

Appendix

I. Literature Review: Databases and Detailed Search Strategy

Search Engine: Pubmed

(health information management[MeSH Terms]) AND nursing homes[MeSH terms]

((Computerized Physician Order Entry (CPOE)) AND nursing homes[MeSH terms])

((computerized electronic prescribing) AND nursing homes[MeSH terms])

((computerized electronic risk management) AND nursing homes[MeSH terms])

((computerized electronic MDS) AND nursing homes[MeSH terms])

((computerized electronic communication) AND nursing homes[MeSH terms])

((computerized decision support) AND nursing homes[MeSH terms])

((electronic health record[MeSH Terms]) AND nursing homes[MeSH Terms]) AND health personnel[MeSH Terms]

((electronic health record[MeSH Terms]) AND nursing homes[MeSH Terms]) AND personnel management[MeSH Terms]

((electronic health record[MeSH Terms]) AND nursing homes[MeSH Terms]) AND job description

((electronic health record[MeSH Terms]) AND nursing homes[MeSH Terms]) AND nursing education

Search Engine: CINAHL

(MH "Information Technology") AND (MH "Nursing Homes")

(MH "health information systems") AND (MH "Nursing Homes")

(MH "Computerized Patient Record") AND (MH "Nursing Homes")

(MH "Electronic Data Interchange") AND (MH "Nursing Homes")

(MH "health information systems") AND (MH "Nursing Home Personnel")

Search Engine: PsychINFO

su(Exact("information technology")) AND su.Exact("nursing homes")

su.Exact("electronic communication") AND su.Exact("nursing homes")

su.Exact("computer applications") AND su.Exact("nursing homes")

Search Engine: Google Scholar

health information technology "nursing homes" personnel

"information technology" "nursing homes" personnel

"electronic health record" "nursing homes" personnel

computerized electronic technology ("physician order entry" OR "medication management" OR "Prescribing" OR "incident reporting" OR "MDS" OR "decision support") "nursing homes" workforce turnover staffing

Search Engine: Web of Science

("information technology" OR "electronic health record") AND TOPIC: ("nursing homes") AND TOPIC: (personnel OR workforce OR staffing)

("information technology" OR "electronic health record" OR "computerized physician order entry") AND TOPIC: ("nursing homes") AND TOPIC: (personnel OR workforce OR staffing OR turnover OR retention OR training OR manpower)

1. Literature Review Flow Diagram for Study Identification and Selection

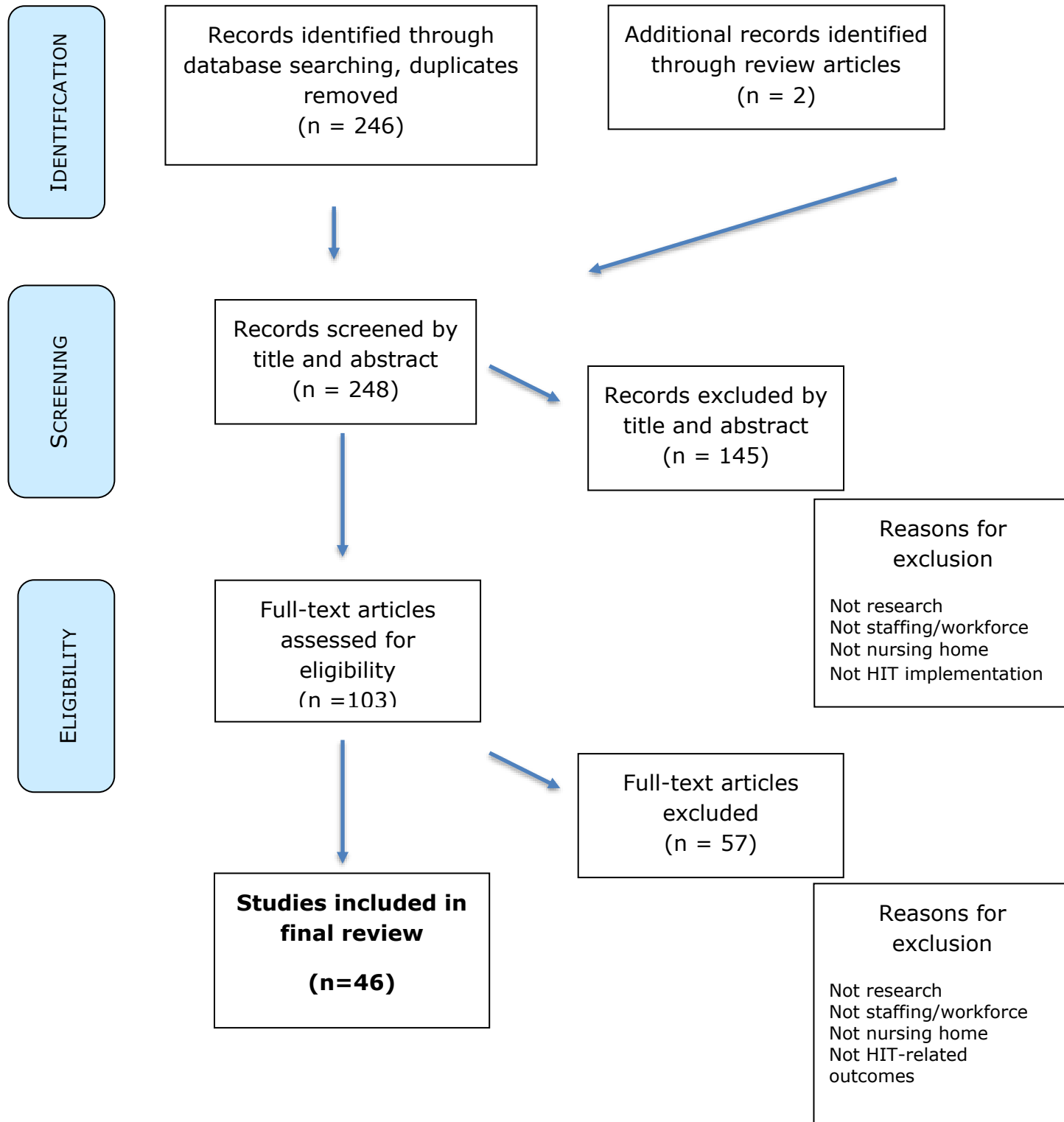


Table 1. Studies examining the impact of Health Information Technologies on staff in nursing homes

