and processes to facilitate PN workflow. Tables A.4 and A.5 display the domains, subthemes, and exemplar quotations from PN interviews to provide contextual information on their core functions and workflow in delivering BC care.

#### 3.2.1. PN Sociotechnical system barriers

All participants described the key elements of the PN role as the provision of resources, information, and communication correspondence across OCPs, BC patients, and external healthcare systems. OCPs and BC patients identified delayed care between BC diagnosis and treatment as a barrier in cancer care and attributed the delay to "un-coordinated communication." Three subthemes emerged from PN

interviews, which reflect PN perspectives on contextual factors contributing to the disruption in their workflows and care: 1) Resources, 2) Insurance coverage, 3) Communication challenges within and across healthcare settings, and 4) Impact of Logistical Tasks on BC Patient Care. A visual map that outlines sociotechnical barriers to PN provision of care is shown in Fig. A.1.

**Subtheme 1) Resources.** Overall, PNs described a limited sense of credible and trustworthy community-based resources such as food, transportation, childcare, financial resources, and mental health resources to provide to BC patients throughout the cancer care continuum. Many PNs reported an absence of consistent and updated resources within their navigation programs, often referring their patients to resources that are no longer available. The absence of standardized community-based resources creates more work for the PN day-to-day in identifying these resources. Additionally, many PNs reported the intricacies in identifying remote and in-person BC patient resources and the availability of patient transportation services to and from cancer care services. These PNs explained that this healthcare access barrier creates missed appointments and additional follow-up work for PNs, detracting from their day-to-day tasks. This is especially problematic when BC patients live alone or are without local support systems to assist with home-based care. Many community-based PNs reported minimal patient-facing forms and resources in other languages as a disruption to their workflow. Community-based PNs reflected on the limited number of bilingual PNs in their jobs and translator services, creating language gaps in care communication for underserved BC patients. For example, on PN remarked,

*"You start wondering what's a legitimate resource? You waste so much time because [there] are so many resources out there. And having done this for over three years, I would never say that I've mastered the resources that are out there."* - PN 9, Community-based support services organization.

**Subtheme 2) Insurance Coverage.** Across healthcare settings, PNs collectively described difficulties navigating BC patient insurance policies and coverage for BC patient programs that can pay for mammograms, screenings, surgical consoles, magnetic resonance imaging (MRIs), or medications. PNs emphasized BC diagnosis as the pivotal time-point within the cancer care continuum, where barriers to insurance coverage disrupt time-sensitive treatment. For example, one community based PN noted, *"Sometimes patients will have high co pays for their imaging studies, which I have not found a solution to that problem. They [the patients] sometimes choose not to have imaging [done] because it's not affordable and unutilize (PN 7)* Community-based PNs also noted undocumented and uninsured patients as influencing complexity of navigation. All community-based PNs described BC patient documentation status as an added "hoop to jump through" in identifying avenues to have their BC patients' care covered.

**Subtheme 3) Communication Challenges.** All PNs recognized variability in communication modalities across oncology providers, hospital departments, and external healthcare systems. PNs reported difficulties obtaining detailed messages through their support teams, and several PNs noted not receiving any messages related to BC patient symptoms or medication prescriptions from administrative support staff. For example, one PN commented:

*"One of the challenges I have at my job is some of the support teams. For example, the admins they don't provide very good messages[or] messaging [and] we don't always get them in a timely fashion. Those kinds of things, make my job more difficult and challenging and sometimes concerning to patients because they're calling about symptoms and I don't get the message, and it's not conducive to being attentive and empathetic."* - PN 11, Academic/University Hospital.

Community-based PNs expressed frustration in their own experiences with care coordination within and across healthcare settings. Several community-based PNs reported feeling unable to leave their

office when waiting for a referring provider, insurance company, or hospital to return their call.

**Subtheme 4) Impact of Logistical Tasks on BC Patient Care.** PNs unanimously described a high workload with minimal structural support from the accumulation of logistical tasks. PNs provided examples of time-intensive logistical tasks, which included assisting with patient application forms, organizing daily BC patient reminder appointment calls, and researching relevant community-based resources for patients. Several PNs described the time-consuming logistical tasks as “automated” or “robotic” in nature. Most PNs reported “organization” and “time management” skills as the biggest surprise in their work role. Many PNs identified a major challenge in completing workflow inefficiencies as focusing on in-person BC patient care needs while juggling care coordination. An overarching consequence identified by the majority of PNs in workflow inefficiencies are delays in timely appointments, treatments, and BC patient follow-up care, as illustrated by this PN comment:

*“It was really frustrating, but I had a cancer patient who was diagnosed in the beginning of the year, and it took months almost a year before I could get her treatment. And that was kind of devastating for me that was one of the biggest challenges to date in my career as a patient navigator.”* – PN 3, Academic/University Hospital.

