Advice for Decision Makers Based on an Electronic Health Record Evaluation at a Program for All-inclusive Care for Elders Site

P.S. Sockolow[1]; J.P. Weiner[2,3]; K.H. Bowles[5]; P. Abbott[6]; H.P. Lehmann[2,3,4]

[1]College of Nursing and Health Professions, Drexel University, Philadelphia, PA; [2]Division of Health Sciences Informatics, School of Medicine, The Johns Hopkins University, Baltimore, MD; [3]Department of Health Policy and Management, Bloomberg School of Public Health, The Johns Hopkins University, Baltimore, MD; [4]Department of Biostatistics, Bloomberg School of Public Health, The Johns Hopkins University, Baltimore, MD; [5]University of Pennsylvania School of Nursing, Philadelphia, PA; [6]School of Nursing, The Johns Hopkins University, Baltimore, MD

Keywords

Evaluation studies, technology evaluation, clinical information systems, patient care team, aged

Summary

Objective: Provide evidence-based advise to "Program of All-inclusive Care for the Elderly" (PACE) decision makers considering implementing an electronic health record (EHR) system, drawing on the results of a mixed methods study to examine: (1) the diffusion of an EHR among clinicians documenting direct patient care in a PACE day care site, (2) the impact of the use of the EHR on the satisfaction levels of clinicians, and (3) the impact of the use of the EHR on patient functional outcomes.

Methods: Embedded mixed methods design with a post-test design quantitative experiment and concurrent qualitative component. Quantitative methods included: (1) the EHR audit log used to determine the frequency and timing during the week of clinicians' usage of the system; (2) a 22-item clinician satisfaction survey; and (3) a 16-item patient functional outcome questionnaire related to locomotion, mobility, personal hygiene, dressing, feeding as well the use of adaptive devices. Qualitative methods included observations and open-ended, semi-structured follow-up interviews. Qualitative data was merged with the quantitative data by comparing the findings along themes. The setting was a PACE utilizing an EHR in Philadelphia: PACE manages the care of nursing-home eligible members to enable them to avoid nursing home admission and reside in their homes. Participants were 39 clinicians on the multi-disciplinary teams caring for the elders and 338 PACE members.

Results: Clinicians did not use the system as intended, which may help to explain why the benefits related to clinical processes and patient outcomes as expected for an EHR were not reflected in the results. Clinicians were satisfied with the EHR, although there was a non-significant decline between 11 and 17 months post implementation of the EHR. There was no significant difference in patient functional outcome the two time periods. However, the sample size of 48 was too small to allow any conclusive statements to be made. Interpretation of findings underscores the importance of the interaction of workflow and EHR functionality and usability to impact clinician satisfaction, efficiency, and clinician use of the EHR.

Conclusion: This research provides insights into EHR use in the care of the older people in community-based health care settings. This study assessed the adoption of an EHR outside the acute hospital setting and in the community setting to provide evidence-based recommendations to PACE decision makers considering implementing an EHR.

Correspondence to:

Paulina S. Sockolow DrPH
Drexel University Mail Stop 1030, Bellet Bldg Room 512
245 N 15th St., Phila., PA 19027
Phone: (215)762-4694, Fax: (215)762-4080
E-mail: pss44@drexel.edu

Appl Clin Inf 2011; 2: 18–38
doi: 10.4338/ACI-2010-09-RA-0055
received: September 21, 2010
accepted: January 1, 2011
published: January 26, 2011
Citation: Sockolow PS et al.: Advice for decision makers based on an electronic health record evaluation at a program for all-inclusive care for elders site. Appl Clin Inf 2011; 2: 18–38
http://dx.doi.org/10.4338/ACI-2010-09-RA-0055

1. Background

The United States (US) have an aging population with a large proportion of patients who have multiple chronic illnesses. For these patients, care coordination is vital to assure comprehensive care and management of the chronic conditions with the goal of maintaining or improving patient outcomes. For the geriatric population, this service coordination among multiple providers necessitates a level of planning and communication beyond that seen in other care settings. An electronic health record (EHR) can foster communication among clinicians and across time [1-3] and place by facilitating coordination of data [4, 5] with remote and asynchronous access to the patient record by multiple clinicians.

Despite this promise, there is little published evidence showing that EHRs are meeting the goals of fostering communication or improving patient outcomes to date. In addition to potential benefits, there are potential concerns which have already been seen in computerized provider order entry systems [6] that may be generalizable to EHRs. There is a lack of evidence that shows the effect that patient outcomes improve when clinicians use an EHR in primary care, [7, 8] specialty care, [9] or long-term care [10]. The yet to be documented promise of EHRs, combined with concerns with unintended consequences, underscores the continued need for evaluation studies.

This situation is notable in the geriatric setting, where informatics evaluation studies are rare. The lack of informatics studies may be due to two possible trends:

1. university-based informaticians tend to focus on implementations at large, tertiary care centers [7, 11] and
2. centers use EHRs for care documentation infrequently due to poor diffusion of the technology [12].

To help address this deficit, this study evaluated an EHR implementation in a community-based health care setting which serves a growing segment of the US elderly population, rather than evaluating an EHR in a tertiary care setting. The EHR implemented was unlike the EHRs in academic medical centers and was similar to EHRs implemented in most health care settings; it was neither custom-designed nor was it the most expensive software on the market. The EHR was from a commercial vendor and was adapted from an EHR developed for a related health care setting.

The research was situated in a community-based setting which is becoming increasingly important as the population ages and hospitals treat more acutely ill patients during shorter admissions, discharging these patients to the community health care setting. Among these community settings are programs developed to help maintain nursing home-eligible elders in the community. One such program is PACE, the Program of All-inclusive Care for the Elderly, which is a national program encompassing 70 sites in 30 states. PACE provides community-based services to over 17,000 dual-eligible Medicare and Medicaid beneficiaries [13]. A PACE site is a day center environment where interdisciplinary care teams provide direct patient care, a central characteristic of PACE programs. Teams can consist of nurses, physicians, physical and occupational therapists, social workers, pharmacists, and paraprofessionals, such as aides [14]. Among team members, nurses are the predominant professional providers of patient care. This report is intended to offer guidance to leaders of community-based geriatric care centers, and specifically PACE sites, as they consider implementing EHRs.

2. Objectives

The research question was to evaluate the initial use of a commercially available EHR in a PACE site by assessing three characteristics of the EHR. The first characteristic was the diffusion of the EHR at the PACE site, and specifically whether clinicians (physicians, nurse practitioners, nurses, physical therapists) utilized the EHR according to the Federal government's criteria for the basic capabilities of an ambulatory EHR [15] documented in the Certification Commission for Healthcare Information Technology (CCHIT) criteria published in 2008 [16]. Describing the EHR and its diffusion within the PACE site facilitates comparison of EHR evaluations and generalizability of results.

Second, the impact of the use of the EHR on the satisfaction levels of clinicians was assessed. Clinician satisfaction is an important measure of clinical information system success from both implementation and operational perspectives [1, 17, 18]. This study used a clinician satisfaction survey and measures developed and validated by the principal investigator specifically for this research. The survey is based on a comprehensive health information technology (HIT) evaluation framework that identifies a range of clinician satisfaction characteristics and dimensions to be measured. The framework, firmly grounded in research evidence, we term the "Health Information Technology Research-based Evaluation Framework" (HITREF), (described in greater detail elsewhere [19]) But in brief, the HITREF was the result of a comprehensive literature review of over 17,000 health information technology evaluation studies that updated and expanded the previously published exhaustive review by Ammenwerth and de Keizer [20]. HITREF includes health services research evaluation methodologies to extend the informatics evaluators' focus beyond user, software, and organizational interactions to include the systematic and environmental levels. The HITREF framework supports perspectives of diverse stakeholders and encompasses six HIT dimensions that can influence clinician satisfaction. The HITREF guided the instrument dimension selection and development.

