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CONTINUING EDUCATION

Factors Influencing Outcomes of Clinical Information Systems Implementation

A Systematic Review

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Healthcare agencies spend significant resources to acquire or develop clinical information systems. However, implementation of clinical information systems often report significant failures. A systematic review of the research literature identified processes and outcomes of clinical information system implementation and factors that influenced success or failure. Of 124 original papers, 18 met the primary inclusion criteria—clinical systems implementation, healthcare facility, and outcome measures. Data extraction elements included study characteristics, outcomes, and implementation risk factors classified according to the Expanded Systems Life Cycle. The quality of each study was also assessed. Forty-nine outcomes of clinical information system implementation were identified. No single implementation strategy proved completely effective. The findings of this synthesis direct the attention of managers and decision makers to the importance of clinical context to successful implementation of clinical information systems. The highest number of factors influencing success or failure was reported during implementation and system "go-live." End-user support or lack thereof was the important factor in both successful and failed implementations, respectively. Following the Expanded Systems Life Cycle management model instead of a traditional project management approach may contribute to greater success over time, by paying particular attention to the underrecognized maintenance phase of implementation.

KEY WORDS

Clinical information systems • Expanded Systems Life Cycle • Implementation • Information management • Nursing informatics

Clinical information systems (CISs) are "large computerized database management systems used by clinicians to access a range of patient data to plan, implement, and evaluate care."[1] In this study, we use the expanded definition of CISs that includes a point-of-care, patient-focused computer system that replaces all or some of the paper medical records.[2] Other terms for CIS are *patient care information systems*, *computer-based patient records*, *medical information systems*, *patient care management systems*, *health information systems*, *nursing intervention systems*, and *electronic medical records*. In the broad context, CIS implementation is viewed as including all phases of an application's full life cycle, from planning through maintenance.

Healthcare is increasingly mediated by technology, and the implementation of CISs represents a new era of technological possibilities. As more sophisticated systems to manage patient information become available, there are rising expectations that these CISs will achieve outcomes for systems, users, managers, and patients. These outcomes, in turn, are expected to improve the efficiency and effectiveness of healthcare services. A successful implementation process is critical to gaining the economic and competitive advantages that innovation offers, but not enough is understood about the implementation process because efforts are often either complete or partial failures.[3] Success may depend in part on developing a better understanding of the factors that influence the success or failure of CIS implementation.[4]

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The value in examining CIS implementation is in relation to the implementation process itself and whether the outcomes expected are actually achieved within the context of clinical healthcare environments. Examining the role of nursing in implementing CISs is also valuable, as nurses may be unprepared for the requisite technological changes to their work. This could result in a significant lag between the creation of the new healthcare enterprise and the end user's ability to fulfill its potential.[5]

This area of study is important for several reasons. Clinical environments are unique and merit their own study, as what has been successful in business arenas has not always worked in healthcare.[6] Registered nurses are the predominant healthcare providers in the healthcare sector,[2] and nursing is healthcare's largest constituency.[7] The implementation of CISs influences the clinical practice environment, nurses, and nursing practice, as well as patient safety and quality of care, management decision making, and funding. It is now possible to capture physiologic observations, communicate with ancillary services such as laboratories, assist bedside clinicians to formulate nursing and medical care plans, and use a sophisticated CIS to capture all of the necessary data required to make sound clinical decisions.[2,8]

The importance of CISs has increased, and efforts to implement automated systems have intensified, as funding methods for health services become increasingly focused on outcomes. Accreditation, chronic disease management, physician remuneration models, and primary care networks all demonstrate a shift to outcomes-based funding. Although literature describing the implementation of computer systems in healthcare organizations is extensive, in a preliminary scoping of the literature, most studies examining CIS implementation were exploratory-descriptive in design, described by Brink and Woods[9] as level 1 research, which is appropriate for a developing field of knowledge. We could not find a synthesis of evidence that describes successful or failed CIS implementation. A review of current literature is important to identify and describe the best available evidence about CIS implementation. The study reported in this article was undertaken to address this gap in knowledge. The strength of our review lies in the rigorous assessment of the literature in a field that is new and lacks common definitions and understanding of the process of CISs implementation and outcomes.

STUDY OBJECTIVE

A systematic review of the research literature was undertaken to determine the current evidence about the process and outcomes of the implementation of CISs in healthcare facilities. The research question guiding the review was "What is the present state of knowledge about the process of CIS implementation and outcomes for the system, users, management or patients?" Content analysis of the literature identified outcomes, which were classified by system, user/provider, management, and patient.

