Cloud Computing Architectures for the Underserved: Public Health Cyberinfrastructures through a Network of HealthATMs

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Abstract

This paper examines the impact of cyberinfrastructure architecture on healthcare services. More specifically, this research details the architectural design for a personal health record system called “HealthATM” that utilizes and integrates services from Google's cloud computing environment. These services are integrated into an unobtrusive and easy to use ATM-style interface for health consumers and care providers to manage and track their health. The impact for such an application, particularly for the underserved, is an important step toward better health management across this population with the end-goal of better health outcomes in the future.

1. Introduction

At the 2009 Hawaii International Conference on System Sciences (HICSS) symposium on Cyberinfrastructures for Public Health and Health Services it was identified that there is a need to develop cyberinfrastructure architectures and applications that can directly benefit users and public health. As noted by Dan Atkins, W.K. Kellogg Professor of Community Information and Associate Vice-President for Research Cyberinfrastructure at the University of Michigan, it is a propitious time within health informatics and there is a lot that needs to be done not only at the data systems level, but also at the behavioral level in order to properly bring patients into the fold [1]. This observation could not be truer when it comes to the use of personal health information technologies within underserved populations.

Recent research has reported that preliminary efforts in the use of health information technologies to assist the underserved in managing their health can have a positive impact on financial and healthcare services [2] [3]. Encouraged by these and related findings, this research explores the implementation of innovative electronic personal health record (PHR) systems for vulnerable health populations across Los Angeles County. Electronic PHR systems offer great potential to positively change the health outcomes of these populations by providing them with timely access to relevant health data and also through mechanisms that streamline communication with their care providers.

An important evolution in PHR systems has come from open platforms such as Microsoft HealthVault™ and Google Health™. While Microsoft and Google provide individuals with comprehensive online systems to manage their personal health data, these systems are often too advanced for individuals with limited computing skills. As a result, they can add levels of stress or confusion that may adversely impact health outcomes or PHR system adoption later on. Fortunately, open application programming interfaces (APIs) are available that allow developers to create more customizable PHR systems, providing an opportunity to build more patient-centric PHR systems that provide individuals with health data that is Timely, Relevant, Actionable and Comprehensible (TRAC).

An inherent feature of open platforms is their ability to integrate with many different information systems and services. Not only does this offer the potential for more rich and customized presentation of personal health data, but it also provides an important scaling factor as populations grow and/or change. Moreover, this scaling ability allows PHR systems to be implemented across multiple devices.

HealthATM looks to meet the needs of medically-underserved populations including non-native English speakers, undocumented individuals, displaced individuals, elderly persons, migrant farm workers and individuals who are homeless.

Figure 1 illustrates the general delivery of health information from a cloud computing environment. Our current research is evaluating the delivery of health information via HealthATM kiosks installed across community health clinics in LA County. HealthATM utilizes computing services such as
health, education, contacts, education, appointments, news and maps from Google APIs and presents it in an easy to navigate, touch-screen interface.

![Figure 1. SaaS Architecture](image)

Similar to how an ATM helps individuals manage financial information, HealthATM provides individuals with a quick transaction-based device for managing health related information.

2. Background

In 2005, Miller [4] documented expected shifts in healthcare, including: 1) The increased use of online support systems; 2) The use of electronic files (or PHRs); 3) Web pages with health promotion, medical and health-related information systems; 4) Health interventions through the use of telehealth applications for health promotion; 5) Prevention interventions, using the web for health education and awareness; 6) Providing incentives for patients.

Currently, there is no system that addresses all of these projected shifts. For example, PHRs look to incorporate features such as a patient’s ability to review personal health information, to comprehend, analyze and choose provider and insurance services, manage prescriptions, appointments, and medical procedures, maintain a continuous health record for themselves and family members, and communicate effectively with doctors and care providers [5].