Due to shortcomings in available instruments, a survey was constructed by combining items from several existing instruments that reflected individual evaluation concepts, such as efficiency or usability. Decisions about data gathering methods (e.g., item selection) were made based on reviews of literature and surveys of clinician satisfaction with HIT and on expert input (described in greater detail elsewhere [21]). The resulting instrument was validated for the intended survey population. The survey comprised 22 questions of clinician satisfaction with the impact of the EHR on clinical process and patient outcome. There were 21 Likert-scale items and one open-ended question to elicit respondent comments about the EHR.

The third characteristic assessed was the impact of EHR use on patient functional outcomes. Activities of Daily Living (ADL) scores provided information to assess the impact of the EHR on patient functional outcome. ADL scores measured patient functional outcomes based on how independently patients performed self-care tasks. ADL capabilities (e.g., feeding, personal hygiene, and locomotion) are important for all populations, and particularly for the elderly, where the goal is to enable them to live in the community, rather than a hospital, for as long as possible. ADL as a patient outcome measure has been shown to be sensitive to patient change within three months in this population [22]. A clinician documents the ADL by recording the patient's self-reported performance over the last three days in response to 16 questions related to locomotion, mobility, personal hygiene, dressing, and feeding. Responses to the 10 questions concerning these activities ranged from independent, scored as 1, to total dependence, scored as 7. The midpoint was limited assistance, scored as 4. Six questions asked about use of adaptive devices, and possible scores were 1 for no and 2 for yes. The ADL instrument's validity and standardization was not available.

3. Methods

3.1 Study Design

We used an embedded mixed methods design [23] as shown in ▶Figure 1. The deployment of the EHR was the focusing event. In the quantitative experiment, we used a post-test design with quantitative data collection and quantitative data analysis at two points in time without a comparison group to measure the impact of the EHR. The embedded qualitative component consisted of concurrent data collection and analysis. Specific methods used to meet the research aims follow. Objective 1, to describe the EHR in terms of functionality and usage, was addressed with a primary quantitative method to measure usage (i.e., volume of notes/orders written) supported by a qualitative method to describe EHR functionality. EHR diffusion data were quantitatively gathered and analyzed. Qualitative data sources were software user manuals and field notes taken during observations in the two time periods, described in greater detail below. Objective 2, to assess the impact of the EHR on clinician satisfaction with team communication and perceived patient outcomes, was addressed with a clinician satisfaction survey as the quantitative method to assess satisfaction, and

observation and followup interviews as the qualitative methods to help explain findings. Lastly, Objective 3, to assess the impact of EHR use on patient functional outcomes, was addressed with a quantitative method, comparing patient functional outcomes at the two points in time.

For each objective, mixed methods data analysis and interpretation were employed to merge quantitative and qualitative data [23]. The lead author sorted findings from each data source by theme, referring to the HITREF. Interpretation included linking qualitative data to quantitative data along themes and comparing findings among data sources. Qualitative data from interview responses was coded for themes and transformed into frequency of themes in the sample [23]. For example, for Objective 2, the frequency of themes in interview responses were linked to clinician satisfaction survey responses. Additionally, among objectives, quantitative outcomes were integrated with qualitative findings (e.g., patient functional outcome results were integrated with findings from EHR diffusion observations and findings from followup interviews). The use of data from various sources to inform each other and the comparison of findings were designed to enrich the interpretation of quantitative findings [23-25].

The study took place at 11 and 17 months following EHR go-live in October 2007, during a period of no system changes. These points in time were purposefully selected, because they were expected to differ in level of clinician satisfaction [26].

This article is part of a larger research effort which developed the HITREF, developed and validated the clinician satisfaction survey, and also assessed the impact of the EHR on clinician satisfaction with the clinical process in a PACE with an EHR, compared to a PACE with a paper-based system. The Institutional Review Boards of both the Johns Hopkins School of Public Health and the University of Pennsylvania approved this study.

3.2 Study Setting

The research setting was a nurse-managed PACE site in Philadelphia, PA that used an EHR. The goal of the PACE organization in implementing the EHR was to maintain quality of care with increasing membership (patients enrolled). The PACE site is managed by a university school of nursing. The university also has a health system, and PACE patients are also cared for at the university's hospitals. The health system uses a leading vendor's EHR system; however, the PACE site chose not to implement the health system's EHR due to cost. The selected EHR is a commercially available product, initially developed for long term care organizations. The vendor worked with a team of users to modify the software for the PACE site. The EHR was implemented in October 2007. One full-time, on-site information technology expert supported the system. This study is the first evaluation of an EHR in a PACE of which the authors are aware.

3.3 Study Sample

The study population of clinicians, as identified by the nurse administrator, was the entire population of 39 clinicians who provided and documented direct patient care at the PACE site. The study participants included nurses, nurse practitioners, LPNs, physical therapists, occupational therapists, social workers, physicians and nurse administrators and were middle-aged and experienced clinicians, as shown in ▶Table 1. The researcher (PS) provided a brief study overview to the study participants and obtained written consent, and obtained oral consent from patients who were viewed during observations of clinicians. No identifying patient information was recorded. Staff turnover was low, and almost all clinicians were available during the course of the study. The study population of patients included all 338 patients (de-identified) whose care at the PACE was documented using EHR during the first time period, which was 11 months post EHR implementation.

3.4 Data Collection

3.4.1 EHR Diffusion

The lead researcher observed clinicians to ascertain their EHR utilization pattern. The EHR audit log was also used to determine the frequency and timing during the time periods of clinicians' usage of the system. Software user manuals provided information to describe the EHR in terms of func-

tionality (e.g., documentation management, medication management). This functionality was compared to the observed functionality documented in field notes from observations, and the 38 CCHIT ambulatory EHR certification criteria as shown in ▶Table 2 [16].

Observations involved shadowing clinicians documenting patient care to provide independent assessment of what information clinicians documented and where in the EHR they documented. Clinicians who would be observed were selected using a work sampling methodology to ensure representative observations were collected for each staff group [27]. Clinicians to be observed were selected to cover each role (e.g., nurse practitioner, nurse, physician, physical therapist) from each of four teams and from those clinicians not assigned to a team. Where multiple clinicians were in each role/team, clinicians were randomly selected. The PACE site has a single shift with most patient clinical visit activity between 10 AM and 1 PM, and observations were made at random times and random days during this interval. The same clinicians were observed during each time period. The lead researcher (PS) observed each clinician for 1-2 hours over the course of multiple visits during a multi-week period and documented observations in field notes until saturation. Notes included details such as EHR functions used, clinicians' comments about the system, what clinicians documented, and where clinicians documented.

Describing the EHR also entailed quantifying the frequency of clinician use as a measure of diffusion, that is the spread of a system's use among people in the organization [28]. Using available usage data from the audit log, the study focused on a numerator of EHR use, presuming patient contact (the denominator) to be relatively constant, as patients were assessed every six months. The selected numerator, and therefore the selected measure of EHR use, was the number of EHR notes or orders created.

3.4.2 Clinician Satisfaction With EHR Impact on Clinical Process

The impact of the use of an EHR on the satisfaction levels of clinicians with regards to clinical process was assessed using a 21-item survey instrument. (Available at the Agency for Healthcare Research and Quality Knowledge Library Health IT Survey Compendium: http://healthit.ahrq.gov/portal/server.pt/community/knowledge_library/653/survey_compendium/12713) The survey cover page had a research identifier code for the participant to maintain confidentiality and enable subsequent tracking and matching. Subsequently, open-ended and semi-structured follow-up interviews were also conducted with small, purposefully selected groups of physicians and nurse practitioners to elicit further information about their areas of concerns or satisfaction with the EHR.

The lead researcher administered the clinician satisfaction survey to all clinicians in the study sample. Semi-structured interviews lasting about 30-minutes were conducted after the survey. Clinicians were selected to be interviewed based on the breadth and depth of their response to the open-ended question. Participants were interviewed to elicit further information about their areas of concern or satisfaction with the EHR. The interviews used an open-ended conversation guided by subject responses with a common set of questions concerning selected survey items. Interview questions embodied the major themes from analysis of survey prompt responses and survey responses indicating most dissatisfaction (i.e., usability, functionality, complete/correct documentation, efficiency, support, hardware). The interview instrument was developed anew after each survey. The interviewer probed subject responses to obtain additional information about EHR use, and documented responses in field notes.