Author, Year	HIT	Study Design	Setting, Population	Methods	Findings			
					Implementation	Staffing	Productivity	Quality of care
Experimental Studies								
Wagner, L. (2005)	Menu Driven Incident Report System (MDIRS): documented on paper and entered into electronic record	Randomized controlled trial: intervention (3NH) and control (3NH) groups at baseline and 1-4 months post	6 NH, Georgia, staff and leadership (not specified)	Mixed methods: Descriptive statistics from facility incident reports; Attended or reviewed minutes from facility QI team meetings; Collected feedback from staff nurses, and leaders	Pilot-testing of instrument, in-service training and nurse feedback; collaboration with developer to create intervention; computer problems limited implementation in one site	1 intervention NH: high turnover, overload of duties, multiple absences, resulting in limited use	No difficulty in completing MDIRS; improved communication	No significant difference in fall incidence; greater completion of documentation on near falls and circumstances in intervention group
Quasi-Experimental Studies								
Engstrom, M. (2005)	Alarm sensors, assault alarms, and EHR	Intervention (2 units), comparison (2 units), 6-, 12-months post	4 units of NH in Sweden, RNs/LPNs/Auxiliary nurses (I: N=17; C: N=16)	Surveys: t-tests/Fisher's exact, repeated-measures ANOVA		Intervention: higher satisfaction and motivation relative to baseline	Intervention: improved documentation, increased workload, no difference in communication	Intervention: perceived quality of care scale increased at 12 months

Fossum, M. (2013)	CDSS	Intervention 1 (4NH), Intervention 2 (7NH), Comparison (4NH), 2 years post-	15 NH in Norway, RNs/CNAs, NH residents; (N=150 pre-; N=141 post-)	Repeated cross- section of intervention and comparison groups; Descriptive statistics and ANOVA	4 nurses involved in CDSS development, 3-day training for "super users"; IT support in training; two 45 min sessions for all other RNs/CNAs		No significant difference in the prevalence of pressure ulcers or malnutrition
Kruger, K. (2011)	CDSS	Pre-post: 2 years; Provider and staff satisfaction: Post- only	3 NH in Norway, Satisfaction: Physicians, nurses, assistant nurses, physiotherapists (N=272); Clinical outcomes: nursing home residents (N=513 pre-; N=183 post-)	Surveys: descriptive statistics; Clinical outcomes: chi- square and one-way ANOVA		67% report CDSS less time consuming; 90% of documentation requirements met; 72% agreed reminders supported work	Decreased %patients taking neuroleptics, warfarin, patients not weighed for last 30 days. Perceived improved medication safety

Rantz, M. (2006)	POC, EHR, nurse clinical quality improvement expert	Intervention 1(4 NH): EHR + nurse expert; Intervention 2 (4 NH): EHR only); Intervention 3 (5 NH): nurse expert only; Comparison (5 NH): neither, 1 and 2 years post-	18 NH: 14 in Missouri, 4 in other states; DON, staff and residents (N=8166)	Descriptive statistics: means, medians, from MDS, costs, staffing reports; I1 only: Interviews (N=130), focus groups, direct observation	I1: Satisfaction up from 6-12 months; 24 months: happy with technology Frustrations: Limited IT support after hours, vendor lack of follow-up and poor responsiveness, staff attempts to troubleshoot by themselves Training: insufficient, need ongoing, refresher, specific individual; Nurse mentors helpful; CNAs w/ limited literacy, English proficiency more difficulties using HIT Adoption: Review of several systems before selection Equipment: unreliable, slow	I1-I3: Increase in sense of team, shared values I1: Improved communication betw staff and w physicians	I1: Documentation errors due to system losses, user errors, continued use of paper: too time consuming, ignoring alerts/messages 24 months: improved documentation and time decreased RNs/LPNs: assessments too long, not flexible, CNAs: reduced time for patient care, increased monitoring “big brother” vs evidence of work, Workarounds: Document before care given, double doc w/ paper, use “quick notes” rather than standard form-inconsistent and not synced with clinical info	I1, I2 have worse scores at baseline bc of improved documentation of problems; Most improvement in I1 I1: Staff report improved quality of care, easier access to information, more thorough assessments, clearer picture of resident conditions, better follow-up
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Rantz, M. (2010) *same as 2006	Bedside EHR, nurse clinical quality improvement expert	Intervention 1(4 NH): EHR + nurse expert; Intervention 2 (4 NH): EHR only); Intervention 3 (5 NH): nurse expert only; Comparison (5 NH): neither, 1 and 2 years post-	18 NH: 14 in Missouri, 4 in other states; staff and residents (N=8166)	Descriptive statistics of costs, staffing totals and mix, staff turnover; no statistical analysis of intervention vs. comparison groups		I1: increased staff hours and costs per resident, total hours per day unchanged No stat signif differences in turnover across all groups	I1: 24 months: all staff report jobs easier	I1, I2: improved in late-loss ADLs; I1-I3 improved behavioral symptoms and pressure sores; I1 improved delirium, depression Overall more quality indicators with no change than with changes
Yu, P. (2008)	EHR, POC	Intervention (1 NH), Comparison (1 NH), Post-only: survey (5 weeks), interviews (5, 11 weeks)	2 NH in Australia; RNs, EENs, PCWs, AINs (N=24)	Survey (response rate I: 82%, C: 43%) calculated means, Mann-Whitney to detect differences between groups; Semi-structured interviews	Training: 2.5 days for RNs/EENs, 1.5 days PCWs/AINs, 1 day for support staff; Staff at both sites supportive of computers and HIT; satisfied with training, support	Intervention: staff reported continued need for training, instruction, practice	Intervention: staff significantly more satisfied with speed, legibility, accessing information	