Successful adoption of PHRs will hinge on the ability of PHR systems to allow patients to directly manage their illness and to make the system transparent enough to invoke a notion of trust [6]. PHRs will not be extensively adopted until they can prove to patients that there is some inherent health value associated with them [5] and will likely necessitate greater integration with electronic health record (EHR) systems. Additionally, the use and access to PHRs and EHRs within underserved populations faces increased barriers to adoption due to challenges pertaining to economic, education and technology access [3][7][8]. Therefore, a solution that addresses all shifts, coupled with the needs of underserved patients is highly sought.

Jimison et al. [9] argue that current Health IT systems offer only a fragment of patient’s needs, emphasizing the need for a complete feedback loop including monitoring of patient status, patient self-monitoring, individual treatment goals, and timely communications to the patient with tailored recommendations or advice. Jimison et al. [9] state that the inclusion of human interactions along with a more complete Health IT system will prove most effective, such as providing rapid and frequent communications from clinicians.

In response to the latter described findings HealthATM seeks to address these needs by providing a comprehensive PHR that also allows for inclusion of care management practices. Underserved populations, who would otherwise have trouble navigating complex web sites and/or using computer-based information systems on their own can have access to a very simple, touch-screen interface that can be used in collaboration with care givers. HealthATM hopes to increase the impact of PHRs by leveraging resources across the cloud of online services provided by 3rd parties such as Google and Microsoft for a population who would otherwise be unable to access this resource or know how to create a PHR. Integration across this cloud allows users to then have access to health promotion and education material, allowing for knowledge to better manage their health. If it is recognized that a majority of personal health information will be accessed via computer and web-based applications, HealthATM assures that underserved populations are not left behind during this major shift, allowing them to have the ability to take advantage of tailored health management tools.

2.1. Challenges for the Underserved

Within the context of healthcare, the term “underserved" often refers to broad and diverse communities of people who are of lower socio-economic status. This population is often uninsured or underinsured and is more at-risk than the general population of experiencing chronic health problems due to fragmented healthcare backgrounds and the lack of a primary care home [10].

Within California and throughout much of the U.S. a considerable number of the underserved are made up of ethnic minorities primarily made up of people of Latino and African-American origins [11]. Within California this same population comprises the
majority of residents living below the federal poverty level [12]. These populations are much more likely to be uninsured than whites (24.7%) with 52.6% of Latinos and 37.8% of African Americans living without some form of health insurance in 2007-2008 [13]. The consequence of these factors are that people within these communities are less likely to seek continuous or preventive health services necessary to identify yearly indicators of health problems [14].

Consistently fragmented healthcare leads to the inability of patients to identify with and frequent a familiar location for healthcare. Therefore, the capacity to create relationships with providers lessens and the opportunities to receive preventative care decreases [3]. Community Based Organizations (CBOs) also face challenges when coordinating care for underserved patients who do not have established primary care homes [2].

In light of these and similar findings that extrapolate on socio-economic issues commonly attributed to the “digital divide” domain (e.g. literacy, access, adoption), there is a need to create health-related self-management resources that are freely available and easily accessible to people within underserved populations. Through use of publicly accessible PHR systems, such as those that are provided through kiosk-style resources located throughout CBOs, there is the potential to assist in bridging communication between patients and their care providers.

3. Addressing Public Health Needs

In information systems literature, technology adoption is correlated with how easy the system is to use and how useful that system actually is to the user. Perhaps, an added complexity in PHR systems is that they surpass simple technology adoption and are responsible for an individual’s personal health outcomes. Therefore an additional, yet equally important research goal is to build and evaluate systems that provide TRAC information. More specifically, TRAC information is:

**Timely:** The information users receive is current, including prescriptions, appointments, contacts, news and education.

**Relevant:** The information users receive is directly catered to their health needs and existing lifestyles.

**Actionable:** The information users receive is directly tied to health outcomes.

**Comprehensible:** The information users receive is presented in a way that is easy for users to navigate and understand their health information.

Users of HealthATM receive simplified and timely information through the PHR they create within Google Health. For example, patients are able to view and update care management appointments through Google Calendar and view their up to date prescriptions.