3.4.3 Patient Functional Outcomes

Patient outcome measures were sought that were internally or externally reported from the EHR, and therefore more likely to be verified. Measures were elicited from internal dashboard documents and externally reported PACE measures and were reviewed with administrators. One indicator was identified: ADL assessment.

The impact of the EHR on patient outcomes was measured using the changes in the functional status of patients. Functional status was assessed using a 16-item ADL questionnaire related to locomotion, mobility, personal hygiene, dressing, feeding, as well the use of adaptive devices. Clinicians documented ADLs in semi-annual patient assessments commencing with enrollment as a

component of the "MDS-Home Care Assessment Form" in the EHR. This form was not a validated instrument. Review of data indicated over 40% of patient assessments were missing.

3.5 Data Analysis

The analysis focused on cross-sectional analyses and comparisons between the 11- and 17-month results, and differences (or lack of differences) between those time points were interpreted as the *impact* of the EHR on the outcome of interest. For this embedded mixed methods research design, the quantitative data were the primary data set (i.e., survey, EHR usage, and ADL data). Concurrently the secondary, qualitative data from observations and interviews were analyzed.

3.5.1 EHR Diffusion

Qualitative analysis was utilized to describe EHR functionality, and quantitative analysis was applied to describe EHR usage. The available EHR functionality was elicited by means of content analysis of the software documentation. To identify EHR functionality actually used, the observed functionality was similarly elicited using content analysis of field notes from observations. The lead researcher reviewed and parsed field notes into comments that were assigned to HITREF evaluation components. Major themes emerged based on their rate of occurrence.

To determine the utilization of the EHR, parametric (ANOVA) and non-parametric (Kruskal-Wallis) analysis of variance tests were applied to compare the frequency of documenting between two observation periods and between orders and clinical notes. The examination of documentation frequency involved analysis by role, day of week, and the number of elapsed days from note creation to completion. Due to sample size, statistical analysis was exploratory, not confirmatory, and used STATA 10 [29].

3.5.2 Clinician Satisfaction With EHR Impact on Clinical Process

Impact of the EHR on clinician satisfaction was assessed with both qualitative and quantitative analyses. Qualitative analysis used field notes from observations (described above in "EHR Diffusion") and interviews at 11 and 17 months after EHR implementation. Quantitative analysis was applied to survey responses.

Field notes were reviewed manually to identify the topic of each comment related to clinician attitudes and perceptions about EHR characteristics. Topics were grouped into themes and the resulting themes were coded and compared to the evaluation components in the HITREF framework [30].

Quantitative analysis of clinician survey responses applied the Wilcoxon signed-rank test to matched clinician survey responses from the first survey administration to responses from the second survey administration. Paired-sample *t*-tests were applied to estimate the magnitude of the difference. Statistical analysis of clinician demographic characteristics and survey responses was used to identify demographic variables that might be confounders of overall satisfaction. That is, the analysis is whether there was a statistically significant difference in clinicians' perception of overall satisfaction between those clinicians having or not having each demographic or job-related characteristic. An example is whether less experienced nurses are more likely to be satisfied with the EHR than more experienced nurses. For each demographic variable, a logistic regression model was constructed containing the remaining demographic variables as independent variables to estimate the propensity score for that demographic variable.

3.5.3 Patient Functional Outcomes

ADLs were scored as a percentage of total possible score to account for questions with different response ranges (activity sub-scores had a range of 1 to 7, and adaptive device use sub-scores had a range of 1 to 2), scores of zero (out of range), and missing data (less than 5%). The investigation of the impact of the EHR on patient functional outcomes entailed two types of quantitative analysis. Graphical analysis was applied to assess whether frailer patients had less stable ADLs by comparing the change in ADL to the initial value of the ADL (Baseline). Graphical analysis and paired-sample *t*-tests used PACE clients' matched ADL scores from the EHR at the two time periods.

3.5.4 Mixed Methods Interpretation

Following analyses of the quantitative and qualitative data, the quantitative findings and qualitative results were reviewed to assess how the information addressed the research questions. Assessing clinician satisfaction (Objective 2) entailed merging quantitative findings from survey responses with qualitative findings from observations and interviews along the HITREF themes. Quantitative findings describing EHR usage and qualitative findings describing EHR functionality (Objective 1) were merged with clinician satisfaction findings. Assessing EHR impact on patient functional outcomes (Objective 3), qualitative results from observations regarding functionality and quantitative finding from surveys were merged with quantitative findings from ADL scores. Interpretation involved deciding how the qualitative data supported or augmented the quantitative data [23].

4. Results

The following sections document the results for each of the study questions. These include:
1. qualitative analysis of EHR functionality and EHR usage and quantitative analysis of EHR usage;
2. qualitative and quantitative analysis of survey results regarding clinician satisfaction with the impact of the EHR on clinical process;
3. qualitative and quantitative analysis of EHR impact on patient ADLs; and
4. interpretation of findings from the three questions.

Thirty-nine clinicians were eligible to participate in the study with different levels of participation in each method. For instance, all were included in EHR diffusion analysis, and only consented clinicians were observed, surveyed and interviewed.

4.1. EHR Diffusion

Qualitative analysis of the software documentation indicated that the EHR met 14 of the 38 CCHIT criteria. Of clinical interest, the EHR supported:
1. managing documentation including medication management and patient history;
2. ordering diagnostic tests and non-medication orders, and managing results; and
3. capturing external clinical documents with scanning.

The EHR did not support functionality related to:
1. workflow management or clinical task assignment/routing;
2. clinical care management, such as clinical decision support (alerts), guidelines, or standard care plans;
3. imaging or laboratory studies (these services were provided by other organizations off-site);
4. medication ordering warnings or alerts; or
5. population health, such as communication with immunization registries or health surveillance systems.

Comparing the EHR's available functionality to observed functionality identified components that were not used as intended. For example, clinicians did not use the problem list available on the system as intended. Primary care clinicians explained that it was not a medical problem list organizing patient clinical information. Additionally, the software documentation stated that managing immunizations and flu shots was supported with reports; however, immunization reporting was not observed in either time period.

Findings related to clinician use of the available functionality were obtained from observations. The first set of observations consisted of the lead researcher observing 15 clinicians (38%) recording assessments; care plans; and episodic care during 8 visits to the EHR site over the course of six weeks. The second set of observations consisted of the researcher observing 10 clinicians (26%) during 5 visits over the course of two and a half weeks. The same roles were observed during both time periods. Twenty-five pages of field notes were taken while shadowing clinicians.

Content analysis revealed that patient care was delivered in a team approach. Delivery of care and documenting of care was differentiated by role:

1. nurses conducted patient assessments;
2. nurse practitioners created care plans and billing documentation;
3. primary care clinicians, i.e., physicians and nurse practitioners wrote orders;
4. nurses, primary care practitioners and therapists documented the interventions; and
5. one designated group of LPNs and nurses documented vital signs, medication administration, and blood glucose results for the patients requiring medication administration or blood glucose readings.

Nurses, LPNs, primary care clinicians, and therapists entered data in the EHR after and not during the patient visit, and they infrequently accessed patient information before or during the visit. Notably, vital signs, blood glucose tests, and medication administrations were not documented in a timely manner. Observed barriers to EHR use before and during the visit included:

1. the lack of a medical problem list to organize patient clinical information;
2. too many screen changes and slow response time that slowed clinician workflow;
3. care plans that did not interface with documentation of interventions which were recorded as narrative or outcomes;
4. printing of medication orders;
5. order results that were difficult to find; and
6. placement of the computer.

