A needs assessment of health information technology for improving care coordination in three leading patient-centered medical homes

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ABSTRACT

Objective We investigated ways that patient-centered medical homes (PCMHs) are currently using health information technology (IT) for care coordination and what types of health IT are needed to improve care coordination.

Materials and Methods A multi-disciplinary team of researchers conducted semi-structured telephone interviews with 28 participants from 3 PCMHs in the United States. Participants included administrators and clinicians from PCMHs, electronic health record (EHR) and health information exchange (HIE) representatives, and policy makers.

Results Participants identified multiple barriers to care coordination using current health IT tools. We identified five areas in which health IT can improve care coordination in PCMHs: 1) monitoring patient populations, 2) notifying clinicians and other staff when specific patients move across care settings, 3) collaborating around patients, 4) reporting activities, and 5) interoperability. To accomplish these tasks, many participants described using homegrown care coordination systems separate from EHRs.

Discussion The participants in this study have resources, experience, and expertise with using health IT for care coordination, yet they still identified multiple areas for improvement. We hypothesize that focusing health IT development in the five areas we identified can enable more effective care coordination. Key findings from this work are that homegrown systems apart from EHRs are currently used to support care coordination and, also, that reporting tools are key components of care coordination.

Conclusions New health IT that enables monitoring, notifying, collaborating, reporting, and interoperability would enhance care coordination within PCMHs beyond what current health IT enables.

Key words: Informatics research; care coordination; electronic health records; health information technology policy

BACKGROUND

Patient-centered medical homes (PCMHs) are primary care practice sites that have undergone structural and process transformations to facilitate patient management and care coordination, particularly for patients with multiple chronic conditions.1,2 Health information technology (IT), especially electronic health records (EHRs), is a foundational requirement for PCMHs.3 For example, a PCMH needs health IT not only to manage patient clinical data, but also to facilitate inter-organizational communication with collaborating clinicians and staff and to monitor patients across care settings.4

There is limited research on whether current health IT has the capabilities necessary to support the myriad care coordination functions a PCMH needs to achieve.5–8 For example, PCMHs may have difficulty with basic reporting of quality data contained in EHRs.9 Additional barriers include inflexible EHRs that insufficiently meet socio-technical requirements for practices, which have limited resources and entrenched practice cultures. These barriers led Rudin and Bates to conclude that the current health IT marketplace “has failed to provide adequate solutions” for care coordination.4 Others have highlighted the need for research that informs technological and policy advancements.6,10,11

We set out to explore current care coordination activities in leading PCMH organizations and describe the types of health IT functionalities they currently employ. Furthermore, we sought to learn from their experiences, as well as their EHR vendors’, as to how future health IT might enable PCMHs to optimize care coordination. These participants’ experiences can inform how health IT needs to evolve in order to better facilitate care coordination for PCMHs.

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METHODS

Our multi-disciplinary team comprised of a biomedical informatician (JR) and health services researchers (JV, CG, LK, RK) conducted an exploratory qualitative study to identify the health IT needs in 3 leading PCMHs. The team conducted semi-structured telephone interviews with PCMH representatives, their EHR vendors, and associated stakeholders from the Northeastern and Northwestern regions of the United States. Sites were identified through literature reviews, discussions within the research team, and in consultation with external researchers.

This study was conducted as part of a broader evaluation of New York’s Healthcare Efficiency and Affordability Law for New Yorkers Capital Grant Program (HEAL-NY). Initiated in 2004, HEAL-NY is the largest state-based public investment to promote interoperable health IT development and EHR adoption. The Health Information Technology Evaluation Collaborative (HITEC), was designated to evaluate New York’s HEAL NY-funded efforts. This study differed from other HITEC studies in that it recruited from outside New York State to gain a broader understanding of PCMH needs. The New York State Department of Health and the Institutional Review Board at Weill Cornell Medical College approved this study, and all participants granted informed consent.

