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Feature Article

Implementing Geographic Information Systems (GIS) into VHA Home Based Primary Care



Jason D. Lind, PhD^{a,*}, Jacqueline Fickel, PhD^b, Bridget A. Cotner, PhD^a, Judith R. Katzburg, PhD^b, Diane Cowper-Ripley, PhD^{c,d}, Marguerite Fleming, MPA^e, Michael K. Ong, MD, PhD^{f,g}, Alicia A. Bergman, PhD^b, Sarah E. Bradley, MA^a, Sarah A. Tubbesing, MD, MSc^{h,f}

^a James A. Haley Veterans' Hospital and Clinics, Research and Development Service, 8900 Grand Oak Circle (151R), Tampa, FL 33637-1022, United States

^b VA HSR&D Center for the Study of Healthcare Innovation, Implementation, and Policy, VA Greater Los Angeles Healthcare System, Los Angeles, CA, United States

^c North Florida/South Georgia Veterans Health System, Center of Innovation, Gainesville, FL, United States

^d VA Office of Rural Health, GeoSpatial Outcomes Division, Gainesville, FL, United States

^e VA Office of Reporting, Analytics, Performance, Improvement, and Deployment, Center for Innovation and Analytics, Washington, D.C., United States

^f University of California at Los Angeles, David Geffen School of Medicine, Los Angeles, CA, United States

^g Division of Hospital Medicine, VA Greater Los Angeles Healthcare System, Los Angeles, CA, United States

^h Home Based Primary Care Program, VA Greater Los Angeles Healthcare System, Los Angeles, CA, United States

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ABSTRACT

The Veteran's Health Administration (VHA) Home Based Primary Care (HBPC) program provides comprehensive in-home primary care services to elderly Veterans with complex chronic medical conditions. Nurses have prominent roles in HBPC including as program leaders, primary care providers and nurses who make home visits. Delivery of primary care services to patients in their homes can be challenging due to travel distances, difficult terrain, traffic, and adverse weather. Mapmaking with geographic information systems (GIS) can support optimization of resource utilization, travel efficiency, program capacity, and management during normal operations, and patient safety during disasters. This paper reports on the feasibility, acceptability and outcomes of an initiative to implement GIS mapmaking in VHA HBPC programs. A mixed method evaluation assessed extent of adoption and identified facilitators and barriers to uptake. Results indicate that GIS mapping in VHA HBPC is feasible and can increase effectiveness and efficiency of VHA HBPC nurses.

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Introduction

Improving access to care is a top priority for the Veterans Health Administration (VHA)¹; therefore, emphasis has been placed on expanding non-institutional care programs. One example is the VHA Home Based Primary Care (HBPC) program which provides comprehensive primary care services to mostly elderly Veterans (mean age 76.5 years) who have complex, chronic conditions, who can be frail and disabled, and who face significant barriers accessing clinic-based services.^{2,3} HBPC delivers cost-effective, long-term, primary care to Veterans in their homes that can include coordination of care, rehabilitation, disease management, and palliative care.⁴

In the VHA, HBPC is provided by an interdisciplinary care team that is comprised of nurses, nurse practitioners, physicians, rehabilitation therapists, dietitians, social workers, psychologists, and pharmacists.⁴ Most of these team members provide face-to-face care to Veterans in their homes. Nurses have prominent roles on the teams.

For example, nurses can provide in-home assessment for acute and chronic medical problems and contribute to healthcare maintenance by providing vaccinations. Nurse practitioners are commonly the primary care providers.

HBPC services have reduced hospital and nursing home stays,^{4–6} reduced costs, and improved access and quality of care.^{7,8} Both urban and rural Veterans who are medically homebound have significantly benefited from HBPC due to increased accessibility to primary care, mental health care, and pharmacy services.² The number of Veterans receiving HBPC services in the 139 HBPC program sites nation-wide has more than tripled since 2002 and, in 2016, reached 37,009, with approximately 38% living in rural areas.^{2,9,10}

HBPC programs face several challenges to meet increased demand for services. One challenge is that HBPC programs have been limited in reach due to service area restrictions. The HBPC team is typically based at a VHA medical center or community-based outpatient clinic (CBOC), with a service area radius of 30–70 miles from the facility.⁴ Another challenge facing HBPC programs relates to program efficiency. Patients enrolled in HBPC services are spread out over large geographical areas. This makes it difficult to determine the most

*Corresponding author.

E-mail address: Jason.Lind@va.gov (J.D. Lind).

effective way to assign patients to HBPC care teams. Staff such as nurses who may need to see many patients in a day face additional challenges in making decisions about how to arrange travel plans to maximize patient visits most efficiently. A final challenge is that HBPC services have been tasked with developing their own emergency preparedness program to meet the increased needs of their Veteran population during disasters. Historically, HBPC programs have received limited information and training on how best to undertake HBPC program emergency preparedness.⁵

To meet these challenges, HBPC services have been encouraged to use technology-based practice management tools to increase access to care and improve overall efficiency.^{11,12} One such tool is a geographic information system (GIS). The VHA Office of Geriatrics and Extended Care (GEC) has been supporting mentored partnerships for local, field-based HBPC staff to learn and use a tool called ArcGIS for Portal (ESRI®). This tool provides a secure web-based platform for gathering, managing and analyzing data. This can provide HBPC programs with the ability to map locations, such as those of patients, clinicians, hospitals, and environmental threats and can also integrate clinically relevant patient information. As such, ArcGIS for Portal can provide HBPC practitioners with advanced tools to facilitate decisions about program expansion, clinical assignments, and emergency preparedness.^{13,14}

Numerous studies have used GIS to address access to care issues for different patient populations, such as acute stroke, multiple sclerosis, and traumatic injuries.^{15–19} There is no known report, however, on the specific use of GIS tools for VHA HBPC. Therefore, an evaluation of ArcGIS for Portal as a tool for VHA HBPC (the VHA HBPC-GIS Project) was conducted with the following goals: (1) evaluate feasibility and acceptability of GIS mapmaking for HBPC programs, (2) evaluate the use of maps in HBPC management (including its use in travel efficiency, program expansion, and emergency preparedness), and (3) identify barriers to and facilitators of ArcGIS for Portal implementation. This paper describes the VHA HBPC-GIS Project findings and impact.