Many PNs reflected on the compounded internal responsibility of attending to these insurmountable logistical tasks because otherwise, BC patients may experience prolonged delays in the provision of care, which can inevitably impact survivorship, or BC patients may become “lost in the healthcare system.”

### 3.2.2. Prospective mHealth app and processes to facilitate PN workflow

Participants provided feedback on the impact of features to include on a prospective mHealth app that could be used by PNs, OCPs, and BC patients and processes to enhance PN workflow and BC care delivery. Three subthemes emerged from stakeholder interviews: 1) User experience, 2) Features of a mHealth tool, and 3) Interoperability customization specific to the user. See [Table A.5](#) for exemplar quotes and a summary of the participant feedback on features to include in a prospective mHealth app.

**Subtheme 1) User experience.** The majority of PNs and BC patients stated a preference for a mHealth app to be accessible on a smartphone and a computer platform. Many participants expressed the importance of avoiding redundancy in information to avoid overlapping information across multiple health informatics systems. Several participants emphasized a “convenient” user experience as critical for continued mHealth app use and recommended an “instructional video” for users on the mHealth app. For example, a PN noted:

*“Anything that is easily clicked in [and] attached ... that isn't difficult transition or having to be printed and scanned and saved and attached. Something that takes many less steps and less clicks is certainly better for everyone.”* -PN 11, Academic/University Hospital.

Additionally, several PNs and OCPs highlighted the need to present patient-facing material in “laymen’s terms” to ensure BC patients understand the information.

**Subtheme 2) Features of mHealth tool.** Participants identified patient-facing educational materials, referral links, and coping resources as relevant features in a prospective mHealth app. One OCP commented:

*“I think, a very patient centered app with education and resources is a great idea. The app could include public support groups or common things you deal with. Like if a patient having many changes from chemo like common solutions to that.”* - OCP 3, Physician

The majority of PNs expressed interest in scheduling and logistical support tools as a mHealth feature to reduce BC patient missed appointments. These PNs elaborated on how scheduling and logical support tools would create a centralized modality to field telephone calls,

messages, a list of active and archived patients, and electronic calendars to help support their workload and workflow.

**Subtheme 3) Interoperability customization specific to the user.** Stakeholder interviews provided contextual information on the potential negative impact of integrating patient records within the mHealth app. Several BC participants expressed anticipatory anxiety around sensitive test results readily available to patients on the mHealth app. These participants indicated that this feature of a mHealth app might create more work for healthcare staff by fielding BC patient calls or messages about their test results. In contrast, most PN’s indicated a mHealth function that integrates EHR by pulling appointments (scheduled, completed, or missed) and a listing of BC stages and transitions between treatment stages for their patients into a patient summary page would improve their workflow. These PNs explained that the function of this mHealth feature would reduce the time-intensive process of manually tracking BC patient key dates using notebooks or computer programs like Excel. For example, one PN noted,

*“I have this notebook that I carry with me that has each patient page where I keep notes about the details of their diagnosis, where they're at [in] their treatment. It is a bit cumbersome and it's hard when I get to the end of my notebook... I don't know how other people do it.”* – PN 7, Community-based hospital.

### 3.3. Participant subgroup associations with impact ratings of mHealth app features

[Fig. A.2.](#) displays participants’ ratings on the impact level of the types of accessible content to include on a mHealth app. Across stakeholder subgroups, information about BC, treatment, survivorship, and quality of life was among the highest impact content to incorporate in a mHealth tool. Fisher’s exact tests examined systematic differences across stakeholder subgroups (PNs, OCPs, and BC patients) and ordinal rankings on the impact of the types of information to include in a mHealth tool. There were no significant associations between stakeholder subgroup and breast cancer information ( $p = 0.42$ ), treatment ( $p = 0.89$ ), survivorship and quality of life information ( $p = 0.38$ ), and information about each BC patient’s status ( $p = 0.18$ ). There was a significant association between stakeholder subgroup and patient needs and patient records ( $p = 0.02$ ).