Each PCMH had attained the highest level from the National Committee for Quality Assurance (NCQA) and was well-supported, either through non-profit public-private partnerships or a for-profit integrated delivery system. Also, each employed an EHR implementation strategy that was in line with its governance model (see Table 1). Although each PCMH employed a multi-payer financial model, they differed in the following ways: profit status, whether or not they were an integrated delivery system, and governance. Furthermore, the PCMHs varied in their use of one or more EHRs and means for achieving health information exchange (HIE): organizational and/or community-based means (regional health information organizations or RHIOs).

The team developed a semi-structured interview guide, with questions regarding care coordination efforts, the ways health IT supports those efforts, and their opinions as to how health IT could better support those efforts (see online appendices). The interview guide was iteratively refined after being presented to external researchers with expertise in PCMH policy, healthcare quality, and biomedical informatics. The interview guide was revised over the course of the investigation as new issues arose, such as the impact of workflow and practice culture.

The team recruited key informants by first e-mailing an organizational point person who had demonstrated PCMH expertise either through their published research, their title, or both. The team subsequently conducted a snowball sampling method, whereby we asked each interviewee for suggested PCMH participants as well as representatives from their EHR and any other health IT vendor representatives. We particularly sought vendor representatives who directly interacted with the PCMHs and who could, therefore, provide on-the-ground assessments of PCMH health IT needs. Finally, we included policy-maker and payer stakeholders, after PCMH participants conveyed their importance for site-specific PCMH activities. The recruiting process continued, until the research team reached thematic saturation, ie, the data did not generate any unexpected findings. The team presented its data and analysis to external researchers, who agreed we had reached thematic saturation.

Table 1: Characteristics of Participating PCMHs

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>PCMH A</th>
<th>PCMH B</th>
<th>PCMH C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Northeast United States</td>
<td>Northeast United States</td>
<td>Northwest United States</td>
</tr>
<tr>
<td>NCQA Certification Level</td>
<td>Level 3</td>
<td>Level 3</td>
<td>Level 3</td>
</tr>
<tr>
<td>Financial Model</td>
<td>Multi-payer</td>
<td>Multi-payer</td>
<td>Multi-payer</td>
</tr>
<tr>
<td>Profit Status</td>
<td>Not-for-Profit</td>
<td>Not-for-Profit</td>
<td>For-Profit</td>
</tr>
<tr>
<td>Integrated Delivery System</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Organizational Structure</td>
<td>Joint venture of two health systems, and a community health center</td>
<td>Collaboration of providers, payers, and public agencies initiated by the state-level insurance commissioner</td>
<td>Centralization through an integrated delivery system</td>
</tr>
<tr>
<td>Governance</td>
<td>State DOH, Payers, Providers</td>
<td>State DOH, Payers, Providers</td>
<td>Member cooperative</td>
</tr>
<tr>
<td>Electronic Health Record Vendor(s)</td>
<td>Multi-vendor</td>
<td>Multi-vendor</td>
<td>Single vendor</td>
</tr>
<tr>
<td>Health Information Exchange Capability</td>
<td>RHIO</td>
<td>RHIO</td>
<td>Internal HIE and RHIO</td>
</tr>
</tbody>
</table>

DOH, Department of Health; HIE, health information exchange; NCQA, National Committee for Quality Assurance; PCMH, patient-centered medical home; RHIO, regional health information organization.
Researchers conducted semi-structured telephone interviews. The team conducted one-on-one as well as group interviews with up to three participants, depending on team member availability. Members of the research team led interviews (JR, JV), and another member asked follow-up questions at appropriate intervals (CG). A minimum of two researchers were in attendance at each interview. We also asked impromptu questions, for clarification or when participants offered unexpected information. Digital recordings and handwritten notes were taken for all interviews. Recordings were transcribed and imported into NVivo qualitative analysis software, Version 10 (QSR International Pty Ltd; Doncaster, Australia).

We iteratively collected data and performed grounded theory analyses. Grounded theory is a method of qualitative analysis whereby labels (codes) are attributed to recurring concepts found in transcribed data; those codes are then aggregated into emergent themes. We developed themes to determine participants’ current care coordination activities and the ways health IT was currently supporting (and could ideally support) those activities.