Methods

Design and setting

The VHA HBPC-GIS Project is a quality improvement implementation and evaluation project consisting of three main types of activities: (1) implementation of GIS mapping at selected HBPC sites, with the goal of recruiting additional HBPC sites over time, (2) development of tools to support program sustainability, and (3) conducting a concurrent mixed method evaluation of the feasibility, acceptability, and barriers to and facilitators of the implementation, including describing and evaluating the ways that the maps are used in HBPC practice management, and exploring their impact on patient care activities.

The implementation and evaluation design were guided by the Consolidated Framework for Implementation Research (CFIR)²⁰ and the VHA HSR&D Implementation Facilitation Manual.²¹ Data from the ongoing evaluation were used to refine the training and support materials used for implementation, and these revised materials were provided to new sites as they were recruited to the project. The project was coordinated by a multi-disciplinary team of a HBPC clinician, GIS experts, and specialists in implementation and evaluation. The team provided support and facilitation to HBPC practice sites nationwide that were implementing the use of ArcGIS for Portal mapping software.

The uptake and use of GIS mapping spread from a single pilot site in 2012 to 21 sites nationwide at the end of 2016. Participating sites represented a range of HBPC programs in terms of practice sizes, geographic locations, and rurality (Table 1): sites were distributed across the United States (Northeast, Southeast, Mid-South, and West) and included 6 small (<206 patients), 11 medium (207–400), and 4 large (>400) HBPC programs. Programs included 2–11 HBPC care teams and patient loads ranging from 83 to 580. Total patient enrollment in the 21 sites participating in this project at the end of 2016 was 6332 Veterans.

Table 1
VA home based primary care GIS project sites: characteristics and mapping activity, 2016.

Site	Joined GIS project	Rurality ^b	HBPC teams (n) ^c	HBPC patient census (n) ^c	Reported mapmaking	Reported map use	Stage of adoption ^d
1	2012	Urban	4	206	Yes, desktop version	Yes	Somewhat active
2	2014	Urban	2	280	Yes	Yes	Very active
3	2014	Mixed	11	580	Yes	Yes	Very active
4	2014	Mixed	4	327	Yes	Yes	Very active
5	2014	Rural	4	165	Yes	Yes	Active
6	2014	Mixed	4	304	Yes	Yes	Active
7	2014	Mixed	4	557	Yes	Yes	Active
8	2014	Mixed	2	83	Yes	Yes	Somewhat active
9	2014	Rural	2	153	No	Yes ^f	Somewhat active
10	2015	Mixed	7	335	Yes	Yes	Very active
11	2015	Mixed	11	436	Yes	Yes	Very active
12	2015	Mixed	4	240	Yes	Yes	Very active
13	2015	Urban	5	362	Yes	Yes	Active
14	2015	Urban	3	298	Yes	Yes	Somewhat active
15	2015	Mixed	5	291	Yes	Yes	Somewhat active
16	2015	Mixed	4	183	No	Yes ^f	Somewhat active
17	2015	Mixed	8	481	No ^e	No ^e	Pre-adoption
18	2016 ^a	Urban	5	203	No ^e	No ^e	Initial adoption
19	2016 ^a	Rural	4	280	No ^e	No ^e	Initial adoption
20	2016 ^a	Mixed	3	252	No ^e	No ^e	Pre-adoption
21	2016 ^a	Mixed	6	316	No ^e	No ^e	Pre-adoption

^a Sites 18–21 joined project in May 2016.
^b Rurality: Rural ≥75% rural patients, Mixed 26–74% rural patients, Urban ≤25% rural patients.
^c Number of clinical teams and Average Daily Census at end of September 2016.
^d Stage of Adoption based on qualitative reports and number of maps created in the ArcGIS software, October 2015 through September 2016: Very active = 45–94 maps, Active = 9–18 maps, Somewhat Active = 1–6 maps.
^e Site is either in pre-implementation or early implementation phase of learning how to make maps. Map making not yet initiated.
^f Using Maps made from a previous year.

Implementation methods

Implementation consisted of a combination of training, technical assistance, supported facilitation, and collaborative learning via a VHA GIS mapping user community. Clinical and support staff interested in GIS mapping were identified during national HBPC conference calls. HBPC sites interested in GIS mapping were then contacted and interviewed by the project staff and selected to participate in the project based on their interest and goals for implementing GIS and their administrative, technical, and clinical staff support. The profile of participating team members was specific to each site, consisting of program directors, medical directors, nurse managers, nurse practitioners, registered nurses, and program support assistants.

Developing GIS training

Learning to use ArcGIS for Portal requires database management skills and familiarity with the mapping interface. Based on feedback from facilitation calls and evaluation interviews with each HBPC site, complementary training was needed for many of the HBPC local program staff. An online computer-based training curriculum was developed and implemented by the project team. To enable ready access to the training, computer-based modules were developed and housed in the VHA national training website. Training consisted of sequential and interactive online training modules that provided real world examples and tasks geared toward mapmaking within the context of HBPC program management. These include: (1) taking the user through the steps of organizing and uploading patient and provider data for mapping, (2) creating desired maps, (3) customizing the maps, and (4) sharing maps with other members of the HBPC team.

GIS technical support

To address technical questions related to database management, mapmaking, and general problem-solving, technical assistance was provided by two GIS experts from the VHA Office of Organizational Excellence/Reporting, Analytics, Performance, Improvement and Deployment (RAPID), which holds the license for ArcGIS for Portal and maintains the software on a secure server.²² Technical assistance was available as-needed through electronically generated help-desk requests that were addressed within 48 h and through a weekly online scheduled teleconference time available to all project participants.

