Critical Care & Patient Information Systems - References

Web Links

Achieving Value from ICT: Key Management Strategies Australian Department of Communications, Information Technology and the Arts 2005 & Summary Booklet
http://www.dcita.gov.au/__data/assets/pdf_file/25466/Achieving_Value_from_ICT_-_Key_Management_Strategies.pdf

BMJ Topic Collection on Information in Practice
http://bmj.bmjjournals.com/cgi/collection/information_in_practice

Clinical Information Systems in Intensive Care June 1999 Critical Care and Resuscitation Journal article by D. J. Fraenkel Intensive Care Facility, Royal Brisbane Hospital, Brisbane
http://www.jficm.anzca.edu.au/aaccm/journal/AACCM-JJune99-f.htm

Connecting for Health NHS Publications such as business plans etc
http://www.connectingforhealth.nhs.uk/publications/

Eleven Critical Success Factors for Implementing Electronic Medical Records GE Medical Systems
http://www.medicalogic.com/emr/user_experience/eleven_factors.html

Health Canada eHealth
http://www.hc-sc.gc.ca/hcs-sss/ehealth-esante/index_e.html

Intensive Care Information Systems
http://www.intensivecare.com/ICISresources.html

Key Capabilities of an Electronic Health Record System: Letter Report Institute of Medicine 2003 "As part of a national effort to encourage the adoption of computer-based health records, a committee of the Institute of Medicine of the National Academies has identified a set of eight core functions that electronic health records (EHRs) should be capable of performing in order to promote greater safety, quality, and efficiency in health care delivery. Detailed in a new report, this list of key capabilities will be used by Health Level Seven (HL7), one of the world's leading developers of health care standards, to devise a common industry standard for EHRs that will guide the efforts of software developers."
"The eight core capabilities that EHRs should possess are:
Health information and data. Having immediate access to key information -- such as patients' diagnoses, allergies, lab test results, and medications -- would improve caregivers' ability to make sound clinical decisions in a timely manner.

Result management. The ability for all providers participating in the care of a patient in multiple settings to quickly access new and past test results would increase patient safety and the effectiveness of care.
Order management. The ability to enter and store orders for prescriptions, tests, and other services in a computer-based system should enhance legibility, reduce duplication, and improve the speed with which orders are executed.
Decision support. Using reminders, prompts, and alerts, computerized decision-support systems would help improve compliance with best clinical practices, ensure regular screenings and other preventive practices, identify possible drug interactions, and facilitate diagnoses and treatments.
Electronic communication and connectivity. Efficient, secure, and readily accessible communication among providers and patients would improve the continuity of care, increase the timeliness of diagnoses and treatments, and reduce the frequency of adverse events.
Patient support. Tools that give patients access to their health records, provide interactive patient education, and help them carry out home-monitoring and self-testing can improve control of chronic conditions, such as diabetes.
Administrative processes. Computerized administrative tools, such as scheduling systems, would greatly improve hospitals' and clinics' efficiency and provide more timely service to patients.
Reporting. Electronic data storage that employs uniform data standards will enable health care organizations to respond more quickly to federal, state, and private reporting requirements, including those that support patient safety and disease surveillance."
http://darwin.nap.edu/books/NI000427/html/
http://www4.nas.edu/news.nsf/6a3520dc2dbfc2ad85256ca8005c1381/856fc5e51dc464d585256d74006b8234?OpenDocument

Medical Informatics for Better and Safer Health Care Agency for Healthcare Research & Quality 2002
http://www.ahrq.gov/data/informatics/informatria.htm

Patient Safety: Achieving a New Standard for Care Institute of Medicine (US)
http://darwin.nap.edu/books/0309090776/html/

Rand Health Health Information Technology Research "The U.S. invests over $1.7 trillion annually in healthcare, yet the healthcare system is still plagued with inefficiency and poor quality. Better information systems could help. Most providers lack the information systems necessary to coordinate a patient's care with other providers, share needed information, monitor compliance with prevention and disease-management guidelines, and measure and improve performance. Other industries have lowered costs and improved quality through heavy investments in information technology. Could healthcare achieve similar results? RAND researchers have estimated the potential costs and benefits of widespread adoption of Health Information Technology (HIT). The team also has identified the actions needed to turn potential benefits into actual benefits."
http://www.rand.org/health/feature/research/0509_hit.html
http://www.rand.org/pubs/research_briefs/RB9136/RAND_RB9136.pdf

Rand Health The State and Pattern of Health Information Technology Adoption "Helps focus the policy agenda for incentives to speed Healthcare Information Technology (HIT) adoption by estimating the current level and pattern of HIT adoption in the different types of healthcare organizations, according to information the Healthcare Information and Management Systems Society (HIMSS)-Dorenfest database, and evaluates factors that affect this diffusion process, using existing empirical studies and regression analysis.
http://www.rand.org/pubs/monographs/MG409/index.html

Journal References

The journal references listed were searched in the PubMed database on 25th January 2006.

AACN Clin Issues. 2003; 14(3): 310-9; quiz 397-8.
Human factors: imperative concepts for information systems in critical care.
Staggers N.
Information Technology Services, Health Sciences Center, University of Utah, Salt Lake City, 84108, USA. nancy.staggers@hsc.utah.edu
This article provides an overview of human factors, ergonomics, human-computer interaction, and usability concepts as they relate to critical care settings. The use of these concepts can improve patient safety and the productivity of nurses, especially as they relate to the use of information systems. A framework for human-computer interaction is presented. Examples illustrate how the suite of human factors concepts is used to create intuitive, effective data presentations for use in critical care including an intensive care unit (ICU) summary display, an alternative graphic display, and modeling information sources of decision making in a neonatal ICU. The importance of integrating these concepts into advanced practice nurses' environments is made apparent.
Publication Types: Journal Article Review
PMID: 12909799

AACN Clin Issues. 2003; 14(3): 295-301.
Clinical decision support in critical care nursing.
Lyons A, Richardson S.
Misys Healthcare Systems, Salt Lake City, Utah, USA.
A clinical decision support system (CDSS) is a computerized application that helps clinicians detect and prevent untoward clinical events such as drug interactions, errors of omission, and trends in symptomatology. A CDSS in healthcare usually is built around an alerting system based on rules of logic. The alerting system of a CDSS can notify clinicians immediately on clinical data entry, or it can generate alerts over time after relating data from multiple sources. A CDSS for nurses and patients offers immediate benefits for nurses and patients by detecting potential drug-laboratory and drug-drug combinations and impending pharmacologic complications, monitoring microbiology results, and helping nurses relate symptoms to pharmacology and medication side effects. Other benefits include savings in time and money and reductions in morbidity and mortality. A CDSS presents an opportunity for nursing informatics and critical care nursing to collaborate for the benefit of the patient and the profession.
Publication Types: Journal Article
PMID: 12909797

AACN Clin Issues. 2003; 14(3): 271-81.
Nursing informatics: the key to unlocking contemporary nursing practice.
Zytkowski ME.
Department of Surgical Services, Cleveland Clinic Foundation, OH 44195, USA. zytkowm@ccf.org
Nursing informatics is a relatively new nursing specialty. Recognized by the American Nurses' Association in 1992, this field within nursing has grown exponentially. Once the purview of highly specialized individuals, nursing informatics has now crept into all dimensions of nursing, from domain of advanced nurse practitioners to prominence in critical care nursing. Nowhere is the management and processing of health-related information more important than in the care of the critically ill patient. Fast-paced environments, split-second decision making, wireless communications, monitoring systems run with computerized backbones, and computerized ordering and documentation, all things unimaginable just a decade ago, are now fundamental to nursing practice. Each requires a baseline understanding of informatics for true mastery. The domain of nursing informatics continues to grow as nursing incorporates expanded roles and new technology into practice. Education for nurse informaticians includes preparation from the baccalaureate level through the doctorate level and national board certification. Areas of practice are expansive, including hospitals, industry, education, policy-making, research, administration, and international settings. Although informaticians work with computers, computing technology is not the heart of the domain. Computers are simply tools that are used. Examples of informatics tools include handheld devices, point-of-care documentation, computerized provider order entry, and bar code medication administration. Nursing informatics plays an essential role in the future directions of

healthcare by defining the relationship between nurses and information technology as well as the knowledge that can be gained when these domains work together.
Publication Types: Journal Article Review PMID: 12909795

Acta Anaesthesiol Scand. 2005; 49(1): 62-5.
Does the implementation of a clinical information system decrease the time intensive care nurses spend on documentation of care?
Saarinen K, Aho M.
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BACKGROUND: The number of intensive care units (ICU) using a clinical information system (CIS) is increasing. It is believed that replacing manual charting with an automatic documentation system allocates nurses more time for patient care. The objective of this study was to measure changes in nurses' working time utilization after the implementation of a CIS in a polyvalent ICU of a large Finnish central hospital. METHODS: An activity analysis-based comparison of the ICU nurses' working time utilization before and after the implementation of a CIS. RESULTS: After the implementation of a CIS the total time the nurses spent on documentation of nursing care increased by 3.6% (NS), 15 min per shift of 8 h per nurse. The total time they spent on patient care increased by 5.5% ($P < 0.05$), 21 min. Intensive care nursing activities increased by 3.7% ($P < 0.05$), 14 min. The length of the nurses' ICU experience had some effect on these figures. The demand for nurse labor remained constant. CONCLUSIONS: After the implementation of a CIS, an increase in the time nurses spent on documentation of care was detected, which suggests a need for further development of the system. As all the measured time changes were relatively small, any plans to reduce the ICU staff number with the aid of computers were not justified.
Publication Types: Journal Article PMID: 15675984

Am J Manag Care. 2004; 10(11 Pt 2): 878-85.
Variation in implementation and use of computerized clinical reminders in an integrated healthcare system.
Fung CH, Woods JN, et al.
Department of Medicine, Division of General Internal Medicine, VA Greater Los Angeles Healthcare System, Los Angeles, CA, USA. cfung@mednet.ucla.edu
OBJECTIVES: To identify patterns of use of computerized clinical reminders (CCRs) across an integrated healthcare system and describe institutional factors associated with their implementation. STUDY DESIGN: Cross-sectional study. METHODS: At a national electronic health record (EHR) meeting, we surveyed 261 participants from 104 Veterans Health Administration (VHA) healthcare facilities regarding the number and types of CCRs available at each facility. Potential explanatory measures included perceived utility and ease of use of CCRs, training and personnel support for computer use, EHR functionalities, and performance data feedback to providers at each facility. RESULTS: The number of conditions with CCRs in use at a facility ranged from 1 to 15; most reported implementation of reminders for 10 of the 15 conditions surveyed. The most commonly implemented CCRs, used in more than 85% of facilities, were for conditions with VHA national performance measures (eg, tobacco cessation, immunizations, diabetes mellitus). The least commonly implemented CCRs were for post-deployment health evaluation and management, medically unexplained symptoms, and erectile dysfunction. Facilities that had implemented greater numbers of clinical reminders had providers who reported greater ease of use and utility of the reminders ($P= .01$). CONCLUSIONS: VHA facilities vary markedly in their implementation of CCRs. This effect may be partly explained by greater incorporation of clinical reminders for conditions with performance measures. Further study is needed to determine how to best implement clinical reminders and the institutional factors important in their use.
Publication Types: Journal Article Multicenter Study PMID: 15609742

AMIA Annu Symp Proc. 2003: 150-4.
The Effects of CPOE on ICU workflow: an observational study.
Cheng CH, Goldstein MK, et al.
Department of Medicine (Stanford Medical Informatics), CA, USA.
Computerized physician order entry (CPOE) has had demonstrated benefits in error reduction and guideline adherence, but its implementation has often been complicated by disruptions in established workflow processes. We conducted an observational study of the healthcare team in an intensive care unit after the implementation of mandatory CPOE. We found that policies designed to increase flexibility and safety led to an increased coordination load on the healthcare team, and created opportunities for new sources of error. We attribute this in part to implicit assumptions in the CPOE system design that

execution of physician orders is a linear work process. Observational workflow studies are an important tool to understand how to redesign CPOE systems so as to avoid harm and achieve the full potential of benefit for improved patient safety.
Publication Types: Journal Article PMID: 14728152

AMIA Annu Symp Proc. 2003: 810.
A real time interface between a computerized physician order entry system and the computerized ICU medication administration record.
Chen J, Shabot MM, et al.
Departments of Enterprise Information Services and Surgery, Cedar-Sinai Medical Center and the UCLA School of Medicine, Los Angeles, California, USA.
Prior attempts to interface ICU Clinical Information Systems (CIS) to Pharmacy systems have been less than successful. The major problem is that in ICUs, medications frequently have to be administered and charted in the CIS Medication Administration Record (MAR) before pharmacists can enter them into the Pharmacy system. When the Pharmacy system belatedly sends medication orders to the CIS MAR, this may create duplicate entries for medications that ICU nurses have had to enter manually to chart doses actually given. The authors have implemented a real time interface between a Computerized Physician Order Entry (CPOE) system and a CIS operating in ten ICUs that solves this problem. The interface transfers new medication orders including order details and alerts directly to the CIS Medication Administration Record (MAR), where they are immediately available for nurse charting. Methods: The Patient Care Expert (PCX) web-based CPOE system was developed at Cedars-Sinai Medical Center and interfaced to a CIS serving 133 beds in 10 ICUs (CareVue CIS, Philips Medical Systems, Andover, MA). The CPOE used an existing CIS interface specification available for Pharmacy systems. At other CIS sites Pharmacy interfaces had enjoyed limited success because in many cases, ICU nurses had to manually add drugs to the MAR to chart urgent and emergent doses. When physician orders were finally processed by the Pharmacy, the orders sent to the CIS were frequently posted on the MAR as duplicate entries, causing confusion in the medical record. Although the PCX CPOE was interfaced to the hospital's Pharmacy system, for ICU patients all medication orders were transmitted to the CIS MAR. As soon as a physician authenticated orders with an electronic signature (Figure 1), all medication orders appeared in the CIS MAR, ready for the nurse to verify the orders and then chart doses. The medications shown in gray in Figure 2 are new automatic entries the nurse will authenticate with an electronic signature. Once authenticated, nurses may chart individual doses Results: 40,170 ICU medication, IV infusion and IV drip orders were automatically transferred from the CPOE to ICU CIS MARs during three months of CPOE operation. The interface eliminated manual order transcription, medication entry errors and improved ICU nurse efficiency and satisfaction.
Publication Types: Journal Article PMID: 14728315

Anaesthesia. 2005; 60(11): 1093-100.
Implementation of a tight glycaemic control protocol using a web-based insulin dose calculator.
Thomas AN, Marchant AE, et al.
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We describe the implementation of a glucose control protocol supported by a web-based insulin dose calculator in a 16-bedded intensive care unit. The protocol was introduced and then modified after 15 months' use. Glucose concentrations were retrospectively reviewed and compared for the 9-month period before introduction of the protocol (288 patients), for 15 months after its introduction (502 patients) and for a further 5 months after its modification to increase insulin dose (101 patients). The mean (SD) blood glucose concentrations decreased from 7.3 (1.8) mmol.l(-1) to 6.6 (1.6) mmol.l(-1) and then to 6.2 (1.3) mmol.l(-1). The proportion of values < 8.0 mmol.l(-1) increased from 69% to 81% and then to 89%. Blood glucose concentrations were increased by the use of intravenous nutrition and by vasoactive drugs but not by the administration of propofol. The odds ratio [95% CI] for death for glucose values > 8.0 mmol.l(-1) was 2.10 [1.19-3.73] compared to values < 6.1 mmol.l(-1). However, patient mortality remained constant during the study. Glycaemic control was improved outside a research setting using a protocol supported by a web-based insulin dose calculator.
Publication Types: Evaluation Studies Journal Article PMID: 16229694

Anasthesiol Intensivmed Notfallmed Schmerzther. 2002; 37(8): 475-6.
Data management in anesthesia and intensive care medicine.
Junger A, Hempelmann G.
Abteilung Anasthesiologie und Operative Intensivmedizin, Justus-Liebig-Universitat Giessen, Germany.
Publication Types: Journal Article PMID: 12165917

Ann Intern Med. 2005; 143(3): 165-73.