## 4. Discussion and conclusion

### 4.1. Discussion

The current study identified barriers in PNs workflow and provision of care and identified how a mHealth app could assist in the provision of BC care from the perspectives of three main stakeholder subgroups: BC patients, PNs and OCPs. Although prior research has explored navigation facilitators and barriers [26], this study, to our knowledge, is one of the first to use the HCD and sociotechnical systems framework to assess healthcare system, provider, and patient-level facilitators to patient navigation through the use of a prospective mHealth app. Our results represent key factors that are applicable to the development and uptake of a mHealth app for PNs use in direct BC patient care, multidisciplinary team care, and interoperability across health information technology systems.

Resources, insurance coverage, and communication challenges were the most frequently discussed subthemes related to barriers to PN workflow and provision of BC care, which are consistent with existing literature [3,6,26,52]. PNs from the current study described BC patient delays in treatment and PN distress from delayed care as compounded negative effects of these identified barriers. However, barriers to PN workflow and provision of care vary depending on the healthcare setting [20], and we found distinct barriers to the provision of BC patient care within community-based PN settings. Community-based PNs reported

increased time spent on coordinating medical appointments and referring patients to community-based resources specific to underserved BC patients (e.g., uninsured patients, immigrants, racial and ethnic minorities, and lower-income). These domains and subthemes represent sociotechnical barriers contributing to delays in care and BC disease burden. The characteristics of BC patients seen in a community-based setting [17] should be taken into account during the design and development of a prospective mHealth app. For example, a prospective mHealth app that offers educational information about BC staging and subtype, treatment, information about survivorship, and quality of life in Spanish, automated appointment reminders, and communication correspondence via direct app messaging are specific design solutions for community-based PN user needs.

As supported by the literature [30,31,34], an introductory video and language that is understandable across all health literacy levels can enhance familiarity with technology and user engagement in a prospective mHealth app. mHealth apps provide a direct communication pathway to the exchange of information [34] and the interoperability of mHealth apps in clinical workflows may improve care delivery [53]. The interoperability of a prospective mHealth app with electronic health records was an important mHealth feature for PN user needs but not BC patient needs. This is an important design consideration for user access features specific to the users' needs. For example, a prospective mHealth app should consider PN, and OCP interoperability of BC patient lab results from EHR records to enhance workflows and communication of care coordination. However, BC patients unmonitored access to some information may result in unintended negative outcomes such as increased patient anxiety and confusion. The issue of patient access to such results warrants further investigation as interoperability across health informatic systems supports the delivery of care [30].

The study has several limitations. First, most BC patients identified as White, non-Hispanic, and completed post-graduate degrees, which does not offer insights into the perspectives of BC patients from other socioeconomic, racial, and ethnic backgrounds. Second, we did not collect quantitative data on BC stage and annual income or PN training background (lay navigators, nurse navigators, etc.) among these two stakeholder subgroups. The absence of data collected on BC stage and BC patients reported annual income does not capture the perspectives of BC patients with advanced cancer or BC patient cost considerations for treatment [54]. Identifying PNs' training background could provide more contextual information regarding the features of a prospective mHealth tool most salient to their roles in their respective care settings. Finally, given changes in study staff over time, individual interviewers captured different levels of details PN impact ratings of mHealth app features; thus we interpret this data with caution.

#### 4.2. Innovation

To our knowledge, this is one of the first studies to incorporate the HCD and sociotechnical systems frameworks to understand barriers to PN workflow and provision of BC patient care across the cancer care continuum. We also sought to explore key features for the design and development of a prospective mHealth app from BC patients, PNs, and OCPs perspectives. Our findings highlight mHealth design considerations specific to PN user needs and the health system environment for improving BC care navigation. By addressing the need for in-depth

formative mHealth design processes, our qualitative results add to the literature by highlighting multidisciplinary perspectives on tailored mHealth app features. These results are presented within the specific contexts in which PNs provide care and the characteristics of the specific BC populations served. Findings from the current study offer mHealth app design considerations unique to varied settings, such as PN delivered through community-based organizations. Findings have implications for clinical practice related to how PNs coordinate timely care across healthcare institutions.

#### 5. Conclusion

Through an HCD and sociotechnical systems framework, results highlight several multilevel factors that contribute to barriers in PNs provision of BC patient care, including healthcare system structures, software systems, PN specific tasks, and BC patient, OCPs, and PNs individual factors. Increased understanding of the interactions of these sociotechnical systems barriers from multiple perspectives supports the identification and application of mHealth app design considerations to optimize PN provision of BC patient care throughout the care continuum.