Implementation facilitation

Implementation facilitation provides help in tailoring implementation activities to site-specific needs through involved interactive problem solving and support using methods described in the VHA HSR&D Implementation Facilitation Manual.²¹ Facilitation support for GIS implementation activities was conducted via telephone and computer-based teleconferences approximately once per month during the initial phases of implementation, with additional support as needed.

Online GIS user's community for HBPC

To create a community of GIS users across HBPC sites and facilitate implementation efforts, representatives from all HBPC-GIS sites were invited to participate in monthly teleconference calls that featured presentations and discussion on key topics of general interest, and project related announcements. Topics included technical aspects of mapmaking plus topics related to use of maps in practice management. Finally, a specific webpage dedicated to the VHA HBPC-GIS Project was created on an internal VA internet networking site

known as VA Pulse. This enabled participants to share documents including GIS user manuals, past presentations, articles and web tutorials. Via the Pulse page, participants were also able to post questions to a community user board.

Evaluation methods

A concurrent mixed-method evaluation using quantitative and qualitative data was conducted to produce formative feedback and document the overall VHA HBPC-GIS project site experiences and outcomes with implementation activities.²³ In order to ensure validity and interpretive potential of program findings and to gain wholistic perspectives of project implementation, multiple data collection methods, both quantitative and qualitative, were used and then triangulated.²⁴ Quantitative data consisted of the number of maps created monthly in Portal for ArcGIS by each site, reported automatically by the ArcGIS software; the number of patients at each of the sites from a VHA administrative database; the number of HBPC staff at each site, as reported by the site. In addition, HBPC staff completed a brief survey of their experiences and satisfaction with Portal for ArcGIS. Qualitative data sources consisted of semi-structured evaluation interviews and field notes from facilitation contacts.

Satisfaction survey

An online evaluation and satisfaction survey were developed in RedCap.²⁵ All HBPC staff involved in the program at each site were invited to complete the survey. A total of 37 HBPC staff at 20 sites completed the survey (program directors and program support assistants were most likely to take the survey). The survey consisted of five demographic items and 19 items focused on map-making ability using GIS maps in practice management, learning to use ArcGIS for Portal, and pilot project participation. All non-demographic items were answered using a Likert scale as follows: (1) poor, (2) fair, (3) good, (4) very good, and (5) excellent. See results from the satisfaction survey in [Table 2](#).

Qualitative interviews with HBPC staff

The semi-structured interviews were conducted over the telephone with 34 HBPC staff at 18 sites. Interviews were commonly conducted with HBPC program directors, nurse managers, and program support assistants. The interview guide consisted of 18 questions and allowed for probes as needed. Interview questions addressed relevant information about site goals, plans, implementation activities, personnel, contextual factors, mapmaking, map use, and barriers and facilitators to making and using GIS maps in HBPC. Interviews were audio-recorded with permission and transcribed for analysis. See all salient quotes from interviews in [Table 3](#).

Analysis

Descriptive analysis of software utilization (the number of maps created in Portal for ArcGIS and the number of patients and HBPC staff at each of the sites) and satisfaction survey data were conducted by Drs. Cowper-Ripley, Fleming, and Fickel. Data were calculated for all sites, with continuous data presented as mean, standard deviation, and minimum and maximum values, and categorical data as frequency (%) using Microsoft Excel.

Qualitative data analysis of the 18 site evaluation interviews was conducted by Drs. Lind, Cotner and Bradley. Interview transcripts were uploaded into ATLAS.ti v 7.2,²⁶ a qualitative data analysis software program. Interviews were coded based on the interview questions and categories from the interview guide. New codes were created based on emerging themes from the interviews and added to

Table 2
GIS HBPC site survey results.

Topic	N	Mean rating	Std dev.	Range
HBPC Survey Participating Sites	21	3.5	0.9	2–5
Map-making				
Ability to upload patient data to mapping software	19	3.3	1.3	1–5
Ability to create GIS maps	19	3.2	1.1	1–5
Overall user-friendliness of Portal for Arc GIS software	23	2.8	0.9	1–5
Using GIS maps in practice				
Overall ability to incorporate ArcGIS into HBPC practice	23	2.8	1.1	1–5
Ability to use GIS maps re program expansion	15	3.0	1.1	1–5
Ability to use GIS maps re boundaries and territories	20	3.6	1.2	1–5
Ability to use GIS maps in day-to-day travel plans	13	2.5	1.2	1–5
Ability to use GIS maps for emergency preparedness	19	3.1	1.1	1–5
Learning to use Portal for ArcGIS				
Quality of training modules	15	3.6	1.0	2–5
Accessibility of training modules	17	3.2	1.4	1–5
Technical support	21	4.0	0.9	3–5
Monthly all-site calls	24	3.6	0.8	2–5
Facilitation calls with individual site	21	3.5	0.7	3–5
Project participation				
Clarity of expectations	31	3.4	1.0	2–5
Ability of site to set goals for use of maps	29	3.1	1.3	1–5
Ability of site to achieve stated goals	29	2.9	1.4	1–5
Overall experience in 2016	30	3.4	1.1	1–5

Likert scale with: (1) poor; (2) fair; (3) good; (4) very good; and (5) excellent.

Total survey respondents $N = 37$. Because of the varying roles of HBPC team members across sites re map-making and use, specific survey topics were relevant to subgroups of respondents.

the coding structure. The constant comparative method of qualitative analysis was used to compare codes across all interviews to identify emerging themes.²³ Consensus of thematic categories was achieved through several discussion meetings with the evaluation team.