Relevant information is communicated through tailored health promotional material. Actionable steps are determined through goals created within their customized care plans. HealthATM then allows users to easily view and access their health information with its easy to use touch screen interface. The user’s health information is then presented in a meaningful and simple manner to help them monitor and track their health progress through the Health Incentive Program (HIP).

3.1. Tailored Health Education

Educating patients about their health also helps empower them. Nevertheless, improving health literacy in a population requires more than simply advancing reading ability. According to Nutbeam [15], helping people to develop confidence to act on that knowledge and the ability to work with and support others will best be achieved through more personal forms of communication, and through community-based educational outreach. The ultimate goal in health literacy is in trying to promote greater independence and empowerment toward managing one’s health among individuals and communities.

Health related material is oftentimes integrated into a patient’s care plan. As attested to by the Elaboration Likelihood Model (ELM), customized health education can increase the likelihood that individuals will discuss the content with others, resulting in greater intention to follow and implement suggested behavior changes addressed within the health educational material [4]. HealthATM supports these needs within the public health domain by providing tailored health education material for each patient, empowering them to make health behavioral changes.

3.2 Tailored Care Plans & Patient Goals

Patients are often given direct guidelines on how to manage their health conditions in the form of care plans. ELM has shown that when an individual receives tailored communication, as in a user-based care plan, they are more likely to process and retain
the information, leading to permanent change [15]. Patients with chronic conditions are known to benefit the most through an evidence based management plan [16]. HealthATM seeks to improve compliance of patient care plans by tailoring its content to the patient’s specific health needs and setting realistic goals the patient can work towards.

Creating goals for a patient to meet has been shown to help patients work towards healthier behavior [15]. A care plan that is provided through HealthATM allows patients to set goals with their care providers. The goal setting engages the patient in discussions with their healthcare provider, furthering the chances for compliance of the care plan. The prevailing goal is broken down into smaller goals, allowing for achievement of goals to come faster. As the smaller goals are established, patients gain confidence to continue and meet the bigger goals within their care plan. Patients also have the ability to monitor their goal setting progress through the HealthATM. HealthATM looks to encourage goal setting by providing incentives for patients to complete tasks within their Care Plan.

4. Cloud Computing Implications

Buyya et al. [17] define cloud computing as virtualized computers that are dynamically provisioned and presented as one or more unified computing resources. Within the specific space of cloud computing that HealthATM functions, Leavitt [18] defines cloud computing as a form of client-server computing, where cloud-computing infrastructures are Internet-connected servers, often times distributed across several locations that house a cloud of applications and data. Clients generally use browsers or dedicated software to access cloud applications, which they frequently control via application programming interfaces (APIs). Vaquero et al. [19] emphasize virtualization and scalability as two critical features of cloud computing that help foster optimized resource utilization.

Cloud computing can consist of any number of topographical situations including, infrastructure as a service (IaaS), software as a service (SaaS) and/or platform as a service (PaaS). Cloud computing offers particular strength since it draws on many existing technologies and architectures and integrates centralized, distributed and software as service computing paradigms into an orchestrated whole [20]. For Phase I of our implementation, we have narrowed the scope of our cloud to services offered by Google, which currently consists of Google Calendar, Google Contacts, Google Maps, Google News and, of course, Google Health. As discussed earlier, long term objectives will be to incorporate feeds from many different health and health related services to include data available from pharmacies and electronic medical records.

4.1. Low Cost Alternative

When considering solutions to meet the needs of vulnerable populations, an important aspect to consider is cost. Any system we provide must be low-cost since many public health organizations, particularly those serving vulnerable health populations, have very limited IT budgets. It is no secret that Google’s business model is driven primarily by advertising revenue. As a result Google provides customers with free services, where they can upload all types of information. Google Health is one such application. Google then mines this information to display relevant search ads.