Clinicians voiced their frustration with these issues during observation. Work-arounds to the observed barriers to EHR use included making notes on paper, which created a time lag before the information was available to other clinicians, and cutting and pasting EHR notes forward. Six months later, there was an increase in the number of clinicians observed using the EHR and accessing patient information from previous visits. The amount of paper documentation decreased and clinicians reported more timely updating of the EHR in response to management's request. However, clinicians continued to document after the patient visit and rarely accessed patient information before or during the visit.

Use of the EHR to access or document patient information related to the daily team meeting (to discuss patient access to external services or durable medical equipment) was not observed. During both time periods nurses, nurse practitioners, and therapists did not access the EHR during team meetings and did not document in patient records after team meetings. Similarly, use of the EHR to access or document patient information related to biweekly primary care practitioner team meetings (to discuss patient progress) was not observed during either time period. Clinician communication solely via EHR was not observed among or between clinical roles.

With regard to clinician usage during the first study period, clinicians created 369 new clinical notes in the EHR during the first observation week in September 2008 and created 412 notes (12% increase) during the second observation week in April 2009, as shown in ▶Table 3, for the assumed constant number of patients seen among the 338 PACE clients. During the first time period, clinicians completed 1% of the clinical notes on the weekend; this percentage increased to over 2% during the second time period. Note creation at both time periods had a statistically significant difference by role ($p = 0.0001$; $p = 0.0001$), with nurses creating the greater proportion of notes, equal to or exceeding their representation in the sample population. The proportion of notes created by primary care practitioners decreased slightly, and the proportion of notes created by social workers and therapists during each time period remained constant. Approximately 1% of the notes were created by roles that were not expected to create notes (home health aides, clinical assistant, medical assistant, and "other"). Between the two times of observations, clinicians completed notes sooner by a statistically significant amount (ANOVA $p<0.000$; Kruskal-Wallis rank test $p = 0.0001$). Clinician role had an effect on the duration of time to complete notes during the first ($p = 0.0001$) and second ($p = 0.0007$) observation weeks. Additionally, clinicians created 918 orders during the first observation week (time 1) and 1106 orders (20% increase) 6 months later during the second observation week (time 2). There was a statistically significant difference by role (ANOVA $p<0.000$; Kruskal-Wallis rank test $p = 0.046$) on the proportion of orders created. All roles were compared;

however, the larger groups were: (1) nurses (including LPNs) and (2) primary care clinicians (i.e., nurse practitioners and physicians) as shown in ▶Table 3. Medical assistants and clinical assistants did not provide and document direct patient care; but, they did transcribe orders into the EHR, and the proportion of orders they created increased in the second time period. Primary care practitioners (nurse practitioners and physicians) created disproportionally more orders than their representation in the sample. Clinicians printed approximately half of the orders they created.

Qualitative analysis of observations and quantitative analysis of audit logs and survey responses (below) suggest that every clinical discipline and every clinician who provided and documented patient care used the EHR during both observation times. EHR usage was differentiated by role and increased between observation periods.

4.2. Clinician Satisfaction With EHR Impact on Clinical Process

The assessment of the impact of the EHR on clinician satisfaction with the clinical process was also informed by observations of EHR use, survey responses, and follow-up interviews. Fifteen clinicians (38%) were shadowed during the first observation and 10 clinicians (26%) were shadowed during the second observation, as previously discussed.

Thirty-seven clinicians (95% of eligible clinicians) completed the first administration of the survey, and 32 clinicians (82%) completed both surveys. Clinicians who completed the first survey were reported to be middle-aged and experienced, as shown in ▶Table 1. Propensity scores indicated there was no confounding of demographic variables. That is, there was no statistically significant difference:

1. in clinicians' perception of overall satisfaction between those clinicians with or without EHR experience who have similar demographic, employment, and computer knowledge characteristics;
2. between clinicians who were nurses or were not nurses;
3. between clinicians over or under the average age; or
4. between clinicians with average and below average self-rated computer knowledge as compared to above average and advanced computer knowledge.

The reported results indicated satisfaction with the EHR, although there was a non-significant decline in satisfaction between 11 months and 17 months post implementation of the EHR. Overall, clinicians were satisfied with the impact of the EHR on the clinical process, but were not satisfied with Usability (Item 3: "The patient health record is user friendly") or Clinician Involvement in EHR Selection, Development or Training (Item 17: "People who use the patient health record should have had more to say about its design"). Clinicians remained satisfied with the EHR's impact on clinical process at Time 2 (17 months post EHR implementation), but were less satisfied compared to Time 1 (11 months post-EHR implementation). When clinicians' survey responses were matched, 3 (14%) items had statistically significant differences between survey administrations among the 21 Likert scale items (n.b., Question 22 is an open-ended question) at the site level (i.e., all clinician respondents) and the clinician level (i.e., matched respondents), as shown in ▶Table 4. Organizational Resources (Item 20: "Sufficient resources are provided for me to learn to use the patient health record") had decreased satisfaction ($p = 0.03$). Worthwhile (Item 13: "The patient health record is worth the time and effort required to use it") had decreased satisfaction ($p = 0.03$). Clinician Involvement (Item 17) had decreased dissatisfaction ($p = 0.03$). Survey responses to the item that asked about patient outcomes (Item 11: "Contributes to patient outcomes") indicated decreased satisfaction with patient outcomes between administrations.

For both survey administrations, half the surveys had written responses to the open-ended prompt (Question 22), most of which expressed dissatisfaction. Usability and Functionality (a finer description of the type of information system), which was not an item on the survey, received most (50%) of the comments at both time periods. Efficiency and Complete/Correct Data also received many comments. These topics were included in the follow-up interviews, in addition to topics that garnered fewer comments (i.e., organizational support and positioning of the hardware).

Four primary care practitioners (10%) participated in followup interviews after the first survey administration. Six primary care practitioners (15%) participated in the followup interviews follow-

ing the second survey administration. Their responses (99 comments) were mostly negative (96%) and focused on the four areas that garnered most comments in response to the survey prompt (Question 22). Primary care practitioners were dissatisfied with:

1. Usability of finding and documenting information, due to silos of data and difficulty navigating within the EHR patient record;
2. Functionality to document medication orders and lab results, lack of a medical problem list, usability issues which decreased the completeness of patient information, and the absence of workflow functionality to support interoperable order results (from external services such as laboratory) or to route medication orders (requiring printing of medication orders);
3. Efficiency due to printing of medication orders, manual annotation, increase in time required to document, and time spent documenting outside the official work day; and
4. Complete/Correct Data (e.g., the incompleteness of lab and medication data). Participants reported they used some functionality less or omitted functionality because it was cumbersome, did not support workflow, or impacted efficiency (slowed them down).

The interview instrument did not have a Team Communication item. Interviewees raised the topic of team communication on the first interview only. Primary care practitioners were satisfied with team members reading clinical notes and stated concerns about clinical documentation not being available to other clinicians during patient visits, and that other disciplines could not access care plans. Patient Outcomes was not a question on the interview instrument and was not raised by interviewees.

4.3. Patient Functional Outcomes

The PACE site had 338 clients served during the first time period. Clinicians documented ADL assessments for 231 of the patients (66%) during the first time period, and 85 patients (25%) during the second, with 48 patients (13%) having assessments in both time periods. Clinicians attributed the large difference in volume between time periods to an effort during the first time period to conduct and document assessments that had been waiting to be done. It was unclear why, six months later, the volume of matched assessments did not approach the initial volume, considering that the patient population was relatively stable.

For patients with matched assessments ($n = 48$), the individual baseline (range: mean 1.0 [standard deviation (SD) 0] to 3.8 [SD 3.0]) and followup (1.0 [SD 0] to 4.3 [3.0]) scores indicated that the average patient required "set-up help only" for activities (score of 2 where 1 indicates independence and 7 indicates total dependence) and did not require an adaptive device. The same questions scored low (feeding device) and high (locomotion device) for both observation periods. There was no statistically significant difference between 11 months and 17 months post implementation of the EHR. However, with 83% of the data missing, no conclusive statements could be made. Based on baseline ADL scores, this group of patients was similar in outcome to the larger population of all patients, requiring set-up help only for activities.