Field notes from facilitation support calls for GIS implementation activities were collected as running notes and were organized in an excel spreadsheet and categorized by site location and broad facilitation and implementation topics. Such topics included: (1) current mapping use; (2) barriers and facilitators to implementation; (3) staffing; (4) goals and objectives for implementation; (5) technical issues; and (6) recommendations. This information was updated concurrently as facilitation support calls occurred.

For this project, we employed a triangulation protocol as a strategy to integrate findings from different data sources.²⁷ Data triangulation was conducted by Drs. Fickel, Katzburg, Lind, Cotner, and Bradley. Data sources included: (1) site specific software utilization; (2) satisfaction surveys; (3) qualitative interviews with HBPC staff; and (4) field notes from facilitation support calls. Specifically, we utilized a site-specific matrix as a strategy to integrate and analyze both quantitative and qualitative findings from different data sources in one place.^{28,29} The site-specific matrix consisted of a separate excel spreadsheet that was used to display salient findings, insights, and themes by site. Site-specific data from multiple sources were then compared and contrasted to determine the extent to which the data triangulate or converge.²³ This approach enables consideration of agreement, partial agreement or dissonance between findings from different data sources²⁸ and led to a greater level of convergent validity of data collected by the implementation and evaluation teams. This process enabled us to produce comprehensive site descriptions based on multiple data sources.

Results

Mapmaking and utilization of GIS in HBPC

According to utilization data, survey data, facilitation notes, and interview findings, 16 of the 21 HBPC sites (76.2%) were making maps

at the end of 2016, while the other 5 were still in the pre-implementation training phase (Table 1). Typically, one or two HBPC team members per site trained to make maps in Portal for ArcGIS. Most of these map-makers were medical support assistants (MSAs) or program support assistants (PSAs), but also included program directors, nurses, and social workers. The profile of team members who used maps to support their practice management activities varied with the local site characteristics, and included program directors, medical directors, nurse managers, staff nurses, other clinical staff, MSAs, and PSAs.

Satisfaction survey respondents ($n = 37$) indicated that use of GIS was feasible and useful. On a scale from 1 (poor) to 5 (excellent) they rated their ability to create maps as “good”, with an average of 3.2 ($n = 19$) and their overall ability to incorporate GIS maps into HBPC practice as “fair to good” with an average of 2.8 ($n = 23$). Among respondents who made maps ($n = 17$), time spent in a typical week working with ArcGIS including training and various mapping-related activities was 1 h or less for 10 participants, 2–3 h for 5 people, and 4–5 h for 2 individuals. See all survey results in Table 2.

Optimization of travel efficiency: assigning patients to providers

In 2016, 15 of the 21 sites used GIS maps to assign new patient admissions (consults) to clinical care teams with the goal of facilitating travel efficiency. GIS maps provide program leadership and administrators an accurate, real-time geographical visualization of clinical care teams relative to new patients waiting to be admitted into HBPC. By mapping pending or new patient admissions alongside current patients color-coded by provider, program directors can more easily plan and make decisions regarding patient clinical assignments (see Table 3). A sample map illustrating this type of map may be seen in Fig. 1. According to several HBPC program directors, GIS maps facilitate sound clinical decisions regarding patient assignments, and ensure that patients are assigned to clinical teams within specific geographical boundaries, thus preventing inefficient overlapping clinical coverage. A HBPC program director at one site explained that the increased efficiency, from the ability to map and plan future patient assignments using GIS, can reduce the time patients spend on the wait list by quickly identifying the appropriate clinical team and by increasing staff efficiency so that clinical teams can handle additional patients, thereby increasing Veterans' access to needed primary care services.

GIS maps can also be used to reorganize existing clinical assignments by providing HBPC program leadership with geospatial information of both patient locations and clinical care team territories. This information can provide HBPC program leadership the ability to reassess and change current patient assignments, resulting in increased travel efficiency for providers in terms of drive time and patient visits (see Table 3). In one example, the program director at an HBPC site recalled that one of her nurses was assigned patients in three different geographical areas. The program director used GIS mapping to reassign that nurse to focus her efforts in one geographical area. In another example, a nurse reported that after she was reassigned a new patient case load based on mapping, she was able to reduce her driving distance by over 600 miles per month.

Another way GIS maps are used by program leadership is to visually communicate HBPC administrative needs to hospital leadership. For example, an HBPC program director reported creating GIS maps to present a visual representation of their patient census to hospital leadership to justify hiring additional nursing staff to address the needs of an expanding patient population. At another rural HBPC site where most clinical staff are authorized to telework, GIS maps were used to justify parking government vehicles in approved federal government locations (e.g. United States Post Offices) located near patient clusters. This decreased staff travel time by eliminating the need for staff to drive to the HBPC office, pick up a government vehicle, and travel to the patients' homes.

Table 3
Exemplar quotes from qualitative interviews.