We took the following steps to improve the trustworthiness of our results: 1) each researcher provided structured notes subsequent to participant interviews; 2) routine team debriefs were held every 1–2 weeks; 3) coding of transcribed data occurred in pairs; and 4) preliminary and final findings were reviewed by external researchers not directly involved in the research.

**RESULTS**

We conducted 19 interviews with 28 out of the 42 people we contacted (67% participation rate). Non-participation was due to factors including scheduling difficulties and phone calls that were not returned. We did not detect notable role-based differences in participation or non-participation. Furthermore, except when explicitly noted, we did not find discernable differences between health IT vendor representatives and other participants. The 28 participants were directly or indirectly involved in the activities of 3 PCMHs. Within PCMHs, 13 participants acted in one or more roles, including: providers, researchers, and administrators. We interviewed 9 representatives from EHR and HIE organizations who directly interacted with the PCMHs as implementation specialists or product developers. EHR participants worked for nationally leading ambulatory EHR-HIE vendors. We additionally interviewed 3 state-level policy makers who worked on PCMH-related matters within their jurisdictions, 2 directly for the state (PCMH B) and 1 who worked for a state-run RHIO (PCMH C). Finally, we interviewed 3 payer organization administrators from a private organization (see Table 2).

Participants described their current use of, and needs for, care coordination health IT, which we define and describe as five inter-related areas: monitoring tools, notification tools, collaborative tools, reporting tools, and interoperability (see Table 3). Although the sites differed in governance and payment models, our team found many commonalities among health IT solutions. Representative quotes from each of the

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**Table 2: Interviewees, by Role and Organization**

<table>
<thead>
<tr>
<th>Group</th>
<th>Roles</th>
<th>PCMH A</th>
<th>PCMH B</th>
<th>PCMH C</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCMH Representatives</td>
<td>Administrators, Project Managers, Physicians, Care Coordinators</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Health IT Vendor Reps</td>
<td>EHR Project Managers, EHR Developers, HIE Administrators and Developers</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>State Reps</td>
<td>Policy Makers</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Payer Reps</td>
<td>Administrators</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>9</td>
<td>11</td>
<td>8</td>
<td>28</td>
</tr>
</tbody>
</table>

EHR, electronic health record; HIE, health information exchange; IT, information technology; PCMH, patient-centered medical home.

**Table 3: Definitions of Health IT Needs for Participating PCMHs**

<table>
<thead>
<tr>
<th>Tools</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring</td>
<td>Surveillance and analytics tools for PCMHs to identify patients by one or more conditions</td>
</tr>
<tr>
<td>Notification</td>
<td>Alerting tools that notify PCMHs of patient transitions of care</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Communication tools to facilitate collaborations between clinicians (physicians, nurses, and nurse practitioners) and patients</td>
</tr>
<tr>
<td>Reporting</td>
<td>Data extraction tools for generating reports for internal and external stakeholders</td>
</tr>
<tr>
<td>Interoperability</td>
<td>Interfaces that enable PCMHs to share patient data with participating and non-participating PCMHs</td>
</tr>
</tbody>
</table>

IT, information technology; PCMH, patient-centered medical home.
areas convey participants’ perceptions of the current and ideal state of health IT for care coordination in PCMHs (see online supplement Table 1).

Monitoring Tools
The participants described current efforts to build health IT infrastructures that enable them to target and monitor patient panels based on clinical conditions and demographics. Participants described building data repositories and developing condition-based registries within those repositories. Furthermore, PCMH B described its effort to invent an algorithm to identify high-risk patients by factoring variables such as patient insurance status and practice site location.

However, participants also noted that their care managers were attempting to monitor patient activities using homegrown tools built from Excel spreadsheets, Microsoft Access databases, and various paper forms. Since these patient data existed apart from EHRs or any other means of integrated health IT, there were obvious barriers in notifying care coordinators of a patient’s status.

Looking ahead, participants described a need for monitoring tools that PCMHs could use to generate patient panels, using real-time clinical data to proactively manage patients with complex conditions, mitigate harm, and control costs: “... [for] a really simple need . . . most EHRs do an okay job. But for those complex care needs . . . it’s just not working well.”