The costs of a national health information network.

Kaushal R, Blumenthal D, et al.

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BACKGROUND: The use of information technology may result in a safer and more efficient health care system. However, consensus does not exist about the structure or costs of a national health information network (NHIN). OBJECTIVES: To describe the potential structure and estimate the costs of an NHIN. DESIGN: Cost estimates of an NHIN model developed by an expert panel. SETTING: U.S. health care system. MEASUREMENTS: An expert panel estimated the existing and the expected prevalence in 5 years of critical information technology functionalities. They then developed a model of an achievable NHIN by defining key providers, functionalities, and interoperability functions. By using these data and published cost estimates, the authors determined the cost of achieving this model NHIN in 5 years given the current state of information technology infrastructure. RESULTS: To achieve an NHIN would cost 156 billion dollars in capital investment over 5 years and 48 billion dollars in annual operating costs. Approximately two thirds of the capital costs would be required for acquiring functionalities and one third for interoperability. Ongoing costs would be more evenly divided between functionality and interoperability. If the current trajectory continues, the health care system will spend 24 billion dollars on functionalities over the next 5 years or about one quarter of the cost for functionalities of a model NHIN. LIMITATIONS: Because of a lack of primary data, the authors relied on expert estimates. CONCLUSIONS: While an NHIN will be expensive, 156 billion dollars is equivalent to 2% of annual health care spending for 5 years. Assessments such as this one may assist policymakers in determining the level of investment that the United States should make in an NHIN.

Publication Types: Journal Article PMID: 16061914

BMC Med Inform Decis Mak. 2004; 4: 18.

Use of and attitudes to a hospital information system by medical secretaries, nurses and physicians deprived of the paper-based medical record: a case report.

Laerum H, Karlsen TH, et al.

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BACKGROUND: Most hospitals keep and update their paper-based medical records after introducing an electronic medical record or a hospital information system (HIS). This case report describes a HIS in a hospital where the paper-based medical records are scanned and eliminated. To evaluate the HIS comprehensively, the perspectives of medical secretaries and nurses are described as well as that of physicians. METHODS: We have used questionnaires and interviews to assess and compare frequency of use of the HIS for essential tasks, task performance and user satisfaction among medical secretaries, nurses and physicians. RESULTS: The medical secretaries use the HIS much more than the nurses and the physicians, and they consider that the electronic HIS greatly has simplified their work. The work of nurses and physicians has also become simplified, but they find less satisfaction with the system, particularly with the use of scanned document images. CONCLUSIONS: Although the basis for reference is limited, the results support the assertion that replacing the paper-based medical record primarily benefits the medical secretaries, and to a lesser degree the nurses and the physicians. The varying results in the different employee groups emphasize the need for a multidisciplinary approach when evaluating a HIS.

Publication Types: Case Reports Journal Article PMID: 15488150

Bmj. 2001; 323(7325): 1344-8.

Doctors' use of electronic medical records systems in hospitals: cross sectional survey.

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OBJECTIVES: To compare the use of three electronic medical records systems by doctors in Norwegian hospitals for general clinical tasks. DESIGN: Cross sectional questionnaire survey. Semistructured telephone interviews with key staff in information technology in each hospital for details of local implementation of the systems. SETTING: 32 hospital units in 19 Norwegian hospitals with electronic medical records systems. PARTICIPANTS: 227 (72%) of 314 hospital doctors responded, equally distributed between the three electronic medical records systems. MAIN OUTCOME MEASURES: Proportion of respondents who used the electronic system, calculated for each of 23 tasks; difference in proportions of users of different systems when functionality of systems was similar. RESULTS: Most tasks listed in the questionnaire (15/23) were generally covered with implemented functions in the electronic medical records systems. However, the systems were used for only 2-7 of the tasks, mainly associated with reading

patient data. Respondents showed significant differences in frequency of use of the different systems for four tasks for which the systems offered equivalent functionality. The respondents scored highly in computer literacy (72.2/100), and computer use showed no correlation with respondents' age, sex, or work position. User satisfaction scores were generally positive (67.2/100), with some difference between the systems. CONCLUSIONS: Doctors used electronic medical records systems for far fewer tasks than the systems supported.
Publication Types: Journal Article PMID: 11739222
http://bmj.bmjjournals.com/contents-by-date.0.shtml

Bmj. 2003; 326(7394): 860-3.
Evaluating computerised health information systems: hard lessons still to be learnt.
Littlejohns P, Wyatt JC, et al.
National Institute for Clinical Excellence, London WC2N 5HR, Knowledge Management Centre, School of Public Policy, University College London, London WC1H 9E2. p.littlejohns@nice.nhs.uk
Publication Types: Journal Article Review PMID: 12702622
http://bmj.bmjjournals.com/contents-by-date.0.shtml

Bmj. 2005; 330(7494): 765.
Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success.
Kawamoto K, Houlihan CA, et al.
Division of Clinical Informatics, Department of Community and Family Medicine, Box 2914, Duke University Medical Center, Durham, NC 27710, USA.
OBJECTIVE: To identify features of clinical decision support systems critical for improving clinical practice. DESIGN: Systematic review of randomised controlled trials. DATA SOURCES: Literature searches via Medline, CINAHL, and the Cochrane Controlled Trials Register up to 2003; and searches of reference lists of included studies and relevant reviews. STUDY SELECTION: Studies had to evaluate the ability of decision support systems to improve clinical practice. DATA EXTRACTION: Studies were assessed for statistically and clinically significant improvement in clinical practice and for the presence of 15 decision support system features whose importance had been repeatedly suggested in the literature. RESULTS: Seventy studies were included. Decision support systems significantly improved clinical practice in 68% of trials. Univariate analyses revealed that, for five of the system features, interventions possessing the feature were significantly more likely to improve clinical practice than interventions lacking the feature. Multiple logistic regression analysis identified four features as independent predictors of improved clinical practice: automatic provision of decision support as part of clinician workflow ($P < 0.00001$), provision of recommendations rather than just assessments ($P = 0.0187$), provision of decision support at the time and location of decision making ($P = 0.0263$), and computer based decision support ($P = 0.0294$). Of 32 systems possessing all four features, 30 (94%) significantly improved clinical practice. Furthermore, direct experimental justification was found for providing periodic performance feedback, sharing recommendations with patients, and requesting documentation of reasons for not following recommendations. CONCLUSIONS: Several features were closely correlated with decision support systems' ability to improve patient care significantly. Clinicians and other stakeholders should implement clinical decision support systems that incorporate these features whenever feasible and appropriate.
Publication Types: Journal Article Review PMID: 15767266
http://bmj.bmjjournals.com/contents-by-date.0.shtml

Bmj. 2005; 331(7528): 1313-6.
Kaiser Permanente's experience of implementing an electronic medical record: a qualitative study.
Scott JT, Rundall TG, et al.
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OBJECTIVE: To examine users' attitudes to implementation of an electronic medical record system in Kaiser Permanente Hawaii. DESIGN: Qualitative study based on semistructured interviews. SETTING: Four primary healthcare teams in four clinics, and four specialty departments in one hospital, on Oahu, Hawaii. Shortly before the interviews, Kaiser Permanente stopped implementation of the initial system in favour of a competing one. PARTICIPANTS: Twenty six senior clinicians, managers, and project team members. RESULTS: Seven key findings emerged: users perceived the decision to adopt the electronic medical record system as flawed; software design problems increased resistance; the system reduced doctors' productivity, especially during initial implementation, which fuelled resistance; the system required clarification of clinical roles and responsibilities, which was traumatic for some individuals; a cooperative culture created trade-offs at varying points in the implementation; no single leadership style was optimal-

-a participatory, consensus-building style may lead to more effective adoption decisions, whereas decisive leadership could help resolve barriers and resistance during implementation; the process fostered a counter climate of conflict, which was resolved by withdrawal of the initial system. CONCLUSIONS: Implementation involved several critical components, including perceptions of the system selection, early testing, adaptation of the system to the larger organisation, and adaptation of the organisation to the new electronic environment. Throughout, organisational factors such as leadership, culture, and professional ideals played complex roles, each facilitating and hindering implementation at various points. A transient climate of conflict was associated with adoption of the system.
Publication Types: Journal Article PMID: 16269467
http://bmj.bmjjournals.com/contents-by-date.0.shtml

Bmj. 2005; 331(7512): 331-6.
Challenges to implementing the national programme for information technology (NPfIT): a qualitative study.
Hendy J, Reeves BC, et al.
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OBJECTIVES: To describe the context for implementing the national programme for information technology (NPfIT) in England, actual and perceived barriers, and opportunities to facilitate implementation. DESIGN: Case studies and in depth interviews, with themes identified using a framework developed from grounded theory. SETTING: Four acute NHS trusts in England. PARTICIPANTS: Senior trust managers and clinicians, including chief executives, directors of information technology, medical directors, and directors of nursing. RESULTS: The trusts varied in their circumstances, which may affect their ability to implement the NPfIT. The process of implementation has been suboptimal, leading to reports of low morale by the NHS staff responsible for implementation. The overall timetable is unrealistic, and trusts are uncertain about their implementation schedules. Short term benefits alone are unlikely to persuade NHS staff to adopt the national programme enthusiastically, and some may experience a loss of electronic functionality in the short term. CONCLUSIONS: The sociocultural challenges to implementing the NPfIT are as daunting as the technical and logistical ones. Senior NHS staff feel these have been neglected. We recommend that national programme managers prioritise strategies to improve communication with, and to gain the cooperation of, front line staff.
Publication Types: Journal Article Multicenter Study
PMID: 16081447
http://bmj.bmjjournals.com/contents-by-date.0.shtml

Chest. 2005; 127(6): 2165-79.
Improving the ICU: part 2.
Garland A.
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ICUs are a vital but troubled component of modern health-care systems. Improving ICU performance requires that we shift from a paradigm that concentrates on individual performance, to a systems-oriented approach that emphasizes the need to assess and improve the ICU systems and processes that hinder the ability of individuals to perform their jobs well. This second part of a two-part treatise establishes a practical framework for performance improvement and examines specific strategies to improve ICU performance, including the use of information systems.
Publication Types: Journal Article Review
PMID: 15947334

Chest. 2005; 128(3): 1766-81.
Bedside ultrasonography in the ICU: part 2.
Beaulieu Y, Marik PE.
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This is the second of a two-part review on the application of bedside ultrasonography in the ICU. In this part, the following procedures will be covered: (1) echocardiography and cardiovascular diagnostics (second part); (2) the use of bedside ultrasound to facilitate central-line placement and to aid in the care of patients with pleural effusions and intra-abdominal fluid collections; (3) the role of hand-carried ultrasound in the ICU; and (4) the performance of bedside ultrasound by the intensivist. The safety and utility of bedside ultrasonography performed by adequately trained intensivists has now been well

demonstrated. This technology, as a powerful adjunct to the physical examination, will become an indispensable tool in the management of critically ill patients.
Publication Types: Journal Article Review PMID: 16162786

Chest. 2005; 128(2): 881-95.
Bedside ultrasonography in the ICU: part 1.
Beaulieu Y, Marik PE.
Division of Cardiology and Critical Care Medicine, Hopital Sacre-Coeur de Montreal, Universite de Montreal, 5400 boul. Gouin O., Montreal, Quebec, Canada, H4J 1C5. ybeaulieu71@videotron.ca
Ultrasonography has become an invaluable tool in the management of critically ill patients. Its safety and portability allow for use at the bedside to provide rapid, detailed information regarding the cardiovascular system and the function and anatomy of certain internal organs. Echocardiography can noninvasively elucidate cardiac function and structure. This information is vital in the management hemodynamically unstable patients in the ICU. In addition, ultrasonography has particular value for the assessment and safe drainage of pleural and intra-abdominal fluid and the placement of central venous catheters. A new generation of portable, battery-powered, inexpensive, hand-carried ultrasound devices have recently become available; these devices can provide immediate diagnostic information not assessable by physical examination alone and allow for ultrasound-guided thoracocentesis, paracentesis, and central venous cannulation. This two-part article reviews the application of bedside ultrasonography in the ICU.
Publication Types: Journal Article Review PMID: 16100182

Clin Med. 2002; 2(4): 349-55.
Intensive care monitoring: past, present and future.
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Monitoring is the serial evaluation of time-stamped data, and the volume of such data in an intensive care unit is huge. Clinical and biochemical data may be available at hourly or more frequent intervals but physiological data are 'continuous'. Although sophisticated monitors display the physiological data in multiple and varied combinations, staff are challenged by the frequency of the false alarms and lack of knowledge of the patterns from which they could predict problems. All these data, together with large amounts of clinical data, lead to information overload. In this paper, the case is made for the development of automatic decision-support system based on statistical and probabilistic analysis of data patterns appropriate for the level of cognition of the user (nurses and juniors at the bedside rather than consultants). Such decision support could both reduce the false-positive alarms that frustrate clinical staff, and improve the early detection of pathophysiological events. We have used the development of a pneumothorax as our paradigm. Our data indicate that the clinical diagnosis of pneumothorax takes a median of 127 minutes, but using short decision algorithms based on routinely available monitoring data, most can be detected within 10-15 minutes of occurrence.
Publication Types: Journal Article Review
PMID: 12195865

Cmaj. 2005; 173(7): 725, 727.
Have paper records passed their expiry date?
Publication Types: Editorial
PMID: 16186566

Comput Inform Nurs. 2004; 22(6): 337-44.
Electronic health records documentation in nursing: nurses' perceptions, attitudes, and preferences.
Moody LE, Slocumb E, et al.
University of South Florida College of Nursing, Tampa, FL 33612, USA. lmoody@hsc.usf.edu
A descriptive study of 100 nursing personnel at a large Magnet hospital in Southwest Florida was conducted to assess their needs, preferences, and perceptions associated with Electronic Health Record (EHR) documentation methods. Nurses' attitudes about the use of EHRs and their perceived effects on patient care were assessed. The five-item, Likert-type attitude scale explained 54% of the variance in attitude scores and demonstrated sound construct validity and internal consistency (r = 0.77). More than one third, 36%, perceived that EHRs had resulted in a decreased workload. The majority of nurses, 64%, preferred bedside documentation but reported that environmental and system barriers often prevent EHR charting at the bedside. Overall, 75% of nurses thought EHRs had improved the quality of documentation and 76% believed electronic charting would lead to improved safety and patient care. Nurses with

expertise in computer use, 80%, had a more favorable attitude toward EHRs than those with less expertise. Results have been used to implement clinical system changes.
Publication Types: Journal Article PMID: 15602303

