Project Title:
A National Report of Nursing Home Quality Measures and Information Technology

Principal Investigator
Gregory L. Alexander, PhD, RN, FAAN
Professor
University of Missouri
Sinclair School of Nursing

Co-Investigators
Richard Madsen, PhD
Emeritus Professor
University of Missouri
Office of Biomedical Research

Staff Support
Keely Wise
Program Coordinator
University of Missouri
Sinclair School of Nursing

Inclusive Dates of Project. 09/30/2013 – 09/29/2017

Federal Project Officer. Denise Burgess, Program Official

Acknowledgment of Agency Support. Project support was by grant number R01HS022497 from the Agency for Healthcare Research and Quality. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Agency for Healthcare Research and Quality.

Grant Award Number. 1R01HS022497-01

Structured Abstract

Purpose: Investigators surveyed a nationally representative sample of Nursing Homes in the United States to describe the dimensions of Nursing Home Information Technology Sophistication (IT Capabilities, Extent of IT Use, Degree of IT Integration) among three domains of nursing home care (Resident Care, Clinical Support, and Administrative Activities). We examined associations between nursing home Information Technology Sophistication, select nursing home attributes (Staffing, Facility, and Market Characteristics), and nationally reported Nursing Home Compare Quality Measures. We characterized patterns of Information Technology Sophistication over 3 years as increasing, stable, decreasing, or unstable (erratic).

Scope: The study had three specific aims: (1) Describe the pattern of changes in overall Information Technology Sophistication determined by changes in overall Information Technology Sophistication over time and examine links between the changes in Information Technology Sophistication and nursing home attributes. (2) Examine whether patterns of overall Information Technology Sophistication changes in nursing homes are associated with changes in Quality Measure scores over 3 years. (3) Investigate relationships between specific types of Information Technology Sophistication (dimensions and domains), nursing home attributes, and nursing home Quality Measures.

Methods: This proposal included a longitudinal, three-wave, repeated measures study measuring Information Technology Sophistication using responses to an annual national survey of information technology stakeholder respondents appointed by nursing home administrators. Investigators used a mixed model approach to estimate and tested changes in each type of survey score among combinations of different nursing home attributes and time, after adjusting for the effect of other NH attributes in analytic models.

Results: In Year 1, researchers contacted 1799 administrators; 815 administrators completed surveys (response rate 48%). In Year 2, 456/815 administrators repeated the survey (56% response rate). In Year 3, 448/815 administrators repeated the survey (55% response rate). Surveys were completed in all years (three times consecutively) by 306/815 administrators (38% response rate). IT sophistication scores increased by statistically significant amounts from Year 1 to Year 3 in all dimensions and domains except IT capabilities in administrative activities. In our analysis, more homes improved a lot (by more than 150 points) than worsened a lot (by more than 150 points). Multiple Quality Measures collected at times when survey respondents completed IT sophistication surveys show statistically significant weak to moderate correlations.

Key Words: Health Information Technology, Nursing Homes, Quality Measures, Survey Methodology

1. PURPOSE

This proposal included a longitudinal, three-wave, repeated measures study measuring Information Technology Sophistication (ITS) using responses to an annual national survey of IT stakeholder respondents appointed by nursing home (NH) Administrators. In Aim 1, we used three annual survey responses to explain variation in three dimensions of ITS (IT capabilities, Extent of IT use, and Degree of IT integration) among three domains of NH care (Resident Care, Clinical Support, and Administrative Activities). In Aim 2, we downloaded Quality Measures (QMs) from the national Nursing Home Compare data set quarterly during the period when NHs were completing ITS surveys. We used NH Medicare provider numbers to link ITS scores with the Nursing Home Compare data. Investigators used data from Nursing Home Compare to determine whether positive associations existed between patterns in ITS scores and QMs. In Aim 3, researchers investigated statistical associations between changes in ITS scores, NH attributes (including Staffing, Facility, and Market Characteristics), and QMs obtained from Nursing Home Compare. The team incorporated a mixed model approach to estimate and test changes in each type of ITS score among combinations of different NH attributes and time, after adjusting for the effect of other NH attributes in the model.

NH ITS was considered two ways in this analysis: 1) as the overall ITS score (the sum of scores from all questionnaires), as stated in RQ 1 ~ RQ 4 (below) and 2) as nine different types of ITS based on nine combinations of three ITS dimensions and three healthcare domains, as stated in RQ 5 ~ RQ 7 (below). The team examined associations between NH ITS, select NH attributes, and nationally reported Nursing Home Compare QMs. We characterized patterns of ITS over 3 years as increasing, stable, decreasing, or unstable (erratic). We integrated classical econometric methods to account for potential endogeneity of ITS scores by incorporating relevant NH attributes, including Staffing, Facility, and Market Characteristics, as covariates using a mixed model approach, including multivariate regression techniques(1). Specific aims and research questions for this project were:

Specific Aim 1: Describe the pattern of changes in overall ITS determined by changes in overall ITS over time and examine links between the changes in ITS and NH attributes.

RQ 1. Are there changes in overall ITS over 3 years?
RQ 2. What is the pattern of overall ITS change in a representative national sample of NHs?
RQ 3. Is there any association between overall ITS patterns and NH attributes (Staffing, Facility, and Market Characteristics)

Specific Aim 2: Examine whether patterns of overall ITS changes in NHs are associated with changes in QM scores over 3 years.

RQ 4. Are patterns of change in overall ITS scores associated with the pattern of QMs?
RQ 5. Are patterns in specific types of ITS scores associated with the pattern of QMs?

Specific Aim 3: Investigate relationships between specific types of ITS (dimensions and domains), NH attributes (Staffing, Facility, and Market Characteristics), and NH QMs.

RQ 6. Is ITS associated with NH attributes (Staffing, Facility, and Market Characteristics)?
RQ 7. Do relationships exist between ITS and QMs?

2. BACKGROUND

2.1 Characteristics of United States Nursing Homes

In 2014, according to the Centers for Disease Control and Prevention, the United States had approximately 15,600 NHs, containing 1.7 million licensed beds and covering approximately 1.4 million older adults. Nearly 42% of the long-term care users in NH are 85 years and older, and approximately 43% are over the age of 65 years(2). The average stay in a NH is 2.3 years for long-stay residents, according to the National Care Planning Council (3).

For discharged residents, which includes short-stay residents (e.g., residents receiving rehabilitation care), the average stay in a NH is 0.7 years. Resident care is complex. The percentage of NH residents with a diagnosis of Alzheimer disease or other dementia-related illness is 50%; many also have depressive disorders (49%) and diabetes 32%. Over 90% of NH residents receive assistance with some activities of daily living, such as bathing, dressing, walking, or locomotion; over 85% receive assistance with toileting and transferring in and out of bed. Approximately 58% required assistance to eat.

The Institute of Medicine's Improving Quality of Long-Term Care (2001) cited IT's important contributions to improved reliability, validity, and timeliness of resident care data used to measure quality. Increased attention to medical error and patient safety prompted recommendations to develop IT systems that support clinical decision making, promote data standards, and communicate with other IT systems(4). Achieving Aim 1 will provide key knowledge of ITS in three domains of NH care (Resident Care, Clinical Support, and Administrative Activities). This will be the first study that describes the capabilities of NH IT systems that are more strongly associated with improved QMs---an understanding that could significantly influence the care of 1.4 million NH residents.

2.2 ITS in Nursing Homes

ITS describes the information technology and software that support three domains of NH care: Resident Care, Clinical Support, and Administrative Activities. The three dimensions of ITS are (1) IT capabilities, which includes healthcare delivery processes or activities supported by technology; (2) extent of IT use, or the extent of use of hardware/software devices; and (3) degree of IT integration with internal/external stakeholders(5-7). The final dimension represents the level of internal and external integration among departments and clinical settings inside and outside a facility. Early development of ITS measures arose as researchers evaluated IT frameworks in manufacturing environments(8). The measures were adapted to acute care hospital settings and demonstrated excellent reliability (Cronbach's alpha) in each dimension mentioned above (IT Capabilities .81-.86; Extent of IT Use .71-.83; Integration, .67-.86)(6). The measures also proved reliable for the domains of care (Patient Care .79-.86; Clinical Support .82-.86; Administrative Activities .67-.81)(6). Our interdisciplinary team's preliminary work adapted the acute care ITS instrument for use in NHs(9). To accomplish this, we interviewed 12 IT stakeholders from four high-sophistication NHs in two states. These interviews included key informants as well as focus groups to explicate the dimensions of the ITS measure among three clinical domains. We further tested the survey instrument in a statewide study of nearly 200 NHs(10); we estimated internal consistency using Cronbach's alpha for each subscale of the NH ITS instrument. Cronbach's alpha values for the ITS dimensions among three clinical domains were as follows: Resident Care .87-.88; Clinical Support .86-.91; and Administrative Activities .69-.80. Values between these ranges have been found suitable for research purposes(11).