Theme	Category	Exemplar quote
Mapmaking and utilization of GIS in HBPC	Benefits	<p>Apart from mapping Veterans, we can now map nurse practitioners, the RNs, social work... all the disciplines. The rationale is that we can visualize, to see where the Veterans are located and what clinicians they are assigned.</p> <p>Because with the maps, a picture is worth a thousand words... It's so much better than 17 paragraphs of verbiage.</p>
	Goals/future plans for using GIS in HBPC	<p>I'd like to use GIS to map where my fleet [cars] are parked, because it's very hard to try to figure out where they are, in relationship to where my nurses live, that's another layer I'd love to have.</p> <p>And because we have a lot of highly rural locations, if there was a reported wildfire, flooding, or some other natural disaster, that we would be able to be able to see which Veterans we absolutely need to call to notify.</p> <p>I want all the HBPC nurses to understand the GIS mapping system so they can plan their patient visits. I want them to know not only the acuity of the Veterans, but where they are located because I know that will increase the productivity, especially because I have nurses that work 10 h and some others work only 8. And the mapping can help me to prove that their productivity increased when the nurses worked 10 h, that would allow me to bring all the nurses to work 10 h.</p> <p>So, for example, one of the things that [the mapmaker] and I talked about at one point was identifying heart failure patients that are actively being seen within the VA and how many of those have had hospitalization in the last six months for that problem, and then be able to show them on a map where do they reside. So, if you're looking at program growth, program development you could use a diagnosis and where the patient lives to help try and map out where that growth needs to occur.</p> <p>I want to be able to make that a tangible instrument as far as what my staff can use, what I can use to make sure that we are doing the right things as far as resources are concerned. So, do we have the right nursing staff and clinical staff in the right places at the right time and how do we consolidate.</p>
Optimization of travel efficiency: Assigning patients to providers	Assigning new patient referrals	<p>Using GIS mapping was helpful when we got some new referrals, to be able to make determinations on which Nurse Practitioner that patient would be assigned to, that might work best with the current patient population that they had, based on location of other patients.</p> <p>My role with the GIS portal is I oversee the consults and so with doing the consults for Veterans that come into or are interested in the HBPC program. I'll look at the map and see where Veterans are located and see what clinical teams are located close to them. And we've got the maps separated into four quadrants, and so we try to keep certain teams in certain quadrants.</p>
	Managing patients on the wait list	<p>One of the things I like to use it for is the EWL [Electronic Waiting List], being able to figure out logically if one Nurse provider's full, all right, who's the next closest, and what can we logically do to try to shift things around again to best assign that patient what they are admitted to our HBPC program.</p>
Optimization of travel efficiency: Staff daily travel	Visualizing better staff organization	<p>We were literally, all over the map. Two different providers are tripping over each other; both traveling to the same areas. Which you can see on the map, literally you can look at the [patient location] and see, that nurse practitioner on team "A" sees patient "X" and that nurse practitioner on team "B" sees that patient "Y" and they're five miles apart. That makes no sense when we have such a wide catchment area. So, the maps help you see it in a way that you wouldn't know otherwise.</p> <p>So, what we had was a nurse basically in three different geographical areas and we were having difficulty with the travel time with her, and her ability to get up to panel size because of it. Right now, we are using the GIS mapping to minimize how many different areas this nurse would have to go into; basically, how best to reorganize the clinical panel.</p>
	Increased travel efficiency and planning	<p>After we reorganized staff based on mapping, the Nurse Practitioner said to me, "I'm finally realizing that I'm not spending 125 miles on the road. I went out the other day, I was out for 47 miles and saw three patients." She said, "That is a real difference."</p> <p>I mapped the average drive times between the medical center and where one of the off-site HBPC centers are; where most of the staff are. So, that was helpful to get estimated drive times and correlate that with our case management territories, so we can start to make better decisions regarding clinical assignments.</p> <p>One of the other things that we're excited about is to be able to show each nurse's caseload and where they are, so the nurses are not overlapping each other.</p> <p>I would say it improved efficiency because of being able to find a logical divide for their territories.</p> <p>We are about to have transponders, geolocators, put on most of our fleet... we'll be able to do some analysis on that and then take it back to the teams and point out to them perhaps how they could be more efficient if they changed some of the things they do.</p>
Identifying geographical areas for potential HBPC program expansion	Examples of HBPC expansion plans	<p>Then we've also used the maps to sort of track potential or past consults that we've had and seen where their population is, where we've received consults beyond our current catchment area, so potential expansion area.</p> <p>We're going to expand to two more pilot locations and hopefully fill that program specialist position, so we can get back up and running... Right now they were looking at, I think it was Pasadena and... Gardena.</p> <p>We are getting ready to expand services and add 125 more patients. So, we definitely, desperately need to implement the GIS mapping because we're going to be expanding by over 75% of our census will be growing in probably the next fiscal year-and-a-half.</p>
Developing emergency preparedness plans	Examples of GIS and emergency preparedness	<p>Yes, we do. We have our emergency preparedness plan for the flooding coming into the area, due to the weather. We're able to notify the patients based on their flood zone.</p> <p>When we've had severe weather and been trying to contact Veterans about potential power outages and what issues those at-risk patients that we have. So again, being able to utilize the mapping and overlay a map of the affected area with our patient population, we know who to contact. That's been helpful.</p> <p>Currently we're mapping for patient by disaster code, you know, who's priority 1, 2 and 3; oxygen, home help, who has community home help. And then, also we are able to use it also for disaster planning because we can map the bad weather; whether it be fire, tornadoes, hurricanes, flooding—so we are currently integrating that into practice.</p>

(continued)

Table 3 (Continued)

Theme	Category	Exemplar quote
Barriers of and facilitators to using GIS maps in HBPC practice	Staff turnover and disruption	We've had some turnover in staff. I know that has been a struggle, at least to me personally, to work with becoming a little more familiar with the mapping system. [The program support assistant] took care of updating the patient lists and all the mapping. Unfortunately, he left for a new position about three months ago, and when he left, everything with the mapping stopped.
	Competing demands and lack of time	I know there's so much more I can be doing with this software, but it is a time-consuming initiative, and I'm just getting caught up on getting that time allotted into my schedule. We lost our administrative support at one of our HBPC sites, so my time is even busier since we have over 320 patients now. Being able to keep up with the GIS became even less of a priority for us. We have many other things going on at the same time. Our big problem is with staffing and budgets. We just don't have enough people to do what needs to be done, not to mention something extra like the GIS mapping.
	Inexperienced staff	We were without a program support assistant for over four months and then we had a couple changes in our staffing during the last year. So, that's been kind of unreliable. The PSA position tends to lead a lot of the utilization of the software. It took the new PSA coming in a long time to learn the GIS mapping software and get reacquainted with it.
	Technical difficulties	Recently, when I went into [the GIS software], I was having difficulty launching the maps, they weren't coming up the same way, so I need to get on the technical support call and see what's going on with that. I have had some glitches with the software. Some of the names didn't populate over. I was given instructions on how to find out which ones, but I still can't figure out, you know, why one nurse only has three patients and I don't know what happened to the rest.