Comput Inform Nurs. 2005; 23(1): 27-37.
A multimethod approach to evaluating critical care information systems.
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There is increasing awareness of the importance of evaluating and measuring the impacts of a critical care information system (CCIS). Recent evaluation studies provide little information useful to a healthcare team in evaluating a CCIS in practice. A CCIS is expected to have many direct benefits, such as increased user job satisfaction and increased documentation efficiency, accuracy, and quality. This paper reviews a rigorous longitudinal evaluation methodology being employed by a freestanding tertiary care pediatric hospital as they implement a CCIS. The metrics are being used to document the impact, strengths, and limitations of the CCIS they are installing. The main phase of the implementation is currently under way, and results will be released when the evaluation is complete. This article serves to provide an overview of the evaluation methodology for others to consider as they embark on similar endeavors.
Publication Types: Journal Article
PMID: 15681992

Comput Methods Programs Biomed. 2000; 63(3): 229-35.
The IBIS system architecture. Improved Monitoring for Brain Dysfunction in Intensive Care and Surgery.
Weller P, Hennessy T, et al.
MIM Centre, City University, Northampton Square, London EC1V 0HB, UK.
An efficient method of interfacing between patient related data and the signal processing methods used to interpret these data is a critical component for a successful patient monitor, particularly for use in high dependency environments. This paper describes the approach adopted in the IBIS project. The key elements of the system are first introduced. A multi-layer structure is then developed in which the outputs from one decision layer are used to enhance the information available for subsequent layers in the system. The resulting system is modular, robust, flexible and easy to modify.
Publication Types: Journal Article
PMID: 11064146

Crit Care. 2001; 5(4): 227-31.
Handheld computers in critical care.
Lapinsky SE, Weshler J, et al.
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BACKGROUND: Computing technology has the potential to improve health care management but is often underutilized. Handheld computers are versatile and relatively inexpensive, bringing the benefits of computers to the bedside. We evaluated the role of this technology for managing patient data and accessing medical reference information, in an academic intensive-care unit (ICU). METHODS: Palm III series handheld devices were given to the ICU team, each installed with medical reference information, schedules, and contact numbers. Users underwent a 1-hour training session introducing the hardware and software. Various patient data management applications were assessed during the study period. Qualitative assessment of the benefits, drawbacks, and suggestions was performed by an independent company, using focus groups. An objective comparison between a paper and electronic handheld textbook was achieved using clinical scenario tests. RESULTS: During the 6-month study period, the 20 physicians and 6 paramedical staff who used the handheld devices found them convenient and functional but suggested more comprehensive training and improved search facilities. Comparison of the handheld computer with the conventional paper text revealed equivalence. Access to computerized patient information improved communication, particularly with regard to long-stay patients, but changes to the software and the process were suggested. CONCLUSIONS: The introduction of this technology was well received despite differences in users' familiarity with the devices. Handheld computers have potential in the ICU, but systems need to be developed specifically for the critical-care environment.
Publication Types: Journal Article
PMID: 11511337

Crit Care. 2004; 8(5): R336-42.
Critical care procedure logging using handheld computers.
Martinez-Motta JC, Walker R, et al.
Technology Application Unit, Mount Sinai Hospital, Toronto, Ontario, Canada. cmartinez@mtsinai.on.ca <cmartinez@mtsinai.on.ca>
INTRODUCTION: We conducted this study to evaluate the feasibility of implementing an internet-linked handheld computer procedure logging system in a critical care training program. METHODS: Subspecialty trainees in the Interdepartmental Division of Critical Care at the University of Toronto received and were trained in the use of Palm handheld computers loaded with a customized program for logging critical care procedures. The procedures were entered into the handheld device using checkboxes and drop-down lists, and data were uploaded to a central database via the internet. To evaluate the feasibility of this system, we tracked the utilization of this data collection system. Benefits and disadvantages were assessed through surveys. RESULTS: All 11 trainees successfully uploaded data to the central database, but only six (55%) continued to upload data on a regular basis. The most common reason cited for not using the system pertained to initial technical problems with data uploading. From 1 July 2002 to 30 June 2003, a total of 914 procedures were logged. Significant variability was noted in the number of procedures logged by individual trainees (range 13-242). The database generated by regular users provided potentially useful information to the training program director regarding the scope and location of procedural training among the different rotations and hospitals. CONCLUSION: A handheld computer procedure logging system can be effectively used in a critical care training program. However, user acceptance was not uniform, and continued training and support are required to increase user acceptance. Such a procedure database may provide valuable information that may be used to optimize trainees' educational experience and to document clinical training experience for licensing and accreditation.
Publication Types: Journal Article PMID: 15469577

Crit Care. 2004; 8(2): 74-6.
Innovations in technology for critical care medicine.
Chapman M, Gattas D, et al.
University of Toronto, Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada. dr.martin.chapman@sw.ca
This new section in Critical Care presents a selection of clinically important examples of advances in critical care health technology. This article is divided into two main areas: diagnostics and monitoring. Attention is given to how bedside echocardiography can alter the cardiovascular physical examination, and to novel imaging techniques such as virtual bronchoscopy. The monitoring section discusses recent claims of improved efficiency with telemedicine for intensive care units.
Publication Types: Editorial PMID: 15025758

Crit Care. 2005; 9(1): 12-5.
Scanning the horizon: emerging hospital-wide technologies and their impact on critical care.
Suntharalingam G, Cousins J, et al.
Northwick Park & St Marks Hospitals, Harrow, UK. ganesh.suntharalingam@nwlh.nhs.uk
This commentary represents a selective survey of developments relevant to critical care. Selected themes include advances in point-of-care diagnostic testing, glucose control, novel microbiological diagnostics and infection control measures, and developments in information technology that have implications for intensive care. The latter encompasses an early example of an artificially intelligent clinical decision support mechanism, the introduction of a national health care information technology programme (UK NPfIT) and its implications, and exotic threats to patient safety due to emergent behaviour in complex information systems.
Publication Types: Journal Article PMID: 15693973

Crit Care Clin. 2000; 16(4): 601-21.
Critical care computing. Past, present, and future.
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With rapidly increasing processing power, networks, and bandwidth, we have ever more powerful tools for ICU computing. The challenge is to use these tools to build on the work of the Innovators and Early Adopters, who pioneered the first three generations of systems, and extend computing to the Majority, who still rely on paper. What is needed is compelling evidence that these systems reduce cost and improve quality. The experience of other industries suggests that we need to address fundamental issues, such as clinical organization, roles, behavior, and incentives, before we will be able to prove the benefits

of computing technology. When these preconditions are met, the promise of computing will be realized, perhaps with the upcoming fourth-generation systems. ICU computing can then finally cross the chasm and become the standard of care.
Publication Types: Journal Article Review PMID: 11070807

Crit Care Clin. 2005; 21(1): 55-79, viii.
The electronic medical record, safety, and critical care.
Bria WF, 2nd, Shabot MM.
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The goal of this article is to introduce the elements of the Electronic Medical Record as they pertain to critical care medicine including order communications and decision support.
Publication Types: Journal Article Review PMID: 15579353

Crit Care Med. 2001; 29(8 Suppl): N196-201.
Online personal medical records: are they reliable for acute/critical care?
Schneider JH.
Department of Pediatrics, Section of Emergency Medicine, Baylor College of Medicine, Houston, TX 77030, USA.
OBJECTIVE: To provide an introduction to Internet-based Online Personal Medical Records (OPMRs), to assess their use and limitations in acute/critical care situations, and to identify potential improvements that could increase their usefulness. DESIGN: A review of publicly available Internet-based OPMRs conducted in April 2001. DATA SOURCES: Twenty-nine OPMR sites were identified in March 2000 using ten Internet search engines with the search term "Personal Medical Records." Through 2000 and 2001, an additional 37 sites were identified using lists obtained from trade journals and through the author's participation in standards-setting meetings. MEASUREMENTS: Each publicly available site was reviewed to assess suitability for acute/critical care situations using four measures developed by the author and for general use using eight measures developed in a standards-setting process described in the article. RESULTS: Of the 66 companies identified, only 16 still offer OPMRs that are available to the public on the Internet. None of these met all of the evaluation measures. Only 19% had rapid emergency access capabilities and only 63% provided medical summaries of the record. Security and confidentiality issues were well addressed in 94% of sites. Data portability was virtually nonexistent because all OPMRs lacked the ability to exchange data electronically with other OPMRs, and only two OPMRs permitted data transfer from physician electronic medical records. Controls over data accuracy were poor: 81% of sites allowed entry of dates for medical treatment before the patient's date of birth, and one site actually gave incorrect medical advice. OPMRs were periodically inaccessible because of programming deficiencies. Finally, approximately 40 sites ceased providing OPMRs in the past year, with the probable loss of patient information. CONCLUSIONS: Most OPMRs are not ready for use in acute/critical care situations. Many are just electronic versions of the paper-based health record notebooks that patients have used for years. They have, however, great promise and, with further development, could form the basis of a new medical record system that could contribute to improving the quality of medical care.
Publication Types: Evaluation Studies Journal Article PMID: 11496043

Crit Care Med. 2001; 29(2): 427-35.
Artificial intelligence applications in the intensive care unit.
Hanson CW, 3rd, Marshall BE.
Department of Anesthesia, Center for Anesthesia Research, University of Pennsylvania Health System, Philadelphia, USA.
OBJECTIVE: To review the history and current applications of artificial intelligence in the intensive care unit. DATA SOURCES: The MEDLINE database, bibliographies of selected articles, and current texts on the subject. STUDY SELECTION: The studies that were selected for review used artificial intelligence tools for a variety of intensive care applications, including direct patient care and retrospective database analysis. DATA EXTRACTION: All literature relevant to the topic was reviewed. DATA SYNTHESIS: Although some of the earliest artificial intelligence (AI) applications were medically oriented, AI has not been widely accepted in medicine. Despite this, patient demographic, clinical, and billing data are increasingly available in an electronic format and therefore susceptible to analysis by intelligent software. Individual AI tools are specifically suited to different tasks, such as waveform analysis or device control. CONCLUSIONS: The intensive care environment is particularly suited to the implementation of AI tools because of the wealth of available data and the inherent opportunities for increased efficiency in inpatient care. A variety of new AI tools have become available in recent years that can function as

intelligent assistants to clinicians, constantly monitoring electronic data streams for important trends, or adjusting the settings of bedside devices. The integration of these tools into the intensive care unit can be expected to reduce costs and improve patient outcomes.
Publication Types: Journal Article Review PMID: 11269246

Crit Care Med. 2003; 31(10): 2488-94.
Changes in intensive care unit nurse task activity after installation of a third-generation intensive care unit information system.
Wong DH, Gallegos Y, et al.
Anesthesiology Service, Veterans Affairs Long Beach Healthcare System, and Department of Anesthesiology, University of California at Irvine, USA.
OBJECTIVE To determine the percentage of time that intensive care unit (ICU) nurses spend on documentation and other nursing activities before and after installation of a third-generation ICU information system. DESIGN: Prospective data collection using real-time time-motion analysis, before and after installation of the ICU information system. SETTING: A ten-bed surgical ICU at a Veterans Affairs medical center. SUBJECTS: ICU nurses. INTERVENTIONS: Installation of a third-generation ICU information system. MEASUREMENTS AND MAIN RESULTS: Ten ICU nurses were studied before and after installation of the ICU information system. Each ICU nurse's activities and tasks, during 4-hr observation periods, were categorized in real-time by a nurse observer and recorded in a laptop computer. Each recorded task was automatically time-stamped and logged into a data file. The percentage of time spent on documentation decreased from 35.1 +/- 8.3% to 24.2 +/- 7.6% (p =.025) after the ICU information system was installed. The percentage of time providing direct patient care increased from 31.3 +/- 9.2% to 40.1 +/- 11.7% (p =.085). The percentage of time doing patient assessment, a direct patient care task, increased from 4.0 +/- 4.7% to 9.4 +/- 4.4% (p =.001). CONCLUSIONS: Installation of a third-generation ICU information system decreased the percentage of time ICU nurses spent on documentation by >30%. Almost half of the time saved on documentation was spent on patient assessment, a direct patient care task.
Publication Types: Journal Article PMID: 14530756

Crit Care Med. 2003; 31(1): 120-5.
Quality benefits of an intensive care clinical information system.
Fraenkel DJ, Cowie M, et al.
Department of Intensive Care Medicine, Royal Brisbane Hospital, Queensland, Australia. david_fraenkel@health.qld.gov.au
OBJECTIVE: This study was performed to quantify the quality benefits and staff perceptions of a computerized clinical information system implementation in an intensive care unit. Although clinical information systems have been available and implemented in many intensive care units for more than a decade, there is little objective evidence of their impact on the quality of care and staff perceptions. DESIGN: A longitudinal observational study before and after clinical information system implementation. SETTING: A 12-bed adult general intensive care unit in a large Australian tertiary referral teaching hospital. INTERVENTION: Implementation of a fully featured clinical information system to replace paper-based charts of patient observations, clinical records, results reporting, and drug prescribing. MEASUREMENTS AND MAIN RESULTS: The frequency of clinical adverse events over a 4-yr period using an established reporting system was examined. Pre- and postimplementation staff questionnaires were distributed and analyzed. There were significant reductions in the rates of medication, intravenous therapy, and ventilator incidents. There was a trend toward a reduction in pressure sores. The survey, utilizing a validated questionnaire, demonstrated a positive perception of the clinical information system by nursing staff, with less time spent in documentation and more time in patient care. Nursing staff recruitment and retention improved after clinical information system implementation. CONCLUSIONS: Implementation of a fully featured clinical information system was associated with significant improvements in key quality indicators, positive nursing staff perceptions, and some positive resource implications.
Publication Types: Journal Article PMID: 12545004

Crit Care Med. 2004; 32(6): 1254-9.
Critical care medicine in the United States 1985-2000: an analysis of bed numbers, use, and costs.
Halpern NA, Pastores SM, et al.
Department of Anesthesiology and Critical Care Medicine, Memorial Sloan Kettering Cancer Center, New York, NY 10021, USA. halpernn@mskcc.org
OBJECTIVE: To establish a database that permits description and analysis of the evolving role, patterns of use, and costs of critical care medicine (CCM) in the United States from 1985 to 2000. DESIGN:

Retrospective study combining data from federal (Hospital Cost Report Information System, Center for Medicare and Medicaid Services, Baltimore, MD) and private (Hospital Statistics, American Hospital Association, Chicago, IL) databases to analyze U.S. hospitals, hospital and CCM beds, and occupancy. CCM costs were calculated by the Russell equation and compared with national health care and financial indexes. SETTING: Nonfederal, acute care hospitals with CCM units in the United States. SUBJECTS: None. INTERVENTIONS: None. MEASUREMENTS AND MAIN RESULTS: We analyzed hospitals with CCM units and focused on hospital and CCM beds, CCM occupancy, and CCM costs. CCM costs were compared with national cost indexes. Between 1985 and 2000, the total number of U.S. hospitals decreased by 8.9% (6,032 to 5,494) and acute care hospitals offering CCM decreased by 13.7% (4,150 to 3,581). The total number of beds in hospitals with CCM units decreased by 26.4% (889,600 to 654,400). In contrast, CCM beds increased by 26.2% (69,300 to 87,400). CCM occupancy was constant at 65%. CCM bed costs per day increased by 126% (1,185 to 2,674 US dollars). Although CCM costs increased by 190.4% (19.1 billion to 55.5 billion US dollars), the proportion of national health expenditures allocated to CCM decreased by 5.4%. In 2000, CCM costs represented 13.3% of hospital costs, 4.2% of national health expenditures, and 0.56% of the gross domestic product. CONCLUSIONS: CCM is increasingly used and prominent in a shrinking U.S. hospital system. CCM occupancy is lower than expected. Despite its increasing use and cost, CCM is using proportionally less of national health expenses and the gross domestic product than previously estimated.
Publication Types: Journal Article PMID: 15187502