Longitudinal Observational Studies

Pre-/Post-

Alexander, G. (2015a)	HIE with hospital	Longitudinal observation of implementation process over 2 years	16 NH in St. Louis, MO area; Direct observation: Licensed clinicians and direct care staff (N=38); Interviews: Staff, administrators (N=230)	Readiness assessments, structured observation (2-3 hour periods; day shifts); Semi-structured interviews	Little/no integration of resident care technologies with external entities; None had onsite IT support	Concerns about lack of equipment at point of care	Non-emergent resident care mostly communicated via paper	Workarounds not secure for protecting health information
Brandeis, G. (2007)	HIE with hospital, including shared EHR	Longitudinal observation of implementation process over 2 years	11 NH in Boston, MA area; Physicians, nursing home staff, NH N not described	Case study: direct observation, methods for NH assessment not described	Difficulty in adaptation of hospital EHR to NH needs; NH had limited internet access, none had wi-fi; NH staff did not have access to EHR		All NH used paper	

Cherry, B. (2011)	EHR	6 months pre-, 9 months post	1 NH in Texas, RNs/LVNs (N=20)	Direct observation: day and evening shifts; process mapping					Decline in workflow steps for most processes; Majority of steps still paper-based; Faster access to information; Allows multiple staff members to work on chart at a time
Colón-Emeric, C. (2009)	CPOE	Pre- 1 month, post: 12 months	2 VA NH in North Carolina, MDs/NPs/PAs (N=8), residents (N=265)	Descriptive statistics: Clinical data; Provider surveys	CPOE algorithms developed with multidisciplinary panel;	Report easy to use, improved communication, useful for training new staff in one site Provider turnover >100% and understaffing in one site: default to verbal orders, bypass algorithms	Reduced order time Workarounds: Verbal communication for acute conditions	Falls reduced 10% Used for falls: Perceived improvement in quality of care, reminders of guidelines Other CPOE not used: User interface failures to direct to algorithms	

Galani, M. (2015)	EHR	Baseline, 6 months, 2 years post	2 NH in Australia; RNs/EENs/PCW, other) Interviews: N=30; Usability study: N=24, 12 experienced; selected at random from list stratified by expertise	Structured interviews; Direct observation video, measured task times, mouse clicks and keyboard strokes, errors; Self-administered surveys); Descriptive statistics, two-way ANOVA, correlation	Training: 30 min individual sessions; Superusers -1 wk onsite with vendor; Add'l single function sessions after start; New staff-ad-hoc training; 50+% reported training met their needs; 43% rated computer skills "below average"/ "poor"; 23% computer experience as "minimal"/"none"; 73% reported easy to use; 47% not enough training time; Satisfied IT support except after hours	Dissatisfaction peaked at 6 mos, lower at 2 years w/ return to paper; Experienced users: lower mental load, worked more efficiently, completed more tasks and made fewer errors; Inexperienced users: mostly PCWs, still having difficulties at 12+ months	Reduced steps and saved time: 87% satisfied with documentation; Easier to access data, more efficient; Improved communication; Challenges: difficulty timely completion of documentation, network constraints, power outages, system crashes, interface design, not enough computers or space for computers	40%: EHR not helpful for care decision; 2 years' post, reported enhanced continuity of care through better tracking
Hustey, F. (2012)	HIE with ED	Baseline, 8 months post	NH and ED in a larger healthcare system in US; NH physicians, nurses (N=26 pre-, N=23 post-) ED physicians, nurses	Surveys and utilization data: frequencies and tabulations of responses	NH training: Too difficult to schedule, optional multi-hour session for assistant nurse managers and unit secretaries; NH MDs not involved; New staff training ad hoc; NH medical director changed 3x		8 months post-: 40% of transitions used HIE: Excessive time to scan information into the network, information transfer prevents computer use for other functions	

-delayed
implementation

Munysisia, E. EHR
(2014)

2 months pre-, 3,
6, 12, 23 months
post: 2009-2011

1 RACH in
Australia;
RNs/EENs/PC
Ws (N=242)

Work sampling
technique: Direct
observation, 5
morning shifts, per
period; q9 minutes,
65-68 rounds per
study day; Pearson
chi-square of
change in
proportion of time
spent on activities
pre-/post-

Training: all staff
30 min individual;
continuous training
by other staff or
NH IT support;
Leaders concerned
length of time for
nursing staff to
learn EHR might
interfere with duties

RNs: At 23 months:
reduced oral
communication,
increased
documentation
time; EENs:
documentation time
reduced; PCWs:
reduced oral
communication at
12 months, return
to baseline at 23
months; reverse for
documentation