Optimization of travel efficiency: staff daily travel

In another effort to improve travel efficiency, 13 out of the 21 sites used GIS maps in day-to-day travel plans. In terms of practice management, GIS maps are a valuable tool for nurses and other clinical staff who regularly provided in-home care because it allows them to more easily visualize their service territory and thus better plan their weekly home visits. For example, having up-to-date GIS maps provides nurses and other clinicians with the ability to visit other patients who are clustered near patients with scheduled visits. As a result, several nurses reported that using maps in their planning of weekly travel allowed them to visit more patients while driving fewer miles (see Table 3). GIS maps can be especially valuable to team members (e.g., nurses, social workers, psychologists, and therapists) who are assigned to cross-cover multiple care teams and work across unfamiliar geographical areas. In these cases, maps provide a means for HBPC staff who perform irregular patient visits, or who are reassigned to different care teams to more efficiently plan patient home visits.

Identifying geographical areas for potential HBPC program expansion

HBPC sites are increasingly being asked to expand services into new geographical areas to serve more Veterans. As of 2016, 7 out of the 21 HBPC sites were using GIS mapping to plan for HBPC program expansion by identifying potential patient populations not currently being served. Using facility-level data, sites can map locations of Veterans with diagnoses and complexity levels who would benefit from HBPC services. Once these Veterans are identified and determined to fit within the HBPC territory, patients can be informed and receive a referral for HBPC through their primary care provider (consults). In one example, a HBPC program director reported that GIS maps of potential HBPC patients were used by hospital leadership to plan for HBPC program expansions (see Table 3).

In another example of using GIS to facilitate HBPC program expansions, a HBPC program in the Eastern US received 20 patients from an adjacent HBPC program site because of administrative restructuring. In order to distribute new patient admissions among providers, the HBPC program director used GIS maps to visualize the most efficient way to modify patient assignments among nurse practitioners. Within one month, all 20 new patients were admitted into the HBPC

program and started receiving care, without the HBPC program needing to hire additional staff.

Developing emergency preparedness plans

All HBPC programs are required to assist patients with emergency preparedness.⁵ At the end of 2016, 8 of the 21 HBPC sites were incorporating the use of GIS maps into their emergency preparedness plans. The remaining sites expressed that using GIS mapping to facilitate their emergency preparedness plans was of top priority, and one of the major reasons they were interested in implementing GIS mapping in their HBPC practice. HBPC program directors reported that GIS maps allowed locations of patients to be displayed relative to the location of natural disasters (see Table 3). In addition, GIS enabled patients to be labeled with an acuity or risk score based on their health needs or vulnerability. Being able to visualize on one map the location of patients, their risk scores, and the location of potential disasters allows HBPC program directors and nurses to quickly identify affected patients and prioritize their care. In one example, a HBPC program used GIS maps to develop a comprehensive emergency preparedness plan. The HBPC program's catchment area is prone to flooding and wildfires with coastal areas at risk for tsunamis. The HBPC program assistant can map the location of current disasters in real time, along with patients' locations and associated risk score on the same map. This information can be used during a real disaster situation to quickly identify which patients might be affected, and to prioritize which patients need to be contacted first to communicate personal disaster management plans and the proper actions to take.

Barriers of and facilitators to using GIS maps in HBPC practice

According to staff, the most common barrier to implementing GIS maps in HBPC practice is staff turnover in the program director, program support assistant, and nursing positions (see table 3). When staffing disruptions occur due to turnover, temporary detail, or extended leave, resources are often diverted to ensure the continuity of patient care and focus is shifted away from making GIS maps. Other common barriers to implementing GIS maps in HBPC were competing programmatic demands, lack of time for the designated map maker to properly learn or consistently use GIS mapping, and having an inexperienced staff member in place who had yet to learn