#### Funding

This work was supported by the Small Business Innovation Research (SBIR) program (Phase I 75N91020C00033). Alaina L. Carr's effort on this project was supported by the National Cancer Institute, T32CA261787 and the National Cancer Institute, 1K99CA277588-01.

#### CRediT authorship contribution statement

**Alaina L. Carr:** Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Naomi Vinod:** Data curation, Formal analysis. **Patrick Farha:** Project administration, Funding acquisition. **Tan Lu:** Conceptualization, Funding acquisition, Resources. **Maen J. Farha:** Conceptualization, Methodology, Validation, Investigation, Resources, Writing – review & editing, Visualization, Project administration, Funding acquisition. **Kristi D. Graves:** Conceptualization, Methodology, Validation, Investigation, Resources, Writing – review & editing.

#### Declaration of Competing Interest

The authors indicated no potential conflicts of interest.

#### Data availability

The data that support the findings of this study are available from the corresponding author, Alaina L. Carr, upon reasonable request.

#### Acknowledgments

We would like to thank Katherine Lopez, MA, for her help with data curation and, Jane Fall-Dickson, PhD, Suzanne O'Neill, PhD, Claire Conley, PhD, and Chandra Char, PhD, MPH for their assistance with proofreading the article.

Appendix A

**Table A.1**  
Participant sociodemographic information and characteristics.

|   | PNs<br>(n = 11) | OCPs<br>(n = 12) | BC Patients<br>(n = 10) |
|---|-----------------|------------------|-------------------------|
| Demographic Information                   | N (%)           | N (%)            | N (%)                   |
| Age (M, SD)                               | 45.3(11.4)      | 40.2 (12.4)      | 46.8 (9.6)              |
| Sex, female                               | 11 (100)        | 12 (100)         | 9 (90)                  |
| Hispanic                                  | 3 (27.3)        | 0                | 1 (10)                  |
| Race                                      |                 |                  |                         |
| American Indian or Alaska Native          | 0               | 0                | 0                       |
| Asian                                     | 0               | 2 (16.7)         | 0                       |
| Black or African American                 | 4 (34.4)        | 2 (16.7)         | 2 (20)                  |
| Native Hawaiian or other Pacific Islander | 0               | 0                | 0                       |
| White                                     | 5 (45.5)        | 8 (66.6)         | 8 (80)                  |
| Multiracial                               | 2 (18.2)        | 0                | 0                       |
| Spanish fluency                           |                 |                  |                         |
| Reading                                   | 3 (27.3)        | 0                | 0                       |
| Speaking                                  | 3 (27.3)        | 0                | 0                       |
| Education                                 |                 |                  |                         |
| Associates degree                         | 1 (9.0)         | 0                | 1 (10)                  |
| Bachelor's degree                         | 5 (45.4)        | 2 (16.7)         | 4 (40)                  |
| Post Graduate Degree                      | 5 (45.4)        | 9 (75)           | 5 (50)                  |
| Other                                     | 0               | 1 (8.3)          | 0                       |

Patient Navigator (PN).  
Oncology Care Provider (OCP).  
Breast Cancer (BC).