CONCEPTUAL FRAMEWORK

A key assumption guiding this study was that the context in which a CIS is implemented can influence success or failure of implementation. Therefore, we determined that a theoretical model that takes account of the role of context in implementation would be used to guide this systematic literature review and selected the Expanded Systems Life Cycle (ESLC) framework by Thompson et al.[10] This model illustrates the full cycle of CIS implementation within complex clinical contexts. The ESLC model (Figure 1) proposes a logical process for planning, executing, and managing system life cycle activities for all types and sizes of healthcare settings.[10] The system life cycle management process is conceptualized in five major steps, which include planning, analysis, design, implementation, and maintenance.[10] In the planning stage, the process is initiated; however, planning continues throughout the entire life cycle. Analysis focuses on requirements for optimal solution. Design relates to the development or customization of the CIS for the clinical setting. Implementation is then initiated. A final phase, solution maintenance, follows implementation.[10]

In the ESLC model depicted in Figure 1, the dotted line surrounding the system life cycle management process conveys the continuous influence of dynamic contextual factors occurring within the healthcare environment.[10] Each segment of the system life cycle process has an identified risk zone and corresponding risk factors, further detailed in Figure 2. Although risk factors exert influence in a particular zone, they can also influence other system life cycle segments.[10] These downstream effects can also shape the progression and outcomes of CIS implementation.[10] Case study analysis has become a frequently used research method to study implementation strategies and context. The stories in case studies reveal how implementation strategies and contextual conditions mutually influence each other and work together to produce implementation outcomes.[11]

Outcomes Defined

We identified and used several types of outcomes relevant to CIS implementation. *System outcomes* refer to the results of a CIS implementation such as documentation

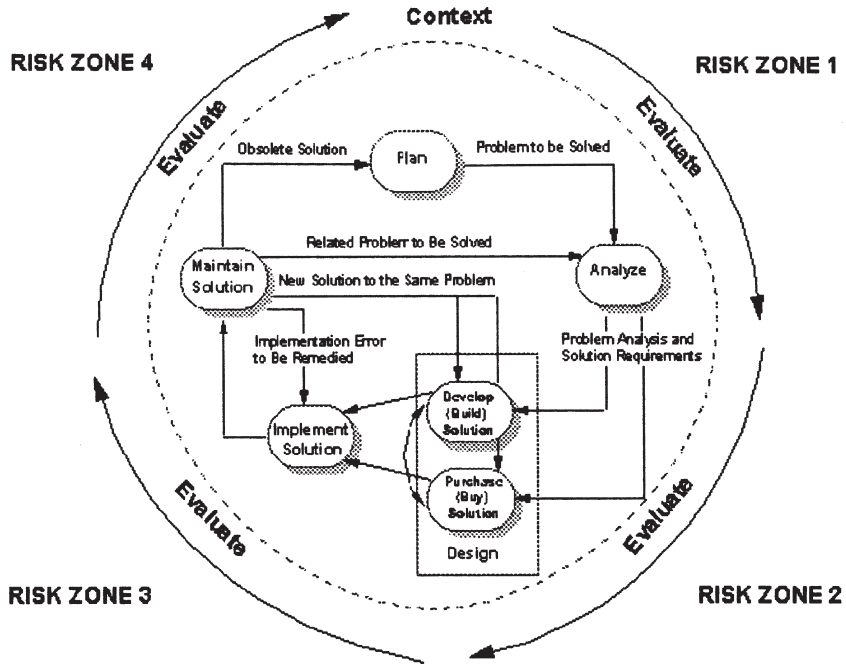

FIGURE 1. Extended Systems Life Cycle. Reprinted with permission from Thompson CB, Snyder-Halpern R, Staggers N. Analysis, process, and techniques: case study. *Comput Nurs.* 1999;17(5):204.

that is legible. *User outcomes* refer to the "end users" of the CIS who have hands-on interaction with the system in the course of providing patient care. *User-friendly* refers to a clinical system that is (1) "easy" to use, with as few "key strokes" as possible to enter data; (2) "intuitive," whereby moving from screen to screen is logical to clinical end users because it matches the work process and flow of information in the clinical setting; and (3) "interfaced" such that information is entered once, but used by many. *Management outcomes* refer to aspects of CIS that assist in managerial decision making, operational management, meeting government regulations, benchmarking organizational performance, and funding decisions within and external to the organization. *Patient outcomes* are those that are directly affected by CIS implementation for patients. Reduced wait times for procedures resulting from system efficiencies, reduced frustration when not being asked the same information by multiple care providers, having direct system access to book their own appointments online, and having access to their information or to faster results reporting to care providers are examples of patient outcomes.