2.3 Quality Measures in Nursing Homes

To answer our study aims, our primary outcomes included resident outcomes as measured by QMs found in the publicly available Minimum Data Set information known as Nursing Home Compare(12). Using this information to analyze quality of care and resident outcomes in NHs is of interest, because NHs are federally mandated to obtain data for all NH residents upon admission, at times of significant changes in condition, quarterly for selected items, and annually for all facilities participating in Medicaid and Medicare(13). The Minimum Data Set's multidimensional, resident-specific items measure quality of care more directly than do proxy measures, such as the facility survey citations commonly used in NH research(14).

QMs were developed by researchers and reviewed by a Technical Expert Panel sponsored by the Centers for Medicare and Medicaid Service (CMS) in 2000. As a result of this work, a national set of QMs were recommended for public reporting and quality improvement initiatives. CMS continuously updates and improves the Nursing Home Compare website. Recent updates mandated by the Affordable Care Act required the development of new MDS 3.0 QM data, available in early 2012. Major changes to the MDS 2.0 assessment that resulted in the MDS 3.0 include two Long-Stay Quality Measures identifying residents who become more depressed or anxious and residents with moderate to severe pain; additionally, two short-stay measures had major changes, including identifying residents with delirium and residents who had moderate to severe pain. Other changes took place in 2015 related to influenza vaccine measures (13). As a result of these changes, resident voice was captured with self-reported interviews included during assessments to evaluate cognition, mood, preferences, and pain. All changes resulted in high-reliability estimates and improved content, clarity, and form of the MDS 3.0 compared to MDS 2.0. Our Dependent Variables in this study included 12 Long-Stay Quality Measures and three Short-Stay measures(12). Long-stay measures are obtained for patients who enter a NH because they are not able to care for themselves at home. These residents' stays range from several months to several years. Short-stay measures are obtained for patients who are admitted to a NH for a stay less than 30 days. Short-stay residents are typically acute-care patients just released from a hospital or those needing high-intensity rehabilitation or clinically complex care.

QMs are risk adjusted to account for variations in resident acuity to allow comparisons of care delivery between different facilities. Risk adjustment helps ensure that Quality Measures provide a true and fair picture

of clinical care for each NH. Researchers obtained publicly reported QMs for all facilities in this study from Nursing Home Compare, a national database that includes NH QMs for every US facility. Characteristics such as functional ability and mobility levels put some residents at higher risk than others. Facilities that care for higher-risk residents will typically have higher QMs; likewise, facilities that care for lower-risk residents will have opportunities for lower QMs. Risk adjustments make the results comparable between facilities by reflecting the quality of care provided rather than differences in resident populations. No previous studies have linked NH IT with national QMs. Our study will supply vital trend data about IT capabilities, extent of IT use, and degree of IT integration, all necessary to improve resident care outcomes in NH. Vital data collected will also include information on the efficacy of certain IT capabilities versus others and overall ITS among participating facilities.

3. METHODS

3.1 Approach

This proposal included a longitudinal, three-wave, repeated measures study measuring ITS using responses to an annual national survey of IT stakeholder respondents appointed by NH Administrators. In Aim 1, we used three annual survey responses to explain trends in three dimensions of ITS (IT Capabilities, Extent of IT Use, and Degree of IT Integration among internal/external stakeholders) among three domains of NH care (Resident Care, Clinical Support, and Administrative Activities). In Aim 2, we downloaded QMs from the national Nursing Home Compare data set quarterly during the period when NHs were completing ITS surveys. We used NH Medicare provider numbers to link ITS scores with the Nursing Home Compare data. The team used linkages among variables to determine whether positive associations existed between patterns in ITS scores and QMs. In Aim 3, we investigated statistical associations between changes in ITS scores, NH attributes (including Staffing, Facility, and Market Characteristics), and QMs obtained from the Nursing Home Compare national dataset. We used a mixed model approach to estimate and test changes in each type of ITS score among combinations of different NH attributes and time, after adjusting for the effect of other NH attributes in the model.

3.2 Sample

As preliminary work to determine the sample for this study, we downloaded Nursing Home Compare files in Sept 2010. Our inclusion criteria were all NHs in the data set located within the continental USA, Alaska, and Hawaii. We excluded NHs in Guam, Puerto Rico, and the US Virgin Islands. In total, 15,689 NHs were identified in the data set. We collapsed the type of ownership into two categories, For-Profit and Nonprofit NHs (Nonprofit included NHs with a government classification in Nursing Home Compare). We used Rural-Urban Commuting Area Codes, using ZIP code information to classify the homes by location. Rural-Urban Commuting Area Codes version 2.0 was created based on 2000 Census commuting data and 2004 ZIP codes (15). ZIP codes from Nursing Home Compare were matched with ZIP codes from the area codes database, which allowed us to classify the homes into four regional locations based on population amounts: Metropolitan >50,000; Micropolitan 10,000-49,999; Small town 2,500-9,999; and Rural <2,500. The majority of US NHs are for profit and in metropolitan areas. Most facilities in this group (54%) have between 60 and 120 beds. The smallest proportion of for-profit homes are located in rural areas with fewer than 2,500 people and are smaller facilities, with <60 beds. Similarly, most nonprofit NHs have between 60 and 120 beds per facility and are metropolitan. Rural areas have the fewest large bed size homes (>120 beds). We drew on this sample of NHs in the US to identify our target sample for the study: 10% of the NHs from each state.

3.3 Recruitment

Drawing on Nursing Home Compare, we recruited 10% of the NHs from each US state that met our inclusion criteria (N=1,570 NH). During our recruitment phase, we excluded NHs with a Special Focus Facility designation in the Nursing Home Compare database. Special focus facilities are those facilities with a history of serious quality issues and are included in a special program to stimulate improvements in their quality of care. Approximately 1.2% of the NHs nationally were considered Special Focus Facilities in Jan 2013(16). The number of facilities selected in each state was proportional to the number of NHs located in that state. For example, because California had the largest number of homes (1241) and Alaska the fewest (15), researchers randomly selected 124 homes from all of California NHs and two Alaskan NHs. We did not stratify the NHs prior to the random selection process because, in some states, there were NHs missing within some strata. Wyoming, for example, had only 38 homes, and there was a deficiency of large homes in rural areas. Every home in each state---regardless of ownership, bed size, or regional status---had an equal opportunity to participate by including every NH in the random selection process prior to stratification. Researchers achieved a

random selection by state by taking a simple random sample that was equal to 10% of the total population of NHs in each state. Based on our previous study in Missouri, approximately 40% of the NHs participated; therefore, we randomly recruited facilities from each state until we reached 10% of the facilities in each state. In SAS (SAS Institute Inc., Cary, NC, USA), random selection can be done by direct programming or by using the SURVEYSELECT procedure.

During initial contact with NH administrators, we described the study purpose. Researchers explained that respondents needed to complete the ITS survey one time annually for 3 years. Based upon our preliminary work with the survey(17), we informed NH administrators that respondents who were knowledgeable of NH IT systems required a maximum of 1 hour to complete the survey. If the NH administrator agreed to participate, a cover letter was sent describing the study's purpose, instructions how to use the ITS tool, voluntary participation, and benefit/risks of participation. Letters from national organizations received in support of this study were included in recruitment materials. The NH administrators were asked to select a site respondent who had oversight of IT functions within the NH facility and who had knowledge of other key IT stakeholders within the organization. The site respondent was responsible for completing the ITS profile for the NH and became the primary point of contact for the study. To reduce respondent burden, repeat respondents who participate in year 2 and/or 3 were not required to complete Section V, 11 questions in the demographic section, but provided updates from the previous year during contacts. If turnover occurred between survey years, we provided information about prior survey(s) for comparison to respondents. To encourage participation, we adopted graded incentive payments for respondents completing surveys: Year 1, $25.00; Year 2, $40.00; Year 3, $50.00 (Maximum $115.00).

We maintained a recruitment table of participating and nonparticipating NH administrators in an Excel file. The recruitment table included the following information about recruitment efforts: number of facilities contacted, persons contacted at each facility, packets/links sent, surveys received, initial numbers of administrators who could not be reached, contact calls made, follow-up calls made, confirmations received (will complete and not completed), stated completions, and follow-ups who could not be reached. To increase response rates, we extended our follow-up period to include at least three follow-up phone calls (more than in previous work) to the administrator and/or the respondent at 2-week intervals. If needed, we repeated mailings. Seven part-time graduate and undergraduate students participated in the recruitment effort over the duration of the study. If an NH did not return the ITS survey 8 weeks after the initial contact, we counted it as an initial nonresponder and randomly selected another facility from the same state. We did not contact initial nonresponders again.

The team used several strategies to minimize nonresponse and attrition. First, we employed an extended call-back schedule over 8 weeks. Investigators undersampled hard-to-reach NHs by half and devoted twice as much effort to contact remaining NHs. We reduced refusals by offering participating NH administrators annual study feedback reports that describe current levels of ITS trended nationally. We provided each responder a yearly incentive after they returned each completed survey. Five facilities that participated in all three annual surveys were offered a $250 gift card to be used at their discretion.