No significant
changes in time
spent on direct care,
medication
management,
personal activities,
in-transit time

Munyisia, E. EHR
(2011)

3 months pre-, 6,
18, 31 months
post): 2007-2009;
Post-only (20
months)

1 NH in
Australia;
RNs/EENs/PC
Ws (Survey
N=32 pre-,
N=25 post-6-18
months, 15 post-
31 months);
Structured
interviews
(N=17)

Survey: descriptive
statistics and non-
parametric tests;
Interviews: methods
not described

Training: Super
users identified by
basic skills test, 1
week training from
vendor, then trained
rest of staff one-on-
one; EHR
introduced over
months only to
nurses: PCWs
progress notes only,
paper assessments
entered by someone
else until finally all
EHR at 31 months

No change in
communication;
Improvement in
legibility, accessing
information, reduce
repetition: PCWs
more positive than
RNs/EENs;

Improvement in
perceived
information quality
and completeness
of documentation at
31 months;
Managers report
better monitoring,
oversight,
identifying ongoing
training needs;
Nurses: no change
in perceived quality
of care,
understanding
problems, decision-
making

Munysisia, E. EHR
(2013)

2 months pre-, 3,
6, 12, 23 months
post): 2009-2011
(work sampling);
Post-only (6-, 12-
months post,
structured
interviews)

1 RACH in
Australia,
PCWs/
recreational
activity officers
(RAOs) (N=109
observations;
N=8 staff for
interviews)

Work sampling
technique: Direct
observation, 5
morning shifts, per
period; observations
made q5 minutes;
Pearson chi-square
of change in
proportion of time
spent on activities
pre-/post-;
Structured
interview: content
analysis

Training: one-on-
one 30 min
sessions; new
employees trained
by other staff or IT
support officer

Preferred verbal
communication;
Perceived increase
in time, required
more steps in EHR;
PCW: time on
direct care work
reduced/
documentation
increased at 3-6
months, returned to
baseline at 23
months; Increased
time spent on
personal duties;
Decreased time on
medication
management; RAO:
decreased time on
communication,
increased time in
transit

PCWs: ease of
access to the
records
significantly
improved
completion after
implementation

Qian, S. (2015)	eMAR	Baseline through 12 months post	2 RACH units in Australia, “medication staff” (nurses) (N=7)	Time motion observation, informal conversations, document review, field notes		No signif change in documentation time Signif reduction in time spent on locating/reading records No net improvement in efficiency	Documentation compliance improved	
Scott-Cawiezell, J. (2009)	eMAR	Baseline, 3, 6, 9 months post: 2003-2007	5 NH in Midwest; RN/LPN/CMT (certified medication technician)	Focus groups, direct observations of medication passes, frequencies and tabulations of medication records	<p> QI teams led implementation, education, met monthly to discuss progress and challenges, establish blame-free environment to facilitate discussion; eMAR information provided feedback reports; rapid-cycle QI approach to implementation; Offered incentives to report errors; </p>	<p> CMTs accustomed to punitive culture for late (rather than incorrect) meds: worked to change culture and incorporate more input from CMTs </p>	<p> Improved medication management: legibility, faster access to information Workarounds: Skipping or checking boxes without actual confirmation </p>	<p> Safety improvements: alerts and signaling features reduced errors </p>

Sharkey, S. (2013)	Combined CDSS/QI intervention	Baseline, 9-15 months post: 2010-2011	14 NH in Washington, DC, Administrators, DON, CNAs, dietitians, nurse managers	NH characteristics obtained from NH leadership, data from CMS Nursing Home Compare; Observations of team participation levels with level of implementation, Spearman rank correlation coefficients	QI facilitator: training, worked with CNAs to redesign workflows, weekly support phone calls; factors associated w/ implementation: high involvement from DON, nurse managers and in house dietitian, team lead, and staff educator; openness to redesign; HIT support (full time), internal champion
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Vogelsmeier, A. (2008)	eMAR, EHR	Longitudinal observation of implementation process from baseline to 6 months	5 NH in Midwest, staff unspecified	Direct observation, workflow process mapping, key informant interviews, document review of medication safety team field notes	Inadequate equipment, slow wi-fi connections, processes should have been re-engineered to fit new system but were not	Workarounds: use of handwritten notes, verbal communication; inefficient and changes in workflow	Workarounds for safety blocks: Entering multiple doses of the same medication instead of discussing the excess ordered dose; skipped steps or documented all steps at once, rather than before and after medication administration
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Zamora, Z. (2012)	HIE with ED	9 months pre, 9 months post	4 NHs in North Carolina, nursing home staff unspecified	Methods for data collection and analysis on NH not described	Training: length not described, including education and practice cases, laminated manuals; weekly to biweekly visits to NH; Research team 1 month "prime" the system involved calling NH to complete referrals and return notes; Basic computer skills training	High staff turnover (near complete every 6 months) led to inadequate training and awareness	Too few computers and limited access to computers; incompatibility with NH systems
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Post-only