METHODS

The search strategy was initiated by searching online bibliographical databases—CINAHL, Medline, and HealthStar from 1995 to 2005. HealthStar yielded the highest number of titles and abstracts. An online search of *Computers in Nursing* was completed for 1997 to 2003; *Computers, Informatics, Nursing*, for 2003 to 2005; and EBM Cochrane Systematic Review. The primary inclusion criteria were that the paper was written in English, involved clinical system implementation, had a healthcare facility/acute care as the setting, and included system, user, management, or patient outcome measures. Only papers that met the primary inclusion criteria were retained for review. Secondary inclusion criteria were used to determine whether research findings/evidence were being used to guide the CIS implementation (nursing informatics, theoretical model or framework, planning or implementation based on literature, adding to nursing domain knowledge, broad context for clinical system implementation, and the importance of this area of study).

Screening

The total yield from online database and online journal searches was 178 titles and abstracts, which were screened using the primary inclusion criteria. The primary author retrieved and screened 124 papers using the three primary inclusion criteria and secondary inclusion criteria of interest. The 124 papers were predominantly exploratory-descriptive in the form of case studies. A second reviewer randomly screened 20 of the 124 papers, blinded to the primary author's review. Discrepancies on four papers were discussed and consensus was reached. Of the original 124 papers,

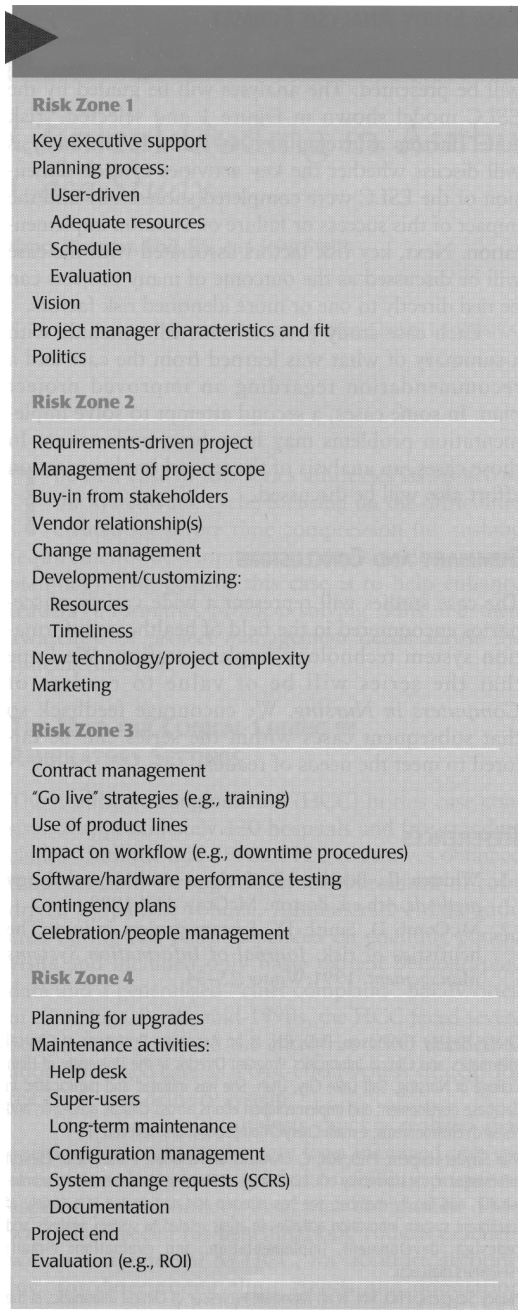

FIGURE 2. Selected risk zone factors. Reprinted with permission from Thompson CB, Snyder-Halpern R, Staggers N. Analysis, process, and techniques: case study. *Comput Nurs.* 1999;17(5):205.

21 were retained for review once screening criteria were applied.

Data Extraction

The following data were extracted from the 21 selected papers: author, journal, year, acute care healthcare facility, clinical system implementation, lessons learned, or outcome measures. The second level of extraction included the use of a conceptual model or framework to guide implementation, nursing informatics, nursing domain knowledge, CIS implementation in a broad context, and the relevance of the papers to this area of study.