However, providing single entry points to data entry would limit Google’s market to those who use their online services (i.e. those who visit Google.com web pages). Therefore, in recent years Google has developed a sophisticated network of APIs that allow non-Google developers to build-out and integrate the Google Platform across external websites. As a result, there are a number of freely available APIs that developers can use to build tailored applications at drastically reduced costs. Consequently, and as described by Hayes [21], this cloud computing environment drastically reduces costs by shifting the location of this infrastructure to the network and along with it those costs associated with managing hardware and software resources.

4.2. Scalability

Utilizing cloud computing architectures allows our applications to scale both vertically and horizontally. Horizontal cloud scalability refers to the ability to connect and integrate multiple clouds to function as one logical cloud [22]. Our current architecture considers specific software services (health, contacts, etc). However, there is the expanded opportunity to request services from additional software providers to enhance the HealthATM. There is also the ability to scale across different devices, including cell phones, computers and kiosks. Depending on the population, as well as the desired health outcomes for that population, some devices will perform better than others. It is the ability to explore each of these delivery mechanisms
while keeping the underlying data schema relatively static that is particularly intriguing.

Vertical cloud scalability also exists and plays a critical role in our research. Mei et al. [22] define vertical cloud scalability as “the ability to improve the capacity of a cloud by enhancing individual existing nodes in the cloud.” While they discuss this aspect in terms of hardware, the concept can be directly applied to software and, more generally, to information. Because our focus is a targeted user population, who are largely unfamiliar with day-to-day computing, the information stored in clouds must be scaled down in a manner so that the information is more easily digested by the user. This might mean providing more limited information at the forefront of the application (such as a subset of the care record) with opportunities for more complete information open to the user. Identifying ways in which to be an effective concierge in support of a users health information needs is an important aspect of HealthATM usability research.

4.3. Vital Health Statistics

While PHR systems can provide users and care providers with the ability to manage their health, they also offer powerful data repositories. Access to the cloud also provides access to their health information which we can then use to anonymize and graph and predict health trends across populations. This concept is illustrated by Figure 1’s bi-directional arrows and describes an opportunity to build feedback mechanisms for capturing and monitoring interaction within PHR systems.

Literature in health informatics supports the notion that there is a corollary effect between individuals who actively manage their health and positive health outcomes [23]. This aspect can be measured through more intelligent systems design, where every action (or non-action) can be monitored, analyzed and tied back to specific health services, in turn, providing individuals with timely feedback in areas of health education, events, and news.

The capability to mine vast amounts of structured medical record data is valuable to public health objectives and can contribute to formulating research priorities, researching the causes and epidemiology of disease, assessing the effectiveness of preventive interventions and clinical care, paying providers based on their performance [24].

5. Methodology

We utilized a design science research methodology, with an interactive process of user needs assessment, followed by artifact design and then systematic assessment. The study utilized qualitative research procedures in order to conduct a preliminary assessment of the application for use within diverse populations. [25].

Qualitative data was gathered through a field research design methodology that consisted of two in-depth case studies, and a series of expert interviews. Research aspects included 1) perceptions of PHR use within underserved communities, 2) care management needs within the safety-net and 3) insights and perceptions of leaders and administrators within community health environments. Data was analyzed through the use of Atlas ti 5.0 in order to code and draw inferences related to the use of PHRs within community health settings. Initial coding constructs were derived from the research literature and included aspects of adoption, integration, usability, design, and health outcomes.

From these findings a Version 1.0 of the artifact was developed in order to properly integrate and implement within the Community Clinic environment, including integration with an existing care management system. Evaluation of this artifact was performed through pre- and post-tests conducted through a pilot study with patients enrolled in a care management program located in Los Angeles County.

6. Results

6.1. User & Organizational Needs Findings

A series of structured and semi-structured interviews were conducted between November 2007 and December 2008 with a total of 30 patients, 12 staff (including a physician, care managers, social workers and administrators) and 5 leaders within community health settings. Patient and organizational staff interviews focused on two different programs currently implementing PHRs within underserved settings. This included the MiVIA Program being run through the St. Joseph Health System of Sonoma County and COPE Health Solution’s Camino de Salud Program working within Los Angeles County.