**Table A.2**  
PN and OCP Practice Setting Characteristics.

| Patient Navigator and Oncology Care Provider Characteristics | PN (n = 11)<br>N (%) | PN Hospital Setting (n = 7)<br>N (%) | PN Community-Based Setting (n = 4)<br>N (%) | OCP (n = 12)<br>N (%) |
|--|----------------------|--------------------------------------|---|-----------------------|
| Time employed, years   |                      |                                      |   |                       |
| 0 - ≤1   | 3 (27.3)             | 1 (14.3)                             | 2 (50.0)                                    | 1 (8.3)               |
| >1 - ≤3  | 2 (18.2)             | 2 (28.6)                             | -   | 5 (41.7)              |
| >3 - ≤5  | 3 (27.3)             | 2 (28.6)                             | 1 (25.0)                                    | 5 (41.7)              |
| >5 - ≤10   | 2 (18.2)             | 1 (14.3)                             | 1 (25.0)                                    | -                     |
| >10  | 1 (9.0)              | 1 (14.3)                             | -   | 1 (8.3)               |
| BC patients navigated per month                              |                      |                                      |   |                       |
| 0-1  | 2 (18.2)             | 2 (28.6)                             | -   | -                     |
| 2-5  | 2 (18.2)             | -                                    | 2 (50.0)                                    | 2 (16.7)              |
| 6-10   | 2 (18.2)             | 1 (14.3)                             | 1 (25.0)                                    | 1 (8.3)               |
| 11-20  | 0                    | -                                    | -   | 2 (16.7)              |
| >20  | 5 (45.5)             | 4 (57.1)                             | 1 (25.0)                                    | 7 (58.3)              |
| Employment setting   |                      |                                      |   |                       |
| Academic/ University hospital                                | 3 (27.3)             | -                                    | -   | 6 (50.)               |
| Hospital in a large healthcare system                        | 4 (36.4)             | -                                    | -   | 4 (33.3)              |
| Community-based clinic                                       | 1 (9.0)              | -                                    | -   | 1 (8.3)               |
| Community-based support services organization                | 3 (27.3)             | -                                    | -   | 1 (8.3)               |
| Primary Type of BC Patient Navigation <sup>a</sup>           |                      |                                      |   |                       |
| Prevention/ Screening  | 0                    | 0                                    | 0   | 0                     |
| Diagnosis/ Treatment   | 2 (18.2)             | 1                                    | 1   | 0                     |
| Social Services  | 1 (9.0)              | 1                                    | 0   | 0                     |
| Diagnosis to Survivorship                                    | 4 (36.4)             | 4                                    | 2   | 0                     |

Patient Navigator (PN).  
Oncology Care Provider (OCP).  
Breast Cancer (BC).

<sup>a</sup> Responses missing from two PNs.

**Table A.3**  
BC Patient Medical Characteristics and Familiarity with Digital Tools.

| BC Patient Characteristics, n = 10  | N (%)     |
|-------------------------------------|-----------|
| Time since diagnosis, years (M, SD) | 7.8 (7.2) |
| Interaction with PN                 |           |
| Information seeking                 | 7 (70)    |
| Scheduling or logistical support    | 7 (70)    |
| Referral to resources               | 5 (50)    |
| Emotional support                   | 4 (40)    |
| Other- Test results and scans       | 1 (10)    |

(continued on next page)

**Table A.3 (continued)**

| BC Patient Characteristics, n = 10    | N (%)    |
|---------------------------------------|----------|
| No interaction with PN                | 2 (20)   |
| Owens Smartphone, yes                 | 10 (100) |
| Familiarity with app download, phone  |          |
| Not at all familiar                   | 0        |
| Slightly familiar                     | 0        |
| Moderately familiar                   | 1 (10)   |
| Very familiar                         | 4 (40)   |
| Extremely familiar                    | 5 (50)   |
| Familiarity with app download, tablet |          |
| Not at all familiar                   | 0        |
| Slightly familiar                     | 0        |
| Moderately familiar                   | 3 (30)   |
| Very familiar                         | 3 (30)   |
| Extremely familiar                    | 4 (40)   |

Breast Cancer (BC).