Quality Review

The authors searched for a quality assessment instrument to review and categorize the included studies according to how well they examined and reported on CIS implementation and outcomes; however, none was found. Therefore, the primary author developed a screening tool that included the inclusion criteria of interest to reflect the dimensions of how research, nursing informatics, and nursing knowledge were applied by the authors. (A copy of the quality assessment tool may be obtained by contacting the primary author.) Possible scores could range from 1 to 16 points. A score greater than 9 was required to meet the minimum inclusion criteria.

RESULTS

Search Results

Only 18 studies met the mandatory inclusion criteria by achieving a score greater than 9. All 18 studies[2,6,11,13–27] in the final inclusion group were published between 1995 and 2003, with 16 completed in the United States, one in Canada, and one in Australia. Of the 21 retained studies, three studies scored less than 9 on the quality assessment tool[28–30] and were eliminated. The quality review-screening tool proved effective in differentiating the quality of the papers for final selection. A summary of the quality assessment scores and characteristics of the final 18 studies is presented in Table 1.

The study objective reported in all studies was the implementation of CISs in acute care facilities. Eight were identified as integrated systems, nine implied integration based on the assumption that point-of-care and nursing documentation systems were more sophisticated systems dependent on integration, and one was a beta stand-alone system. The articles included 14 case studies of exploratory-descriptive design and four research studies of preimplementation/postimplementation design. The four pre/post design studies used surveys, and of the 14 case studies, four used a survey as part of their preimplementation planning process to target appropriate end-user training.

The study populations included clinical nurses (registered and licensed practical nurses) and other healthcare practitioners. Nurses were identified as the only

Table 1

Characteristics of Included Studies and Quality Assessment Scores

Author (Year)/Study	Study Objective	Study Method	Population	Implementation Lead	Study Setting
Dillon et al (2003)[13]/ Research	Integrated clinical and administrative hospital-wide system in staged implementation phases Measurement Survey: 10-point questionnaire, 612 surveys, 22.7% return rate	Pre/post design	Nurses	Not known	450-Bed regional hospital center in the United States
Larrabee et al (2001)[14]/ Research	Study investigating influence on documentation completeness, to evaluate chart data validity for use in care decision making, quality improvement, and research of an NIS implementation Measurement Retrospective chart reviews using nursing care plan data collection instrument, a criterion-referenced instrument	Pre/post design	Nurses	Nurse project coordinator and four other nurses for NIS customization	100-Bed urban university hospital in Memphis, West Tennessee Study units: 31- and 32-bed medical-surgical units and 23-bed ICU step-down unit
Marasovic et al (1997)[2]/ Research	Preimplementation of a computerized CIS to be for patient charting and medical records Identify factors that affect attitude toward computers in a critical care environment to target training and support for users Measurement Survey Tested the presence and strength of association of age, education, nursing experience, and years of ICU experience with satisfaction, beliefs, and motivation of the users of CIS	Pre/post design	RNs	Not known	Installed in 6 of 15 beds in an ICU of a 900-bed tertiary referral hospital in Australia Westmead hospital ICU, New South Wales, Australia
Nahm and Poston (2000)[15]/ Research	Measured effects of nursing module point-of-care CIS on nursing documentation and patient satisfaction Measurement Data collection preimplementation and 6, 12, and 18 mo after. Nurse documentation sample size: 288 charts. Patient satisfaction: convenience sample, sample size: 108	Pre/post design	Nurses Patients	Unknown	General Hospital, North Carolina Four study nursing units randomly picked from 11 of 13 units scheduled for clinical system; 10-bed ICU, 20-bed progressive

(continues)