3.4 Data Sources/Collection

Two data sources were used in this study (1) a survey of ITS dimensions and domains and (2) nationally reported NH QMs from Nursing Home Compare.

3.4.1 Measuring Dimensions of ITS. The entire survey had 58 questions; of those, 47 questions related to the ITS dimensions and domains of NH care, and 11 questions gathered descriptive information. The majority of survey questions assessed the degree of IT Integration with other care delivery systems. In the IT Capabilities ITS dimension, respondents checked boxes for computerized IT capabilities; non-computerized IT capabilities did not receive checkmarks. For the analysis, codes for respondents' checkmarks were give as IT is Available or Not Available and scored as either 1 or 0, respectively. In this section, an 'Other' checkbox with free text allowed respondents to include any IT capability used in resident care not identified on the survey. The 'Other' checkbox was coded as 1 if IT capabilities were noted in the free-text field. In the Extent of IT Use dimension, respondents choose the most appropriate response after evaluating the extent of IT use in each domain of healthcare. Responses range from 0 to 7. A response of 0 indicated that IT capabilities for that domain were not available. If NH IT capabilities, such as a clinical decision support system, were being used, respondents rated the extent of use of each capability on a scale from 1 (barely used) to 7(extensively used). In the Integration with Internal/External Stakeholders ITS dimension, respondents indicated the extent of

integration (electronic and automatic transfer of information) among systems in the NH. Responses range from 0 (not at all) to 6 (very much) integration.

3.4.2 Domains of ITS in NH Care (Resident Care, Clinical Support, and Administrative Activities): In the Resident Care domain, respondents evaluated clinical IT applications that staff used while performing resident care, including how IT was used by nurses during admission, discharge, and transfer of NH residents and how IT was used for tracking medical records. The Resident Care portion of the survey was composed of two sections. The first section, Resident Management, evaluated which technologies were used to support resident care processes. The second section, Resident Care Activities, asked respondents to identify technologies used by Physicians, Nurses, and Physical Therapy/Occupational Therapy disciplines. The third section, Clinical Support, investigated clinical IT capabilities in laboratory, radiology, and pharmacy. For instance, under Clinical Support activities for laboratory, the survey asked whether NH administrators have the capability to capture laboratory test results electronically and if recurring laboratory tests are available via computer systems. In radiology, respondents evaluated whether NHs have picture-archiving systems that allow integration and sharing of radiological images between settings, such as nursing. Clinical Support for pharmacy processes was also assessed, such as if resident drug profiles can be checked electronically, if medication delivery systems exist, and if pharmacists can check for drug interactions or provide allergy alerts for staff. The fourth section, Administrative Activities, assessed IT staffing, connectivity technologies, automation, and internet-based applications. Respondents described IT staffing as how many regular IT personnel were available for the NH and how many external consultants or subcontractors assist with maintaining IT systems. We also measured the databases, networks, operating systems and inter/intranet applications used to maintain systems. Finally, section V asked for general demographic information about the respondent, such as job title, education, and number of years in their current position. We also requested basic information about the NH, including the IT budget, outsourcing of IT, the NH name, and Medicare provider number. We used the Medicare provider number for dispersing incentive payments and linking to the Nursing Home Compare QMs.

3.4.3. Nursing Home Compare. Files downloaded from the Nursing Home Compare website yield four zipped data files, including (1) About Nursing Home Compare, which included NH demographics, ownership information, and total number of residents; (2) Inspect Results, which provided data on inspection results, including citation history and date of last inspection; (3) About NH Residents, which contained the QM scores; and (4) Nursing Home Compare—About Staff, which contained staffing data. We used elements of all four data sets to complete the analyses.

Outcome measures were collected from Nursing Home Compare and included 12 Long-Stay QMs that identified the percentage of residents 1) whose need for help with activities of daily living has increased; 2) who have moderate to severe pain; 3) who are at high risk and have pressure sores; 4) who are at low risk and who have pressure sores; 5) who are physically restrained; 6) who are more depressed or anxious; 7) who are at low risk and lose control of their bowel or bladder; 8) who have/had a catheter inserted and left in their bladder; 9) who spend most of their time in bed or on a chair; 10) whose ability to move in and around their room got worse; 11) who have a urinary tract infection; and 12) who lose too much weight. Three Short-Stay QM outcomes identified the percentage of residents 1) with delirium; 2) who have moderate to severe pain; 3) and who have pressure sores.

We selected time-variant and time-invariant variables that represented NH attributes related to Staffing, Facility, and Market Characteristics from Nursing Home Compare because of consistent links with quality outcomes. Examples of study variables obtained from Nursing Home Compare included 1) Staffing Characteristics: Registered Nurse Staffing Intensity (RN hours/resident/day) and Skill Mix (RN hours out of total staff hours)---both variables are time variant; 2) Facility Characteristics: Organizational Size (Number of Beds), NH Ownership Type, and Occupancy Rate---the first two are time invariant and the last one is time variant.

3.5 Procedures

3.5.1 Conducting ITS Surveys: We collected data from each NH using three consecutive annual surveys. Recruiters contacted each NH administrator by phone and asked to select a site respondent who had oversight of IT functions and knowledge of other key IT stakeholders in the facility. The site respondent had to be responsible for completing the ITS profile and would receive increasing monetary incentives each time they complete a survey.

Respondents completed surveys either online or in paper form. Letters with paper forms included cover letters and postage-paid return envelopes. The team maintained an online account for electronic surveys, http://freeonlinesurveys.com. The online method was beneficial, because reporting can occur on up to 1,000

responses, investigators performed less manipulation of respondent data, privacy and confidentiality were excellent, no time limit existed on storage of information, password protection was offered, customization and personalization with the School of Nursing logo was possible, and results were automatically downloaded into a database that allowed real-time data collection, storage, and analysis. Study staff monitored and downloaded all data at regular intervals during the study to avoid reaching the maximum 1,000-response limit.

After receiving each paper ITS survey, the Project Director and Graduate Research Assistants double-entered data using Microsoft Office XP, Excel 2010, to ensure accuracy. The team resolved uncertainties and discrepancies in data entry by agreement between two independent reviewers. After all the online ITS measures were completed, the team exported data electronically from the stored files on the password-protected website into an Excel database. After all the ITS measures (paper and online) have been obtained, the two files were merged into one Excel file and stored on a password-protected computer in the team's private research office. Statisticians downloaded Excel databases to the statistical processing package in SAS for data analysis. All missing responses on each ITS survey was given a score of 0, which was a conservative approach to estimate ITS.

3.5.2 Scoring ITS Surveys. Here is an example of how we tabulated scores. The instrument's Resident Care Management and Resident Care Activity sections included four questions about IT Capabilities. Question 1 is a general question about how IT Capabilities support resident care management, such as in admission processes; its scoring range is 0-6. Question 4 asks whether physicians have IT Capabilities for resident care activities, such as documenting progress notes; its scoring range is 0-7. Question 9 asks about IT Capabilities to support nursing activities, such as medication administration, documenting nursing flow sheets, and incident reporting; its scoring range is 0-14. Question 12 inquired about IT Capabilities supporting physical therapy/occupational therapy activities, such as care planning or consultations; its scoring range is 0-9. The sum of these questions' maximum scores (6+7+14+9=36) gives a total possible range of 0-36 for IT Capabilities in the Resident Care ITS domain. The maximum overall raw ITS score that a NH facility can receive for all dimensions and domains is 628.

In all analyses, we derived initial weights according to the proportions of homes in a state that responded. The responding homes differed typically relative to numbers of homes with characteristics of size, ownership, and location. Statisticians used post-stratification to re-weight homes to reflect the distribution of homes with these characteristics in the population. These post-stratified weights were used in all analyses.

3.5.3 Quality Measures: We unzipped and downloaded QM data captured from the Centers for Medicare and Medicaid website into Access (Microsoft Office 2003), a relational database used to manipulate data. Using the power of the relational database, we extracted data elements stored in Nursing Home Compare using a distinct identifier or Medicare provider number for each NH. We used the Medicare provider number that distinctly identifies each home and is common to each dataset as we created the final database with all the elements needed for the analyses. This provider number was linked to the provider number that site respondents provided on the ITS survey. In this way, we linked QM data and ITS survey data for each home. The team did not report individual provider numbers that linked data sets. To prepare for analysis, we queried each of the four datasets described for the appropriate data elements.

In this study, we extracted QMs from Nursing Home Compare quarterly during the period that the ITS survey was being conducted. Linking survey responses and QMs that are reported at similar times enabled the team to reflect QM scores present when ITS is being evaluated in the facilities. For each facility, we used four quarters of data to estimate annual QM averages for each QM type for the period that the annual ITS survey is conducted in each facility (see Timeline Table 2).