**Table A.4**  
PN Sociotechnical Barriers in PN Workflow Exemplar Quotes.

| Domain and subthemes                          | Exemplar Quote:   |
|---|---|
| <b>Barriers in PN Workflow</b>                |   |
| Resources for BC patients                     | <i>“For my patients, they might need support in terms of navigating the system because... they don’t speak English and they [are] not able to read in English. I need to be able to understand everything and tell them in their own language and make sure they understand what they have, they have to follow up, forms and things like that...I have to make sure we like eliminating barriers.”</i> - PN 2, Bilingual, Community-based supportive services organization   |
| BC patient insurance coverage                 | <i>“[The]majority of our patients now, their primary language isn’t English. It makes it harder for us to communicate with them because we all speak the same language. We don’t have a translator, but things can get lost in translation. That’s still a barrier. We do have a bilingual patient navigator, but she’s one person and our Hispanic population is increasing. That’s a major barrier for our patients.”</i> - PN 3, Academic/ University Hospital<br><i>You have to wait to see if they [the patients] qualify. That could be difficult because you don’t know if the person is going to be eligible... And if that patient is not eligible for that particular program or they don’t qualify for Medicaid, [it] is going to be pretty hard on the patients to get treatment... I think some of the patients who have to pay for their insurance, it can be a financial hardship for them.</i> -PN 5, Academic/University Hospital<br><i>They [patients] don’t want to get it [scans] because of [their] age and because of insurance. They’re saying they don’t want to get acquire medical bills. I feel stuck as far as being the navigator trying to influence them because it’s based on their health, but for the patient it’s a little bit iffy. By their age, they don’t want it, and prefer to have certain surgeries and because they don’t have the means of being able to pay.</i> -PN 8, Hospital in a large healthcare system |
| Communication challenges                      | <i>“If they [the patients] don’t pick up the phone, you may try to reach them and they’re not picking up the phone, you have to call their contact. [With] some people, the follow up is hard because you don’t want to lose them. That would be the most challenging.”</i> -PN 6, Hospital in a large healthcare system<br><i>“I think there are some doctors and nurses and providers who are better at making referrals and reaching out to me, there are some that I know who aren’t so I reached out to them. There’s different modalities for communication and again how to figure out what works for what doctor unfortunately it’s not the same for everyone.”</i> - PN 9, Community-based support services organization<br><i>“One of the challenges I have at my job is some of the support teams. For example, the admins they don’t provide very good messages messaging [and] we don’t always get them in a timely fashion. Those kinds of things, make my job more difficult and challenging and sometimes concerning to patients because they’re calling about symptoms and I don’t get the message, and it’s not conducive to being attentive and empathetic.”</i> - PN 11, Academic/ University Hospital  |
| Impact of Logistical Tasks on BC Patient Care | <i>“I need an assistant... it would be nice if somebody can just go ahead, get the information, those people call, can get the information because when it’s either that I cannot get that phone call or I’m doing an intake with the patient. I’m putting my focus on getting the patient to these campaigns, making sure they’re coming also pick their people work takes time.”</i> - PN 4, Community-based support services organization<br><i>“I don’t know how other people do it. When I started this job I took over from somebody who had already retired, so I didn’t have her walking me through it. I did talk with a couple of navigators at the time, they were kind enough to spend some time with me on the phone, but I do feel like I need to revisit with somebody who does this all the time to see how they keep track. This is how I figured out so far.”</i> -PN 7, Community-based hospital<br><i>“It was really frustrating, but I had a cancer patient who was diagnosed in the beginning of the year, and it took months almost a year before I could get her treatment. And that was kind of devastating for me that was one of the biggest challenges to date in my career as a patient navigator.”</i> – PN 3, Academic/University Hospital   |

Patient Navigator (PN).  
Breast Cancer (BC).