4.4. Mixed Methods Interpretation

Eight themes, or characteristics of the EHR, emerged when quantitative findings describing EHR usage and qualitative findings describing EHR functionality (Objective 1) were merged with clinician satisfaction findings (Objective 2) and ADL results (Objective 3). The first theme was functionality that did not match the workflow. Such functionality was observed (e.g.,) and reported in interviews. Observed functionality included vital sign input, medication administration documentation, care plans that did not interface with interventions or outcomes, infrequent access of the EHR before or during a patient visit. Functionality reported in interviews included retrieval of out-of-clinic order results such as laboratory results, printing of medication orders, lack of medical problem list.

The second theme was usability. Cumbersome usability was observed (e.g., many screen changes, slow response time) and reported in interviews (e.g., problems navigating among screens, data silos), and expressed in survey responses.

The third theme was EHR's impact on complete/correct data. Clinician dissatisfaction with late, missing or non-locatable data were observed (e.g., documentation of medication administration, vital signs, blood glucose test results, and documentation of interventions as narrative instead of coded data) and reported in interviews (e.g., results from out-of-clinic services). Incomplete data were exemplified by missing ADL assessments. However, clinicians improved the timeliness of their documentation as indicated by diffusion findings (e.g., notes, orders), as observed (e.g., patient information on paper input forms), and clinicians expressed increased satisfaction between survey administrations.

The fourth theme was EHR's impact on efficiency, which had four different dimensions. First, reduced efficiency was observed as duplicate recording of clinical data for clinical documentation and billing. A second aspect of reduced efficiency was observed and indicated by results of diffusion analysis: printing of half the medication orders. Additionally, clinicians reported dissatisfaction with efficiency in survey responses and interviews. Lastly, clinicians reported in interviews and results of diffusion analysis indicated increased amount of notes completed over the weekend and increased time spent documenting after work hours.

The fifth theme was EHR's impact on team communication. Observation indicated the EHR was not a primary means of team communication, and that face-to-face communication was the primary team communication method. Clinicians reported satisfaction with team communication in interviews and surveys. However, access by multiple primary care practitioners to patient information was cumbersome (e.g., lack of a medical problem list).

The sixth theme was clinicians' overall satisfaction or whether the EHR was worth the time and effort. Clinician dissatisfaction was indicated in observations and interviews (e.g., not using the EHR as it was intended to be used, articulated frustration with the EHR), and in survey responses and results of diffusion analysis (e.g., statistically significant decrease in satisfaction as usage increased).

The seventh theme was EHR's impact on patient outcomes. Clinicians reported satisfaction with EHR's impact on patient outcomes in surveys; however, there were insufficient patient ADL assessments to measure the impact of the EHR on patient outcomes.

The eighth theme was organizational support for the EHR. Clinician survey responses indicated a statistically significant decrease in satisfaction with organizational resources (Sufficient Resources) and an increase in satisfaction with organizational support (Sufficient Support-Item 20) for the EHR between time periods. During observations, clinicians reported a management request for more timely updating of patient clinical information, indicating a level of organizational support.

5. Discussion

This study is the first known evaluation of HIT used in a nurse-managed geriatric care facility. Using mixed methods to assess the impact of an EHR on clinician satisfaction with clinical process and the EHR's impact on patient functional outcomes enabled us to describe the EHR use and provided information about how the EHR potentially achieves its effect on the clinical process and ultimately on patient outcomes. Merging findings from multi-dimensional methods strengthened the interpretation of results. The evaluation results inform the evidence-based advice that is offered here to PACE decision makers considering deploying EHRs.

5.1 EHR Diffusion, EHR Impact on Clinician Satisfaction and Patient Functional Outcomes

The EHR was developed for the long term care market and was adopted for the PACE setting by the vendor. The EHR adequately supported aspects of the clinical process, including documentation. EHR diffusion statistics indicated that clinician adoption of the EHR for documenting notes and orders was wide and universal. Clinician use increased between the two time periods of the study, with clinicians documenting in a more timely manner in terms of completing notes in fewer days and a slight increase in the percentage of notes documented on the weekends. The results indicated that there was a statistically significant difference in the volume of clinical notes and clinical orders

documented by provider type, which was consistent with observations. With increased volume of orders, the percentage of orders entered by medical assistants and clinical assistants increased. Order entry for clinical assistants was limited to orders focused on physical therapy as communicated by a physical therapist. Less was known about the focus of orders documented by medical assistants. Documentation of notes generally reflected the proportion of clinicians represented in the population. Documentation of orders may reflect the different aspects of the clinical process carried out by each role.

Observation suggested that where the EHR functionality was cumbersome to use or did not support the clinical workflow, clinicians did not embrace the EHR as intended. Clinicians reported dissatisfaction with EHR usability on the survey, and as their use of the EHR increased, clinicians reported decreased satisfaction with the EHR, although overall, they remained satisfied. Interview results reiterated clinician dissatisfaction with EHR usability and also indicated dissatisfaction with functionality, completeness/correctness of data, and impact on efficiency. Linking qualitative findings with quantitative results indicated: clinicians had difficulty entering and accessing clinical information, and clinicians had issues with the organization of data and navigating the EHR. In addition, functionality and workflow mismatch introduced inefficiency and was a barrier to clinician access of the EHR before and during patient visits.

In assessing EHR's impact on clinician satisfaction and patient functional outcomes, this evaluation found that clinicians did not use the system as intended, which may help to explain why the benefits related to clinical processes and patient outcomes as expected for an EHR were not reflected in the results of Objectives 2 and 3. The unexpected lack of documentation of ADL scores at the second time period could reflect the lack of alignment between clinical processes and the use and design of the EHR. This observation is hypothetical, based on the observed lack of reminders for ADL assessments in the EHR as either a prompt or a report and the lack of explanation offered by the PACE staff.

5.2 EHR Implementation Considerations for PACE Decision Makers

The promise of the EHR is to improve the safety, quality, and efficiency of patient care (31) by improving timeliness and access to clinical information (20), and communication among clinicians and across time (1). Attaining this promise involves matching system functionality and usability to workflow, which is complex (6, 32).

The PACE study setting is very different from hospital practice settings which contribute most of the EHR evaluation studies focused on nurses. Adoption studies at typical inpatient settings indicate nurses were satisfied with EHR functionality (33-36) and were dissatisfied with access to (33, 37) and quality of (38, 39) patient information in the EHR, and the EHR's impact on their efficiency (33). Our results show clinicians were dissatisfied with EHR functionality, and EHR impact on accessibility and quality of patient information and their efficiency, providing an alternative perspective. We can expect adoption at other community-based settings to be between these alternative perspectives.

It is suggested that PACE decision makers planning to deploy an EHR consider assessing the EHR's functionality and usability in regard to the site's workflow before and during the implementation. As was observed at this research site, this analysis and subsequent design may be outside the expertise of the user and technical personnel and it may be more dependent on organizational support and organizational resources. An opportunity for organizational support is encouraging technical support staff to collaborate with users during the processes of identifying issues and communicating progress towards resolution.