Table 1

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Author (Year)/Study	Study Objective	Study Method	Population	Implementation Lead	Study Setting
					care telemetry unit, 20-bed general surgery unit, and a 12-bed gynecological surgery unit
Anderson and Stafford (2002)[6]	Integrated clinical and administrative information system (ADT, finance, clinical, and medical records) 3-y Project, ''big bang'' implementation	Case study	Clinical staff (2000), including 538 nurses and 220 physicians	Five FT RNs dedicated to the project for 2 y; integrated clinical nurse expertise with IT knowledge	University Hospital, United States 2000 Clinical staff First of three inpatient hospitals and >60 outpatient clinics
Barr (2002)[16]	Integrated perioperative patient documentation system 18-mo Project Persuading nurses to overcome reluctance to embrace and master computer technology	Case study Survey (37 questionnaires, 86% return rate)	Nurses	Nurse educator, perioperative nurse leader	125-Bed acute care facility in mid-Atlantic region part of a larger for-profit corporation in the United States
Brooks Massanari (1998)[17]	Integrated multidisciplinary point-of-care CIS Implementation of NANDA nursing diagnosis in a CIS	Case study	Nurses and other care providers	PM: background unknown	250-Bed community hospital in the United States Multidisciplinary, integrated care
Cheung and Hamilton (1997)[18]	Introduction of a disease management system; integrated (not stated) 1-y Project	Case study	Clinical end users; IS support staff	Not known	Cancer Center in the United States 1800 Inpatient and >250 000 outpatient visits a year
Doyle and Kowba (1997)[19]	Integrated CIS inpatient medical record implementation Focused on the human side of change	Case study	Specialty and nursing unit staff, physicians	Nurse and physician leads	Military hospital in the United States
Halley and Kambic (1996)[20]	Implemented clinical documentation system 6-mo ''Big bang'' project	Case study	Clinical staff; ancillary staff: rehabilitation, respiratory, pharmacy, laboratory, DI, and dietary; physicians	VP operations and VP IS leadership	350-Bed hospital and multiple off-site outpatient clinics in the United States

(continues)

Table 1

(continued)

Author (Year)/Study	Study Objective	Study Method	Population	Implementation Lead	Study Setting
Johnson (2000)[21]	Implementation of an online nursing assessment module that branches to selection of nursing diagnosis in the hospital CIS Full year of planning before go-live	Case study	Nurses and unlicensed assistive personnel	NI specialist and IS analyst, with input from nursing practice committee	Metropolitan city hospital in the United States Pilot in four medical-surgical units of 35 beds each
LaDuke (2001)[22]	Implementing an online nursing documentation system 3-mo Project for revision to nursing documentation system	Case study	Nurses	IS coordinator as PM; input from nursing practice committee and nursing documentation committee	150-Bed rural community hospital in the United States Medical-surgical unit
Lytle et al (1999)[23]	Beta site implementation of a knowledge-based information system in a specialty area Not integrated system related to beta implementation 5-mo Project	Case study	Nurses Physicians (50–60 staff total)	Dedicated physician champion, nursing leader, nursing systems analyst, vendor PM, clinical oversight group	Southwestern hospital in the United States
Murphy et al (1995)[24]	Integrated point-of-care nursing documentation system implementation About providing education and support to nursing staff prior to, during, and after implementation to maximize consistent support and to minimize costs	Case study Survey	Nurses IS support staff	Nurse educator and IS representative conducted education sessions	Three units in a two-site 1175-bed tertiary care teaching hospital in Canada
Pare and Elam (1998)[11]	Implementation of a nursing flow sheet system Integrated: not stated	Case study	Nurses	Nurse project leader	Trauma center of a large, not-for-profit, teaching hospital in the United States Two trauma units: RESUS and ICU
Stebbins et al (1997)[25]	Integrated system to hold computer-based patient records implementation to provide access at all points in the HC enterprise (PCIS) Presurvey and postsurvey training components, attitudes toward PCIS, self-confidence using PCIS, and PCIS outcome expectations	Case study (preimplementation and postimplementation survey)	Nurses, ancillary departments, physicians (1800 personnel, 39 patient care areas)	Nursing task force formed with representation from all units to provide leadership	800-Bed tertiary level teaching hospital in the United States

(continues)

Table 1

(continued)

Author (Year)/Study	Study Objective	Study Method	Population	Implementation Lead	Study Setting
Travers (1997)[26]	Integrated ED patient tracking system development and implementation 1 y from planning to implementation; 9-mo preimplementation project; 1 mo dual systems—manual and computerized	Case study; survey of computer attitudes of nurses used to develop training plan	ED clinical staff Physicians Registration staff Bed control staff 160 staff trained in 25 classes in the nursing informatics computer laboratory	Dual PMs: MSN-prepared emergency nurse educator with expertise in computer systems and IS director. Team included a physician with informatics experience	University hospital in the United States Level I trauma center emergency department move from 23- to 53-bed ED
Whitman et al (1997)[27]	Pilot project of a bedside documentation system Focused on training	Case study	Nurses Nurse assistants	Nurse manager leadership; contract between management, IS, and staff development	Pilot project on two acute care facilities in the United States; cardiac/telemetry unit and a 29-bed orthopedic and neurology unit
Summary of 18 studies	CIS implementation integrated system (8) CIS implementation integrated likely but not stated (9) CIS implementation: not integrated	Pre/post design (4) Case study (14)	Nurse/nurse assistants (8) Clinical staff + physicians + ancillary departments (7) Nurses + patients (1) Clinical end users + IS staff (2)	PM PM/coordinator: nurse (3) PM: other or unknown (15) Leadership Nurse (8) Nursing task force/nurse practice committee (4) Other or unknown (6)	Facility size 100–249 Beds (3) 250–499 Beds (3) 500–1200 Beds (3) Unknown, but bed number of university hospital, etc, suggest medium to large (5)