Alexander, G. (2005)	CDSS	6-, 12-months post	3 NH in Missouri, 98-240 beds, staff unspecified	Estimated correlations between clinical alerts and staff responses using data from EHR			No significant difference between alert activity and clinical actions; no change in CNA task lists in response to alerts
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Alexander, G. (2014)	HIT	6 months post	5 NH in Missouri high IT, CNA/LPN/RN, wound nurses: 35 focus groups: N=137	Direct observation: interactions and communications; Focus groups; Correlations between level of IT, interactions and centrality of communication network		High IT negatively correlated with unique staff interactions; Improved teamwork between physicians, licensed staff, and certified staff	High IT easily accessible, improves decision-making process and greater collaboration; standardization allowed for better monitoring
Alexander, G. (2007)	EHR, POC	Post-only, time not specified	4 NH in Midwest; RN/LPN/CNA (N=120)	Focus groups (22), direct observation	Dedicated training space and partial implementation: whole system startup "overwhelming"; Availability of equipment inconsistent; Lack of on-site IT support; Need for increased staff; Lack of back-up systems and equipment failures; Ongoing training, designated space and "nurse mentors"	Frustration with slow implementation, increased tasks, poor understanding about CIS, slow PDA screens and synching processes; Technical difficulties led to distrust, perception that workload increased and reduced direct patient care; Site staff member designated as IT support with mixed reception	Usability problems led to lower quality documentation; CNAs: inconsistency in new messaging led to residents not receiving necessary care; RNs: technology improved care by access to information and oversight

Avgar, A. (2010)		Post-only, time not specified	15 NH in New York City, RN/LPN/CNA, Other (e.g. social work); (N=962)	Survey (response rate 48%); Descriptive statistics and multivariate regression including nursing home quality and vendor data	Implementation costs lower in NH with greater employee satisfaction and discretion		
Lapane, K. (2006)	Pharmaceutical care planning software	Post-only: time not specified	13 NH contracting with pharmacy; Pharmacists (N=17)	Survey, Utilization data: frequency and tabulations	Multiple training sessions with test usage; Adaptations to NH limitations, e.g. lack of internet connectivity; 71 % of dispensing and 40% of consultant pharmacists reported using the software most/ all the time	Technical difficulties: connectivity, synchronization, system instability-->inconsistent use of system	23% of residents received intervention to prevent medication problem; 71% prior to mandatory 30-day medication review

Rantz, M. (2011)	EHR, POC	Post-only, 6-, 12-18-months, 24 months	4 NH in U.S., Administrators, RNs, LPNs, CNAs (22 focus groups, N=110 participants)	Interviews, focus groups, direct observation; content analysis	Staff expectations unrealistic; More training and on-site support needed; Staff unclear about responsibilities; Concern over non-English speaking staff ability to use EMR; Administrators did not budget for ongoing hardware, software updates, staff IT support	Both staff and residents resistant to wearable microchip; Staff perceptions of EHR monitoring: demonstrate work vs. excess oversight; Ongoing lack of reliability in equipment and system, insufficient IT support after hours	Licensed staff: better communication with physicians as information was received more readily; CNAs: concerned increased time on documentation and managing technology reduced patient care; Staff inconsistent on timely completion of documentation; Continued paper use, double documentation, and under-utilized alerts/messaging tools; Text notes as lengthy and less flexible assessments Perceived improvement in documentation at 12-24 months	Administrators and licensed staff: improved ability to trend clinical problems and manage residents, medication; Concerns documentation errors due to system problems, continued use of paper and incomplete transfer of information between the two
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Schoville, R. EHR (2015)	Post-only: 2012-2013	3 NH in Michigan, two sites post-implementation and 1 site during, DON (Interviews, N=3), RNs/LPNs/CNAs (N=30); randomized purposeful sampling, English speaking, working 20+ hours per week	Semi-structured focus groups and individual interviews	<p>Decisions to adopt EHR at leadership level, w/o staff input; DON and staff not clear on motivations, CNAs perceive related to laws/billing;</p> <p>Training: single 4-6hr sessions for nurses, 1hr for CNAs: not tailored to staff needs, too rushed, need for ongoing training</p> <p>DON reported multiple communication strategies about new EHR, but CNAs reported limited communication</p> <p>Successful strategies:</p> <p>Vendors: close implementation support including conversion from paper and upgrading internet connectivity;</p> <p>Leadership: Prepare systems so ready to</p>	<p>DON: concerned re CNA computer skills; CNAs: want to learn new technology</p> <p>New roles: Superusers: sometimes they and staff did not know who they were, unclear how they were selected;</p> <p>"Key persons": Lead projects</p> <p>Not clear staff compensated for new roles other than for additional hours worked</p> <p>Nursing staff: limited computer literacy</p> <p>CNAs: perceived EHR as a system to enforce daily documentation with penalties; less knowledgeable about IT support available to them</p> <p>Staff: work more efficiently, improved communication ,</p>	<p>Changes in workflow processes</p> <p>Computer and system unreliable, lack of CNA access to reboot systems, user interface and functions not well fit for needs;</p> <p>Nurses: EHR efficient, thorough, allows the payor source to determine reimbursement for resident care</p> <p>CNAs: mixed on time spent on direct resident care, documentation time increased, adjusting to frequent interruptions in workflows, increased workload for tasks that required both electronic and paper documentation</p> <p>Workarounds: Reverted to paper, verbal communication;</p>
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use when introduced to staff	fostered ongoing teamwork
Training: Superusers	Staff not aware of rewards/incentives, requested raises
IT support: 24/7on- site initially, then on call, then HelpDesk	

Yu, P. (2013)	EHR	Post-only: 2009, 2010-2011	9 RACHs in Australia, Managers(31)RNs(15), EENs(6), PCWs (45), other staff (13), Total N=110	Semi-structured interviews, content analysis, quantitative frequencies and tabulation of codes and themes	Insufficient support for the development of care plans; data storage problems; managers report resistance to use EHRs	40%:inadequate functionality and poor user-interface design led to inability to input data and retrieve information; lack of electronic forms, inability to find information quickly, difficulty in generating reports; paper-based documenting preferred; 22%: increased documentation burden	Quality of documentation not improved
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Cross-sectional