3.6 Limitations

We recognize there are limitations to our research. First, this study is a longitudinal, three-wave, repeated measures design that takes into account the longitudinal patterns in changes of ITS measures over 3 years and the effects of IT use on quality of care and resident outcomes. To reduce the potential effect of history on this study, ITS data collection was limited to three annual waves. We completed each wave over six quarters.

We also recognized response bias as another limitation for the NHs that chose not to participate. Some NHs may not have participated because they had no technology, which could have resulted in overall higher level of ITS than actually existed. Some NHs may not have joined the study because administrators did not have requisite knowledge to complete the survey. We offered help to overcome these barriers by providing our contact information and answering questions. Our team's availability should have reduced respondent burden

and did result in increased participation. Additionally, our large sample size provided greater representation across different types of homes.

The use of the publicly available Nursing Home Compare dataset is another limitation. The federal dataset is an important tool that the public and long-term care industry use to evaluate performance; however, the accuracy and completeness of data have been problematic in the past, creating some question regarding its reliability. Two General Accounting Office reports(18, 19) examined accuracy and reporting of measures in Minimum Data Set and found limitations in the measures and opportunity for misinterpretation; however, others have concluded that data could still be used to measure good and poor quality-of-care practices(20). No feasible alternatives exist for measuring quality across the 16,100 NHs in the United States.

A lack of consistent terminology or consistent usage of terms for some of the variables in the ITS survey could affect the accuracy of estimating IT. For example, respondents from different facilities may interpret the same term differently. Furthermore, we tested the ITS tool in only one statewide pilot study. However, it was not likely that any estimation led to substantial differences that would render our assessments invalid. For example, if a respondent misunderstood the question asking about the extent of use of electronic laboratory test results reporting in the NH, it is unlikely that the point estimation by the respondent was so far off that it changed the inferences made from this evaluation. Last, as a result of recent standardization efforts, terminology for variables is better defined, which leads to less ambiguity in questionnaire items. We worked with our IT consultants to ensure that our terminologies were consistent with other national surveys on similar topics.

Table 1: IT Sophistication Survey Completion Results for Three Annual Surveys

Year	Total Surveys/Completed	Response Rate
Year 1: 2015	815/1799	45%
Year 2: 2016	456/815	56%
Year 3: 2017	448/815	55%
All YEARS	306/815	38%

4.0 RESULTS

Table 1 provides an overview of survey completion results of the three annual surveys by year and for all years in this study. Response rates were higher, especially in years 2 and 3, in this study compared to preliminary studies. We had 38% of NH respondents complete all 3 years of the annual survey. Every year, recruiters were able to get respondents from every state in the US to complete surveys. Figure 1 illustrates the location of facilities completing surveys in Year 1.

4.1 Principal Findings

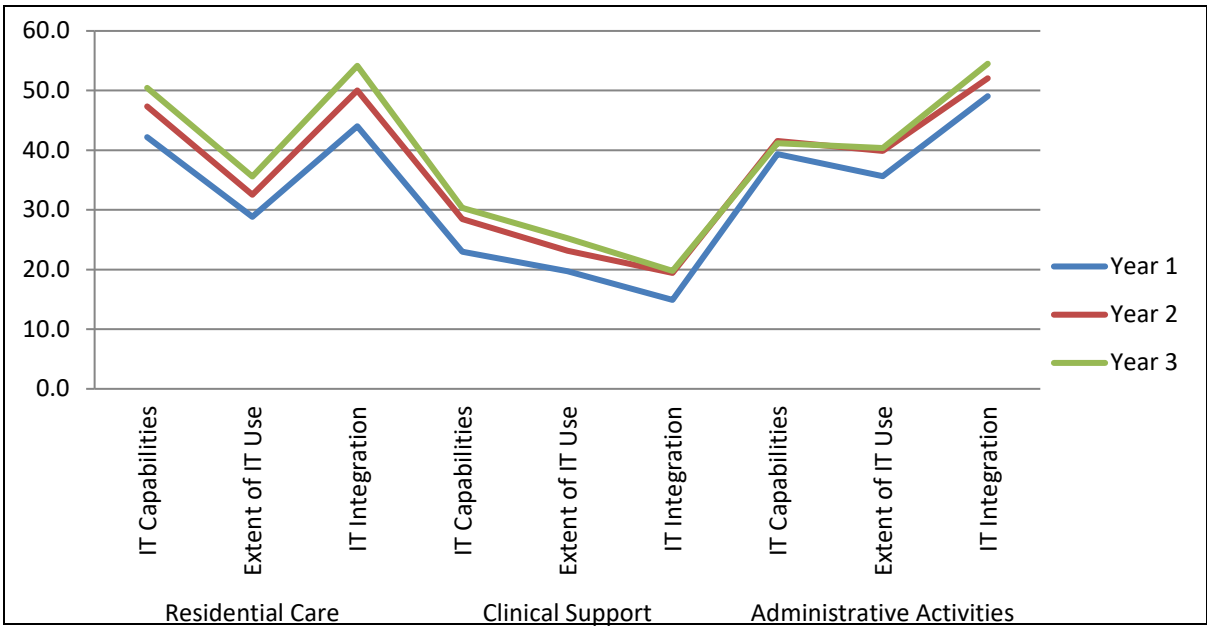
The research team conducted several analyses beginning with data from Year 1. The principal findings from the study follow a logical sequence of analysis, followed by peer-reviewed publications beginning with baseline assessments of ITS reported in participating facilities in Year 1 and then by trends identified in each ITS dimension and healthcare domain in Years 2 and 3. From the graph (Figure 2), you can see that, for each subscale and the total, the means are consistently in the order Y1 < Y2 < Y3. Although the means are consistently increasing, the changes may not be statistically significant. To address this issue, we used the 306 homes that returned surveys in all 3 years. For each pair of years (Y2-Y1, Y3-Y1, and Y3-Y2), we obtained estimates of the mean differences. Additionally, we found 99% confidence interval estimates (we incorporated 99% intervals rather than 95% to be conservative in our conclusions about changes). The team considered the change significant if the confidence interval did not contain zero. For Y2-Y1 changes, all resident care ITS dimensions significantly increased, as did IT capabilities and extent of IT use in the clinical support domain. Clinical support integration and all ITS dimensions in administrative activities did not reach significance. The Y3-Y2 changes were not as great, with only IT integration in resident care and administrative activities and Total-ITS having positive confidence intervals. When looking at the 2-year change of Y3-Y1, all ITS dimensions and health domains were significant except IT capabilities in administrative activities.

4.1.1 Year 1 Baseline ITS Results. During Year 1, the research team made over 27,600 phone calls during the recruitment period. The recruitment team reached 2,627 NH administrators across the US. Of these, we sent a survey to 1,799 administrators who agreed to participate. Of those, 815 completed surveys (45.3% response rate) by the end of the recruitment period; 735 facilities (90%) completed electronic surveys, and the remainder were paper surveys. Although our recruitment goal was 10% from each state, the team did not reach the goal. However, facilities represented each state in the final sample.

Figure 1: Nursing Homes Participating in IT Sophistication Survey Located by Zip Code (Year 1, N=815)

In analysis, our team initially assessed NH demographics in the sample compared to the remainder of NHs in the national population. All but two ownership categories had similar national statistics represented (within 1%) for each ownership type. In the sample, the majority of NHs that completed surveys were corporately owned for-profit (54.9%) and nonprofit (25.9%) agencies. The two types of ownership not as well represented in the sample were county-owned government facilities and nonprofit corporations. In the sample, slight under-representation occurred in county-owned government facilities, and over-representation in nonprofit corporations compared to national statistics. Similar to other homes in the US, most NHs sampled were located in metropolitan areas with a population greater than 50,000. In the sample, 97 facilities (11.9%) were located in rural locations with fewer than 2,500 people. This compares with 9.3% of the NHs in rural locations nationally. Finally, the majority of facilities in the sample were medium-sized facilities with 60-120 beds. The proportion of our sample comprising smaller facilities, those with <60 beds, were within 1% of national averages. Mean nursing home bed size was 100.2 per facility, compared to the national mean of 106.6 certified beds per facility. The team calculated means for total residents occupying a certified bed. Nationally, an average of 87.7 residents per facility occupied certified NH beds, versus 82.3 residents per facility in this NH sample.

Figure 2: 3-Year Trends in IT Sophistication Dimensions in Health Domains



When comparing healthcare domains, there appear to be greater IT capabilities in resident care and administrative activities than clinical support. The extent of use of IT across the three healthcare domains overall appears to be greatest in administrative activities, followed by resident care. The extent of use of IT appears to be lowest in clinical support domains of care. There is a higher level of IT integration in resident care than in administrative activities or clinical support. IT for clinical support activities has the lowest IT sophistication scores across each survey dimension, capabilities, extent of use, and integration. However, in the clinical support domain, a few outlier facilities reported greater IT capabilities, extent of use, and integration than the majority of facilities. A particularly interesting finding, occurring in each healthcare domain, is that IT capabilities appear to be greater than IT extent of use, with the greatest difference appearing in resident care. This could indicate that facilities may not be using IT capabilities to their fullest extent possible.