Crit Care Med. 2004; 32(1): 31-8.
Effect of a multiple-site intensive care unit telemedicine program on clinical and economic outcomes: an alternative paradigm for intensivist staffing.
Breslow MJ, Rosenfeld BA, et al.
VISICU, Baltimore, MD 21224, USA. mbreslow@visicu.com
OBJECTIVE: To examine whether a supplemental remote intensive care unit (ICU) care program, implemented by an integrated delivery network using a commercial telemedicine and information technology system, can improve clinical and economic performance across multiple ICUs. DESIGN: Before-and-after trial to assess the effect of adding the supplemental remote ICU telemedicine program. SETTING: Two adult ICUs of a large tertiary care hospital. PATIENTS: A total of 2,140 patients receiving ICU care between 1999 and 2001. INTERVENTIONS: The remote care program used intensivists and physician extenders to provide supplemental monitoring and management of ICU patients for 19 hrs/day (noon to 7 am) from a centralized, off-site facility (eICU). Supporting software, including electronic data display, physician note- and order-writing applications, and a computer-based decision-support tool, were available both in the ICU and at the remote site. Clinical and economic performance during 6 months of the remote intensivist program was compared with performance before the intervention. MEASUREMENTS AND MAIN RESULTS: Hospital mortality for ICU patients was lower during the period of remote ICU care (9.4% vs. 12.9%; relative risk, 0.73; 95% confidence interval [CI], 0.55-0.95), and ICU length of stay was shorter (3.63 days [95% CI, 3.21-4.04] vs. 4.35 days [95% CI, 3.93-4.78]). Lower variable costs per case and higher hospital revenues (from increased case volumes) generated financial benefits in excess of program costs. CONCLUSIONS: The addition of a supplemental, telemedicine-based, remote intensivist program was associated with improved clinical outcomes and hospital financial performance. The magnitude of the improvements was similar to those reported in studies examining the impact of implementing on-site dedicated intensivist staffing models; however, factors other than the introduction of off-site intensivist staffing may have contributed to the observed results, including the introduction of computer-based tools and the increased focus on ICU performance. Although further studies are needed, the apparent success of this on-going multiple-site program, implemented with commercially available equipment, suggests that telemedicine may provide a means for hospitals to achieve quality improvements associated with intensivist care using fewer intensivists.
Publication Types: Evaluation Studies Journal Article PMID: 14707557

Crit Care Med. 2004; 32(6): 1306-9.
Computerized physician order entry of diagnostic tests in an intensive care unit is associated with improved timeliness of service.
Thompson W, Dodek PM, et al.
Center for Health Evaluation and Outcome Sciences, St. Paul's Hospital and University of British Columbia, Vancouver, BC, Canada.
OBJECTIVE: To measure the effect of computerized physician order entry on timeliness of urgent laboratory and imaging tests. DESIGN: Before-after. SETTING: Eleven-bed medical-surgical intensive care unit in a tertiary teaching hospital. PATIENTS: All patients who had "stat" laboratory or imaging tests

ordered during each of two 1-month periods 10 months before and 2 months after introducing computerized physician order entry. INTERVENTIONS: Introduction of computerized physician order entry. MEASUREMENTS AND MAIN RESULTS: After computerized physician order entry was introduced, median time from ordering to obtaining laboratory specimens decreased from 77 to 21.5 mins, median time from ordering to laboratory result being reported decreased from 148 to 74 mins, and median time from ordering to imaging completed decreased from 96.5 to 29.5 mins. CONCLUSIONS: Introduction of computerized physician order entry for ordering "stat" tests in an intensive care unit is associated with improved timeliness of these tests.
Publication Types: Journal Article PMID: 15187511

Crit Care Med. 2004; 32(11): 2227-33.
A system factors analysis of airway events from the Intensive Care Unit Safety Reporting System (ICUSRS).
Needham DM, Thompson DA, et al.
Pulmonary & Critical Care Medicine, and Dana Center for Preventive Ophthalmology Wilmer Eye Institute, Johns Hopkins University School of Medicine, Baltimore, MD, USA.
OBJECTIVE: To evaluate the contributing and limiting factors for airway events reported in the Intensive Care Unit Safety Reporting System (ICUSRS) developed in partnership with the Society of Critical Care Medicine. DESIGN: Analysis of system factors in airway vs. nonairway events reported to a voluntary, anonymous, Web-based patient safety reporting system (the ICUSRS). SETTING: Sixteen adult and two pediatric intensive care units (ICU) across the United States. PATIENTS: Incidents reported during the 12-month period ending June 30, 2003. INTERVENTIONS: None MEASUREMENTS: Descriptive characteristics of incidents (defined as events that could have, or did, cause harm), patients, and patient harm; separate multivariable logistic regression analyses of contributing and limiting factors for airway vs. nonairway events. MAIN RESULTS: There were 78 airway and 763 nonairway events reported. More than half of airway events were considered preventable. One patient death was attributed to an airway event. Physical injury, increased hospital length of stay, and family dissatisfaction occurred in at least 20% of airway events. Important factors contributing to reported airway events (odds ratio (OR), 95% confidence interval (CI)) included patients' medical condition (5.24, 3.07-8.95) and age <1 yr old (4.15, 1.79-9.59). Factors limiting the impact of airway events (OR, 95% CI) included adequate ICU staffing (3.60, 1.71-7.56) and use of skilled assistants (3.20, 1.62-6.32). CONCLUSIONS: Patients are harmed by unintended and preventable incidents involving airway management. Prevention efforts should focus on critically ill infants and patients with complex medical conditions. Managers should ensure appropriate ICU staffing to limit the impact of airway events when they occur.
Publication Types: Journal Article PMID: 15640634

Crit Care Med. 2005; 33(1): 110-4.
Specificity of computerized physician order entry has a significant effect on the efficiency of workflow for critically ill patients.
Ali NA, Mekhjian HS, et al.
The Dorthy M. Davis Heart & Lung Research Institute, The Ohio State University, Columbus, OH, USA.
BACKGROUND: Critically ill patients require rapid care, yet they are also at risk for morbidity from the potential complications of that care. Computerized physician order entry (CPOE) is advocated as a tool to reduce medical errors, improve the efficiency of healthcare delivery, and improve outcomes. Little is known regarding the essential attributes of CPOE in the intensive care unit (ICU). OBJECTIVE: To assess the effect of CPOE on ICU patient care. DESIGN: Retrospective before and after cohort study. SETTING: An academic ICU. PATIENTS: Patients admitted to the ICU during use of the initial CPOE application and those admitted after its modification. INTERVENTIONS: Comprehensive order interface redesign improving clarity, specificity, and efficiency. MEASUREMENTS: Orders for complex ICU care were compared between the two groups. In addition, the use of higher-efficiency CPOE order paths was tracked. RESULTS: Patients treated with both the initial and modified CPOE system were similar for all measured characteristics. With the modified CPOE system, there were significant reductions in orders for vasoactive infusions, sedative infusions, and ventilator management. There was also a significant increase in orders executed through ICU-specific order sets after system modifications. LIMITATIONS: This retrospective study cannot assess issues related to learner expertise and is meant to only suggest the importance of developing CPOE systems that are appropriate for specialty care environments. CONCLUSION: Appropriate CPOE applications can improve the efficiency of care for critically ill patients. The workflow requirements of individual units must be analyzed before technologies like CPOE can be properly developed and implemented.
Publication Types: Journal Article PMID: 15644656

Crit Care Med. 2005; 33(3): 533-40.
A controlled trial of smart infusion pumps to improve medication safety in critically ill patients.
Rothschild JM, Keohane CA, et al.
Division of General Medicine and Department of Medicine, Brigham and Women's Hospital, Boston, MA, USA. jrothschild@partners.org
OBJECTIVE: Intravenous medications are vital during inpatient management. Errors associated with the administration of medications through intravenous infusion pumps to critically ill patients can result in adverse drug events. We sought to assess the impact of smart pumps with integrated decision support software on the incidence and nature of medication errors and adverse drug events. DESIGN: We performed a prospective, randomized time-series trial and compared the serious medication error rate between intervention (decision support on) and control (decision support off) periods. Serious medication errors included both near-misses and preventable adverse drug events. Pump software produced log reports to help identify potential events. Events were presented to physicians for rating of event type, preventability, and severity. SETTING: Cardiac surgical intensive care and step-down units between February and December 2002. PATIENTS: Pump data were available for 744 cardiac surgery admissions. INTERVENTIONS: Decision support during medication administration provided feedback including alerts, reminders, and unit-specific drug rate limits. MEASUREMENTS AND MAIN RESULTS: We found a total of 180 serious medication errors, including 14 and 11 preventable adverse drug events and 73 and 82 nonintercepted potential adverse drug events in the control and intervention periods, respectively. The serious medication error rates in the control and intervention periods were 2.03 and 2.41 per 100 patient-pump-days, respectively (p = .124). We also found numerous opportunities for safety improvement. Violations of infusion practice during the intervention periods included 571 (25%) bypasses of the drug library. Medications were also frequently administered without documentation of physician orders in both periods (n = 823; 7.7%). CONCLUSION: Intravenous medication errors and adverse drug events were frequent and could be detected using smart pumps. We found no measurable impact on the serious medication error rate, likely in part due to poor compliance. Although smart pumps have great promise, technological and nursing behavioral factors must be addressed if these pumps are to achieve their potential for improving medication safety.
Publication Types: Clinical Trial Journal Article Randomized Controlled Trial PMID: 15753744

Crit Care Med. 2005; 33(12): 2858-9; author reply 2859.
Intensivists should use bedside echocardiography.
Souza LF.
Publication Types: Comment Letter PMID: 16352980

Crit Care Med. 2005; 33(12): 2849-51.
How accurate are currently used methods of determining glycemia in critically ill patients, and do they affect their clinical course?
Chrousos G, Kaltsas G.
Publication Types: Comment
Editorial PMID: 16352973

Crit Care Med. 2005; 33(12): 2778-85.
Reliability of point-of-care testing for glucose measurement in critically ill adults.
Kanji S, Buffie J, et al.
Department of Pharmacy, The Ottawa Hospital, Ottawa, Canada.
BACKGROUND: Glycemic control is increasingly being recognized as a priority in the treatment of critically ill patients. Titration and monitoring of insulin infusions involve frequent blood glucose measurement to achieve target glucose ranges and prevent adverse events related to hypoglycemia. Therefore, it is imperative that bedside glucose testing methods be safe and accurate. OBJECTIVE: To determine the accuracy and clinical impact of three common methods of bedside point-of-care testing for glucose measurements in critically ill patients receiving insulin infusions. DESIGN: Prospective observational study. SETTING: A 21-bed mixed medical/surgical intensive care unit of a tertiary care teaching hospital. PATIENTS: Thirty consecutive critically ill patients who were vasopressor-dependent (n = 10), had significant peripheral edema (n = 10), or were admitted following major surgery (n = 10). MEASUREMENTS: Findings from three different methods of glucose measurement were compared with central laboratory measurements: (1) glucose meter analysis of capillary blood (fingerstick); (2) glucose meter analysis of arterial blood; and (3) blood gas/chemistry analysis of arterial blood. Patients were enrolled for a maximum of 3 days and had a maximum of nine sets of measurements determined during this time. RESULTS: Clinical agreement with the central laboratory was significantly better with arterial blood

analysis (69.9% and 76.5% for glucose meter and blood gas/chemistry analysis, respectively) than with capillary blood analysis (56.8%; p = .039 and .001, respectively). During hypoglycemia, clinical agreement was only 26.3% with capillary blood analysis and 55.6% and 64.9% for glucose meter and blood gas/chemistry analysis of arterial blood (p = .010 and <.001, respectively). Glucose meter analysis of both arterial and capillary blood tended to provide higher glucose values, whereas blood gas/chemistry analysis of arterial blood tended to yield lower glucose values. CONCLUSIONS: The magnitude of the differences in the glucose values offered by the four different methods of glucose measurement led to frequent clinical disagreements regarding insulin dose titration in the context of an insulin infusion protocol for aggressive glucose control.
Publication Types: Journal Article
PMID: 16352960

Crit Care Med. 2005; 33(8): 1874-5.
Pleural effusions in the critically ill: the evolving role of bedside ultrasound.
Jones AE, Kline JA.
Publication Types: Comment Editorial
PMID: 16096476

Crit Care Med. 2005; 33(8): 1757-63.
Quantitative assessment of pleural effusion in critically ill patients by means of ultrasonography.
Vignon P, Chastagner C, et al.
Medical-Surgical Intensive Care Unit, Dupuytren Teaching Hospital, Limoges, France.
OBJECTIVE: To assess the ability of ultrasonography to identify the presence and assess the volume of pleural effusion in the intensive care unit setting. DESIGN: Prospective descriptive clinical study. SETTING: Medical-surgical intensive care unit of a teaching hospital. PATIENTS: Initial study group (group I) consisted of 97 patients (mean [+/-SD] Simplified Acute Physiology Score II, 40 +/- 14) with clinically suspected pleural effusion. Fifty-one patients were mechanically ventilated and 55 patients underwent a unilateral or bilateral thoracentesis (58 procedures). All patients underwent supine chest radiography and pleural ultrasonography at bedside. The testing group (group II) consisted of 19 additional patients (17 under ventilation) who underwent thoracentesis. INTERVENTIONS: None. MEASUREMENTS AND MAIN RESULTS: Maximal interpleural distance was measured at the base and apex of the pleural space, at both end-expiration and end-inspiration. In group I, interpleural distances were compared to actual volume of fluid in the subset of patients who underwent a complete thoracentesis (n = 49). Prediction of the volume of pleural effusion was subsequently tested prospectively in group II (25 complete thoracenteses). Portable chest radiography and pleural ultrasonography yielded discordant results for 47 patients (48%) in the diagnosis of pleural effusion. The expiratory interpleural distance measured at the thoracic base with ultrasonography was significantly correlated with the volume of fluid (p < .0001; coefficient of determination: right, 0.78; left, 0.51). A pleural effusion > or =800 mL was predicted when this distance was >45 mm (right) or >50 mm (left), with a sensitivity of 94% and 100% and a specificity of 76% and 67%, respectively. In group II, the mean bias between the predicted and observed volumes of pleural effusion determined by thoracentesis was 24 +/- 355 mL, and this decreased to 28 +/- 146 mL for the prediction of pleural effusion <1400 mL. CONCLUSIONS: Bedside ultrasonography is well suited for the quantitative assessment of unloculated pleural effusions in intensive care unit patients.
Publication Types: Evaluation Studies Journal Article
PMID: 16096453

Crit Care Nurs Clin North Am. 2005; 17(1): 45-50, x.
Use of handheld devices in critical care.
Taylor PP.
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Emergencies happen everyday in the acute care environment and demand nurses to make decisions quickly that can have serious, if not potentially fatal, ramifications. Being prepared to make decisions is partly the results of experience, but having access to ready resources can provide even the newest nurse with the potential to make critical decisions accurately. Handheld devices, such as personal digital assistants, can provide access to resources that can improve patient safety and, ultimately, patient care delivery.
Publication Types: Journal Article Review
PMID: 15749401