Participants also expressed a need for integrating claims data to better detect patients at varying levels of risk for exacerbations of their medical conditions. PCMHs could presumably better respond to patient needs and more efficiently plan care coordination activities.

Notification Tools
Participants described needs for tools that notify clinicians when patients use specific healthcare services as they move across the healthcare system.

Participants from all three sites described ongoing efforts to generate and deliver automated messages to PCMH clinicians whenever patients were admitted to, transferred within, or discharged from any local hospitals. Furthermore, one EHR vendor was mapping notifications with business processes, so that PCMH staff could be informed if a recently discharged patient did not show for a follow-up appointment.

The discussions around notification tools led many participants to identify needs for health IT tools that help notify all members of assigned healthcare team about changes or updates to a patient’s status. They particularly requested that care managers, who were utilized in all three sites, receive notifications to better coordinate care. Participants also highlighted the need for tools that could support care managers by notifying when patient transitions across care settings occurred or were planned to occur and for making available care manager data for other caregivers to view.

Building on transition notification tools, participants described the need for health IT that visually communicates patient utilization patterns, so that PCMHs can perform more effective outreach. Participants described a need for end-user systems that graphically reveal patients who may be in particular need of outreach, due to the number and types of interactions with the healthcare system: “... in my ideal world, there’s a . . . very visual . . . way to describe the practice patterns and treatment patterns [across PCMH sites].”

Participants, such as one vendor, described the need for and difficulty of designing information displays that effectively aggregate and display data to support patient care within clinic constraints: “In the context of a 15-minute visit . . . that is a big challenge.” Any displays would go beyond patient-specific data to include displays that visually and intuitively communicate which specialists are involved in a patient’s care and the actions taken.

Collaboration Tools
Participants described multiple needs for collaboration tools that would optimize care coordination for teams, both within practices and across practices.

PCMHs used existing health IT to support cooperative work within their practices. To promote care team cooperative work through health IT, one interviewee stated that her organization was altering EHR permissions to authorize non-providers (such as care managers and social workers) to view the same patient data as providers. Participants also described holding regularly scheduled team-based planning sessions (“huddles”) to coordinate care activities.

In support of those activities, multiple participants described a need for dynamic electronic care plans that help teams of clinicians quickly get up to speed on a patient’s status and come to an agreement on goals for that patient. They were undertaking the research themselves because neither their current EHR systems nor any other types of health IT supported this perceived need. PCMH C participants reported conducting their own internal research into ways that condition-specific care plans could effectively support team-based care.

Participants also described needs for cross-clinic cooperative tools that could better coordinate care with affiliated as well as non-affiliated practice sites for specialty care. Once again, electronic care plans shared across practices were hypothesized to be one potential solution for organizing and documenting care across distributed teams: “... it all comes down to the information sharing of assessments, and the care plans, and goals, and having that all available in one place for everybody who’s part of the treatment team; even if they’re . . . in different settings of care.”

Participants also pointed to the possibility of using real-time messaging tools and video chats to coordinate with subspecialists. Participants expressed a critical need for continued advances in health IT to promote effective patient-oriented communication tools. Their current approaches primarily included patient portals to connect patients with providers, although not all practices had such portals. However, participants highlighted the need for tools to help care managers engage patients at specific times in a care process, such as when a patient gets discharged from a hospital.
Participants expressed a need for improved reporting, so that they could disseminate best practices to affiliated practice sites across their health systems. PCMH A participants, for example, believed that such a capability could not only promote standards of care across practice sites but could also spotlight top performing sites according by quality and cost.

Another perceived challenge was implementing data management strategies to improve the quality of clinical data. One participant from PCMH A expressed surprise that EHR data quality varied as much as it did across practice sites and attributed the variation to users inputting data in non-standardized EHR fields.

Interoperability
Participants emphasized the need to exchange clinical data with providers within and outside of their own PCMH networks.