Abbreviations: ADT, admissions discharge and transfer system; DI, diagnostic imaging; ED, emergency department; FT, full-time; HC, healthcare; IS, information system; IT, information technology; NI, nursing informatics; NIS, nursing information systems; PCIS, patient care information system; PM, project manager; RESUS, resuscitation unit; VP, vice president.

participants in eight of the 18 studies, whereas in seven studies, nurses were combined with other study participants such as physicians and staff from ancillary departments. An implementation project manager was identified in only three studies. In each of these, the project manager was reported to be a nurse. Project leadership by a nurse was reported in eight studies, leadership by a nursing committee in four studies, and no leadership type identified in 6 studies. Of the 18 studies, nine reported using a theoretical model to guide planning or implementation; eight referred to nursing informatics; six referred to nursing knowledge and/or the practice of nursing; and five based the CIS implementation on nursing or other literature, such as change management or adult teaching theories.

The study settings included facilities ranging in size from 100 to 1 200 beds, with 15 studies in the 250- to 1 200-bed size range. The study setting unit type was identified in nine studies as critical care only, critical care combined with medical-surgical, or medical-surgical settings alone. Nine studies did not identify a specific setting.

Study Outcomes

The studies were examined to identify the outcomes of CIS implementation that were anticipated by each agency. The outcomes were then categorized as system, user, management, or patient outcomes. As shown in

Table 2

Summary of Outcomes of CIS Implementation Anticipated by Healthcare Agencies

	No. of Outcomes
System outcomes	
User-friendly, meaningful screen and lists, system performance, functionality	4
Integration between areas and other systems, accessibility decision tools, data availability, reduce duplication	5
Total system outcomes	9
User/provider outcomes	
Acceptance/adoption/motivation to use system	6
Confidence/self-efficacy/preparedness	4
Satisfaction	3
Feel supported (IT and administration)	2
Data integrity, validity, quality, accuracy	3
Clinical staff using system, completeness of documentation entered, clinical staff sharing information electronically	6
Optimal clinical management of patients, speed of communication to improve patient care	2
Seamless patient care, efficiency of care processes, decrease documentation time	3
Total user/provider outcomes	29
Management outcomes	
Use of data, reports, benchmarking for decision making and quality control	1
Meet regulatory requirements, clinical and financial	2
Compliance of staff with charting standards	2
Demonstrate leadership and trust through communication, willingness to invest in staff development	1
Efficiency of care processes, operational efficiencies, improve worker productivity, decrease training costs	3
Total management outcomes	9
Patient outcomes	
Satisfaction regarding nurse-patient relationship	1
Reduced frustration related to multiple requests for same information by different disciplines	1
Total patient outcomes	2
Total CIS implementation anticipated outcomes	49

Abbreviation: IT, information technology.
Each paper represents from one to four outcomes and from one to four categories.

Table 2, this content analysis resulted in 49 outcomes that consisted of nine system outcomes, 29 user/provider outcomes, nine management outcomes, and two patient outcomes.

The outcomes anticipated by the agency in each study were compared with those actually measured and achieved. A summary of anticipated outcomes of CIS implementation in the retained 18 papers and the number of times each outcome was reported is presented in Table 3. These data include factors that were observed, measured, or self-reported as leading to success or failure of implementation. System, user, management, and patient outcomes were reported, with the greatest number relating to user outcomes. In the four research studies, five outcomes were measured, with a mixed result of successes and failures. In the 14 case studies, which reported a total 45 anticipated outcomes, only 26 were achieved, of which 23.5 were identified as successes.