Crit Care Nurse. 2004; 24(2): 66-72, 114.
Using wireless technologies to improve information flow for interhospital transfers of critical care patients.
McGrow KM, Roys R, et al.
University of Maryland, Baltimore, USA.
Publication Types: Journal Article Review PMID: 15098312

Curr Opin Crit Care. 2002; 8(4): 321-30.
Recent innovations in intensive care unit risk-prediction models.
Rosenberg AL.
Robert Wood Johnson Clinical Scholars Program, Department of Anesthesiology and Critical Care Medicine, University of Michigan, Ann Arbor, Michigan 48109-4270, USA. arosen@umich.edu
During the past 20 years, ICU risk-prediction models have undergone significant development, validation, and refinement. Among the general ICU severity of illness scoring systems, the Acute Physiology and Chronic Health Evaluation (APACHE), Mortality Prediction Model (MPM), and the Simplified Acute Physiology Score (SAPS) have become the most accepted and used. To risk-adjust patients with longer, more severe illnesses like sepsis and acute respiratory distress syndrome, several models of organ dysfunction or failure have become available, including the Multiple Organ Dysfunction Score (MODS), the Sequential Organ Failure Assessment (SOFA), and the Logistic Organ Dysfunction Score (LODS). Recent innovations in risk adjustment include automatic physiology and diagnostic variable retrieval and the use of artificial intelligence. These innovations have the potential of extending the uses of case-mix and severity-of-illness adjustment in the areas of clinical research, patient care, and administration. The challenges facing intensivists in the next few years are to further develop these models so that they can be used throughout the IUC stay to assess quality of care and to extend them to more specific patient groups such as the elderly and patients with chronic ICU courses.
Publication Types: Journal Article
Review PMID: 12386493

Curr Opin Crit Care. 2002 Dec;8(6):616-24.
Clinical information systems and the electronic medical record in the intensive care unit.
Varon J, Marik PE.
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The integration of computers into critical care is by no means a new concept. Clinical information systems have evolved in the critical care setting over the past three decades. Their use by critical care healthcare providers has increased exponentially in the past few years. More recently, with the advent of the electronic medical record, clinicians in the ICU may obtain and share useful information both bedside and remotely. Clinical information systems and the electronic medical record in the ICU have the potential to improve medical record movement problems, to improve quality and coherence of the patient care process, to automate guidelines and care pathways, and to assist in clinical care and research, outcome management, and process improvement. In this article, we provide some historical background on the clinical information system and the electronic medical record and describe their current utilization in the ICU and their role in the practice of critical care medicine in decades to come.
Publication Types: Review
PMID: 12454551

Curr Opin Crit Care. 2004; 10(5): 399-403.
Bayesian analysis, pattern analysis, and data mining in health care.
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PURPOSE OF REVIEW: To discuss the current role of data mining and Bayesian methods in biomedicine and heath care, in particular critical care. RECENT FINDINGS: Bayesian networks and other probabilistic graphical models are beginning to emerge as methods for discovering patterns in biomedical data and also as a basis for the representation of the uncertainties underlying clinical decision-making. At the same time, techniques from machine learning are being used to solve biomedical and health-care problems. SUMMARY: With the increasing availability of biomedical and health-care data with a wide range of characteristics there is an increasing need to use methods which allow modeling the uncertainties that come with the problem, are capable of dealing with missing data, allow integrating data from various sources, explicitly indicate statistical dependence and independence, and allow integrating biomedical

and clinical background knowledge. These requirements have given rise to an influx of new methods into the field of data analysis in health care, in particular from the fields of machine learning and probabilistic graphical models.
Publication Types: Journal Article Review
PMID: 15385759

Curr Opin Crit Care. 2004; 10(4): 238-45.
Medical technology in the intensive care unit.
Scales DC, Sibbald WJ.
Department of Critical Care, St. Michael's Hospital, Toronto, Ontario, Canada. damon.scales@utoronto.ca
Publication Types: Journal Article Review
PMID: 15258495

Curr Opin Crit Care. 2005; 11(4): 345-8.
Organizational characteristics and the quality of surgical care.
Dimick JB.
VA Outcomes Group, VA Medical Center, White River Junction, VT 05009, USA. Justin.B.Dimick@Dartmouth.edu
PURPOSE OF REVIEW: Public recognition of wide variations in surgical outcomes has prompted numerous efforts aimed at measuring and improving quality. Given that many of the most prominent efforts focus on organizational factors, this paper reviews the growing body of evidence underlying these initiatives. RECENT FINDINGS: Physician, nurse, and pharmacist staffing are strongly related to outcomes for critically ill surgical patients. New technologic innovation, particularly computerized physician order entry, has the potential to markedly reduce medical errors in this population. Creating an infrastructure for the measurement and improvement of surgical quality also shows significant promise for improving outcomes. SUMMARY: Several organizational characteristics are strongly related outcomes for critically ill surgical patients. Increasing the number of surgical patients receiving care in hospitals adhering to these organizational practices would save many lives each year.
Publication Types: Journal Article Review
PMID: 16015113

Health Aff (Millwood). 2005 Sep-Oct;24(5):1121-3.
Hope and hype: predicting the impact of electronic medical records. RAND's vision of "gold in them than hills" owes more to Merlin than to metallurgy.
Himmelstein DU, Woolhandler S.
Harvard Medical School, Massachusetts, USA.
The current fascination with electronic medical records (EMRs) is not new. For decades, vendors have capitalized on this enthusiasm. But hospitals and clinics have ended up with little to show for their large outlays. Indeed, computing at a typical hospital has not gotten much beyond what was available twenty-five years ago. The RAND analysis continues the tradition of hope and hype. Unfortunately, behind their impressive predictions of savings lie a disturbing array of unproven assumptions, wishful thinking, and special effects.
PMID: 16162553

Health Aff (Millwood). 2005; 24(5): 1103-17.
Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. The adoption of interoperable EMR systems could produce efficiency and safety savings of $142-$371 billion.
Hillestad R, Bigelow J, et al.
RAND, Santa Monica, California, USA. Richard_Hillestad@rand.org
To broadly examine the potential health and financial benefits of health information technology (HIT), this paper compares health care with the use of IT in other industries. It estimates potential savings and costs of widespread adoption of electronic medical record (EMR) systems, models important health and safety benefits, and concludes that effective EMR implementation and networking could eventually save more than $81 billion annually--by improving health care efficiency and safety--and that HIT-enabled prevention and management of chronic disease could eventually double those savings while increasing health and other social benefits. However, this is unlikely to be realized without related changes to the health care system.
Publication Types: Journal Article
PMID: 16162551

Health Aff (Millwood). 2005; 24(5): 1138-46.
Medicare's next voyage: encouraging physicians to adopt health information technology. Policymakers seem to agree on the necessity of HIT in Medicare but need to commit the resources needed to effect change.
Rosenfeld S, Bernasek C, et al.
Avalere Health, Washington, D.C., USA. srosenfeld@avalerehealth.net
Although there is growing consensus that health information technology (HIT) will be critical to improving health care quality and reducing costs, physicians' investments in technology remain limited. As the largest single U.S. purchaser of health care services, Medicare has the power to promote physician adoption of HIT. The Centers for Medicare and Medicaid Services should clarify its technology objectives, engage the physician community, shape the development of standards and technology certification criteria, and adopt concrete payment systems to promote adoption of meaningful technology that furthers the interests of Medicare beneficiaries.
Publication Types: Journal Article PMID: 16162556

Health Aff (Millwood). 2005; 24(5): 1118-20.
Electronic medical records and health care transformation. EMR-supported health care transformation is too immature for credible estimates of its costs or benefits.
Walker JM.
Geisinger Health System, Danville, Pennsylvania, USA. jmwalker@geisinger.edu
Effective electronic medical care record (EMR) systems will make a critical contribution to health care transformation. However, we need to know more about the total costs of EMRs and the ways in which they will interact with existing health care systems to make compelling predictions about their clinical benefits or the savings they can enable.
Publication Types: Journal Article PMID: 16162552

Health Manag Technol. 2004; 25(5): 12-3, 16, 21.
Enhancing the enterprise. EMRs offer big gains for healthcare organizations of all sizes.
Rogoski RR.
rogoski@aol.com
Publication Types: Journal Article PMID: 15154137

Health Manag Technol. 2005; 26(2): 54, 56-7.
Clinical information systems. Against the grain.
Miller S.
University of Arizona Medical Center, Tucson, USA.
Publication Types: Journal Article PMID: 15756997

Health Policy. 2005; 71(3): 289-301.
Evaluating and planning ICUs: methods and approaches to differentiate between need and demand.
Wild C, Narath M.
Institute of Technology Assessment at the Austrian Academy of Sciences, Strohgasse 45, A-1030 Vienna, Austria. cwild@oeaw.ac.at
OBJECTIVE: In all western countries the demand for ICU-services is increasing and complaints about a lack of ICU-beds arise--independent of the actual density of ICU-services. The demand for more ICU-beds triggered a debate on whether it is possible to define an "objective" need. It was the aim of the assessment to analyze conventional as well as innovative approaches to plan and to evaluate ICU-services. METHOD: Systematic review, multistep searches in Medline, EmBase, Cochrane, HTA-Database, websearches, informal searches through planning and HTA-networks. INTRODUCTION: The differences between the density of intensive care in Europe and other parts of the western world is enormous. At a first superficial glance, Austria and Germany--in absolute figures--have many more ICU-beds than any other European country. In relative figures, taken into consideration that Austria and Germany have also many more acute care beds, the number of ICU-beds is among European average. It is therefore, impossible to analyze the need for ICU-beds without taking into account the national context of delivered acute hospital services. Although ICU-services take about 15-20% of the hospital budgets, there are still more questions than answers. RESULTS: Recent planning-documents: a review of trends in recent planning shows that all planners calculate on the basis of existing style of practice within their countries; the figures change only marginally. But while planners in countries with a relatively low ICU-bed density (Great Britan, Australia, Canada) certify a certain need for an increase, planners in countries with high density (USA, Germany, Austria) state a "satisfied need" and an over-provision of ICU-services. Innovative

planners apply an "appropriateness of ICU-use" approach with analysing the actual utilisation by interpreting scores (especially TISS) and by identifying "low-risk" groups and propose a more flexible organisation of ICUs and a higher proportion of (intermediate care unit) IMCU-beds. Clinical and ICU-management tools, such as admission and discharge guidelines, strategies to reduce treatment-variations, certain organisational changes (leadership, horizontal hierarchy) and costing methods gain importance for better, more efficient and co-ordinated use of ICU-resources. CONCLUSION: In countries with a high density of ICU-services--such as Austria and Germany--not an expanding of the capacities, but a better use of the existing resources is recommended. For a fair comparison, participation in national databases, in registers as well as benchmarking and quality-assurance programs should be enforced.
Publication Types: Journal Article Review PMID: 15694497

Health Serv J. 2001; 111(5781): 28-9.
Critical care. Only connect.
Hague A.
The establishment of a network for critical care services in five hospitals has led to a decrease in transfers of patients for non-clinical reasons. There have been no transfers outside the network's area. The introduction of common admission policies has led to more openness about bed availability. The introduction of the network has standardised data collection. The availability of extra funds and facilities was a big incentive to staff involvement.
Publication Types: Journal Article PMID: 11729631

Healthc Financ Manage. 2005; 59(1): 62-6.
The Kaiser Permanente IT transformation.
Raymond B.
Kaiser Permanente Institute for Health Policy, Oakland, Calif, USA. brian.raymond@kp.org
Kaiser Permanente's major health IT initiative, KP Health-Connect, will integrate all patient information in a single system linking medical information with billing, scheduling, and registration data throughout the organization. Healthcare financial leaders whose organizations want to undertake a similar initiative should: Ensure dedicated financial leadership on the team, Maintain a collaborative relationship with other team members, Champion the project, Plan for contingencies, Develop new processes, Provide financial oversight for every phase of the project.
Publication Types: Journal Article PMID: 15689013

Hosp Health Netw. 2003; 77(12): 56-60, 2.
Pressures converge in the ICU. Hospitals turn to IT and process changes to improve outcomes and satisfaction.
Haugh R.
The ICU is where all the pressures of a hospital show themselves in high relief. Quality, work processes and staffing are more challenging here. This Clinical Management article examines how hospitals are reducing mortality rates, increasing patient and staff satisfaction, and bringing efficiencies to the ICU through high- and low-tech solutions.
Publication Types: Journal Article PMID: 14712538

IEEE Eng Med Biol Mag. 2001; 20(3): 58-62.
The challenges in creating critical-care databases.
Korhonen I, van Gils M, et al.
VTT Information Technology, Tampere. ilkka.korhonen@vtt.fi
Publication Types: Journal Article PMID: 11446211

IEEE Trans Biomed Eng. 2004; 51(3): 484-92.
On-line segmentation algorithm for continuously monitored data in intensive care units.
Charbonnier S, Becq G, et al.
Laboratoire d'Automatique de Grenoble, BP 46, 38402 St Martin d'Heres, France. Sylvie.Charbonnier@inpg.fr
An on-line segmentation algorithm is presented in this paper. It is developed to preprocess data describing the patient's state, sampled at high frequencies in intensive care units, with a further purpose of alarm filtering. The algorithm splits the signal monitored into line segments--continuous or discontinuous--of various lengths and determines on-line when a new segment must be calculated. The delay of detection of a new line segment depends on the importance of the change: the more important the change, the quicker the detection. The linear segments are a correct approximation of the structure of the signal.