This evaluation suggests that the EHR was not used as it was intended to be used, and the potential benefit of the EHR as a clinician memory aid before or during visits was reduced, such that the clinician may have missed an opportunity for a timely patient care intervention. The study results suggest the various workflows related to patient visits have corresponding workflows for clinician access of the EHR, and the variation reflects clinician role. Based on our evaluation, we suggest there are two categories of clinical documentation reflecting different workflows: rapid data entry, and documentation of interventions and outcomes. Clinicians who obtain vital signs, administer blood glucose tests, weigh patients, etc: may be more likely to record results in an interface for recording information for multiple patients rapidly (e.g., spreadsheet) as opposed to navigating

through individual patient records. Clinicians who document interventions and outcomes had two workflows. First, clinicians who were familiar with a patient were less likely to consult the EHR before or during the visit, and were unlikely to benefit from memory jogs or alerts within the patient record. These clinicians may prefer to see reminders from the EHR (e.g., ADL assessment, vaccination, diabetic foot check) at the start of their patient visit hours. Displaying patient specific reminders associated with the clinician's patient schedule may require the EHR to interface with the patient schedule, a capability not included in the CHHIT criteria, and may also require reporting and clinical care management functionalities that are both CCHIT criteria. The second workflow variation of clinicians who document interventions and outcomes was clinicians who were not familiar with the patient: clinicians articulated the need for a medical problem list. For any workflow involving clinician documentation of interventions and outcomes, seamlessly integrating this documentation with updating the care plan would enable interventions and outcomes to be organized in the care plan, and possibly reduce double documentation in the care plan.

Decision makers may also want to consider the interoperability of the EHR, as it affects the continuity of patient information. PACE sites are frequently associated with academic institutions, and if the academic institution has a health system, the PACE site may refer patients for services (e.g., laboratory) and patients may use the health system's acute care services (e.g., emergency room, hospitalization). As observed at the research site, the lack of key interoperability between health system and PACE site resulted in order results (e.g., laboratory) being scanned into the PACE EHR, and clinicians reported the scans were difficult to locate. We suggest that PACE decision makers consider the EHR configuration of the Billings Clinic which includes a hospital, physician practices, and a PACE that use the same EHR. The integrated EHR increases clinician access to the patient record, facilitates coordination of care, and supports measurement of outcomes. The EHR enables the sharing of standardized and consistent information, an accurate and complete patient record, and workflow efficiencies [40].

Impact on communication is also an EHR attribute, and team communication is a key characteristic of the PACE [14]. Clinicians reported satisfaction with team communication; however, the EHR was not observed to impact team communication by either providing support for team communication or altering communication patterns, such as having team members assume that information in the EHR is seen by other team members [41]. PACE decision makers should consider the impact of the EHR on clinician satisfaction with team communication as clinician satisfaction with communication among team members and team work have been shown to lead to improved patient safety [42, 43] and outcomes [44].

In addition to considering how the EHR is used to support direct patient care, PACE decision makers should consider the role of the EHR as a data repository to support improving patient care, patient safety, and population health. A repository of valid and reliable patient information can provide data for the CCHIT functionalities of capturing variances from standard care plans, guidelines, and protocols, as well as present alerts for disease management, preventive services and wellness as shown in ▶Table 2 [16]. This study initially identified patient ADL assessments as the sole patient outcome measure available in the EHR repository. Additional electronic measures would have provided more information about quality and safety. Further analysis indicated the ADL data were incomplete, was not used by the PACE site for quality reporting, and was not validated. The reliability of the data was also unknown: it was unclear if the data had been consistently collected and recorded across patient populations. The ADL data highlight an opportunity for the future – the need to integrate these types of functional status data for care management and evaluation. PACE decision makers should consider whether and how the data in the EHR repository will be reported. Having valid and reliable quality data would enable the organization to support efficient workflow and implement clinical decision support and condition management [40].

5.3 Study Strengths and Limitations

One of this study's strengths is its interpretation of findings from diverse sources and the application of mixed methods, which enabled information from varied sources to be analyzed together. For example, diffusion data, employing observations, survey item responses, and interview responses provided multiple inputs for interpreting patient outcome findings. A second strength is that the study attempted to examine measures of quality of care in a community care setting that implemented an

EHR. This study contributes to the literatures on the impact of HIT on long-term care, evaluation technique, and geriatric clinical care and dual-eligible community-based populations. Looking forward, findings regarding differentiation in EHR use by provider type offer insight to facilitate implementation of EHRs in community-based geriatric practices, including nursing homes, as EHR adoption in these types of settings increases in the face of a graying American population.

In terms of limitations, given its small sample size, this study should be considered exploratory. Also, given the lack of a comparison group, the research design may not have controlled sufficiently for other parallel changes at the site. Additionally, the lead author solely conducted observation, analyses, and sorting of findings into themes, which may have introduced bias. Lastly, clinician usage and patient ADL data obtained from the EHR were limited. If available, additional electronic measures, such as blood glucose results or vaccination documentation, would have provided more information about quality of care. There are additional limitations related to the ADL data. ADL scores collected by the PACE were not validated. Also, a comparison group would be needed to meaningfully interpret patient outcome findings. Finally, the generalizability of the study may be specific to the software, inner-city academic PACEs, and the specific population in the study.

6. Conclusion

This study was intended to contribute to the body of research related to the use of EHRs to support the care of the growing aging population. Our research merged and interpreted information derived from a mixed methods study to evaluate the geriatric care program that was an early adopter of HIT. This study assessed the adoption of an EHR outside the acute hospital setting and in the community setting to provide evidence-based recommendations to PACE decision makers considering EHR implementation. Key findings were: 1) clinicians were satisfied with the EHR, however, as usage increased, clinicians were less satisfied; and 2) the importance of the interaction of workflow and EHR functionality and usability as it impacts clinician satisfaction, efficiency, and clinician use of the EHR. We suggest that PACE decision makers consider the EHR's ability to support various paths for clinician access, reflecting the clinical role. A second key finding was the potential benefit of the EHR data repository to support patient care, patient safety, and population health. Realizing the potential of an EHR data repository relies on the consistent collection and reporting of valid, reliable data. These data are captured in the process of patient care when an EHR is used as it was intended, and EHR data are validated when they are reported either internally or externally in patient quality reports. Further work is warranted to confirm our findings in larger study populations and other study settings. The results of this evaluation can inform the iterative process of development and implementation of EHRs in geriatric practice settings – a process that will become more common as health care systems across the globe increasingly apply EHRs to better meet the needs of the growing population of older people with chronic health care conditions.

Clinical Relevance Statement

Practitioners involved in the selection and implementation of an EHR in a community-based health care setting should consider that the interaction of workflow and EHR is likely to impact the EHR's ability to achieve its intended effect on the clinical process and patient outcome. The EHR should not be cumbersome to use and the EHR should support the different aspects of the clinical process carried out by each clinical role, so that clinicians embrace the EHR and use it as intended.

Conflict of Interest

None of the authors has a conflict of interest.

Institutional Reviews

The Institutional Review Boards of the researchers' academic institution and of the research site approved the research study.

Acknowledgements

Grant support: NLM Informatics Training Grant T15LM07452, Robert Wood Johnson Foundation Public Health Informatics Training Grant; School of Medicine, The Johns Hopkins University School of Medicine.