Alexander, G. (2015b?)	Multiple HIT applications: EHR, CDSS, automated alerts, wireless data capture, POC, eMAR, real-time MDS	Cross-sectional: observation	16 NH in Missouri, with low, medium and high IT (based on statewide survey); CNAs (N=213)	Focus groups (31); Survey on roles, training and employment of NAs, descriptive statistics		High IT: greater variety of communication strategies Low IT: paper to communicate very important details or updates	High IT: enabled nursing assistants to make better clinical decisions (e.g. track and access patient needs at the point of care) and improved
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workflow, care activities

Alexander, G. (2015c)

Multiple HIT applications: EHR, CDSS, automated alerts, wireless data capture, POC, eMAR, real-time MDS

Cross-sectional: observation; case studies

2 NHs in Missouri, one high, one "low" (based on a statewide survey, CNAs (N=21)

Direct observation, administrative data, Focus groups (5); social network analysis and document analysis

High IT: interactions less frequent, more variety of communication and back-up systems

Low IT: more verbal discussions about risk assessment and skin care inspection, inefficiencies due to incomplete electronic and paper documentation, having to check two systems and no backup

Less paper improves security (protection and backup hardware) HIT: better quality based on AHRQ guidelines (e.g risk reassessment and skin care inspection)

Alexander, G. (2009)	Multiple HIT applications	Cross-sectional: observation	4 Midwest NH: high IT; Non-specific: administrators and leaders in implementation	Key informant structured interviews (4), focus groups (3)	Internet access limited to management; IT support: helpful to implementation team, maintenance staff, central integration point; use of consultants if no IT staff;	Administrators provided IT support (only one had on-site IT)	Lack of integrated product to link clinical, fiscal, and regulatory needs which reinforces silo problems	IT allowed better oversight and identification of high risk residents
Bezboruah, K. (2014)	Multiple HIT applications	Case study; cross sectional: observation	6 NH in Dallas/Fort Worth, Texas metro area: adopters and non-adopters, Administrators; DON, case managers, nursing staff, kitchen staff, admin interns (N=42)	Semi-structured interviews, Direct observation	"trial and error" implementation process; Incomplete communication regarding the benefits IT; One admin noted no plan to adopt HIT beyond MDS due to costs and training personnel Concerns re: older nurses who had "never worked with computers" Admin have poor understanding of IT	Staff reluctant to learn: slows pace and make more mistakes, additional work hours Staff "actively or passively" avoid using IT, e.g. pulling out cables and turning off systems	Nurses at one site: IT overly technical and not useful; Inefficient: Doubled workload w no reduction in paper; Slow system response times	

Cherry, B. (2011b?)	EHR	Cross-sectional: observation	600 randomly selected NH in Texas; Administrators, DON (N=92)	Survey; item analysis Cronbach's alpha	Facilities with higher readiness scores on leadership and employee willingness to adopt IT have higher scores on items related to plans for implementation		
Cherry, B. (2008)	EHR	Cross-sectional: observation	NH in Texas, users and non-users of EHRs; DONs, administrators and corporate executives, recruited from conference (N=34)	Focus groups	Implementation barriers: training, need for additional staff/consultants, culture change/staff resistance to change, staff lack of familiarity with computers including low CNA education levels	Perceived staff satisfaction increases due to "pride and empowerment"	Ease of access to information, staff have more time for direct care

Cherry, B. (2011c?)	EHR	Cross-sectional: observation	10 NH in Texas, "early adopters" using EHRs at least one year; DONs, administrators, nurses, staff	Semi-structured interviews (DON, administrators), Focus groups (nurses, staff, residents and families), direct observation	Minimal CNA training needed for icon-based programs on touch screens; Request for ongoing input with IT/vendor IT: inconsistent internet access, system downtime and glitches	Nursing supervisors: Improved staff recruitment and retention esp younger nurses; Admin: improved staff satisfaction but also frustration Direct care staff: new staff quit due to "information overload", challenges with learning how to type/use computers; CNAs: positive, feel greater respect bc their work merited computer documentation	All: rapid access to information, greater legibility; Nursing supervisors; mixed on whether time spent on activities changed; Direct care staff: overall time savings, mixed on time spent on direct care, maintaining care plans, frustration with unreliable systems; CNAs: difficulty learning computers but improved 1-2 wks, system access limited	Admin: increased documentation accuracy, monitoring, and implementation of evidence-based practices; Nurses: no change in quality of care; Nursing supervisors: more thorough assessments; Direct care staff: more proactive due to alerts, better able to monitor residents' conditions; CNAs: more accurate and thorough documentation, perceived by residents and families to be "playing" on the computer
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Faxvaag, A. (2011)	EHR	Cross-sectional: observation	29 NH, 21 hospital departments in Norway; Clinicians (NH N=239) (Hospitals N=206)	Survey (NH: Response rate 41%; Hospital response rate:15%): frequencies and tabulations		Delays and disruptions in patient care, time consuming Workarounds: verbal communication because more reliable	Issues in log-in procedures: Failure to look into the patient's EHR in advance of providing care to the patient, incorrect documentation
Filipova, A. (2013)	EHR	Cross-sectional: observation	NH in Midwest, Administrators (N=156)	Survey (Complete response rate 39%): descriptive statistics, factor analysis of constructs, Pearson Chi-square for associations with use of HIT automation and perceived benefits/barriers	Costs (not training/staff) as main barrier	HIT improves access to information; all facilities continued use of paper	HIT improves monitoring of patient care, oversight

Fossum, M.
(2011)