Table 2 provides a breakdown of the estimated ITS scores for the NH sample in quartiles. There is nearly a 200-point difference in total ITS reported by survey respondents in facilities within the lowest (25%) and highest (75%) quartiles. NHs with the lowest (25%) total ITS scores were 193.6 or below. Facilities in the highest quartile (75%) of NHs reported 388.2 and above (maximum total ITS score is 900). Based on quartiles, the highest ITS scores present were reported in the resident care domain and degree of integration with internal and external stakeholders, for which the 75th percentile was 68.0 (Maximum score 100). The lowest ITS scores are noted in the clinical support domain, for degree of IT integration with internal and external stakeholders, for which both the 25th percentile and the median were 0.

Table 2. IT Sophistication Scores by Quantiles Year 1

	25th Percentile	Median	75th Percentile
*Residential Care			
IT Capabilities	27	42.8	58.8
Extent of IT use	14.3	29.3	41.4
Degree of Integration	22	43.9	68
*Clinical Support			
IT Capabilities	1.3	17.6	33.2
Extent of IT use	0	13	32.8
Degree of Integration	0	0	22.6
*Administrative Activities			
IT Capabilities	21.3	37.3	57.7
Extent of IT use	24.1	35.7	46.3
Degree of Integration	36.1	47.7	59.8
**Total IT Sophistication	193.6	284.3	388.2

* Maximum score=100; **Maximum score=900

4.1.2 Year 1 Baseline ITS Relationships to QMs. Table 3 provides statistics comparing QMs between the study sample and all other (non-study) NH. Calculated QM means for the study sample are within 1% of all other homes nationally. The largest difference (0.9%) between long-stay QMs is the number of residents receiving antipsychotic medications, with residents in non-study homes receiving slightly more of these medications (18.1%) than did those in study homes (17.2%). The largest difference (1.0%) in short-stay QMs is the number of residents who were given pneumococcal vaccinations. A greater percentage of residents in the study homes receive vaccinations (82.8%) than did all other residents nationally (81.8%).

Table 4 provides results of calculated Spearman correlation values between NH QMs and ITS scores for the sample. Correlations with QMs are illustrated within combinations of the three healthcare domains (resident

care, clinical support, and administrative activities), three ITS dimensions (IT capabilities, extent of IT use, and degree of IT integration), and total ITS. The largest correlations (r = 0.13 to 0.21), although weak by

Table 3: QM Comparisons Between the National and Study Sample Population Year 1

Quality Measures Percent of Long-Stay Residents	National Sample (N)	Study Sample (n)	National Mean μ	Sample Mean μ
Activities of Daily Living Needs Increased	13999	794	15.6	16.1
Who Report Mod to Severe Pain	13936	792	8.1	8.6
With Pressure Ulcers	13938	787	5.9	5.6
Who Lose Too Much Weight	14183	798	7.4	7.5
Bowel or Bladder Incontinent	13038	743	46.0	45.6
With Cath Inserted and Left in Bladder	14165	798	3.2	3.0
With a Urinary Tract Infection	14188	798	5.1	5.1
Who Have Depressive Symptoms	14168	797	5.6	5.1
Who Were Physically Restrained	14203	798	0.9	0.7
One or More Falls with Major Injury	14204	798	3.3	3.6
Assessed/Given Seasonal Flu Vaccine	14188	799	94.9	95.2
Assessed/Given Pneumococcal Vaccine	14204	798	93.6	93.5
Received an Antipsychotic Med	14152	795	18.1	17.2
Percent of Short-Stay Residents				
Who Report Mod to Severe Pain	13866	767	17.2	17.4
With New or Worsened Pressure Ulcers	14293	786	1.2	1.1
Assessed/Given Seasonal Flu Vaccine	14203	785	81.4	82.0
Assessed/Given Pneumococcal Vaccine	14339	786	81.8	82.8
Newly Received an Antipsychotic Med	13353	751	2.2	2.0

statistical standards, were found within all three resident care ITS subdimensions and the QM for Percentage of Low-Risk, Long-Stay Residents with Bowel or Bladder Incontinence. More specifically, these were positive correlations, indicating that, as ITS scores increased in resident care, so did the percentage of residents with bowel or bladder incontinence. This may indicate that facilities with more ITS may be accepting residents with higher care needs. Another notable finding was the range of negative correlations (r =−0.09 to −0.13) found in all ITS dimensions for clinical support and the QM identifying the Percentage of Long-Stay Residents with a Urinary Tract Infection. This relationship indicates that, as ITS scores increases, the percentage of residents with urinary tract infections appears to decline. Similarly, there appears to be a weak negative correlation (r = −0.11) between total ITS scores and the QM for Percentage of Residents Receiving Antipsychotic Medications. This suggests that, as ITS increases, the percentage of residents receiving antipsychotic medications decreases. These results may indicate that facilities with more ITS may be using IT to help staff track both of these clinical interventions and limit their use, having a potentially positive impact on clinical care.

4.1.3 Y2-Y1 Change from Baseline ITS. In examining differences between years 1 and 2, there were 456 of 815 homes with data at both times (56% response rate). In year 2, participating homes were from every US state. There were some differences in the homes that responded (in the sample) and those that did not (all other homes in the US) with regard to ownership, bed size, and location. The sample homes tend to be smaller (more in the 60-120 range and fewer in the >120 range) and more often from small town/rural areas. For this reason, post-stratification to reweight the homes was appropriate. Our team calculated estimated median differences between Year 2 and Year 1 for each subscale and the total ITS (see Figure 2). The differences that were significantly different from 0 (at the 0.01 level, based on 0 being included in a 99% confidence interval estimate) were resident care IT capabilities, resident care extent of IT use, resident care IT integration, and total IT sophistication (not shown). The median difference in resident care IT capabilities between Year 2 and Year 1 was +3.39; the difference in extent of IT use in resident care was +1.91; and the difference in degree of IT integration in resident care was +4.02. All other IT sophistication dimensions in clinical support and administrative activities also increased but did not reach significance. Overall, total IT sophistication increased by+28.1 from Year 1 to Year 2, and the change was significant.

Table 4: Spearman's Rank Correlations Between IT Sophistication Scores and QM Year 1										
	Residential Care Activities			Clinical Support			Administrative Activities			
Quality Measures: Percent of Long-Stay Residents	IT Capability	Extent of IT Use	Integration	IT Capability	Extent of IT Use	Integration	IT Capability	Extent of IT Use	Integration	total_IT
ADL Needs Increased	0.00	-0.04	0.02	-0.08	-0.08	-0.09	-0.02	-0.01	-0.03	-0.03
Who Report Mod to Severe Pain	0.08	0.03	0.06	-0.01	-0.07	-0.05	-0.11	0.02	0.01	0.00
High Risk With Pressure Ulcers	-0.01	-0.05	0.01	0.05	0.02	0.04	0.05	0.02	-0.01	0.01
Who Lose Too Much Weight	0.05	0.05	0.05	0.01	-0.02	-0.02	0.02	0.01	0.02	0.02
Low Risk Bowel or Bladder Incontinent	0.16	0.21	0.13	0.00	-0.01	0.05	0.09	0.19	0.16	0.16
With Cath Inserted and Left in Bladder	0.05	0.04	0.06	-0.01	-0.02	-0.02	0.01	0.04	0.03	0.03
With a Urinary Tract Infection	-0.06	-0.07	-0.05	-0.09	-0.13	-0.09	-0.08	-0.04	-0.09	-0.10
Who Have Depressive Symptoms	0.02	-0.03	0.00	-0.05	-0.04	-0.05	-0.07	-0.03	-0.05	-0.04
Who Were Physically Restrained	-0.02	-0.02	0.01	0.01	0.01	0.01	0.01	0.00	-0.02	0.00
One or More Falls with Major Injury	0.06	0.05	0.04	0.04	-0.02	0.05	-0.04	0.02	0.03	0.04
Assessed/Given Seasonal Flu Vaccine	-0.05	-0.03	-0.10	0.02	0.03	-0.05	-0.05	-0.02	-0.05	-0.05
Assessed/Given Pneumococcal Vaccine	-0.06	-0.02	-0.07	-0.02	-0.01	-0.03	-0.04	0.01	0.00	-0.03
Received an Antipsychotic Med	-0.09	-0.15	-0.11	-0.02	-0.05	-0.07	-0.08	-0.07	-0.09	-0.11
Percent of Short-Stay Residents										
Who Report Mod to Severe Pain	0.07	0.05	0.07	0.03	-0.03	-0.05	-0.04	0.01	0.01	0.02
With New or Worsened Pressure Ulcers	-0.01	-0.01	-0.04	0.03	-0.01	0.01	0.03	0.03	-0.01	0.00
Assessed/Given Seasonal Flu Vaccine	-0.11	-0.04	-0.10	0.01	0.02	-0.01	-0.04	-0.05	-0.04	-0.06
Assessed/Given Pneumococcal Vaccine	-0.07	-0.03	-0.07	0.02	0.02	-0.01	-0.02	0.00	0.00	-0.03
Newly Received an Antipsychotic Med	-0.03	-0.06	-0.05	0.05	0.02	0.02	0.01	-0.04	-0.03	-0.02
KEY: For all values, where *r* </= -.08 or >/= .08 is shaded in grey, findings are significant *(P <.05)*										