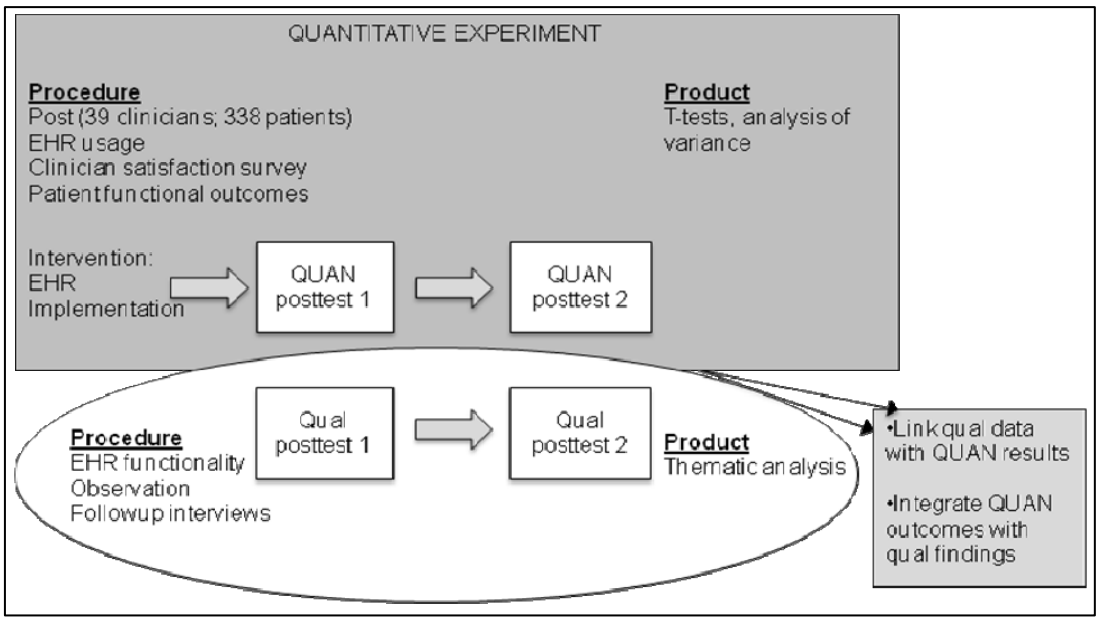

Fig. 1 Embedded Mixed Methods Study Design

Table 1 Demographics of survey respondents

Characteristics	Number (N = 37)	%
Age (years)		
<25	5	13
25-34	5	13
35-44	5	13
45-54	13	35
55-64	9	24
Gender		
Male	4	11
Female	33	89
Occupation		
Nurse	10	27
Nurse practitioner	9	24
LPN	5	13
Physical therapist	4	11
Occupational therapist	3	8
Physician	3	8
Social worker	2	5
Nurse administrator	1	3
Health care years		
1-10	6	16
11-20	9	24
21-30	16	43
>30	6	16
CPOE/EHR use (years)		
0	16	43
1-3	5	13
4-6	6	16
7-9	5	13
>9	2	5
Missing	3	8
Computer Knowledge		
Below average	4	11
Average	20	54
Above average	9	24
Advanced	4	11

Table 2 CCHIT criteria and EHR functionality

CCHIT EHR Category	CCHIT EHR Criteria	EHR Capability as per Vendor Contract
Security and confidentiality	Access control	
	Audit trial	Yes
	Authentication	
	Enforcement of confidentiality	
	Entity Identity Assertion	
	Nonrepudiation of origin	
	Secure communication	
Data integrity	Data integrity auditability	
	Data retention, availability and destruction	
	EHR's Traceability	
	Legal business record	
	Patient identity	
Interoperability	Capture external clinical documents	Scanning
	Clinical documentation document exchange	
Clinical trials		
Technical	Consistent time	
	Inter-domain backup/recovery	
	Technical services	Vendor technical support
	Concurrent use	Yes
Clinical care management	Clinical decision support system guidelines updates	
	Capture variances from standard care plans, guidelines, protocols	
	Chronic disease management / patient communication	
	Manage documentation of clinician response to decision support prompts	
	Present alerts for disease management, preventive services and wellness	
	Support for standard care plans, guidelines, protocols	
Clinical functionality	Documentation	• Review and collect vitals • Review and collect medications • Document on intervention • Review problems and collect the ratings scale • Add a summary note to the clinical note • Document time • Print a clinical note summary that will summarize all the data

Table 3 Diffusion: Number and (Percent*) of notes and orders created by role

Role (Clinical Discipline)	Notes		Orders	
	Time 1 (N = 369)	Time 2 (N = 412)	Time 1 (N = 918)	Time 2 (N = 1106)
Art therapist	8 (2%)	1 (0%)	0 (0%)	0(0%)
Clinical assistant	0 (0%)	2 (0%)	28 (3%)	107 (10%)
Home health aide	1 (0%)	0 (0%)	0 (0%)	0 (0%)
Medical assistant	0 (0%)	1 (0%)	0 (0%)	43 (4%)
Nurse	168 (45%)	274 (53%)	96 (10%)	252 (23%)
Occupational therapist	4 (1%)	1 (0%)	0 (0%)	0 (0%)
Other	3 (1%)	5 (1%)	0 (0%)	0 (0%)
Primary care practitioner	94 (25%)	113 (22%)	784 (85%)	688 (62%)
Physical therapist	73 (20%)	75 (15%)	6 (1%)	16 (1%)
Recreational therapist	0 (0%)	2 (0%)	0 (0%)	0 (0%)
Social worker	18 (5%)	22 (5%)	4 (0%)	0 (0%)

Table 4 Means and standard deviations for items at PACE site with EHR

Dimension		Time 1		Time 2	
Item Number	Item	Mean (N = 37)	S.D.	Mean (N = 37)	S.D.
Structural quality#					
1	System availability	4.4	0.72	4.2	1.0
2	Infrequent system problems*	2.7	1.2	2.5	1.7
3	User-friendly	2.1	1.4	2.4	1.8
4	Sufficient support	3.7	1.4	4.1+	1.0
20	Sufficient resources	3.8	1.3	3.6	1.3
Quality of informatics logistics#					
5	Patient care recorded complete/correct	3.6	1.3	3.8	1.3
6	Patient concerns about privacy, confidentiality*	3.8	1.4	4.0	1.5
13	Worth time and effort	3.5	1.3	3.0+	1.4
14	Overall satisfaction	3.0	1.3	2.7	1.4
15	Patient satisfaction	3.1	1.2	3.0	1.2
Effects on quality of processes#					
7	Timely patient care (efficiency)	3.5	1.3	3.4	1.2
8	Appropriate patient care orders	3.7	1.4	3.8	1.0
10	Team communication	3.6	1.3	3.4	1.3
16	Department involvement	3.4	1.5	3.7	1.3
17	Clinician involvement*	1.1	1.8	2.1+	1.9
Unintended consequences/benefits					
18	Interferes with patient care*	2.8	1.6	2.4	1.6
Barriers or facilitators to adoption					
19	Interoperability	3.5	1.6	2.8	1.8
Effects on outcome quality of care#					
9	Patient safety	3.7	1.0	3.5	1.1
11	Patient outcomes	3.6	1.0	3.3	1.3
12	Patient knowledge	2.5	1.4	2.6	1.4
21	Costs*	3.4	1.5	3.7	1.3

Abbrevations: S. D.: Standard deviation
From Ammenwerth and de Keizer, 2005
* Negatively phrased question, reverse coded for analysis
+ Statistically significant difference ($\alpha = 0.05$)
Note: higher numbers indicate greater satisfaction; scale is 0-5 with 5 being most satisfied