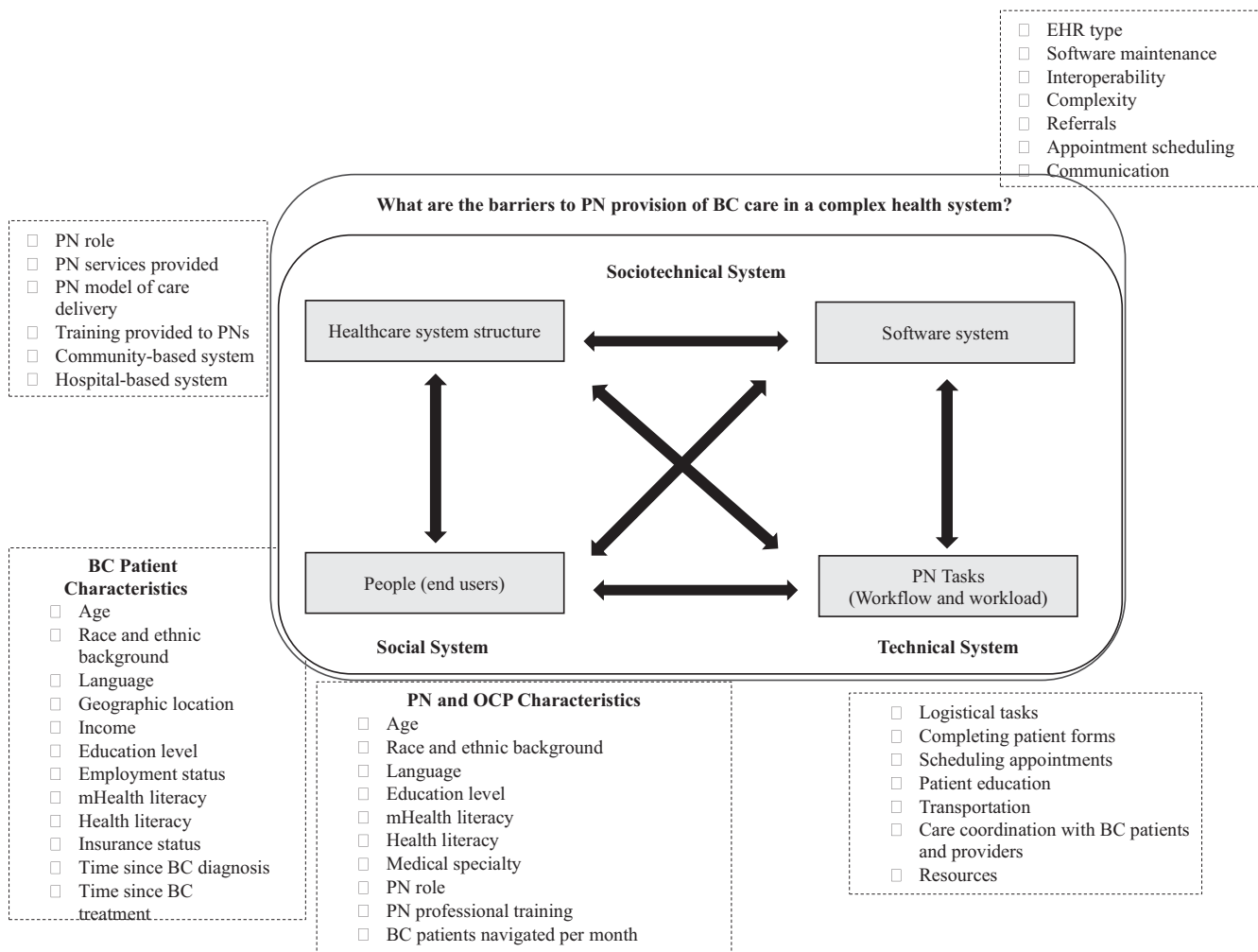


Fig. A.1. PN Sociotechnical System [26,27] Barriers.

Table A.5  
Prospective mHealth app and processes to enhance PN workflow.

| Subtheme  | Exemplar Quotes  | Features to include in a prospective mHealth app   |
|---|--|--|
| User experience                                     | <p>"I feel like the app will be good if it was supplemental because you already have your databases, where you pull health records and get health information from the patient. I think it will be more helpful if the app was designed to be a support for patients and also almost like a navigator kind of virtual assistant, so this makes you get your tasks." -PN 5, Academic/University Hospital</p> <p>"You're never going to have something that's one size fits all... I would say and not even caution, but just think about who the target audiences, are they younger patients are they older patients, because [of] what they need and want." - PN 9, Community-based support services organization</p>  | <p>Instructional user video</p> <p>Mobile printing</p> <p>Balance text with visual content</p> <p>Low click-through rate</p> <p>Accessible on smartphone, tablet, or computer</p>  |
| Features of a mHealth tool                          | <p>"It's helpful to see images and when you're talking about lumpectomies [and] mastectomies. It's always helpful to see that even actual photographs... creation [of] information and educational materials is paramount. And it's nice if the app had that. It's up to them [the patient] if they want to click on that and read more information it's there at their fingertips literally." -BC Patient 7</p> <p>"I have to go fishing for when someone was first diagnosed and [when] treatment started that seems like very basic stuff and it's in there [EHR], but it's so hard to find... I felt like what's the timeline? When do you plan to start treatment? Just a timeline and key dates, are something that are really helpful." - PN 9, Community-based support services organization</p> | <p>List of active and archived patients</p> <p>Personalized features (PN can add new BC patients or archive BC patients who completed treatment)</p> <p>Multiple custom channels of messaging with BC patients and care team members or different groups of individuals.</p> <p>Access to a list of patients reporting distress at or above the NCCN distress tool for time-sensitive referrals to mental health professionals</p> |
| Interoperability customization specific to the user | <p>"It is tricky, though, because a lot of doctors like to go over test results with patients, either in person or over the phone. Because it's pretty sensitive information, so I could see doctors having some hesitation and even patient navigators probably can't deliver the news... Any test results through the app are [a] cause [for] more anxiety to the patient, because here, they have the results, but they don't have the perspective and the context and they don't have the doctor available right there and then". - BC Patient 7</p>   | <p>Integration with EHR to pull appointments, scheduled, completed, and missed</p> <p>A view of appointments that are missed, at risk, and other needs</p> <p>A listing of stages and transitions between treatment stages for BC patients</p>   |

(continued on next page)