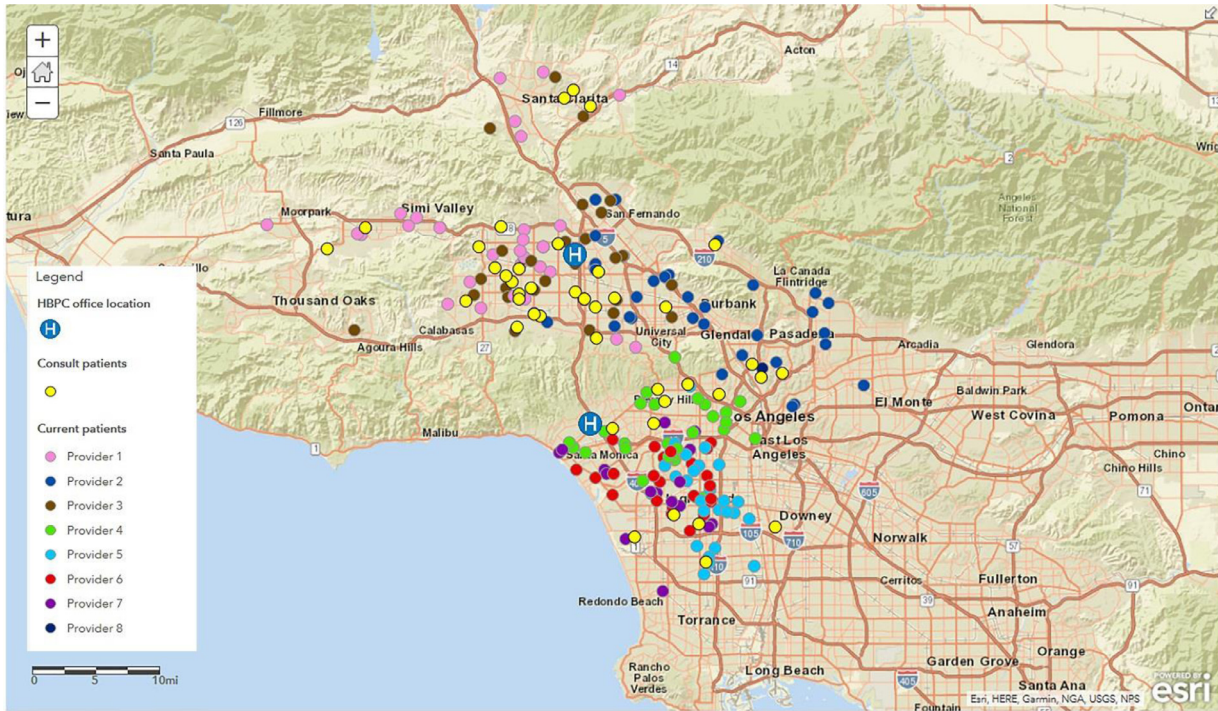


Fig. 1. Example of map of patient admissions alongside current patients color-coded by provider.

to use the Portal for ArcGIS software. Prior to the training modules becoming readily available via the VHA national training website, a lack of hands-on training with the software, or not enough training, was also commonly mentioned as a barrier. The main technical barrier were perceived glitches in the software and difficulty properly formatting and uploading HBPC patient database files into the Portal for ArcGIS software for the creation and updating of maps. This included the time-consuming task of manually updating patient database files on a regular basis, which is necessary to maintain maps with up-to-date patient information.

Based on interviews conducted with key informants regarding their ability to make and use GIS maps for their HBPC practice, staff reported that the main facilitators were: (1) having access to training materials (the computer-based video modules and the implementation manual), (2) having access to the GIS experts for problem-solving issues, (3) having staff members in key positions who have relevant computer skills such as database management and prior experience with GIS software, and (4) having key HBPC staff members who championed the use and implementation of GIS mapping. HBPC sites reported that the training modules provided them with the necessary knowledge to successfully make maps. In addition, many of the sites reported that having a GIS expert available during weekly “office hours” meetings, as well as on an individual basis via a “help desk” request, was invaluable to their ability to successfully make maps.

Discussion

The primary goal of HBPC teams is to improve Veterans' health and independence by utilizing a network of professionals who can provide comprehensive care in the home environment.⁴ Tools that increase the efficiency and effectiveness of HBPC programs have the potential to improve patient care. These findings show that, for most HBPC programs, staff members including nurses were able to learn how to use the ArcGIS for Portal mapping software and how to make useful maps.

Both clinicians and administrative staff perceived that implementing GIS mapping into HBPC practice was beneficial in several ways: (1) to improve program planning and organization in ways that benefit nurses and other clinical staff and lead to increased travel efficiency, (2) to increase access to primary care services for Veterans by identifying areas for service area expansion, and (3) helping HBPC program directors with emergency preparedness planning.

There has been relatively little work studying this type of locally-tailored GIS mapping by field-based clinical teams. One early study described the development of a GIS-based spatial decision support system for scheduling and route-planning for visiting nurses.⁴ Other work has described planning health services for populations of patients with specific medical conditions.^{15–18} The feasibility and desirability of field-based GIS mapping demonstrated by these VHA HBPC programs suggests that additional research on the benefits of using GIS mapping as it relates to nursing care delivery in HBPC settings would be worthwhile.

Planning for sustainability and spread will need to consider competing demands for staff time. In addition, collaboration of administrative stakeholders or funders will be important to assure adequacy of access to the software and technical support, including options for improved automation of data management. Ongoing evaluation will be beneficial to understanding the full potential of utilizing GIS in VHA HBPC. Many of the HBPC sites had implementation plans or goals that had not yet been realized by the time of this evaluation. These included using the software to organize the fleet cars used to reach patient homes, so that care team driving time can be as efficient as possible. Sites also hoped to increase use of the GIS mapping for emergency preparedness and management.

Conclusion

This evaluation shows that using GIS tools via a secure portal platform can assist field-based clinical teams in planning and decision-making processes to enhance nursing care efficiency and practice.

The evaluation of this project was focused on the HBPC program as whole (including all clinical staff) and was not directed specifically at nursing personnel, though nurses fill the largest percentage of personnel slots in HBPC (including over 40% of the program director positions). The evaluation established both the feasibility and acceptability of GIS mapping in the context of HBPC in general. However, more information is needed to definitively generalize the program results to nursing practice. Given the sizable percentage of nurses who staff the HBPC program and the mapping project, data suggest that GIS mapping provided benefits to both nursing management and staff and, concomitantly, to their patients. An important next step would be to focus research on the efficacy and value of GIS mapping to HBPC nursing staff specifically. Additional study is worth pursuing, both to more definitively establish benefits for nursing managers, nursing staff, and patients, and to develop additional uses of GIS mapping to improve HBPC nursing services.

This project evaluation was successful in confirming the value of field-based personnel utilizing GIS tools to a variety of HBPC program needs. However, as a national system, the VHA includes more than 130 diverse local HBPC program sites. While Portal for ArcGIS has fulfilled a need for a limited number of HBPC programs, the eventual goal of this project is to institute a national solution that provides all HBPC programs with GIS tools and capabilities. The next step for the implementation team is finding the platform whereby this can be accomplished. As the program is expanded, ongoing evaluations will be beneficial for expanding understanding of how the use of GIS in VHA HBPC can best benefit practitioners and patients at sites across the country.

Limitations

The VHA HBPC programs sites participating in this implementation project represent a diverse range of program sizes, geographic locations, and rurality. However, they were selected based on their interest and capacity to adopt this innovation, and the findings may not generalize across all VHA HBPC sites enterprise-wide. Also, as there are differences between VHA and non-VHA HBPC programs, the results of this study may not be generalizable to non-VHA HBPC programs.

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Declaration of Competing Interest

The authors have no conflicts of interests to disclose. The contents of this article do not represent the views of the Department of Veterans Affairs or the United States Government.