References

1. Berg M. Patient care information systems and health care work: a sociotechnical approach. Intl J Med Inf 1999; 55(2): 87-101. doi:10.1016/S1386-5056(99)00011-8
2. Maekawa Y, Majima Y. Issues to be improved after introduction of a non-customized Electronic Medical Record system (EMR) in a Private General Hospital and efforts toward improvement. Stud Health Technol Inform 2006; 122: 919-920. PMid:17102464
3. Moller-Jensen J, Lund Pedersen I, Simonsen J. Measurement of the clinical usability of a configurable EHR. Stud Health Technol Inform 2006; 124: 356-361. PMid:17108548
4. Berg M. The search for synergy: interrelating medical work and patient care information systems. Methods Inf Med 2003; 42(4): 337-344. PMid:14534631
5. Starfield BH, Simborg DW, Horn SD, Yourtee SA. Continuity and Coordination in Primary Care: Their Achievement and Utility. Med Care 1976; 14(7): 625-636. doi:10.1097/00005650-197607000-00008 PMid:940406
6. Campbell EM, Guappone KP, Sittig DF, Dykstra RH, Ash JS. Computerized provider order entry adoption: implications for clinical workflow. J Gen Intern Med 2009; 24(1): 21-26. doi:10.1007/s11606-008-0857-9 PMid:19020942 PMCid:2607519
7. Goldzweig CL, Towfigh A, Maglione M, Shekelle PG. Costs and benefits of health information technology: New trends from the literature. Health Aff 2009; 28(2): w282-w293. doi:10.1377/hlthaff.28.2.w282 PMid:19174390
8. Crosson JC, Ohman-Strickland PA, Hahn KA, DiCicco-Bloom B, Shaw E, Orzano AJ et al. Electronic medical records and diabetes quality of care: results from a sample of family medicine practices. Ann Fam Med 2007; 5(3): 209-215. doi:10.1370/afm.696 PMid:17548848 PMCid:1886493
9. Ross SE, Moore LA, Earnest MA, Wittevrongel L, Lin CT. Providing a web-based online medical record with electronic communication capabilities to patients with congestive heart failure: randomized trial. J Med Internet Res 2004; 6(2): 4/06.
10. Daly JM, Buckwalter K, Maas M. Written and computerized care plans. Organizational processes and effect on patient outcomes. J Gerontol Nurs 2002; 28(9): 14-23. PMid:12240516
11. Chaudhry B, Wang J, Wu S, Maglione M, Mojica W, Roth E et al. Systematic review: Impact of health information technology on quality, efficiency, and costs of medical care. Ann Intern Med 2006; 144(10): 742. PMid:16702590
12. Resnick HE, Alwan M. Use of health information technology in home health and hospice agencies: United States, 2007. JAMIA 2010; 17: 389-395. doi:10.1136/jamia.2010.005504 PMid:20595305
13. CMS. Program of All inclusive Care for the Elderly (PACE). Available at: http://www.cms.hhs.gov/PACE/. Accessed 1/11, 2010.
14. Mukamel DB, Peterson DR, Temkin-Greener H, Delavan R, Gross D, Kunitz SJ et al. Program characteristics and enrollees' outcomes in the Program of All-inclusive Care for the Elderly (PACE). Milbank Q. 2007; 85(3): 499-531. doi:10.1111/j.1468-0009.2007.00497.x PMid:17718666
15. Blumenthal D. Stimulating the Adoption of Health Information Technology. N Engl J Med 2009; 360(15): 1477-1479. doi:10.1056/NEJMp0901592 PMid:19321856
16. CCHIT certification for ambulatory electronic health records – CCHIT Certification Commission for Healthcare Information Technology. Available at: http://www.cchit.org/certify/ambulatory/index.asp. Accessed 9/9/2008, 2008.
17. Ash JS, Stavri PZ, Kuperman GJ. A consensus statement on considerations for a successful CPOE implementation. JAMIA 2003; 10(3): 229-234. doi:10.1197/jamia.M1204 PMid:12626376 PMCid:342045
18. Banker RD, Chang H, Kao YC, editors. Measurement of user satisfaction with web-based information systems: an empirical study. Proceedings of the Eighth Americas Conference on Information Systems; 2002; Atlanta, GA: AIS; 2002.
19. Sockolow PS, Crawford PR, Lehmann HP. Broadening a general framework for evaluating health information technology through health services research evaluation principles. Methods of Medical Information. In Review.
20. Ammenwerth E, de Keizer N. An inventory of evaluation studies of information technology in health care – Trends in evaluation research 1982-2002. Methods Inf Med 2005; 44(1): 44-56. PMid:15778794
21. Sockolow PS, Weiner JP, Bowles KH, Lehmann HP. A new instrument for measuring clinician satisfaction with electronic health records. CIN in press. PMid:18091616
22. Sands LP, Xu H, Craig BA, Eng C, Covinsky KE. Predicting change in functional status over quarterly intervals for older adults enrolled in the PACE community-based long-term care program. Aging Clin Exp Res 2008; 20(5): 419-427. PMid:19039283

23. Creswell JW, Plano Clark VL. Designing and conducting mixed methods research. 2nd ed. Thousand Oaks CA: Sage; 2011.
24. Morse JM. Principles of mixed methods and multimethod research design. In: Tashakkoru A, Teddlie C, editors. Handbook of mixed methods in social and behavioral research. 1st ed. Thousand Oaks CA: Sage; 2003. p. 189-208.
25. Greenacre MJ editor. Theory and applications of correspondence analysis. Orlando: Academic Press; 1984.
26. Fine MJ, Murkofsky RL, editors. Trends in clinician perceptions of a new electronic health record. JGIM; Apr 9, 2008; Washinton,DC: Springer; 2008.
27. Sittig DF. Work-sampling: a statistical approach to evaluation of the effect of computers on work patterns in healthcare. Methods Inf Med 1993; 32(2): 167-174. PMid:8321135
28. Ash J. Organizational factors that influence information technology diffusion in academic health sciences centers. JAMIA 1997; 4(2): 102-111. PMid:9067876 PMCid:61499
29. StataCorp LP. Stata Statistical Software. 2007; Release 10.
30. Bazeley P. Computerized data analysis for mixed methods research. In: Tashakkoru A, Teddlie C, edi-tors. Handbook of mixed methods in social and behavioral research. 1st ed. Thousand Oaks CA: Sage; 2003. p. 385-422.
31. Tang PC et al. Key capabilities of an electronic health record system: Letter Report. 2003; available at: http://www.nap.edu/catalog.php?record_id=10781. accessed 1/18, 2011.
32. Koppel R, Wetterneck T, Telles JL, Karsh BT. Workarounds to barcode medication administration systems: Their occurrences, causes, and threats to patient safety. JAMIA 2008; 15(4): 408-423. doi:10.1197/jamia.M2616 PMid:18436903 PMCid:2442264
33. Kossman SP. Perceptions of impact of electronic health records on nurses' work. Stud Health Technol Inform 2006; 122: 337-341.PMid:17102276
34. Lee T, Mills ME, Bausell B, Lu M. Two-stage evaluation of the impact of a nursing information system in Taiwan. International Journal of Medical Informatics 2008; 77(10): 698-707. doi:10.1016/j.ijmedinf.2008.03.004 PMid:18457988
35. Ammenwerth E, Mansmann U, Iller C, Eichstadter R. Factors affecting and affected by user acceptance of computer-based nursing documentation: Results of a two-year study. JAMIA 2003; 10(1): 69-84. doi:10.1197/jamia.M1118 PMid:12509358 PMCid:150360
36. Simpson G, Kenrick M. Nurses' attitudes toward computerization in clinical practice in a British general hospital. Comput Nurs 1997; 15(1): 37-42. PMid:9014392
37. Moody LE, Slocumb E, Berg B, Jackson D. Electronic health records documentation in nursing: nurses' perceptions, attitudes, and preferences. Comput Inform Nurs 2004; 22(6): 337-344. PMid:15602303
38. Smith K, Smith V, Krugman M, Oman K. Evaluating the impact of computerized clinical documentation. Comput Inform Nurs 2005; 23(3): 132-138. doi:10.1097/00024665-200505000-00008
39. Tornvall E, Wilhelmsson S. Nursing documentation for communicating and evaluating care. Journal of Clinical Nursing 2008; 17(16): 2116-2124. doi:10.1111/j.1365-2702.2007.02149.x PMid:18710374
40. les JB, Weiner JP, Chan KS, Coon PJ, Krizak JT, Dancha L et al. Performance measures using elec-tronic health records: Five case studies. The Commonwealth Fund 2008; 1132.
41. Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: The nature of patient care information system-related errors. JAMIA 2004; 11(2): 104-112. doi:10.1197/jamia.M1471 PMid:14633936 PMCid:353015
42. Makary MA, Sexton JB, Freischlag JA, Holzmueller CG, Millman EA, Rowen L et al. Operating room teamwork among physicians and nurses: Teamwork in the eye of the beholder. J Am Coll Surg 2006; 202(5): 746-752. doi:10.1016/j.jamcollsurg.2006.01.017
43. Pronovost P, Weast B, Rosenstein B, Sexton JB, Holzmueller CG, Paine LD R et al. Implementing and validating a comprehensive unit-based safety program. Journal of Patient Safety 2005; 1(1). doi:10.1097/01209203-200503000-00008
44. Baggs JG, Schmitt MH, Mushlin AI. Association between nurse-physician collaboration and patient outcomes in three intensive care units. Crit Care Med 1999; 27: 1991. doi:10.1097/00003246-199909000-00045 PMid:10507630