All PCMH participants expressed frustration with and concern about their ability to appropriately coordinate care and meet PCMH reporting requirements using current HIE. This was particularly challenging for each of the two PCMH organizations (A and B) in which practice sites could use different EHRs. Although both PCMHs were sending clinical data to partnering RHIOs, participants from PCMHs and RHIOs each discussed having to dedicate resources to clean and harmonize CCD-based data. The challenges at these two organizations led the PCMH participants and non-vendor stakeholders to conclude that their quality and cost-containment efforts would have been more effective had each PCMH mandated use of the same EHRs. PCMH C noted that its health system’s providers had difficulty exchanging data with specialists outside the system. EHR vendor participants also recognized there were barriers to interoperability using today’s CCD standard, which could limit care coordination among PCMHs.

PCMH participants expressed a need for low-cost solutions for HIE interfaces to achieve effective interoperability. Given that PCMHs A and B maintained multiple EHRs, they noted that the costs were too high for them to pay vendors to develop and maintain HIE interfaces between those EHRs. Still, the reported need for lower cost HIE interfaces extended to PCMH C, which used a single EHR system: “The maintenance of all those interfaces — the costs are ridiculous . . . .”

Table 4: Recommendations for PCMH Health IT

<table>
<thead>
<tr>
<th>Health IT Tool</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring</td>
<td>Develop tools that filter patients by condition, to target clinical interventions that mitigate, if not prevent, poor outcomes</td>
</tr>
<tr>
<td>Notification</td>
<td>Provide real-time notifications to PCMHs whenever a defined patient interacts with the healthcare system, particularly during care transitions</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Integrate messaging applications that help PCMH clinicians identify care gaps among generalists, specialists, and patients</td>
</tr>
<tr>
<td>Reporting</td>
<td>Invent data extraction tools that enable PCMHs to efficiently report performance and quality metrics to internal and external stakeholders</td>
</tr>
<tr>
<td>Interoperability</td>
<td>Investigate ways that EHRs and HIEs can reduce interface costs</td>
</tr>
</tbody>
</table>

EHR, electronic health record; HIE, health information exchange; IT, information technology; PCMH, patient-centered medical home.

DISCUSSION
The major conclusions from this study suggest that existing health IT needs to evolve from digitized patient record repositories into interoperable electronic collaboration platforms that support both individual patients and patient populations to enable PCMH care coordination efforts. We recommend focusing health IT advances on improving monitoring, notification, collaboration, reporting, and interoperability within and among PCMHs (see Table 4). Focusing technological solutions in these areas can offer transformative approaches to improving care coordination and quality.

Although the PCMH represents a relatively new care delivery model, the need for improved care coordination that is continuous and comprehensive has been recognized as far back as the inception the medical home concept in the late 1960s.17,18 Our findings from leading PCMHs only reinforce the need for health IT to advance by providing continuous preventive care (monitoring), maintaining a central database that includes information regarding hospitalizations (notification), and enabling communication and collaboration with specialists, schools, and community agencies (collaboration).19 While notable investigators have identified central requirements for supporting population-based and longitudinal-based care,6,9,12 our findings go further, by highlighting the need for effective tools that enable PCMHs to monitor and report their patient care activities. These functionalities will likely enable PCMHs to not only identify patients in need of support but also how to best target limited
PCMH resources. A basic need, identified in this study, are monitoring tools that manage panels of patients and allow PCMHs to risk-stratify patients based on multi-modal data (both clinical and claims). This highlights a growing need among primary healthcare providers: identifying and tracking patients who are most at risk for incurring high utilization costs and who most need care coordination.20 These types of advanced patient analytics for patient populations and sub-populations may have once solely been the domain of payers and researchers, albeit in limited capacities. However, these capabilities will be increasingly based on sophisticated algorithms, developed by both vendors and PCMHs with the means, which are the core of future development. The ability to identify and categorize patients is a necessary step in care coordination,19,23 and we hypothesize that this need will extend beyond PCMHs to other practice models, such as Accountable Care Organizations.