They emphasise steady-states, level changes and trends occurring on the data. The information returned by the algorithm, which is the time at which the segment begins, its ordinate and its slope, is sufficient to completely reconstruct the filtered signal. This makes the algorithm an interesting tool to provide a processed time history record of the monitored variable. It can also be used to extract on-line information on the signal, such as its trend, in the short or long term.
Publication Types: Evaluation Studies Journal Article Validation Studies PMID: 15000379

IEEE Trans Inf Technol Biomed. 2003; 7(2): 130-40.
Neurointensive care unit system for continuous electrophysiological monitoring with remote web-based review.
van der Kouwe AJ, Burgess RC.
Cleveland Clinic Foundation, Cleveland, OH 44195, USA. andre@nmr.mgh.harvard.edu
There is a need in the neurological intensive care unit for a single integrated bedside monitor for continuously monitoring the function of the patient's central nervous system. In this paper, we demonstrate the feasibility of building such a system and operating it in the intensive care environment. We have developed a fully automated system that samples electrophysiological waveforms of various modalities according to a schedule of predefined intervals along with routinely monitored cardiac and respiratory parameters. The system provides stimulation and acquires responses without requiring supervision. The electrophysiological data include brainstem auditory and somatosensory evoked potentials and epochs of the electroencephalogram. The system applies peak detection and spectral analysis to extract salient parameters from the raw waveforms. The results are made available immediately in real time on the local network for local review and further analysis. A web-based interface makes review by a qualified neurologist possible anywhere within the hospital's secure intranet during and after monitoring. This system could potentially give an early warning of impending herniation, subclinical seizures, and brain or spinal cord ischemia. We demonstrate its application in a few diverse neurological intensive care cases and a case in the interventional neuroradiology suite.
Publication Types: Evaluation Studies Journal Article PMID: 12834169

IEEE Trans Inf Technol Biomed. 2004; 8(2): 161-72.
SIVA: a hybrid knowledge-and-model-based advisory system for intensive care ventilators.
Kwok HF, Linkens DA, et al.
Department of Automatic Control and Systems Engineering (ACSE), University of Sheffield, Sheffield SI 3JD, UK. hoi.kwok@sunderland.ac.uk
The Sheffield Intelligent Ventilator Advisor is a hybrid knowledge-and-model-based advisory system designed for intensive care ventilator management. It consists of a top-level fuzzy rule-based module to give the qualitative component of the advice, and a lower-level model-based module to give the quantitative component of the advice. It is structured to offer adaptive patient-specific decision support. It can be operated in either invasive or noninvasive modes depending on the availability of data from invasive clinical measurements. The user can choose between the full-advisory mode and the clinician-directed mode. The advice given by the top-level module has been validated against retrospective real patient data and compared with intensivists expertise and performance under simulation conditions. Closed-loop simulations were performed assuming various clinical scenarios including sudden changes in the patient parameters such as the shunt or deadspace with noise and disturbances. They have shown that the advice given was appropriate and the blood gases resulting from the closed-loop decision support were acceptable. The system was also shown to be tolerant to noise and disturbances. It is implemented in MATLAB/SIMULINK and LabVIEW.
Publication Types: Evaluation Studies Journal Article Validation Studies PMID: 15217261

IEEE Trans Inf Technol Biomed. 2005; 9(3): 468-74.
Artificial neural network medical decision support tool: predicting transfusion requirements of ER patients.
Walczak S.
University of Colorado at Denver, Denver, CO 80217-3364, USA. swalczak@carbon.cudenver.edu
Blood product transfusion is a financial concern for hospitals and patients. Efficient utilization of this dwindling resource is a critical problem if hospitals are to maximize patient care while minimizing costs. Traditional statistical models do not perform well in this domain. An additional concern is the speed with which transfusion decisions and planning can be made. Rapid assessment in the emergency room (ER) necessarily limits the amount of usable information available (with respect to independent variables available). This study evaluates the efficacy of using artificial neural networks (ANNs) to predict the transfusion requirements of trauma patients using readily available information. A total of 1016 patient

records are used to train and test a backpropagation neural network for predicting the transfusion requirements of these patients during the first 2, 2-6, and 6-24 h, and for total transfusions. Sensitivity and specificity analysis are used along with the mean absolute difference between blood units predicted and units transfused to demonstrate that ANNs can accurately predict most ER patient transfusion requirements, while only using information available at the time of entry into the ER.
Publication Types: Journal Article PMID: 16167701

Infect Control Hosp Epidemiol. 2004; 25(11): 974-8.
Catheter-associated urinary tract infections in intensive care units can be reduced by prompting physicians to remove unnecessary catheters.
Huang WC, Wann SR, et al.
Intensive Care Unit, Kaohsiung Veterans General Hospital, Kaohsiung, Taiwan, Republic of China.
OBJECTIVE: Indwelling urinary catheters are the most common source of infections in intensive care units (ICUs). The aim of this study was to evaluate the efficacy of nurse-generated daily reminders to physicians to remove unnecessary urinary catheters 5 days after insertion. DESIGN: A time-sequence nonrandomized intervention study. SETTING: Adult ICUs (medical, surgical, cardiovascular surgical, neurosurgical, and coronary care) of a tertiary-care university medical center. PATIENTS: All patients admitted to the adult ICUs during a 2-year period. The study consisted of a 12-month observational phase (15,960 patient-days) followed by a 12-month intervention phase (15,525 patient-days). INTERVENTION: Daily reminders to physicians from the nursing staff to remove unnecessary urinary catheters 5 days after insertion. RESULTS: The duration of urinary catheterization was significantly reduced during the intervention phase (from 7.0 + 1.1 days to 4.6 +/- 0.7 days; P < .001). The rate of catheter-associated urinary tract infection (CAUTI) was also significantly reduced (from 11.5 +/- 3.1 to 8.3 +/- 2.5 patients with CAUTI per 1,000 catheter-days; P = .009). There was a linear relationship between the monthly average duration of catheterization and the rate of CAUTI (r = 0.50; P = .01). The excess monthly cost of antibiotics for CAUTI was reduced by 69% (from 4021 dollars +/- 1800 dollars to 1220 dollars +/- 941 dollars; P = .004). CONCLUSION: This study demonstrated that a simple measure instituted as part of a continuous quality improvement program significantly reduced the duration of urinary catheterization, rate of CAUTI, and additional costs of antibiotics to manage CAUTI.
Publication Types: Evaluation Studies Journal Article PMID: 15566033

Int J Med Inform. 2005; 74(7-8): 643-56.
Simplifying the complexity surrounding ICU work processes--identifying the scope for information management in ICU settings.
Munir SK, Kay S.
Department of Information Systems, Turitea Campus, Massey University, New Zealand.
A multi-site study, conducted in two English and two Danish intensive care units, investigates the complexity of work processes in intensive care, and the implications of this complexity for information management with regards to clinical information systems. Data were collected via observations, shadowing of clinical staff, interviews and questionnaires. The construction of role activity diagrams enabled the capture of critical care work processes. Upon analysing these diagrams, it was found that intensive care work processes consist of 'simplified-complexity', these processes are changed with the introduction of information systems for the everyday use and management of all clinical information. The prevailing notion of complexity surrounding critical care clinical work processes was refuted and found to be misleading; in reality, it is not the work processes that cause the complexity, the complexity is rooted in the way in which clinical information is used and managed. This study emphasises that the potential for clinical information systems that consider integrating all clinical information requirements is not only immense but also very plausible.
Publication Types: Journal Article Multicenter Study PMID: 16023407

Int J Qual Health Care. 2004; 16(5): 407-16.
A systematic review of computer-based patient record systems and quality of care: more randomized clinical trials or a broader approach?
Delpierre C, Cuzin L, et al.
Centre Hospitalo Universitaire Purpan, Service des Maladies Infectieuses et Tropicales, Toulouse, France. cisih@chu-toulouse.fr
PURPOSE: To analyse the impact of computer-based patient record systems (CBPRS) on medical practice, quality of care, and user and patient satisfaction. DATA SOURCES: Manual and electronic search of the Medline, Cochrane, and Embase databases. STUDY SELECTION: Selected articles were published from 2000 to March 2003. CBPRS was defined as computer software designed to be used by clinicians as a direct aid

in clinical decision making. To be included, the systems should have recorded patient characteristics and offered online advice, or information or reminders specific to clinicians during the consultation. DATA EXTRACTION: Keywords used for the search were: electronic record, informatic record, electronic medical record, electronic patient record, patient order entry, computer-based patient system, clinical decision support systems, and evaluation. RESULTS: Twenty-six articles were selected. Use of a CBPRS was perceived favourably by physicians, with studies of satisfaction being mainly positive. A positive impact of CBPRS on preventive care was observed in all three studies where this criterion was examined. The 12 studies evaluating the impact on medical practice and guidelines compliance showed that positive experiences were as frequent as experiences showing no benefit. None of the six studies analysing the impact of CBPRS on patient outcomes reported any benefit. CONCLUSIONS: CBPRS increased user and patient satisfaction, which might lead to significant improvements in medical care practices. However, the studies on the impact of CBPRS on patient outcomes and quality of care were not conclusive. Alternative approaches considering social, cultural, and organizational factors may be needed to evaluate the usefulness of CBPRS.
Publication Types: Journal Article Review PMID: 15375102

Intensive Care Med. 2003; 29(1): 83-90.
Intensive care information system reduces documentation time of the nurses after cardiothoracic surgery.
Bosman RJ, Rood E, et al.
Department of Intensive Care, Onze Lieve Vrouwe Gasthuis, 1e Oosterparkstraat 279, PO box 10550, 1090 HM Amsterdam, The Netherlands. R.J.Bosman@OLVG.nl
OBJECTIVE: Nowadays, registration of patient data on paper is gradually being replaced by registration using an intensive care information system (ICIS). The aim of this study was to evaluate the effect of the use of an ICIS on nursing activity. DESIGN: Randomized controlled trial with a crossover design. SETTING: An 18-bed medical-surgical ICU in a teaching hospital. PATIENTS, NURSES AND INTERVENTIONS: During a 6week period 145 consecutive adult patients admitted to the ICU after uncomplicated cardiothoracic surgery were randomized into two groups: for one group the documentation was carried out using a paper-based registration (Paper), in the second group an ICIS was used for documentation. MEASUREMENTS AND RESULTS: The nursing activities for these patients were studied during two separate periods: the admission period and the registration phase (the period directly following the admission procedure). The duration of the admission procedure was measured by time-motion analysis and the nursing activities in the registration phase were studied by work sampling methodology. All nursing activities during the registration phase were grouped in four main categories: patient care, documentation, unit-related and personal time. The duration of the admission procedure was longer in the ICIS group (18.1+/-4.1 versus 16.8+/-3.1 min, $p<0.05$). In the registration phase, a 30% reduction in documentation time (Paper 20.5% of total nursing time versus ICIS 14.4%, $p<0.001$), corresponding to 29 min (per 8h nursing shift) was achieved. This time was completely re-allocated to patient care. CONCLUSIONS: The use of the present ICIS in patients after cardiothoracic surgery alters nursing activity; it reduces the time for documentation and increases the time devoted to patient care. Electronic supplementary material: is available if you access this article at http://dx.org/10.1007/s00134-002-1542-9. On that page (frame on the left side), a link takes you directly to the supplementary material.
Publication Types: Clinical Trial Journal Article Randomized Controlled Trial PMID: 12528027

Intensive Care Med. 2004; 30(7): 1487-90.
Automatic calculation of the nine equivalents of nursing manpower use score (NEMS) using a patient data management system.
Junger A, Brenck F, et al.
Department of Anaesthesiology, Intensive Care Medicine and Pain Therapy, University Hospital Giessen, Rudolf-Buchheim-Strasse 7, 35392 Giessen, Germany.
OBJECTIVE: The most recent approach to estimate nursing resources consumption has led to the generation of the Nine Equivalents of Nursing Manpower use Score (NEMS). The objective of this prospective study was to establish a completely automatically generated calculation of the NEMS using a patient data management system (PDMS) database and to validate this approach by comparing the results with those of the conventional manual method. DESIGN: Prospective study. SETTING: Operative intensive care unit of a university hospital. PATIENTS: Patients admitted to the ICU between 24 July 2002 and 22 August 2002. Patients under the age of 16 years, and patients undergoing cardiovascular surgery or with burn injuries were excluded. INTERVENTIONS: None. MEASUREMENTS AND MAIN RESULTS: The NEMS of all patients was calculated automatically with a PDMS and manually by a physician in parallel. The results of the two methods were compared using the Bland and Altman approach, the interclass correlation

coefficient (ICC), and the kappa-statistic. On 20 consecutive working days, the NEMS was calculated in 204 cases. The Bland Altman analysis did not show significant differences in NEMS scoring between the two methods. The ICC (95% confidence intervals) 0.87 (0.84-0.90) revealed a high inter-rater agreement between the PDMS and the physician. The kappa-statistic showed good results (kappa>0.55) for all NEMS items apart from the item "supplementary ventilatory care". CONCLUSION: This study demonstrates that automatical calculation of the NEMS is possible with high accuracy by means of a PDMS. This may lead to a decrease in consumption of nursing resources.
Publication Types: Journal Article PMID: 15085320

Isr Med Assoc J. 2004; 6(10): 583-7.
Electronic medical record systems in Israel's public hospitals.
Lejbkowicz I, Denekamp Y, et al.
Galil Center for Medical Informatics and Telemedicine, Technion Faculty of Medicine, Haifa, Israel. izabella@tx.technion.ac.il
BACKGROUND: Various medical centers in Israel have recently incorporated electronic medical record systems. Knowing the EMR systems' features and pattern of use is an essential step for developing locally and nationally integrated systems. OBJECTIVES: To evaluate the status of EMR systems in all major general hospitals in Israel in terms of the applications used and the patterns of use. METHODS: Structured questionnaires were sent to hospital directors and directors of medical informatics units of 26 general and pediatric hospitals serving the vast majority of the population in Israel. The questionnaire included questions pertaining to the EMR systems, their usage, and the attitude of the participants to data security issues. RESULTS: Of the 26 general hospitals 23 (88.4%) returned the questionnaires. Of these, 21 (91.3%) use EMR systems. Twenty-seven different types of systems are in use in Israeli hospitals, and generally more than one type is used in a hospital. Physicians work with EMR systems in over 98% of the departments. Also, the EMR systems are used for clinical admission and discharge in over 90% of the departments and for medical daily follow-up in about 45%. CONCLUSIONS: Most of the hospitals in Israel use EMR systems but there is no standard data model. Physicians are the main users but the amount of data entered is still limited. Adoption of standards is essential for the integration of electronic patient records across Israeli healthcare organizations.
Publication Types: Journal Article PMID: 15473582

J Am Coll Surg. 2005; 200(4): 538-45.
A randomized, controlled trial evaluating the impact of a computerized rounding and sign-out system on continuity of care and resident work hours.
Van Eaton EG, Horvath KD, et al.
Department of Surgery, University of Washington, Seattle, WA 98195, USA.
BACKGROUND: Adoption of limits on resident work hours prompted us to develop a centralized, Web-based computerized rounding and sign-out system (UWCores) that securely stores sign-out information; automatically downloads patient data (vital signs, laboratories); and prints them to rounding, sign-out, and progress note templates. We tested the hypothesis that this tool would positively impact continuity of care and resident workflow by improving team communication involving patient handovers and streamlining inefficiencies, such as hand-copying patient data during work before rounds ("prerounds"). STUDY DESIGN: Fourteen inpatient resident teams (6 general surgery, 8 internal medicine) at two teaching hospitals participated in a 5-month, prospective, randomized, crossover study. Data collected included number of patients missed on resident rounds, subjective continuity of care quality and workflow efficiency with and without UWCores, and daily self-reported prerounding and rounding times and tasks. RESULTS: UWCores halved the number of patients missed on resident rounds (2.5 versus 5 patients/team/month, $p = 0.0001$); residents spent 40% more of their prerounds time seeing patients ($p = 0.36$); residents reported better sign-out quality (69.6% agree or strongly agree); and improved continuity of care (66.1% agree or strongly agree). UWCores halved the portion of prerounding time spent hand-copying basic data ($p < 0.0001$); it shortened team rounds by 1.5 minutes/patient ($p = 0.0006$); and residents reported finishing their work sooner using UWCores (82.1% agree or strongly agree). CONCLUSIONS: This system enhances patient care by decreasing patients missed on resident rounds and improving resident-reported quality of sign-out and continuity of care. It decreases by up to 3 hours per week (range 1.5 to 3) the time used by residents to complete rounds; it diverts prerounding time from recopying data to more productive tasks; and it facilitates meeting the 80-hour work week requirement by helping residents finish their work sooner.
Publication Types: Clinical Trial Journal Article Randomized Controlled Trial
PMID: 15804467