Cross-sectional:
observation

4 NH in
Norway, RNs,
CNAs, Special
Needs Educator
(Focus groups
(N=25))
Usability
evaluation:
N=5)

Focus groups (4);
Direct observation
for usability
evaluation

Barriers: Training
not made available
to all and was
optional; Lack of
information about
implementation;
Lack of computer
skills and resistance
to using computers

Usability: overall
high satisfaction
scores in evaluation
unlike focus
groups; other
challenges: lack of
workstations;
functions not fit to
tasks; Poor
integration of
systems; Poor
design of user
interface

Concerns with
patient security
because of poor
interface of CDSS
with EHR

Hudak.S. (2007)	Multiple HIT applications	Cross-sectional: observation:	LTC facilities in California: SNF, assisted living, and residential care facilities for the elderly; Administrators, DON, care managers (Survey: N=103; response rate SNF: 47%; ALF: 21%); Focus groups: facilities without HIT; Interviews: early adopters (3), stakeholders and HIT experts (9)	Survey: response rate: SNF: 47%; ALF: 21%; Focus groups, semi-structured interviews	Staff lack computer skills and fear technology; lack of hardware and IT support; challenges with English as a second language; No strategic planning; Leadership: Lack of knowledge on HIT; Underestimate change management needs; Account for training/support staff- facilities don't usually have manpower to do this themselves Success strategies: Implementation systematic, roll-out not all at once Ongoing training for CNAs	Recognize leadership buy-in and expect turnover	HIT too complicated, not flexible, not easy to learn or use; modification too costly or difficult; Poor integration of systems makes work flow too tedious and complex; Perceived benefits in reducing paper and automated charting Recommend redesign workflow prior to implementation	Administrators: Less likely to perceive benefit, believe limited evidence for benefit; Providers: establishing uniform data, decreasing errors, and monitoring compliance
Liu, D. (2009)	MDS	Cross-sectional: observation	NH in U.S, Administrators, RN/LPN/SNA (N=2397)	Survey, CMS data; Multivariate regression on use of IT, quality and nurse staffing; mediation tests of IT in the staffing levels-outcome relationship				HIT mediates and moderates association between nurse staffing and quality of care

Meehan, R. (2015)	EHR	Cross-sectional: observation	1 LTPAC (long-term post-acute care) in Midwest; Direct care nurses: RNs/ LPNs (N=20)	Semi-structured interviews; Content analysis and descriptive statistics: frequencies, tabulations	<p>Most respondents familiar with computers outside of work;</p> <p>Training: one day on site, sufficient at the time but staff wanted ongoing training to navigate EHR</p> <p>No on-site IT; Central IT Helpdesk available 24/7 but some delays in response</p> <p>Staff members asked to help were frustrated that colleagues did not use IT support</p>	More challenges with intermittent staff and after vacations	<p>Majority reported HIT as useful and easy to use, satisfied with system, improved access to information, legibility and visibility;</p> <p>Challenges: lack of fit for functions; lack of integration with hospital communication; more time spent on EHR when unforeseen incidents occurred; double systems, lack of integration</p>	<p>Majority of staff agree that EHR is better than paper records for improving quality of care</p> <p>Lack of flexibility/functionality negatively impact patient safety</p>
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Qian, S. (2014)	EHR	Cross-sectional: observation	1 RACH in Australia; RNs/EENs/PC Ws (N=?)	Direct observation, informal conversation, field notes: workflow process mapping	Training: 30-min one-on-one, 3 mos prior to implementation	<p>Many functional deficiencies: lack of: tools to remind nurse about wound chart, functions to carry out work tasks, information about resident care needs, point-of-care system:</p> <p>Workarounds: printed wound care charts from EHR to create wound care book, then re-entered into EHR (plus separate paper note) •nurses relied on paper, verbal communication</p>
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Vanneste, D. (2013)	Web-based assessment tools	Cross-sectional: observation	NH, home care, hospitals in Belgium; Nurses, PT, OT, social work, podiatrists, physicians, psychologists, dentists, pharmacists (N=282)	Survey: asses anxiety, self- efficacy, and attitudes towards using technology (ATUT); multivariate structural equation modeling to estimate influences on intent to use HIT, (response rate 42.7%)	"Facilitating conditions": having resources and knowledge required to use the system, availability of assistance, and compatibility with existing system; Self-efficacy to complete new tasks, having someone to call for help, and having time to practice	Performance expectancy (e.g. belief that system would improve ability to do job), effort expectancy (easy to use system) and social influence (perceived support from organization) do not have a significant influence on intent to use
Wang. T. (2012)	Multiple HIT applications	Cross-sectional	NH in Texas, Administrators (N=913)	Survey (response rate 15%): Descriptive statistics	Multiple barriers to implementation: Lack of time (29%) Lack of technical support staff (21%) Lack of HIT knowledge (12%) Fear of technology (8%) Unclear on benefits of EHR (15%)	Concerns on reductions in productivity: EHRs not user friendly, too complex, products do not meet needs

Yu, P. (2006)	EHR, electronic care plans	Cross-sectional: observation; Nurse managers, EENs/PCWs/AINs, clerks (N=159)	13 RACH in Australia, 11 electronic care plans, no other HIT functions, PCW/AINs did not have access to computers in any study sites	Survey (Response rate 39.8%): Descriptive statistics	Majority: neutral with current paper-based practices; willing to use if easy to use and reduces time spent on documentation	89% report trust in computer systems and support introduction of electronic nursing documentation to better manage care;
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Health Information Technologies: EHR: Electronic health record; HIE: Health information exchange; eMAR: Electronic Medication Administration Record; CDSS: Clinical Decision Support System; POC: Point-of-Care documentation system; CPOE: Computerized order entry; MDS: Electronic Minimum Data Set entry system