6.1.1. Patients. Findings identified that the majority of participants were interested in PHRs for personal use (versus as a tool for their families) and
that they did not have overt concerns about having health information online. While only a few participants thought the use of PHRs had a positive impact on their health, a majority of the respondents did feel that they knew more about their health because of it. Most respondents reported not having prior computer experience. Two valuable aspects identified the importance of a Health I.D. card and easy access to their health information.

Importantly, patients believed that use of these programs would assist them in managing their chronic illnesses. The majority of patients reported having no other way to access health information on their own and instead relied upon care managers to assist them with their medical documentation. Some of the key health information components that patients identified a need for were the ability to manage appointments, obtain education about their conditions, and the ability to manage their prescriptions.

Initial feedback was gathered from patients with a limited prototype of the HealthATM. In general, participants felt as though the interface was easy to understand. Many of the patients with no computer experience felt as though they understood how to navigate between pages and thought the HealthATM looked like a system that they would be able to use.

6.1.2. Community Health Staff: Factors such as technology access, privacy, outreach, empowerment, technology education, data processing, communication bridging, patient collaboration and the use of Health I.D. cards were reported most often as experiences and perceptions encountered by healthcare staff (Figure 2). Further issues raised by staff included trust, staffing and infrastructure challenges, health record storage, healthcare access and education, data accuracy, and cultural issues.

Technology education for patients was discussed upwards of nine different times and pointed to the need for computer training and effectively accessing health information. An important topic that surfaced during these conversations was that PHR systems could not be simply handed over to this community of patients. Care staff maintained that the only way for PHRs to be effectively used within community clinic settings is through constant trainings, education, outreach and collaboration.

6.1.3. Community Health Professionals. Semi-structured interviews were conducted with community health professionals and experts in order to gain insight and individual perceptions of how PHR systems will work within safety-net provider organizations. Related to user requirements, experts discussed the unique requirements of safety-net populations including a lack of technological assets and education as well as a clear understanding of the role technology can play in regards to their health. Technology issues discussed most often related to usability and interoperability of PHR systems and included comments on the need to design easy to use systems that are extensible to a broader group of users. The need to have systems that were not limited to reporting health transactions, but could be used also as tools for health improvement and illness prevention was also discussed.

Organizational topics focused primarily on the lack of resources and sustainability of health information technology investments for community health organizations. Another topic discussed, was the steep cost of implementing EHRs for safety-net providers and that although there has been a national push to integrate EHRs within health service organizations, funding is generally lacking. One expert commented on how per clinician, the cost for the roll-out of an EHR system can reach tens of thousands of dollars for an organization and that his price tag did not even include the loss to profits due to slowdowns in organizational routines as doctors and healthcare personnel learn to operate and assimilate new systems into their practice. In other words, if effective EHR integration within community clinic settings cannot be accomplished then PHR integration will be that much further out in terms of adoption.

7. Artifact Design

Based on these findings [25] the HealthATM artifact is driven with the overarching goal of providing all individuals with a personal health record (PHR) and doing so through multiple methods.
of outreach, education, incentivizing, usability and sustainability. As noted, studies indicate that when individuals take control of their health, they become more proactive towards maintaining a healthy lifestyle. In other words, provide health consumers with a simple to use valuable mechanism to manage their health and it should increase the likelihood that they will (at least according to the widely cited Technology Acceptance Model [26]).

From these findings, discussions surrounding what technologies are most accessible to those who fall within the digital divide ensued. It was recognized that while not every person has a credit card or debit card, most individuals, if not all, have encountered and most likely have used an automated teller machine (ATM). ATMs are ubiquitous devices now found in supermarkets, gas stations, and on street corners. We encounter ATMs in all types of media on the news, in movies, and read about them in newspapers and magazines. As a single entity, the ATM is a monolith for providing financial services 24x7x365 and thus represents a potentially effective model that a PHR could embody.