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References

1. US Department of Veterans Affairs. VHA's priorities for strategic action, spotlight on access, [cited 2017 October 15]. Available from: <https://www.hsrd.research.va.gov/news/feature/access-priority.cfm?ID=1490>.
2. Edes T, Burris JF. Home-based primary care: a va innovation coming soon. *Phys Leadersh J*. 2014;38–42.
3. Egan E. *VA Home Based Primary Care Program: A primer and Lessons for Medicare*. Washington, DC: Am. Action Forum; 2012.
4. Beales JL, Edes T. Veterans affairs home based primary care. *Clin Geri Med*. 2009;25:149–154.
5. Claver ML. Disaster preparedness in home based primary care: policy and training. *Prehosp Disaster Med*. 2015;337–343.
6. Chang C, Jackson SS, Bullman TA, Cobbs EL. Impact of a home-based primary care program in an urban Veterans affairs medical center. *JAMDA*. 2009;10(2):133–137.
7. Hughes SL, Weaver FM, Giobbie-Hurder A, Manheim L, Henderson W, Kubal JD, et al. Effectiveness of team-managed home-based primary care: a randomized multicenter trial. *JAMA*. 2000;284:2877–2885.
8. DeJonge KE, Jamshed N, Gilden D, Kubisiak J, Bruce SR, Taler G. Effects of home-based primary care on medicare costs in high-risk elders. *JAGS*. 2014;62:1825–1831.
9. US Department of Veterans Affairs. Office of rural health: rural veterans. [cited 2016 March 14]. Available from: <https://www.ruralhealth.va.gov/aboutus/ruralvets.asp>.
10. Davis, D. National program director, Veterans health administration home based primary care program. Personal Communication, October 2, 2019.
11. Edes T, Kinoshian B, Vuckovic NH, Nichols LO, Becker MM, Mossain M. Better access, quality, and cost for clinically complex veterans with home-based primary care. *JAGS*. 2014;62:1954–1961.
12. Edes T. Future of home health care: the value of team-based care. The National Academies of sciences, engineering, and medicine. Washington, DC [cited 2016 march 10]. Available from: <https://iom.nationalacademies.org/~media/Files/Activity%20Files/Aging/Future%20of%20Home%20Health/EDES.pdf>.
13. Cowper D, Yu W, Kuebler M, Kubal JD, Manheim LM, Ripley BA. Using GIS in government: an overview of the VHA's healthcare atlas, FY-2000. *J Med Syst*. 2004;28(3):257–269.
14. Department of Veterans Affairs, Veterans health Administration. VHA handbook 1141.01. home-based primary care program. Washington, DC, Available from: http://www.eohhs.va.gov/Portals/0/Uploads/Documents/Procurement%20Library/VA_HBPC_Program_Directive_Hand_Book.pdf.
15. Cowper Ripley DC, Kwong PL, Vogel WB, Kurichi JE, Bates BE, Davenport C. How does geographic access affect in-hospital mortality for veterans with acute ischemic stroke? *Med Care*. 2015;53(6):501–509.
16. Cowper Ripley DC, Litt ER, Jia H, Vogel WB, Wang X, Wilson LK, et al. Using gis to plan specialty health services for veterans: the example of acute stroke. *J GIS*. 2014;6:177–184.
17. Cowper Ripley DC, Reker DM, Hayes J, Vogel WB, Wu SS, Beyth RJ, et al. Geographic access to VHA rehabilitation for traumatic injured OEF/OIF veterans. *Federal Practitioner*. 2009;28(10): 28–39.
18. Culpepper WJ, Cowper Ripley DC, Litt ER, McDowell T, Hoffman PM. Using GIS tools to improve access to MS-specialty care in the Veterans Health Administration. *J Rehabil Res Dev*. 2010;47(6):583–592.
19. Nykiforuk CL, Flaman LM. *Exploring the Utilization of Geographic Information Systems in Health Promotion and Public Health*. Edmonton, AB, Canada: University of Alberta School of Public Health Center for Health Promotion Studies Technical Report #08-001; 2000.
20. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implement Sci*. 2009;4:50.
21. Ritchie MJ, Dollar KM, Miller CJ, et al. *Using Implementation Facilitation to Improve Care in the Veterans Health Administration (Version 2)*. VHA Quality Enhancement Research Initiative (QUERI) for Team-Based Behavioral Health; 2017. Available from: <https://www.queri.research.va.gov/tools/implementation/Facilitation-Manual.pdf>.
22. ESRI, ArcGIS Enterprise. What is portal for ARCGIS? [cited 2016 march 20] available from: <http://server.arcgis.com/en/portal/latest/use/what-is-portal-for-arcgis-htm>.
23. Creswell JW, Plano Clark VL. *Designing and Conducting Mixed Methods Research*. 3rd Ed Thousand Oaks, CA: SAGE Publications Inc; 2018.
24. Patton M. *Qualitative Evaluation and Research Methods*. 2nd Ed Thousand Oaks, CA: SAGE Publications Inc; 2001.
25. REDCap. 6.16.8. 2017. Vanderbilt University. Available from: <https://www.project-redcap.org/>.
26. ATLAS.ti.7.2. 2016. Berlin, Germany. Available from: <https://atlasti.com/>.
27. Farmer T, Robinson K, Elliott SJ, Eyles J. Developing and implementing a triangulation protocol for qualitative health research. *Qual Health Res*. 2006;16:377–394.
28. O' Cathain A, Murphy E, Nicholl J. Three techniques for integrating data in mixed methods studies. *BMJ*. 2010;341:c4587.
29. Miles M, Huberman A. *Qualitative Data Analysis: An Expanded Sourcebook*. 2nd Ed Thousand Oaks, CA: SAGE Publications Inc; 1994. Beales JL, Edes T. Veteran's affairs home-based primary care. *Clin Geriatr Med*. 2009;25:149–154.