Investigators created a scatterplot (see Figure 3) to examine Year 2-to-Year 1 differences in total ITS scores. The scatterplot illustrates change in total ITS scores for each facility, Year 2-Year 1. Extreme changes correspond to points beyond the outer lines in the plot; some extreme changes are positive, indicating a drastic increase in total ITS in Year 2. Some extreme changes are negative, indicating a major loss in total ITS in Year 2 in some of the sample facilities. Next, the team looked at differences in total ITS score relative to NH characteristics. In the sample, there were no differences in total IT sophistication based on ownership. Estimated mean differences in total ITS scores in for-profit facilities (29.1) were similar to those in nonprofit facilities (31.1) and were not significant (P= .89). No significant differences in total ITS were found because of location (P = .66). Mean differences in total ITS relative to location ranged from 25.5 in metropolitan locales to 48.4 in rural locales. There were differences in total ITS due to bed size (P = .02). Small NHs (<60 beds) had a mean difference of only 8.4, but midsized NHs (60-120 beds) had a mean difference of 45.6.

4.1.4 Year 2-Year 1 ITS Differences and Relation to QMs. The team estimated correlations (using weights) between each of the QM differences and each of the ITS subscale differences. There were 26 estimated correlations that were at least 0.10 (in absolute value), including 12 different QMs (see Table 5). Some QMs were correlated with only one ITS sophistication scale, but the QM for % Long-Stay Residents Receiving an Antipsychotic Medication correlated with six different ITS scales. The team then examined each of the QMs separately using regression models. There were three in which the ITS scales were not significant predictors of QM change after adjusting for NH characteristics: % Long-Stay Residents Assessed/Given

Seasonal Flu Vaccine, % Short Stay With New or Worsened Pressure Ulcers, and % Short Stay Assessed/Given Pneumococcal Vaccine. Generally, when there were multiple ITS scales showing a relationship to QM differences, after backward elimination, only one QM scale was ultimately significant. The exception was % Long Stay with Urinary Tract Infection, in which differences in IT capabilities in Administrative Activities (P < .02) and in Clinical Support Extent of IT Use (P < .04) were both significant.

4.1.5 Year 3-Year 1 Change from Baseline ITS. In other Y1-Y2-Y3 analyeis, we noted the 2-year change in ITS scores from Year 3 to Year 1, and all were significant except IT capabilities in administrative capabilities.

Figure 3: Total IT Sophistication Difference Year 2-Year 1
Points above mid-line Year 2 Total IT Score higher
Points beyond outer reference lines Total ITS Score differs by 150

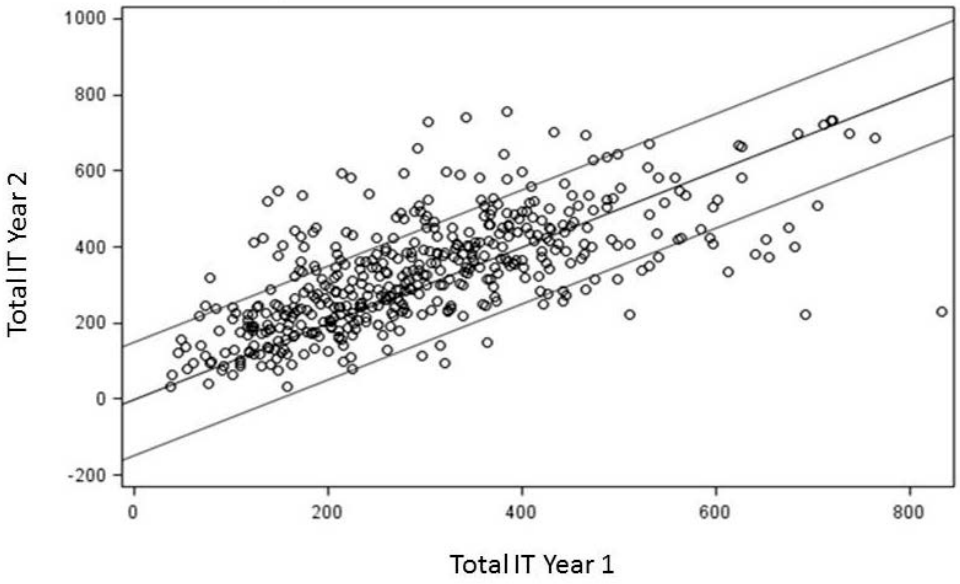


Table 5: Y2-Y1 estimated correlations (using weights) between ITS and QMs

Health Domain	IT Sophistication Dimension	Quality Measure (% Residents)	r	p
Resident Care	IT Capabilities	Received an Antipsychotic Med	0.17	0.02
	Extent of IT Use	Risk LS Bowel or Bladder Incontinent	-0.18	0.09
		Received an Antipsychotic Med	0.12	0.13
		With New or Worsened Pressure Ulcers	-0.10	0.23
	IT Integration	Received an Antipsychotic Med	0.11	0.14
		Assessed/Given Pneumococcal Vaccine	0.11	0.09
Clinical Support	IT Capabilities	ADL Needs Increased	-0.11	0.05
		Who Were Physically Restrained	0.11	0.05
		Assessed/Given Seasonal Flu Vaccine	0.11	0.13
		Assessed/Given Pneumococcal Vaccine	0.14	0.09
		Received an Antipsychotic Med	0.22	0.00
	Extent of IT Use	With a Urinary Tract Infection	0.12	0.05
		Who Were Physically Restrained	0.10	0.05
		Assessed/Given Pneumococcal Vaccine	0.20	0.03
	IT Integration	Who Were Physically Restrained	0.13	0.01
		Assessed/Given Pneumococcal Vaccine	0.14	0.13
		Received an Antipsychotic Med	0.11	0.09
Administrative Activities	IT Capabilities	Who Report Mod to Severe Pain	-0.18	0.00
		Who Lose Too Much Weight	0.10	0.06
		with Cath Inserted and Left in Bladder	-0.12	0.02
		With a Urinary Tract Infection	-0.14	0.01
	Extent of IT Use	ADL Needs Increased	-0.14	0.02
	IT Integration	Assessed/Given Pneumococcal Vaccine	0.14	0.13
	Total IT Sophistication	Who Were Physically Restrained	0.11	0.02
		Assessed/Given Pneumococcal Vaccine	0.11	0.26
		Received an Antipsychotic Med	0.18	0.02

We estimated the effect of NH characteristics on the total ITS score changes (Year 3-Year 1). For location, the overall test is not quite significant at the 0.05 level (p=0.07). There is a suggestion that small towns (estimated mean difference 80.2) improved more than rural areas (estimated mean difference 18.3). For bed size, differences were not significant (p=0.16). Larger homes had a greater increase (73.9) than did smaller homes (34.7). For ownership, for-profit homes had a mean increase of 61.1, but nonprofits had an increase of 45.3. The difference was not significant (p=0.23). We also looked at being part of a chain. Those facilities that were members of a chain had an increase of 49.8, but non-chain members had an increase of 58.1. The difference was not significant (p=0.67).

4.1.6 Year 3-Year 1 ITS Differences and Relation to QMs. To look for consistency in what was seen in previous analysis in our Year 3-Year 1 estimates, we looked at simple correlations between ITS scales and the total with each of the QMs (using post-stratified weights). Roughly, correlations > 0.15 in magnitude are significant at the 0.01 level (see Table 6). There are 19 such values. A magnitude of 0.15 is still not terribly large in explanatory value. Total IT is correlated with three different QMs. The most common IT variable in the list of 19 is extent of IT use in resident care, which shows some correlation with five different QMs. One of the most interesting QMs in the list of 19 is the % of Low-Risk, Long-Stay Residents with Bowel or Bladder Incontinence, which shows some correlation with five different IT scales, all in a positive direction.