J Am Med Inform Assoc. 2003; 10(2): 177-87.
The effect of computer-generated reminders on charting deficiencies in the ICU.
Oniki TA, Clemmer TP, et al.
Oracle Corporation, Redwood Shores, California, USA. tom.oniki@oracle.com
OBJECTIVE: To examine the effect of computer-generated reminders on nurse charting deficiencies in two intensive care units. DESIGN: Nurses caring for a group of 60 study patients received patient-specific paper reminder reports when charting deficiencies were found at mid-day. Nurses caring for a group of 60 control patients received no reminders. A group of 60 retrospective patients was also formed. MEASUREMENTS: The average numbers of charting deficiencies at the end of the shift in each of the three groups were compared using two planned orthogonal contrasts. RESULTS: The average in the study group patients was 1.02 deficiencies per day per patient, whereas the control group the average was 1.40 deficiencies per day per patient ($p = 0.001$). The average number of end-of-shift deficiencies in the pooled prospective (study/control) population was 1.21 deficiencies per day per patient, compared with the average in the retrospective group of 1.56 deficiencies per day per patient ($p < 0.001$). CONCLUSION: The decrease was likely due both to the appropriate response of the nurses to the reminders and to a learned attentiveness to the tasks on the part of the nurses who cared for study patients. Greater gains were hindered by incomplete "coupling" of the reminders to the end-of-shift deficiencies and by inaccuracies in the reminders.
Publication Types: Evaluation Studies Journal Article PMID: 12595407

J Am Med Inform Assoc. 2003; 10(1): 94-107.
The use of computers for clinical care: a case series of advanced U.S. sites.
Doolan DF, Bates DW, et al.
Clinical Services, Greater Newcastle Sector, Hunter Health, Newcastle, New South Wales, Australia.
OBJECTIVE: To describe advanced clinical information systems in the context in which they have been implemented and are being used. DESIGN: Case series of five U.S. hospitals, including inpatient, ambulatory and emergency units. Descriptive study with data collected from interviews, observations, and document analysis. MEASUREMENTS: The use of computerized results, notes, orders, and event monitors and the type of decision support; data capture mechanisms and data form; impact on clinician satisfaction and clinical processes and outcomes; and the organizational factors associated with successful implementation. RESULTS: All sites have implemented a wide range of clinical information systems with extensive decision support. The systems had been well accepted by clinicians and have improved clinical processes. Successful implementation required leadership and long-term commitment, a focus on improving clinical processes, and gaining clinician involvement and maintaining productivity. CONCLUSION: Despite differences in approach there are many similarities between sites in the clinical information systems in use and the factors important to successful implementation. The experience of these sites may provide a valuable guide for others who are yet to start, or are just beginning, the implementation of clinical information systems.
Publication Types: Evaluation Studies Journal Article PMID: 12509360

J Am Med Inform Assoc. 2003; 10(6): 588-95.
Effects of scanning and eliminating paper-based medical records on hospital physicians' clinical work practice.
Laerum H, Karlsen TH, et al.
INM, Faculty of Medicine, NTNU, Trondheim, Norway. hallvard.larum@medisin.ntnu.no
OBJECTIVE: It is not automatically given that the paper-based medical record can be eliminated after the introduction of an electronic medical record (EMR) in a hospital. Many keep and update the paper-based counterpart, and this limits the use of the EMR system. The authors have evaluated the physicians' clinical work practices and attitudes toward a system in a hospital that has eliminated the paper-based counterpart using scanning technology. DESIGN: Combined open-ended interviews (8 physicians) and cross-sectional survey (70 physicians) were conducted and compared with reference data from a previous national survey (69 physicians from six hospitals). The hospitals in the reference group were using the same EMR system without the scanning module. MEASUREMENTS: The questionnaire (English translation available as an online data supplement at <www.jamia.org>) covered frequency of use of the EMR system for 19 defined tasks, ease of performing them, and user satisfaction. The interviews were open-ended. RESULTS: The physicians routinely used the system for nine of 11 tasks regarding retrieval of patient data, which the majority of the physicians found more easily performed than before. However, 22% to 25% of the physicians found retrieval of patient data more difficult, particularly among internists (33%). Overall, the physicians were equally satisfied with the part of the system handling the regular electronic data as that of the physicians in the reference group. They were, however, much less satisfied with the use of

scanned document images than that of regular electronic data, using the former less frequently than the latter. CONCLUSION: Scanning and elimination of the paper-based medical record is feasible, but the scanned document images should be considered an intermediate stage toward fully electronic medical records. To our knowledge, this is the first assessment from a hospital in the process of completing such a scanning project.
Publication Types: Journal Article PMID: 12925550

J Am Med Inform Assoc. 2004; 11(4): 300-9.
Impacts of computerized physician documentation in a teaching hospital: perceptions of faculty and resident physicians.
Embi PJ, Yackel TR, et al.
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OBJECTIVE: Computerized physician documentation (CPD) has been implemented throughout the nation's Veterans Affairs Medical Centers (VAMCs) and is likely to increasingly replace handwritten documentation in other institutions. The use of this technology may affect educational and clinical activities, yet little has been reported in this regard. The authors conducted a qualitative study to determine the perceived impacts of CPD among faculty and housestaff in a VAMC. DESIGN: A cross-sectional study was conducted using semistructured interviews with faculty (n = 10) and a group interview with residents (n = 10) at a VAMC teaching hospital. MEASUREMENTS: Content analysis of field notes and taped transcripts were done by two independent reviewers using a grounded theory approach. Findings were validated using member checking and peer debriefing. RESULTS: Four major themes were identified: (1) improved availability of documentation; (2) changes in work processes and communication; (3) alterations in document structure and content; and (4) mistakes, concerns, and decreased confidence in the data. With a few exceptions, subjects felt documentation was more available, with benefits for education and patient care. Other impacts of CPD were largely seen as detrimental to aspects of clinical practice and education, including documentation quality, workflow, professional communication, and patient care. CONCLUSION: CPD is perceived to have substantial positive and negative impacts on clinical and educational activities and environments. Care should be taken when designing, implementing, and using such systems to avoid or minimize any harmful impacts. More research is needed to assess the extent of the impacts identified and to determine the best strategies to effectively deal with them.
Publication Types: Journal Article
PMID: 15064287

J Am Med Inform Assoc. 2005; 12(4): 398-402.
Handheld computer-based decision support reduces patient length of stay and antibiotic prescribing in critical care.
Sintchenko V, Iredell JR, et al.
Centre for Health Informatics, University of New South Wales, UNSW, Sydney 2052. v.sintchenko@unsw.edu.au
OBJECTIVE: This study assessed the effect of a handheld computer-based decision support system (DSS) on antibiotic use and patient outcomes in a critical care unit. DESIGN: A DSS containing four types of evidence (patient microbiology reports, local antibiotic guidelines, unit-specific antibiotic susceptibility data for common bacterial pathogens, and a clinical pulmonary infection score calculator) was developed and implemented on a handheld computer for use in the intensive care unit at a tertiary referral hospital. System impact was assessed in a prospective "before/after" cohort trial lasting 12 months. Outcome measures were defined daily doses (DDDs) of antibiotics per 1,000 patient-days, patient length of stay, and mortality. RESULTS: The number of admissions, APACHE (Acute Physiology, Age, and Chronic Health Evaluation) II and SAPS (Simplified Acute Physiology Score) II for patients in preintervention, and intervention (DSS use) periods were statistically comparable. The mean patient length of stay and the use of antibiotics in the unit during six months of the DSS use decreased from 7.15 to 6.22 bed-days ($p = 0.02$) and from 1,767 DDD to 1,458 DDD per 1,000 patient-days ($p = 0.04$), respectively, with no change in mortality. The DSS was accessed 674 times during 168 days of the trial. Microbiology reports and antibiotic guidelines were the two most commonly used (53% and 22.5%, respectively) types of evidence. The greatest reduction was observed in the use of beta-lactamase-resistant penicillins and vancomycin. CONCLUSION: Handheld computer-based decision support contributed to a significant reduction in patient length of stay and antibiotic prescribing in a critical care unit.
Publication Types: Evaluation Studies Journal Article
PMID: 15802478

J Am Med Inform Assoc. 2005; 12(6): 589-95.
Enhanced notification of critical ventilator events.
Evans RS, Johnson KV, et al.
Department of Medical Informatics, LDS Hospital, Salt Lake City, UT 84143-0001, USA. ldevans@ihc.com
Mechanical ventilators are designed to generate alarms when patients become disconnected or experience other critical ventilator events. However, these alarms can blend in with other accustomed sounds of the intensive care unit. Ventilator alarms that go unnoticed for extended periods of time often result in permanent patient harm or death. We developed a system to monitor critical ventilator events through our existing hospital network. Whenever an event is identified, the new system takes control of every computer in the patient's intensive care unit and generates an enhanced audio and visual alert indicating that there is a critical ventilator event and identifies the room number. Once the alert is acknowledged or the event is corrected, all the computers are restored back to the pre-alert status and/or application. This paper describes the development and implementation of this system and reports the initial results, user acceptance, and the increase in valuable information and patient safety.
Publication Types: Evaluation Studies Journal Article PMID: 16049226

J Am Soc Nephrol. 2001; 12 Suppl 17: S83-6.
Patient data management systems in critical care.
Fretschner R, Bleicher W, et al.
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Electronic patient data management systems (PDMS) were clinically used for the first time in the 1970s. Their purpose was to automatically document vital parameters sampled by monitors and to replace handwritten medical files. Because of the continuous development of computer technology, however, demands on PDMS have increased immensely. PDMS are currently expected to assist clinicians at every level of intensive care, i.e., at the strategic level of physicians' orders and prescriptions, at the operational level, and at the administrative level. In 1994, a PDMS (CareVue; Agilent Technologies) was installed and further developed in the anesthesiologic intensive care unit of the university hospital in Tubingen. The goals of this article were to describe the current demands on PDMS, to communicate our experiences in implementing a PDMS, to list the costs of purchasing and maintaining the system, and to report on the acceptance among physicians and nursing personnel. This article may assist new users in planning for, purchasing, and implementing a PDMS.
Publication Types: Journal Article Review PMID: 11251038

J Biomed Inform. 2005; 38(3): 229-38.
Technology, work, and information flows: lessons from the implementation of a wireless alert pager system.
Reddy MC, McDonald DW, et al.
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The combination of collaborative work practices and information technology affect the flow of information in clinical settings. The introduction of a new technology into these settings can change not only established work practices but also the information flows. In this paper, we examine the introduction of a wireless alerts pager in a surgical intensive care unit (SICU). Through a qualitative study, we analyze the effects that this new information tool had on both the work practices in the SICU and the information flow in the unit. We describe four challenges that SICU staff members faced with respect to the alerts pagers. We found that the pager provided new routes of information to SICU staff but in doing so disrupted existing work practices and information flows.
Publication Types: Journal Article PMID: 15896696

J Clin Neurophysiol. 2004; 21(5): 353-78.
Data analysis for continuous EEG monitoring in the ICU: seeing the forest and the trees.
Scheuer ML, Wilson SB.
Department of Neurology, University of Pittsburgh Epilepsy Center, Kaufmann Medical Building, 3471 Fifth Avenue, Pittsburgh, PA 15213, U.S.A. scheuer@pitt.edu
Continuous EEG monitoring (CEEG) is a powerful tool for evaluating cerebral function in obtunded and comatose critically ill patients. The ongoing analysis of CEEG data is a major task because of the volume of data generated during monitoring and the need for near real-time interpretation of a patient's EEG patterns. Advances in digital EEG data acquisition, computer processing, data transmission, and data display have made CEEG monitoring in the intensive care unit technically feasible. A variety of

quantitative EEG tools such as Fourier analysis and amplitude-integrated EEG, and other methods of data analysis such as computerized seizure detection, increasingly allow for focused review of EEG epochs of potential interest. These tools reduce the tremendous time burdens that accompany analysis of the complete CEEG data stream, and allow bedside personnel and nonexpert staff to potentially recognize significant EEG changes in a timely fashion. This article uses literature review and clinical case examples to illustrate techniques for the display and analysis of intensive care unit CEEG recordings. Areas requiring further research and development are discussed.
Publication Types: Journal Article Review PMID: 15592009

J Clin Nurs. 2004; 13(1): 17-25.
'Rage against the machine?': nurses' and midwives' experiences of using Computerized Patient Information Systems for clinical information.
Darbyshire P.
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BACKGROUND: Computerized Patient Information Systems (CPIS) are used increasingly in health care, yet few studies have asked clinicians to describe their experiences of using these systems and what they mean to their practice and patient care. AIMS AND OBJECTIVES: The aim of this study was to explore clinical nurses' and midwives' perceptions and understandings of computerized information systems in everyday practice. The objective was to provide a detailed and faithful account of clinicians' experiences of using such systems. DESIGN: A qualitative design was used, based upon interpretive phenomenology. METHODS: A total of 13 focus groups involving 53 practitioners was conducted in hospitals across five Australian states with nurses and midwives from a wide range of practice settings. The participants ranged from Level 1 RNs to Clinical Nurse Consultants and nurses with an IT project management role. RESULTS: This study focuses specifically on clinicians' experiences of using CPIS to manage clinical information. Clinicians' experiences were characterized by digital disappointment rather than electronic efficiencies. Clinicians reported generally that computerization had neither enhanced their clinical practice nor patient care, nor had it improved patient outcomes. CONCLUSIONS: Participants' experiences were predominantly negative and mostly critical of CPIS and their: perceived inability to capture 'real nursing', difficulty in use, incompatibilities, non-responsiveness and irrelevance to patient care and meaningful clinical outcomes. RELEVANCE TO CLINICAL PRACTICE: Technological 'solutions' to health care problems are endlessly seductive and easily entrance policy and decision makers. Computerization will continue to impact upon clinical practice and cannot be wished away. Today's computerized systems may have been developed with scant regard for clinician end-users. A crucial issue facing everyone in health informatics is how point-of-care systems can be developed in ways that involve clinicians meaningfully and which recognize and respond to the complexity and subtlety of the world of nursing and midwifery practice.
Publication Types: Journal Article PMID: 14687289

J Crit Care. 2002; 17(2): 138-45.
Changing physician behavior: a review of patient safety in critical care medicine.
Landry MD, Sibbald WJ.
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The publication of the Agency for Healthcare Research and Quality (AHRQ) report in July 2001 entitled "Making Health Care Safer: A Critical Analysis of Patient Safety Practices," represents a significant perceptual change in health care ideology. It can be argued that this compilation recognizes not only that medical errors occur in the health care system, but also that there are significant learning opportunities that may arise in the identification of these errors that are otherwise known as medical misadventures. The report concluded and outlined a series of 11 highly rated practices whose usage are associated with increased safety. The AHRQ report also articulated that there is a need to investigate methods used to align medical practice with evidence regarding patient safety. In other words, after the identification of the 11 priority safety practices, it is thus important to determine the most effective methods to change physician behavior toward these practices that will intuitively result in increased safety performance. Five different educational-based strategies have been identified as techniques to change physician behavior: (1) Academic Detailing, (2) Audit and Feedback, (3) Local Opinion Leaders, (4) Reminder Systems, and (5) Printed Material. This article reviews these strategies in the context of critical care medicine and offers some opinions regarding setting the future research agenda in this investigative field.
Publication Types: Journal Article Review
PMID: 12096377