Long-Term Care Facilities: NH: Nursing Homes, RACH: Residential Aged Care Home

Workforce Roles: Personal Care Worker (PCW), Certified Nursing Assistant (CNA), Assistants in Nursing (AIN), Licensed Vocational Nurse (LVN), Licensed Practical Nurse (LPN), Enrolled Employed Nurse (EEN), Registered Nurse (RN), Director of Nursing (DON)

II. Key informant interviews and focus groups:

Table 2. Characteristics of participants and nursing home settings

		Number
Role	Administrator	2
	Director of Nursing/Chief Nursing Officer	2
	Director of Clinical Specialist	1
	Staff or Charge nurse	5
	Staff Development Coordinator	1
	Infection Control Nurse	1
	Certified Nursing Assistant (CNA)	3
Type	Free-standing	11
	Free-standing with hospital affiliation	1
Ownership	For-profit	9
	Non-profit	3
Setting	Rural	2
	Suburban	4
	Urban	5

Interview Guides

INTERVIEW GUIDE: Aide Version

STAFF POSITION

1. Are you: FT, PT, PerDiem, Agency
2. How long have you worked here?
3. Tell me what you know about the history of the implementation of Health Information Technology in your facility?
4. What forms of Health Information Technology are used in your facility? (Check off: AM/PM Care, BMs and % intake of meals documentation)

Quality

On a scale of 1-5, how would you rate the current quality of the following factors associated with Health Information Technology at your facility?

1. Legibility
2. Provider (MD/NP/PA) Communication
3. Accessibility
4. Usability
5. Ease

Implementation

1. What kind of training did you receive when HIT was introduced? (Classroom, preceptor, simulation, etc)
2. Tell me about the implementation process? Duration of training? Who led the program (RN, IT, etc.)?
3. How did the training program prepare you for the EHR system? Please describe.

TIME/EFFICIENCY

1. What percentage of your shift is spent using (health) technology?
2. How has your workflow benefited or been negatively impacted from introducing HIT? In term of quality of care? And productivity?
3. What kind of workarounds do you currently do to “override” the HIT system in order to get your work completed?
4. What HIT differences have you noticed between facilities?

STAFFING

1. Have you noticed any turnover as a result of HIT introduction? Please describe.

2. Have you noticed any changes in roles as a result of HIT introduction? Please describe.

STAFF SUPPORT

1. Do you have a FT IT support? Part time? Consultant? Central Help Desk?
2. Is there a wait time when support is needed? If so, how long on average?
3. Do you have 24-hour access to support?
4. How are you notified of any changes/modifications?
5. How are you trained when any changes to the software occurs?

INTERVIEW Guide: RN/LVN/Administrator Version

STAFF POSITION

1. What is your title? (RN, LVN/LPN, CNA, MD/NP/PA, PT/OT/ST, SW, RPh, Administrator, DON, Nurse Manager, MDS nurse, Other)
2. Are you: FT, PT, PerDiem, Agency
3. How long have you worked here?
4. Tell me what you know about the history of the implementation of Health Information Technology in your facility?
5. What forms of Health Information Technology are used in your facility? (Check off: EHR, MDS, IR/RM (same or separate system), CPOE, MAR, Treatment Record, Restorative Care, AM/PM Care, BMs and % intake of meals documentation)

QUALITY

1. On a scale of 1-5, how would you rate the current quality of the following factors associated with Health Information Technology at your facility?
 6. Legibility
 7. Provider (MD/NP/PA) Communication
 8. Accessibility
 9. Usability
 10. Ease

Implementation

1. What kind of training did you receive when HIT was introduced? (Classroom, preceptor, simulation, etc)
2. Tell me about the implementation process? Duration of training? Who led the program (RN, IT, etc.)?
3. How did the training program prepare you for the EHR system? Please describe.
4. How did the nurses' years of nursing experience affect their ability to use technology?

TIME/EFFICIENCY

1. What percentage of your time is spent on using HIT?
2. Are you able to access HIT off site?
3. How has your work-flow benefited from introducing HIT? In term of quality of care? And productivity?
4. How has your work-flow been negatively impacted after introducing HIT? What challenges have you faced? In term of quality of care? And productivity?

5. What kind of work arounds do you currently do to “override” the HIT system in order to get your work completed?
6. Does your EHR system enable communication between different types of providers in your facility- e.g. nursing and medical, nursing and physical therapy? If so, how has this affected workflow and communication? If not, what are the barriers?
7. What HIT differences have you noticed between facilities?

STAFFING

1. Have you noticed any turnover as a result of HIT introduction? Please describe.
2. Have you noticed any changes in staffing models (i.e team composition, how teams work together) as a result of HIT introduction?
3. Have you noticed any changes in roles as a result of HIT introduction? Please describe.

CARE TRANSITIONS

1. How do you use HIT when a resident is admitted, transferred to the ED, re-admitted/returned from the hospital, specialists appointments/consultants?
2. Do you receive paper or electronic copies of resident information when there is a care transition?
3. Is the handoff between external care providers done: verbally, on paper, electronically, in person, there is no handoff?

STAFF SUPPORT

1. Do you have a FT IT support? Part time? Consultant? Central Help Desk?
2. Is there a wait time when support is needed? If so, how long on average?
3. What support was provided to nurses who were challenged by the new technology?
4. Do you have 24-hour access to support?
5. How are you notified of any changes/modifications?
6. How are you trained when any changes to the software occurs?