Another health IT need is to support active case management. Participants stressed their needs for communication and collaboration tools that help patient care teams, needs which may extend beyond their PCMH, and their patients to literally get onto the same page. Again, this is not a novel concept, yet it is one that has been proven to be a barrier in care coordination for decades. While case management with care coordinators is becoming more common,22 we discovered that these established PCMHs relied on paper or off-the-shelf tools, such as Microsoft Excel or Access databases, for documenting these activities. These resources existed aside from the EHR and, therefore, represent shadow systems that likely contain valuable patient-related data that do not get captured in EHRs, if at all. This supports the need for health IT to evolve, so that clinicians can use electronic care plans across PCMH and non-PCMH sites to improve communication and documentation of theses care coordination activities.23,24 Our results also suggest that areas open to further investigation include how and when patient information should be made available to entire care teams, rather than only to select clinicians, and how to best utilize synchronous and asynchronous communication tools among PCMH providers, care coordinators, and patients.

Third, a strongly expressed need among participants was for more effective data extraction tools, for reporting purposes. This need was noted by PCMH, EHR, and third-party participants alike; despite the fact that the EHRs met the Meaningful Use standard. PCMHs require robust reporting on operational, quality, and financial metrics and depend on their EHRs to provide customizable reports to meet the requirements of various stakeholders. Current barriers that hamper PCMHs from reporting the clinical data they collect in and out of EHRs mean that these organizations may often be inefficiently working to meet guideline requirements.25,26 Reporting mechanisms based on better access to data could result in new ways to demonstrate care coordination’s effects on outcomes, quality, and costs. Although others have not considered effective reporting as a need,4,11 we found that it is critical in order for PCMHs to exist and meet their requirements.

As discussed previously, participants described a growing need to support data sharing efforts among PCMHs both within and outside of their health systems, for collaborative efforts. However, challenges with interoperability – including uniform agreement on the types of data to collect, how the data would be collected, and how the data would be stored for eventual reporting requirements – impede such data sharing. This issue speaks to acknowledged needs for increased standardization in data representations.27,28 However, we also interpret that these PCMHs, in concert with their vendors, were wrestling with ways to appropriate technology that would achieve the means for more effectively capturing user-generated data. It is for these reasons that standards-making bodies must continue to work more closely with technology developers to align the goals of care coordination with the capabilities of existing health IT and data structures.

A limitation to our findings is that they represents perspectives from PCMHs that have had access to funding and resources available to neither other existing PCMHs nor sites considering PCMH transformation. In addition, these exploratory findings were generated from qualitative data from a small number of PCMHs. We also developed the purposive sample based on the prominence of the PCMHs and their having been covered in previous literature. Importantly, our findings speak to the types of tools desired, but not the complex challenges associated with implementing tools, governing data usage, or ensuring quality control. Lastly, we did not collect PCMH-level data regarding duration of PCMH certification, patient visit counts, the percentages of PCMH payer agreements, the number of independent billing providers, or the ratio of care coordinators per patient panel. Taken together, these exploratory findings may have limited generalizability. Our findings, however, may be transferable,29 in that they provide insights and lessons learned that inform activities in similar settings. In addition, these results provide important insights that may lead to fruitful areas of research and development including: pattern detection tools directed at patient panels, care coordinator needs and tools, and overcoming barriers to EHR data extraction for reporting.

CONCLUSIONS
We conducted interviews with PCMHs, health IT vendors, and associated stakeholders to assess, based on their experiences, how health IT could better support future efforts towards care coordination. We discovered important needs for monitoring tools that enable PCMHs to analyze patient populations; notification tools that enable PCMHs and care managers to detect or be alerted to patterns in their patient populations; collaboration tools that bring together providers and non-providers within as well as across care settings; data extraction tools that enable more efficient reporting; and robust HIE that enables these activities to be achieved efficiently and economically. We encourage further efforts between PCMHs and health IT vendors to focus on these areas of needs in order to improve ongoing and future care coordination efforts.
**FUNDING**

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**COMPETING INTERESTS**

None.

**CONTRIBUTORS**

All authors contributed to the recruiting strategy, design of the data collection tools, and monitored data collection for the whole trial. JR managed the recruiting and transcription processes. Jr, JV, and CG were involved in data collection and were responsible for primary analysis of the qualitative data. RK and LK provided secondary analysis and approved the final analysis. JR drafted and revised the paper with editorial input from the other co-authors.

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**SUPPLEMENTARY MATERIAL**

Supplementary material is available online at http://jamia.oxfordjournals.org/.

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