Table 6: Year 3–Year 1 Simple Correlations between ITS and QMs (using post-stratified weights)

Healthcare Domain	IT Dimension	Quality Measure	R	R^2	p Value
Resident Care	IT Capabilities	Low Risk LS Bowel or Bladder Incontinent	0.14	0.02	0.012
		LS With a Urinary Tract Infection	-0.19	0.03	0.002
		LS Assessed/Given Seasonal Flu Vaccine	-0.15	0.02	0.028
	Extent of IT Use	High Risk LS With Pressure Ulcers	-0.18	0.03	0.004
		Low Risk LS Bowel or Bladder Incontinent	0.19	0.04	0.004
		LS With a Urinary Tract Infection	-0.14	0.02	0.018
		SS With New or Worsened Pressure Ulcers	-0.16	0.02	0.003
		SS Newly Received an Antipsychotic Med	-0.15	0.02	0.049
	Degree of IT Integration	Low Risk LS Bowel or Bladder Incontinent	0.20	0.04	0.001
Clinical Support	IT Capabilities	SS Who Report Mod to Severe Pain	-0.18	0.03	0.001
	Extent of IT Use	LS Who Report Mod to Severe Pain	-0.16	0.03	0.004
	Degree of IT Integration	LS Received Antianxiety/Hypnotic Meds	-0.17	0.03	0.004
Administrative Activities	IT Capabilities	Low Risk LS Bowel or Bladder Incontinent	0.20	0.04	0.004
	Extent of IT Use	SS Residents Improved in Function	0.15	0.02	0.030
	Degree of IT Integration	LS Worsened Ability to Move Independently	0.16	0.03	0.008
		LS Received Antianxiety/Hypnotic Meds	-0.16	0.03	0.006
	Total IT Sophistication	Low Risk LS Bowel or Bladder Incontinent	0.15	0.02	0.027
		LS With a Urinary Tract Infection	-0.15	0.02	0.010
		LS Received Antianxiety/Hypnotic Meds	-0.15	0.02	0.008

Key: LS=Long Stay; SS=Short Stay

5.0 DISCUSSION

Increasing ITS in healthcare may be a grand solution toward improving quality of care, maximizing efficiencies, and increasing confidence in safe care. Therefore, trending both ITS and quality of care concurrently to establish the validity of this claim is paramount. However, gaps continue in our understanding of trends in ITS and quality, at least in long-term care settings. This research addresses this gap by specifically reporting on ITS trends in NH care and QMs over 3 years. Trending ITS provides a new measure of how work processes are changing through gains/losses in IT capabilities, extent of IT use, and degree of integration. Trends in ITS then become important indicators for change in QMs, two variables that have not been studied and reported together on a consistent basis. This study found that, during a 3-year period, participating facilities increased ITS in each dimension and domain of healthcare. Significant relationships were discovered in every dimension of ITS and Total ITS in all healthcare domains. One important finding is that significantly more facilities had gains than losses in ITS during this study (Figure 3). This finding supports preliminary work describing significant gains in clinical support technologies in nursing homes. In the current study, change in extent of use of clinical support technologies (e.g., IT used for laboratory systems) was an important predictor of the % of residents with urinary tract infections. Another finding, rapid ITS fluctuation,

indicates that some facilities are experiencing significant instability in their adoption process, either through IT implementation (gains) or abandoning IT systems (losses); this finding also supports preliminary work. Information technology implementation creates disruptive forces, possibly augmenting provider workflows, clinical processes, or access to key information. Disruptive experiences can influence user satisfaction and perceptions of the effectiveness of technologies, which can impact adoption and quality and safety. Abandonment of IT systems can occur because of unmanageable issues encountered by leadership and staff, also leading to potential quality and safety risks. Important issues identified by LTC administrators include health IT design, fit to workflow, lack of information to support the process of care, excessive documentation and handoffs, and interoperability. Ultimately, this study demonstrates that increasing IT sophistication in every health domain seems to influence QMs in these facilities. For example, QMs significantly correlate with multiple ITS scales, indicating that IT may have broader impacts across an organization. Continuing to trend IT capabilities, extent of IT use, and degree of integration beyond this 3-year period provides an opportunity to assess the future impact of federal legislation driving IT adoption to improve quality.

6.0 CONCLUSION

Some healthcare leaders believe that IT creates patient safety issues and workarounds across all types of settings, patient populations, and IT vendors. This belief provides evidence that trends in ITS have implications for all professionals who lead clinical practice interventions, including IT implementation. Some of those implications, such as ITS gains/losses in short periods, have impacts on care delivery and stakeholders, such as IT developers, who are building systems for care delivery and nurses who use them. In this study, knowledge about trends in IT help us understand the impact on quality of care occurring in NHs. The realization that multiple dimensions of ITS influence QMs in every healthcare domain provides an opportunity to design a reporting system that joins these important variables, to be assessed on a national scale, which can help define greatest areas of need for which IT systems can improve care quality.

7.0 PUBLICATIONS

Accomplishments and Deliverables Initial AHRQ RO1 Study		
Peer Reviewed Journal	Published Alexander GL, Madsen RW, Miller EL, Schaumberg MK, Holm AE, Alexander RL, Wise KK, Dougherty ML, and Gugerty B. (2017). A National Report of Nursing Home Information Technology: Year One Results. *Journal of the American Medical Informatics Association*, 24*(1)*, 67-73. DOI: dx.doi.org/10.1093/jamia/ ocw05. First published online: 23 April 2016	PMID: 27107444 Supported by grant No. R01HS022497 from AHRQ
	Alexander GL and Madsen RW. (2017). A Report of Information Technology and Health Deficiencies in Nursing Homes. The Journal of Patient Safety. Epub ahead of print 06/2017.	PMID: 28562423
	Alexander GL, Madsen RW, and Newton M. (2017). Analyzing Change in Nursing Home Information Technology Sophistication: A 2-Year Survey. Journal of Gerontological Nursing.doi: 10.3928/00989134-20161215-05	PMID: 28091687 Supported by grant No. R01HS022497 from AHRQ.
	Alexander GL, Madsen RW, Miller EL, Wakefield D, Wise K, Alexander RL. (2017). The State of Nursing Home IT Sophistication in Rural and Non-Rural US Markets. Journal of Rural Health, 33(3), 266-274. Available early online access June 2016. First published online Jun 22, 2016. doi: 10.1111/jrh.12188.	PMID: 27333002 Supported by grant number R01HS022497 from AHRQ
	Alexander GL, Madsen RW, Miller EL, and Wise K. (2016). A National Report of Nursing Home Information Technology Adoption and Quality Measures. *Journal of Nursing Care Quality*, 31(3), 201-206. DOI: 10.1097/NCQ.0000000000000187	PMID: 27219627 Supported by grant number R01HS022497

Peer Reviewed Journal	Little, M.O., Rantz, M., Alexander, G.L. (2016). Health Information Technology in Long-Term Care: Potential for the Future [Editorial]. *Journal of the American Medical Directors Association,* 17, 279-380. DOI: 10.1016/j.jamda.2016.02.029 Miller, E., Madsen, R. and Alexander, G.L. (2016). Effects of Staffing and Regional Location on Influenza and Pneumococcal Vaccination Rates in Nursing Home Residents. *Journal of Gerontological Nursing*, 42(2):38-44. DOI: 10.3928/00989134-20151124-05 In Press Alexander GL, Madsen RW, Miller EL, Jones C, Newton M, and Wise K. (2017). A National Report of Nursing Home Information Technology, Staffing, and Health Deficiencies in United States Nursing Homes. *Journal of Patient Safety* In Review: Powell, K., Alexander, G.L., & Madsen, R. (2018 under review). A National Assessment of Nursing Home Residents Access to Technology. *Proceedings of the American Medical Information Association.*	PMID: 27052779 Supported by grant No. R01HS022497 from AHRQ. PMID: 26651864 Supported by grant No. R01HS022497 from AHRQ.
Books	In Progress Alexander GL, Derr J, and Pettit L. (in progress, 2017). An Introduction to Clinical Health Information Technology for Long Term/Post-Acute Care (LTPAC) Healthcare Professionals. Taylor & Francis Group. Available June 2017.	
Peer-Reviewed Conference Proceeding *International	Alexander, G.L. & Madsen R.W. (2018). National Trends in Nursing Home Information Technology Sophistication and Relationships to Quality Measures. Proceedings of Midwest Nursing Research Society (MNRS), Paper Presentation. April, Cleveland OH. Alexander, G.L. and Madsen, R.W. (2016, Nov). A National Report of Information Technology Sophistication and Health Deficiencies in Nursing Homes. American Medical Informatics Association. Chicago IL. Alexander GL. (2016, July). Building Bridges to Quality Through Health Information Exchange. Summer Institute in Nursing Informatics. Invited Paper Presentation. Baltimore Maryland. *Alexander G, Sensmeier J, Goosen W. and McDonald J. (2016, June). Panel: Leveraging Interoperable Health Information Exchange Systems among Healthcare Communities. Nursing Informatics. Geneva Switzerland. DOI: 10.3233/978-1-61499-658-3-735 *Alexander G, Abbott P, Fossum M, Shaw R, Yu P. (2016, June). Panel: The Future of Informatics in Aged Care: An International Perspective. Nursing Informatics. Geneva Switzerland. DOI: 10.3233/978-1-61499-658-3-780 Alexander G. & Pettit L. (2016). Paper: The Adoption and Impact of HIT in U.S. Nursing Homes. Health Information Systems Society. Las Vegas, NV.	PMID: 27332323 PMID: 27332339