As described earlier in this paper, the ESLC framework (Figure 1) was chosen to categorize the factors associated with success and failure in each study into risk zones to determine if any patterns emerged. The summary of risk zone factors found to influence CIS implementation success/failure is presented in Table 4. Of the final 18 studies, 17 reported a combination of factors leading to success and failure, one reported failure only, and none reported success only. Analysis of each article revealed risk zone factors identified with each implementation in one to four of the risk zones, with risk zone factors crossing greater than or equal to three of the four zones in 15 of the 18 articles.

This analysis revealed a total of 47 success factors and 38 failure factors across several risk zones. The highest number of success and failures were in zone 3 (implementation—the zone focusing on preimplementation

Table 3

Summary Comparison of Anticipated, Measured, and Achieved Outcomes

Study Type (n)	Anticipated Outcomes	Measured Outcomes	Successful Outcome[a]
Research (4)			
System	0	0	0
User	3	3	1
Management	1	1	1
Patient	1	1	1
Subtotal	5	5	3

Study Type (n)	Expected Outcomes	Self-reported Outcome	Self-reported Successful Outcome
Case studies (14)			
System	9	5	5
User	26	16	13.5
Management	8	4	4
Patient	2	1	1
Subtotal	45	26	23.5

[a]Yes, 1 point; partial, 0.5 point.

Table 4

Summary of Risk Factors Found to Influence Implementation Success and Failure

Risk Factors per ESLC Zone	Presence Contributed to Success	Absence Contributed to Failure
Zone 1—plan		
Resources: other	1	
Nurse leadership, nursing committee leadership, nurse PM, nurses dedicated to the project, clinical input	4	4
Staff and physician empowerment	2	
Discussions with IS to increase their understanding of clinical business	1	
Buy-in by top executives along with financial support	1	1
Change management, manage anxiety, resistance	2	2
Vendor partnership	1	
Implemented non–system-dependent functionality early	1	1
Define new processes earlier in a project		1
Recognized uniqueness of clinical area	2	1
Initiate automation slowly	1	
Clear evaluation criteria		1
Ensure system value	1	
Enough PCs, standards for hardware/software		2
Zone 2—analyze		
Resources' availability—impact of vacation time on clinical environment		1
Broad representation	1	
Peer trainers' testing of training content	1	
Project team very representative, including nursing informatics	1	
Managing change—people		3
Staff access to developers for customization	1	
Nurse participation/customization; attention to unique design	2	1
Creation of small dictionaries using standardized language	1	
Match of logic underlying paper and computer-based systems	1	1
System functionality to guide nurses through documentation	1	
Extensive testing	1	
Zone 3—implement		
Communication	4	2
Training of technical support staff		2
Change management, staff satisfaction, fostered working relationships, computer acceptance	4	2
Manager involvement and appreciation of impact of CIS	1	
Staff training		2
Testing of screens by competent individuals knowledgeable in practice		1
Training/education, attention to training, policy, and process changes, training to clinical content	9	4
Go-live support, on-site support	4	3
Sufficient time to document, screens too long and too detailed to be practical		2
Extensive testing to identify system and operational problems	1	1
Enough PCs		1
Zone 4—maintain		
Key resources post–go-live	3	1
Lack of performance measurement of staff or vendors		2
Competency test at end of training		1
Adequate support		2
Outsourcing of IS support		1
Staff satisfaction		1
Ongoing training		2
Staff learning curve variances, needed rounds to assess user needs and to observe interaction between users and system		1
Process reengineering post–go-live, attention to making changes needed to meet needs of users, establishing process to manage change requests	3	2

(continues)

Table 4

(continued)

Risk Factors per ESLC Zone	Presence Contributed to Success	Absence Contributed to Failure
System changes—responsiveness	1	1
Ongoing user errors in system use		1
Strong emphasis on policies, procedures and role changes		1
End-user help desk support issues addressed	1	1
Mixed technical environment created support difficulties		1
Periodic evaluation of documentation, benchmarking	2	2
System problems		1

Abbreviations: IS, information system; PC, personal computer; PM, project manager.

training and "go-live" of the system). Figure 2 provides the original risk factors associated with influencing outcomes of the ESLC. Table 4 adds additional detail to some of the risk zone factors currently listed in Figure 2 and presents the additional factors found in this review.

DISCUSSION

This study was completed to identify the state of knowledge about the implementation of clinical systems and outcomes for systems, end users, management, and patients. Applying the ESLC framework to identify risks at each phase of the implementation in the included studies yielded evidence of an emphasis on go-live dates and limited support for end users. End-user support or lack thereof was an important factor in both successful and failed implementations, respectively. This study may also be the first to test the application of the ESLC in examining CIS implementation in a systematic review. In doing so, we have suggested additional risk factors based on the empirical findings and their associations with success or failure of implementation.