Table A.5 (continued)

| Subtheme | Exemplar Quotes  | Features to include in a prospective mHealth app   |
|----------|--|--|
|          | <p>"I have this notebook that I carry with me that has each patient page where I keep notes about the details of their diagnosis, where they're at [in] their treatment. It is a bit cumbersome and it's hard when I get to the end of my notebook... I don't know how other people do it." – PN 7, Community-based hospital</p> | Tailored notifications for when a BC patient is admitted to the inpatient unit or emergency department |

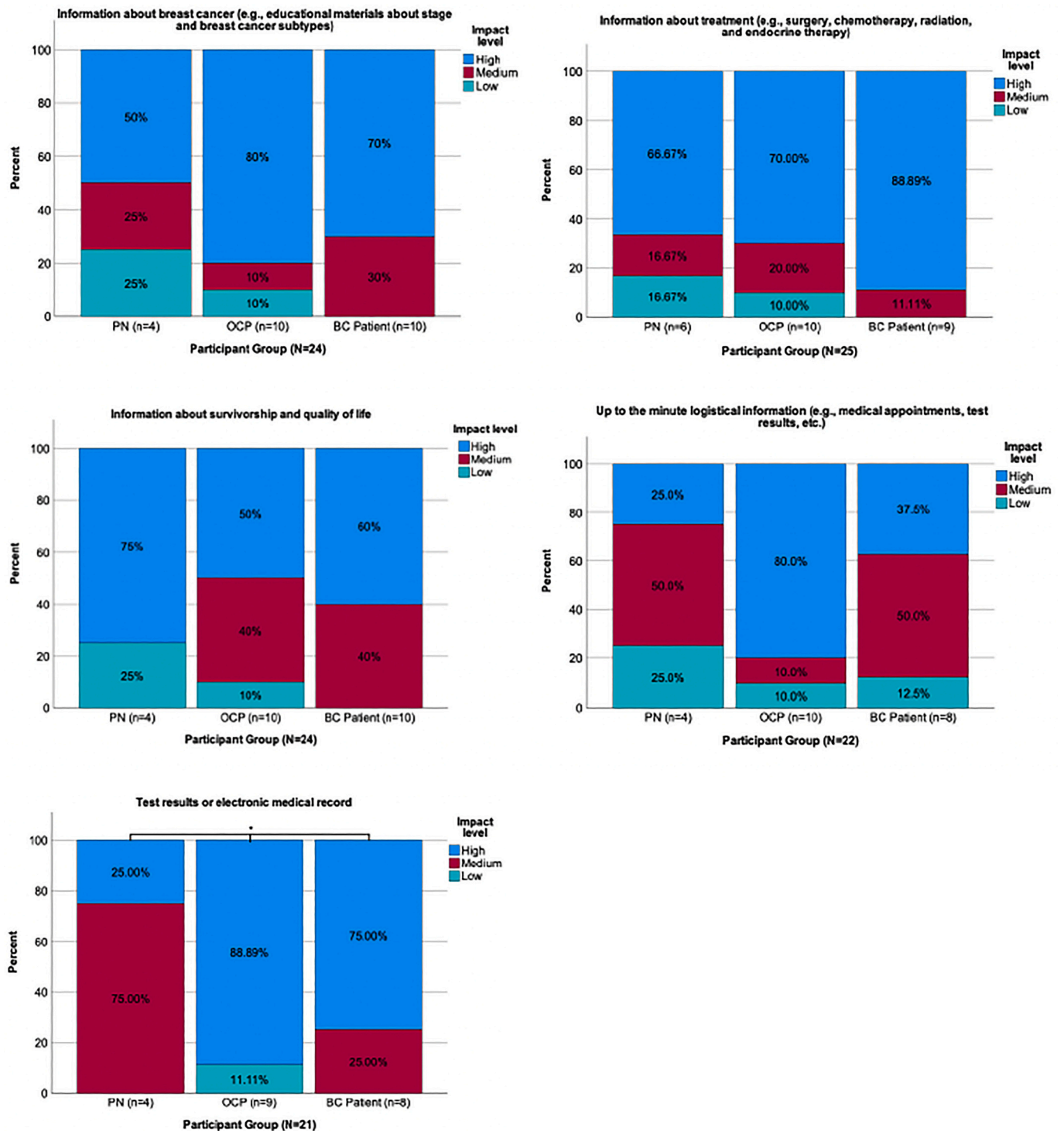


Fig. A.2. Participant self-reported types of information readily available on a digital tool.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pecinn.2023.100226>.

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