### 7.1. HealthATM Architecture

While the HealthATM incorporates a physical entity through the use of kiosks that will reside in health clinics across Los Angeles County, the underlying infrastructure is the Internet, which means that health information transactions need not be conducted through the HealthATM itself. Similar to how financial transactions no longer require individuals to interact with a physical ATM but through secure online transactions, individuals will be able to review personal health account information and even perform necessary transactions in order to continually manage their care. This can be extremely important for individuals with chronic conditions who must critically monitor their health on a daily basis.

The architecture for HealthATM is straightforward. While most of the information HealthATM processes will be delivered by external services such as Google Health, HealthATM is its own standalone service. In other words, it is hosted at HealthATM.com and maintains a database of active users, their Google account information and services.

### 7.2. HealthATM Interface Design

HealthATM is a web application that corresponds to current XHTML and CSS design standards and currently passes all 508 Standards according to Section 1194.22 [27]. Site design makes use of a highly visual and intuitive interface meant to mimic the ease of function found in standard ATMs. The site was developed using elements of HTML for web design, PHP for processing of data elements and MySQL for data storage.

Figures 3 and 4 represent a sample user interface. While the system does store important user data, it is largely a thin-client, where Conditions, Medications, Allergies, etc. are all stored in external systems. Currently, our system relies on data entered into Google, but going forwards, external data can be fed directly into Google via PHR data feeds. However, unlike the Google suite, this user interface is all touch-screen, eliminating the mouse and keyboard and bringing full attention to the information displayed on the screen.
button, which would then take them to a menu containing a “Care Plan” button which would then take them to their personal care plan.

Most every section of the site is limited to finite textual information with no more than three sentences of information. Again, these aspects are designed in regard to the ease of functionality and the transactional nature of ATM systems.

7.3. Health Incentive Plan (HIP)

Research has shown that providing patients with financial incentives has promoted compliance of healthcare treatments [28]. Moreover, if non-compliance is associated with low income (such as our target population, the underserved) financial incentives are expected to have a greater impact on this population.

HealthATM provides incentives for patients through a point-reward system called HIP. Through HIP, patients receive points for each task they complete with the HealthATM, essentially encouraging and motivating them to meet all of their goals. Tasks such as taking their medication on time and coming in for their scheduled appointments earn them points. HIP also allows the patient to monitor the progress of their points through a dashboard accessible through the HealthATM. Once patients accumulate a specified amount of points, they can then redeem them for financial rewards through HealthATM printouts for items that range from discounted prescription refills to gift cards to their favorite store.

The HIP program is easy to use and simplified for patients through its break down of three categories: 1) My Health, which includes tasks such as signing up for and maintaining their Google Health PHR, 2) My Activities, which includes items such as viewing their health education documents focused on their health concerns and communicating with their physician, and 3) My Rewards, which includes two aspects for meeting care plan goals and performing tasks such as printing and discussing their tailored Care Plans with their physician.

7.4. HealthATM Data Cloud

For the first phase of implementation we have focused our efforts on Google’s cloud computing environment, which offers the greatest range of functionality. Illustrated in Figure 5, Google provides one ID to be able to access Gmail, Google Health, Google Contacts, Google Calendar and Google Docs. Moving forward, the HealthATM network will be comprised of a hybrid of PHRs (e.g. Google Health, Microsoft HealthVault), care management software and HealthATM software and interoperability will be determined by health information technology data standards (e.g., Continuity of Care Record, Continuity of Care Document) and permission to share data such as the measures outlined by consumer legislation such as the Health Insurance Portability and Accountability Act of 1996 (HIPAA).