This systematic review demonstrates that implementation of CIS, as point-of-care clinical systems in healthcare facilities, is of significant interest to healthcare administrators, nurses, and the nursing profession and to furthering nursing knowledge. Although the case studies are predominantly descriptive in nature, they discuss expected and achieved outcomes related to the system, users, management, and patients. Successful implementation was largely dependent on the "context" of the clinical environment, system maintenance, end-user support, evaluation to ensure system benefits, and key actors to ensure success. This review has also demonstrated the value of case study research to better understand the complexities of the implementation process.

Implementation methodology is complex, and despite research and experience, it is not possible to designate a single implementation approach that will work in all situations.[11] More in-depth research is needed to identify how costly errors in implementation can be avoided.[12] The findings of this synthesis suggest several areas where ongoing research could be focused or strengthened. First, future research into the implementation of CIS should consider the influence of context in the clinical environment. Second, it is important for researchers to report a clear description of the CIS interventions. The expected outcomes and approaches to measurement of the intervention and outcome should also be reported at the levels of the system, users, managers, and patients. Effects on operational procedures such as patient wait-lists and on broader issues such as system sustainability should also be documented. Longitudinal investigation is required to observe the complexity of CIS, to develop strategies to mitigate risks associated with CIS implementation, and to support and maintain outcomes over time.

The findings of this review also suggest the need to establish regular processes for auditing electronic documentation to measure and ensure data quality, target areas of improvement, and increase confidence in decision making based on the data. Long-term attention to end-user training and support is key to data quality and reliability for management decision making and healthcare funding decisions. To shortchange training and long-term support when implementing a CIS jeopardizes anticipated return on investment in quality patient care.

It is important to develop evidence-based funding decisions and CIS postimplementation support models that help decision makers determine how best to support clinical end users and that provide direction to information technology departments and administrators on how best to support and maintain CIS on an ongoing basis.

The importance of involving and educating nurses in all aspects of CIS implementation and support is evident from the findings of this review. Nurses can and should be educated in nursing informatics and project

management methods to prepare for, participate in, and lead clinical systems implementation. Nurses should also be informed about the importance of data integrity to support decision making related to patient care and organizational outcomes. Research into training methods best suited to this workforce is needed with the recognition that an investment in training can bring about the best of all that is already being invested in a highly skilled and specialized workforce.[5]

These findings also suggest that it is important for nurses to recognize the potential influence that clinical systems implementation can have on nursing practice and the nursing profession and on furthering nursing knowledge. Nurses use advanced information technology to provide care, document that care, research better treatment methods, and transfer knowledge to colleagues at every level of experience, in every specialty and in every care setting imaginable.[8] It is also valuable for nurses to recognize the opportunity that CIS can bring about in standardizing, describing, and studying the contribution of nursing in achieving positive patient outcomes.

This review has three potential limitations. First, a potential reporting bias may exist by including only published studies that tend to overreport positive findings. However, in this review, we have balance, as both negative and positive findings were reported in most of the literature reviewed, with none of the published studies reporting positive findings only. Second, only US, Canadian, and Australian articles describing the process of CIS implementation and outcomes were reported in the literature. Although implementation of computer systems in healthcare organizations is extensive, it is apparent that more countries are experiencing CIS implementation than are publishing their findings. Third, our search strategy restricted titles or abstracts to English language because it was the language of proficiency of our research team. This may have resulted in overlooking additional evidence of specific cultural factors that influence CIS implementation in nursing.

CONCLUSION

In this systematic review, we have demonstrated that research into the process of CIS implementation and outcomes is (1) relatively recent, (2) of significant interest, (3) primarily descriptive, and (4) an evolving field given the existence of very little theoretical work. The findings of this review confirm the rapid advancement of CISs, the complexity of CIS implementation, and the importance of viewing system implementation in the context of diverse clinical environments. Use of the ESLC model confirms that support within and across each risk zone is key to facilitating clinical system implementation and to achieving defined outcomes.[9] Time pressures are often associated with the implementation of clinical systems, and research is urgently needed to mitigate the risks of failure, guide the implementation process within specific clinical environments, and achieve expected outcomes. Technology is leaving its mark on nursing,[7] and nursing professionals will become active participants and leaders in the development and implementation of CIS as they recognize the impact and potential of CIS on nursing practice.

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