Peer-Reviewed Conference Proceeding *International	Alexander G. & Derr J. (2016). Roundtable Session 1: Critical Conversations in Transitions of Care PART 1: Transferring Patient Data from the Hospital to LTPAC. Health Information Systems Society. Las Vegas, NV. Alexander G. & Derr J. (2016). Roundtable Session 2: Critical Conversations in Transitions of Care PART 2: Transferring Resident Data from LTPAC to the Hospital. Health Information Systems Society. Las Vegas NV. *Yu, P., Gong, Y., Moen, A., Georgiou, A., and Alexander, G.L. (2015). Panel: New Frontier of Health Informatics: Aged Care Informatics. MedInfo, Sao Paolo Brazil. Striegel, B. and Alexander, G.L. (2015, Nov). Relationship of IT Sophistication to Quality Measures in a National Study of Nursing Homes. American Medical Informatics Association. San Francisco, CA. Alexander, G.L., Schaumberg, M., Holm, A. (2015). Presentation at LTPAC Hit Summit, June 21-23, Baltimore, MD. Harvell, J., Byrne, C., Dougherty, M., and Alexander, G.L. (2014). HIE Enablers: A Crucial Need for Care Coordination Communication Among Long-Term and Post-Acute Care Front Line Nursing and Other Staff. American Medical Informatics Association. Washington, DC.	
Posters	Newton, M., Jones, C., and Alexander, G.L. (2016, Mar). A National Report of Nursing Home Deficiencies Reported in the United States. University of Missouri Informatics Symposium, Columbia, MO. Miller, E., Madsen, R. and Alexander, G.L. (2015, Aug). Effects of staffing and location on seasonal influenza and pneumococcal vaccinations in nursing homes. Poster session presented at: Interdisciplinary Center on Aging; 25th Annual Caring for the Frail Elderly Conference and Health Services Research Day, Columbia, MO. DOI: 10.3928/00989134-20151124-05	PMID: 26651864 Supported by the Agency for Healthcare Research and Quality (AHRQ) (grant R01HS022497).
Webinars	Price, S. & Scott, S. (2016, Dec). Care Coordination and Analytics: Hospitals and LTPAC Data-Driven Partnerships. Health Information Management Systems Society (HIMSS) LTPAC Roundtable. Chairs: Alexander, G.L., Derr, J., and Pettit, L. Alexander, G.L., Sonin, J., and Herlin, B. (2016, Oct). Care Coordination and Person-Centric Longitudinal Care. Health Information Management Systems Society (HIMSS) LTPAC Roundtable. Chairs: Pettit, L. Halley, E., Palena-Hall, E., and Baird R. (2016, Sept). Engaging LTPAC Providers in Hospital Care Coordination Efforts: The Why and How. Health Information Management Systems Society (HIMSS) LTPAC Roundtable. Chairs: Alexander, G.L., Derr, J., and Pettit, L. Alexander, G., Popejoy, L.L., and Pettit, L. (2016, June). Nursing Home IT Maturity Models and Quality Measurement. Health Information Management Systems Society (HIMSS) LTPAC Roundtable. Chairs: Alexander, G.L., Derr, J., and Pettit, L.	

Webinars	Chies, S., and O'Malley T. (2016, May). Clinical and Technology in Harmony. Health Information Management Systems Society (HIMSS) LTPAC Roundtable. May 10, 2016. Chairs: Alexander, G.L., Derr, J., Pettit, L. McColm, D. and Czarnik, C. (2016, April). LTPAC Health IT Leadership Challenges/Strategies. Health Information Management Systems Society (HIMSS) LTPAC Roundtable. Chairs: Alexander, G.L., Derr, J., Pettit, L. Alexander, G.L. and Derr, J. (2016, Mar). Critical Conversations in Transitions of Care. Health Information Management Systems Society (HIMSS) LTPAC Roundtable. Chairs: Pettit, L. Pettit, L., and Damgard, J. (2016, Feb). EMR Options in the LTPAC Market Today. Health Information Management Systems Society (HIMSS) LTPAC Roundtable. Chairs: Alexander, G.L., Derr, J. Klinedinst, J., and McCracken, L. (2016, Jan). IT Staffing/Professional Development in LTPAC Setting. Health Information Management Systems Society (HIMSS) LTPAC Roundtable. Chairs: Alexander, G.L., Derr, J., Pettit, L. Alexander, G.L. (2015). Webinar: The Impact of Technology on Quality in U.S. Nursing Homes. McKnights Online Expo. Alexander, G.L., Derr, J., and Pettit, L. (2015, Dec). Long-Term Post-Acute Care Community of Practice Kick-Off Meeting: Webinar.	
Invited Presentations and Other National Organizations *International	Alexander G.L. (2018, April). National Trends in Nursing Home Information Technology and Quality Measures in the U.S. Faculty Research Spotlight. MU Informatics Institute. Missouri Informatics Symposium. Monsanto Auditorium (Bond Life Sciences Center). Columbia, MO. *Alexander G.L. (2017, Feb). Building International Collaborations Measuring IT Adoption in Aged Care. Center for Health Systems and Safety Research (CHSSR). Sydney Australia. Health Information Management Systems Society. (2016, Feb). HIMSS16 Long Term/Post-Acute Care Stakeholders Meeting. Las Vegas, NV. Centers for Medicaid and Medicare. (2015, May). HIT Presentation Office of the National Coordinator of Health Information Technology. (2014, Jan). IT Sophistication in the United States. Alexander, G.L. (2014, July). AHRQ HIT and Quality Research. American Health Information Management Association CMS/ONC CMS/ONC Joint Webinar (2013, Aug). Accelerating Health Information Exchange. Federal Communications Commission with the Alliance for Nursing Informatics (2013, June). Nursing Home IT Adoption.	

REFERENCES

1. Hamilton BH, Nickerson JA. Correcting for endogeneity in strategic management research. Strategic Organization. 2003;1(1):51-78.
2. National Center for Health S. Centers for Disease Control and Prevention FastStats Homepage https://www.cdc.gov/nchs/fastats/nursing-home-care.htm: National Center for Health Statistics; 2014 [
3. Breeding B. My Life Site Blog http://www.mylifesite.net/blog/post/so-ill-probably-need-long-term-care-but-for-how-long/2016
4. IOM. Institute of Medicine: Improving the Quality of Long Term Care. In: Wunderlich GS, Kohler PO, editors. Washington DC National Academy Press; 2001.
5. Jaana M, Ward MM, Pare G, Wakefield DS. Clinical information technology in hospitals: A comparison between the state of Iowa and provinces in Canada. International Journal of Medical Informatics. 2005;74:719-31.
6. Pare G, Sicotte C. Information technology sophistication in health care: An instrument validation study among Canadian hospitals. International Journal of Medical Informatics. 2001;63:205-23.
7. Cheney PH, Dickson GW. Organizational characteristics and information systems: An exploratory investigation. Academy of Management Journal. 1982;25 (1):170-84.
8. Nolan RL. Managing the computer resource: A stage hypothesis. Communications of the ACM. 1973;16(7):399-405.
9. Alexander GL, Wakefield DS. IT sophistication in nursing homes. Journal of the American Medical Directors Association. 2009;10(6):398-407.
10. Alexander GL, Madsen R, Wakefield DS. A Regional Assessment of Information Technology Sophistication in Missouri Nursing Homes. Policy, Politics & Nursing Practice. 2010;11(3):214-25.
11. Pedhazur EJ, Pedhazur-Schmelkin L. Reliability. Measurement, Design, and Analysis: An Integrated Approach. Hillsdale, NJ: Lawrence Erlbaum Associates; 1991. p. 81-117.
12. CMS. Nursing Home Compare https://www.medicare.gov/NursingHomeCompare/Data/About.html: Centers for Medicare and Medicaid; 2018 [
13. CMS. Centers for Medicare and Medicaid Long-Term Care Facility Resident Assessment Instrument 3.0 User's Manual. In: CMS, editor. Baltimore MD: CMS; 2015.
14. Harrington C, Woolhandler S, Mullan J, Carrillo H, Himmelstein DU. Does investor ownership of nursing homes compromise the quality of care? American Journal of Public Health. 2001;91(9):1452-5.
15. Morrill R, Cromartie J, Hart G. Rural Urban Commuting Area Codes. http://deptswashingtonedu/uwruca/ruca-dataphp. 2005.
16. CMS. Special Focus Facility Initiative. https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/CertificationandComplianc/downloads/SFFList.pdf: Centers for Medicare and Medicaid; 2013.
17. Alexander GL, Wakefield DS. Information technology sophistication in nursing homes. Journal of the American Medical Directors Association. 2009;10(6):398-407.
18. Hayden G. Nursing Home Compare website fails inspection. Long Term Care Interface. 2005;6(2):22-7.
19. Ochinko W. Nursing Homes: Public reporting of quality indicators has merit, but national implementation is premature. In: Office UGA, editor. Washington DC: GAO; 2002.
20. Hicks L, Rantz MJ, Petroski GF, Mukamel DB. Nursing home costs and quality of care outcomes. Nursing Economics. 2004;22 (4):178-92.