7.5. HealthATM User Transactions

A description of the network from the user viewpoint is as follows: 1) The patient accesses the HealthATM at the clinic or community organization; 2) As managed through secure authentication between HealthATM and Google Health, a query is initiated to the Care Management System for a pre-determined set of patient care data, also retrieving Google Health specific data entered by patients, caregivers or relatives; 3) Data is bridged between each system through Google Health via ASTM’s Continuity of Care Record (CCR) format; 4) The data is then combined with other Google Health data and securely transmitted to the HealthATM in CCR format for presentation by the HealthATM application; 5) The user has the opportunity to select and initiate mobile reminders and monitors that are sent back through the HealthATM network.

7.6. Design of Pilot Assessment

A significant aspect of this effort is development and execution of an assessment plan within a larger research agenda that will be enabled by the products and services deployed through the HealthATM. Toward this effort a pilot study will be conducted through COPE Health Solution’s Camino de Salud Network (CDSN) with three community clinics located in Los Angeles County. The research context
for this study will consist of the CDSN service area and its entire patient population. The CDSN Care Management program will provide specific focus on tracking progress through the HealthATM. The Care Management program targets the subset of patients who are frequent users of hospital inpatient and emergency department services. These patients seek care for conditions and needs that could otherwise be managed through well-coordinated primary care and social services, at a lower cost and with improved quality of care outcomes. By pairing frequent users with care managers, the program teaches these patients how to navigate available health and social resources, empowering them with the tools and knowledge to appropriately manage their health.

Once the assessment plan for this specific population is developed, the HealthATM software and related back-end systems will be modified to collect any transactional data needed to support the evaluation. The assessment plan will focus on four key levels of analysis:

**The patient**: The team will examine the impact HealthATM has on a patient’s perceived health outcomes as well as the patient’s attitudes about the technology, the clinics, and his or her health. System logs, automated surveys, and focus group sessions will be used to elicit these observations.

**The organization**: Supplemental data will be collected from the clinic workers through focus groups and surveys to assess how this technology has impacted the organization and affected its provision of care to the patients. Equally important will be to document the numerous considerations to be made when trying to incorporate a PHR within community health environments.

**The community**: Community stakeholders will be interviewed on the value of the HealthATM network, including perceptions about the need for and value of de-identified data on patient health conditions, health activities and health outcomes. A key component of the assessment will be to include the clinic personnel, associated care managers and interested patients as much as possible in the design and implementation of the HealthATM system.

**The network**: The HealthATM system will be equipped with the ability to interface with COPE Health Solutions NaviLinx care management tool utilized by the CDSN. This interface capability will be leveraged to incorporate the HealthATM as a tool in the care management process, allowing for enhanced outcomes tracking.

The implications derived from outcomes of this study will identify community-wide impacts on the target population and provide the opportunity to replicate similar implementations on a broader scale.

**8. Implications**

The broad impact of our research includes better health management for vulnerable populations and better communication for individuals and their care managers. As part action research, part design research, project success hinges not only on the ability to implement functional PHR systems, but also in building systems that can directly affect positive health outcomes. This research also has the broader potential to collect, anonymize and analyze health statistics from these populations to understand trends and identify future research needs.

One of the reasons we do not simply use the Google Platform (i.e. log onto google.com/health) is because much of our user population are individuals who have limited exposure to the Internet and the vast array of Internet applications available. Therefore, HealthATM is an important first step toward educating individuals on technologies that can be used to improve their lifestyle.

While there are critical underlying technologies needed for the HealthATM, there is also a critical human factor, including the care providers and patients themselves. Care providers are the first piece of the puzzle. Care providers are important brokers who are responsible for overseeing the information contained within underlying HealthATM databases and Google Health. In other words, these individuals must be able to operate at both levels.

As organizations and government look for better ways to improve healthcare in more global terms, the implementation of a cloud computing architecture is a viable step towards better healthcare management by individuals. Additionally, the use of Google’s freely available, open interfaces provides a low-cost and powerful way to do so.

**9. Conclusion**

In this research we discuss the cyber-infrastructure for a HealthATM. Our design showcases how cloud computing can support the needs of vulnerable health populations and their care providers. Additionally, a cloud computing environment offers flexibility in building low-cost, scalable PHR systems.
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11. References