J Crit Care. 2003; 18(1): 41-7.
Medical informatics in the intensive care unit: overview of technology assessment.
Adhikari N, Lapinsky SE.
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Effective patient care in the intensive care unit (ICU) depends on the ability of clinicians to process large amounts of clinical and laboratory data. Recently, medical informatics applications have been developed to store and display patient information and assist clinical decision making. Despite the proliferation of these systems and their potential to improve patient care, there are no comprehensive health technology assessments incorporating considerations of safety, functionality, technical performance, clinical effectiveness, economics, and organizational implications. The objectives and methods of informatics evaluations depend on the type of application and the stage of development. Qualitative and quantitative nonrandomized evaluations of comprehensive information management systems like electronic medical records and picture archiving and communications systems should concentrate on technical and functional issues. Specific applications like clinical decision support systems and computerized patient care systems are designed to improve patient outcomes and clinical performance; randomized controlled trials (RCTs) to assess clinical effectiveness are important in their assessment. Although studies of these applications in the ICU setting are increasing, there are currently very few published randomized trials.
Publication Types: Journal Article Review PMID: 12640613

J Crit Care. 2004; 19(4): 283-9.
Computerized physician order entry from a chief information officer perspective.
Cotter CM.
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Designing and implementing a computerized physician order entry system in the critical care units of a large urban hospital system is an enormous undertaking. With their significant potential to improve health care and significantly reduce errors, the time for computerized physician order entry or physician order management systems is past due. Careful integrated planning is the key to success, requiring multidisciplinary teams at all levels of clinical and administrative management to work together. Articulated from the viewpoint of the Chief Information Officer of Lifespan, a not-for-profit hospital system in Rhode Island, the vision and strategy preceding the information technology plan, understanding the system's current state, the gap analysis between current and future state, and finally, building and implementing the information technology plan are described.
Publication Types: Journal Article PMID: 15648047

J Crit Care. 2004; 19(4): 271-8.
Computerized physician order entry in the critical care and general inpatient setting: a narrative review.
Rothschild J.
Division of General Medicine and Primary Care, Department of Medicine Brigham and Women's Hospital, 1620 Tremont St, Boston, MA, USA. jrothschild@partners.org
Computerized physician order entry (CPOE) is an increasingly used technologic tool for entering clinician orders, especially for medications and laboratory and diagnostic tests. Studies in hospitalized patients, including critically ill patients, have demonstrated that CPOE, especially with decision support, improves several outcomes. These improved outcomes include clinical measures such as reductions in serious medication errors and enhanced antimicrobial management of critically ill patients resulting in reduced length of stay. Additionally, several process outcomes have improved with CPOE such as increased compliance with evidence-based practices, reductions in unnecessary laboratory tests and cost savings in pharmacotherapeutics. Future studies are needed to demonstrate the benefits of more patient specific decision support interventions and the seamless integration of CPOE into a wireless, computerized medication administration system.
Publication Types: Journal Article Review PMID: 15648045

J Crit Care. 2004; 19(4): 248-56.
Using computerized medical databases to measure and to improve the quality of intensive care.
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This article reviews the potential for using computerized databases to measure the quality of care in the intensive care unit. There are 2 types of computerized databases used to assess quality of care:

administrative databases used primarily for purposes other than medical care and electronic medical record databases collected specifically for clinical purposes. Quality of care is a difficult property to measure but is generally assessed along 3 domains: structure, process, and outcome. There are several problems with using computerized medical databases to measure and improve quality of care. Many factors known to be important to measuring the severity of illness and process of care in critically ill patients are not captured in routine administrative databases. The criteria for the ethical use of electronic medical record data for research, clinical care, and quality improvement are identical to those that should be applied to using paper medical records. Standardizing a minimal intensive care unit dataset, identifying and measuring optimal processes of care, and understanding the limits of risk adjusted outcomes are all important steps in the process of the optimal use of computerized databases to study and improve the quality of care in the intensive care unit.
Publication Types: Journal Article Review PMID: 15648042

J Crit Care. 2004; 19(1): 10-5.
Comparison of a commercially available clinical information system with other methods of measuring critical care outcomes data.
Ward NS, Snyder JE, et al.
Medical Intensive Care Unit, Brown Medical School, Rhode Island Hospital, Providence, RI 02903, USA. Nicholas_Ward@brown.edu
PURPOSE: To compare the quality of data recorded by a commercially available clinical information system (CIS) to other commonly used methods for obtaining large amounts of patient data. MATERIALS AND METHODS: Five sets of clinical patient data were chosen as a cross-section of all the data collected by a CIS in our intensive care unit (ICU): 1) Length of stay in the ICU, 2) Vital signs, 3) Days of mechanical ventilation, 4) medications, and 5) diagnoses. Data generated by our ICU CIS was compared with other parallel data sets commonly used to obtain the same data for clinical research. RESULTS: When compared with our CIS, the hospital database recorded a length of stay at least 1 day longer than the actual length of stay 53% of the time. A search of 139,387 sets of vital signs showed less than 0.1% rate of suspected artifact. When compared to direct observation, our CIS correctly recorded days of mechanical ventilation in 23 of 26 patients (88%). Two other data sets, medical diagnoses and medications given showed significant differences with other commonly used databases of the same information collected outside the ICU (billing codes and pharmacy records respectively CONCLUSIONS: Compared to other commonly used data sources for clinical research, a commercially available CIS is an acceptable source of ICU patient data.
Publication Types: Journal Article PMID: 15101000

J Crit Care. 2004; 19(4): 226-33.
CIS: where are we going and what should we demand from industry?
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Clinical information systems designed for use in the critical care setting have been available for many years. Yet, despite significant evidence that these systems contribute to patient safety and efficiency of care, they have not achieved widespread use. This paper examines some of the factors responsible for the slow growth in use of clinical information systems in the intensive care unit. We further examine the elements that will be necessary to support widespread adoption of future clinical information systems. We give an outline of functionalities, processes, and standards that users will demand from industry as they develop the information systems of the future.
Publication Types: Journal Article PMID: 15648039

J Crit Care. 2004; 19(4): 221-5.
The accuracy of clinical information systems.
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The clinical information system (CIS) is becoming more common in intensive care units. These systems have the ability to record, store, and retrieve large amounts of clinical patient data with great ease. This should greatly facilitate outcomes research and quality assurance. Unfortunately, there is not much information available about the accuracy of the data coming from these systems. True accuracy of a patient record requires both completeness of data and correctness of data as well as legibility. Automated systems are clearly superior to human entered data in terms of completeness and legibility but the

correctness of entered data remains unclear. There are aspects of automated data entry that facilitate erroneous data entry. This article reviews the existing literature on accuracy of CISs with special attention to the qualities of automated data entry that can lead to false data. Additionally, data are presented from a newly published study by the author evaluating the validity of data from a commercially available CIS.
Publication Types: Journal Article Review PMID: 15648038

J Crit Care. 2004; 19(4): 208-14.
Clinical information systems: CareSuite from Picis.
de Mul M, Berg M, et al.
Department of Health Policy & Management, Erasmus Medical Center, 3000 CB Rotterdam, the Netherlands.
In this article, we discuss the implementation of the CareSuite system (Picis, Wakefield, MA) in 5 intensive care units of the Erasmus Medical Center, Rotterdam, the Netherlands. We give a description of the implementation process, and the system as it is currently being used. We also confront the lessons learned during the implementation of this clinical information systems with insights from the research field of implementation, and thereby show the value of a socio-technical approach to clinical information systems implementation.
Publication Types: Journal Article PMID: 15648036

J Crit Care. 2004; 19(4): 199-200.
Computers in the intensive care unit.
Levy MM.
Publication Types: Editorial PMID: 15648034

J Crit Care. 2005; 20(1): 12-9.
A systematic review of the Charlson comorbidity index using Canadian administrative databases: a perspective on risk adjustment in critical care research.
Needham DM, Scales DC, et al.
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The Charlson index is commonly used for risk adjustment in critical care health services research. However, the literature supporting this methodology has not been thoroughly explored. We systematically reviewed the literature related to administrative database adaptations of the Charlson index. Our review has 3 major findings. First, 2 studies compared Canadian administrative databases with chart review for obtaining Charlson comorbidity data. Agreement between the database and chart review was substantial (kappa > 0.70), and mortality prediction did not differ. Second, 5 database adaptations were identified with the Deyo and Dartmouth-Manitoba adaptations being most popular. Three studies directly compared these 2 popular adaptations and demonstrated substantial agreement (kappa > 0.70) and similar predictive ability for mortality. Third, one study validated the Charlson index for critically ill patients but demonstrated that APACHE (Acute Physiology and Chronic Health Evaluation) II better discriminates inhospital mortality (area under curve 0.67 vs 0.87). Time and cost barriers prevent widespread use of physiology-based risk adjustment in population-based research. The decreased predictive ability of the Charlson index must be weighed against the advantages of using this instrument for population-based research. Future research should focus on updating the Charlson index for recent changes in the prognosis of comorbid diseases and introduction of International Statistical Classification of Diseases, 10th Revision coding of discharge abstracts.
Publication Types: Journal Article Review PMID: 16015512

J Eval Clin Pract. 2005; 11(2): 133-8.
Use of a patient information system to audit the introduction of modified early warning scoring.
Quarterman CP, Thomas AN, et al.
Medical Student, University of Manchester, Manchester, UK.
Modified early warning scoring (MEWS) uses abnormalities in routine observations to identify patients at risk of critical illness. Nurses recorded scores at or above the medical response score of 3 on a hospital clinical information system during the first year of introducing MEWS to 10 wards in a university hospital. A total of 619 triggers were recorded in 365 patients. Fifty-nine required intensive care unit (ICU)/high dependency unit (HDU) care; 71 died. Survival was significantly worse for initial scores >4 (35/104 patients died) than for scores 3-4 (P<0.004). Multivariant analysis showed age (P<0.001) and trigger score (P<0.001) but not ward specialty (P=0.1) predicted death. Mean ages of survivors and non-survivors were 64 years (SD 18) and 74 years (SD 17), respectively. Addition of a score for age did not significantly increase the

area under a receiver operator characteristic curve for the predictive value of MEWS scores. The study shows that increasing MEWS score is associated with worse outcome across a range of specialties and that nursing staff will use a patient information system to audit MEWS scores.
Publication Types: Journal Article PMID: 15813711

J Health Care Finance. 2004; 31(2): 16-25.
Making the business case for hospital information systems--a Kaiser Permanente investment decision.
Garrido T, Raymond B, et al.
Clinical Systems Planning and Consulting, Kaiser Foundation Health Plan, Inc, Oakland, CA, USA.
Further evidence in favor of the clinical IT business case is set forth in Kaiser Permanente's cost/benefit analysis for an electronic hospital information system. This article reviews the business case for an inpatient electronic medical record system, including 36 categories of quantifiable benefits that contribute to a positive cumulative net cash flow within an 8.5 year period. However, the business case hinges on several contingent success factors: leadership commitment, timely implementation, partnership with labor, coding compliance, and workflow redesign. The issues and constraints that impact the potential transferability of this business case across delivery systems raise questions that merit further attention.
Publication Types: Journal Article PMID: 15839526
http://www.kpihp.org/publications/briefs/business%20case.pdf

J Health Organ Manag. 2003; 17(5): 349-59.
Physicians' and nurses' reactions to electronic medical records. Managerial and occupational implications.
Darr A, Harrison MI, et al.
Department of Sociology and Anthropology, Haifa University, Haifa, Israel.
Aims to understand the managerial implications of the perceptions hospital physicians and nurses hold toward the introduction of electronic medical records (EMRS). In-depth interviews were used with 18 hospital physicians and eight nurses from several different hospital wards at a large government-run, university-affiliated hospital in Israel, where EMRs were gradually introduced over the last 20 years. Physicians identified six different domains of impact. Senior physicians, most of whom held managerial roles, tended to emphasise managerial outcomes and to view these as positively affecting their organisations. Junior doctors emphasised mostly negative occupational effects of the EMR on their work--including limits to professional autonomy, heavier administrative burdens, and reinforcement of existing professional hierarchies. Nurses identified different domains and saw benefits for quality and administration of patient care.
Publication Types: Journal Article PMID: 14628488

J Healthc Inf Manag. 2004; 18(1): 30-5.
Assessing recommendations from the IOM's quality chasm report.
Staggers N.
Health Sciences Center, University of Utah, USA.
The most recent Institute of Medicine report recommends immense changes for healthcare institutions and places information technology as a central component of proposed changes. This paper gives an overview of the IOM report, analyzes several key IT topics, and suggests required actions to effect the IOM's recommendations.
Publication Types: Journal Article PMID: 14971077

J Healthc Inf Manag. 2005; 19(3): 47-55.
Developing and implementing a patient-centered IT strategy.
Malone EB, Kirchbdoerfer RG, et al.
The Army Medical Department (AMEDD), a comprehensive worldwide integrated healthcare system with an annual budget of more than $6 billion, more than 50,000 employees, and 2.4 million beneficiaries, developed and implemented a comprehensive patient-centered enterprise-wide information management and information technology strategy to facilitate information management systems and infrastructure decisions by leaders. This article describes a patient-centered model used to organize and link healthcare activities and activity leaders to portray patient care, administrative, business, financial, supply, and strategic support information systems. Activity and IT leaders applied a refined strategic alignment model to identify specific clinical, business, and IT goals and to detail the necessary infrastructure investments using a systems view. The use of patient and process outcome measures tied to the AMEDD's Balanced Score Card' helped leaders to manage IT strategy execution. Now, two years into the effort, a sample

activity strategy--outpatient care--is used to illustrate the application of these tools to the development and implementation of a patient-centered IT strategy.
Publication Types: Journal Article PMID: 16045084

J Healthc Inf Manag. 2005; 19(4): 75-86.
The patient safety institute demonstration project: a model for implementing a local health information infrastructure.
Classen DC, Kanhouwa M, et al.
First Consulting Group, USA.
The increasing focus on patient safety has uncovered many unsafe conditions in the current US. healthcare system. One of the most glaring problems is the inability of a fragmented healthcare system to provide critical and timely clinical information at the point of care. The Institute of Medicine has called for the development of a National Health Information Infrastructure to rectify this deficiency. This NHII will be built on Local Health Information Infrastructures, or LHIIs. The Patient Safety Institute is a potential model for an LHII that was developed and implemented in Seattle using the Swedish Medical Centers and associated ambulatory clinics. This model was piloted and evaluated among 365 clinical users across three hospitals, three clinics, and family practice residency programs involving access of records of more than 5300 distinct patients within a five-month period and involved the collection of more than 23 million clinical data results. User responses revealed the technology was intuitive to learn, easy to use, easy to navigate, and helpful in clinical care. The PSI demonstration project has developed an approach to the creation and implementation of LHIIs that is potentially transferable to other local communities.
Publication Types: Journal Article PMID: 16266036

J Intensive Care Med. 2003; 18(6): 330-9.
Test-ordering strategy in the intensive care unit.
Krinsley JS.
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The objective of this study was to assess the effect of an intervention designed to reduce utilization of portable chest x-rays (CXRs) in the intensive care unit (ICU). In this prospective observational study, patients representing 2734 consecutive admissions over a 35-month period were studied. Data collected from the comprehensive ICU database included patient days, ventilator days, number of admissions to the unit, number of CXRs ordered, costs for CXR, Acute Physiology and Chronic Health Evaluation II (Apache II) scores, ICU length of stay (LOS), length of mechanical ventilation, inadvertent extubations from mechanical ventilation, and reintubation within 48 hours of planned extubation. There was a 22.5% reduction in the rate CXR utilization during the study period, resulting in a $109,968 cost savings, and these savings were not associated with any adverse clinical outcomes.
Publication Types: Journal Article PMID: 14984661

J Intensive Care Med. 2004; 19(3): 154-63.
Clinical informatics in critical care.
Martich GD, Waldmann CS, et al.
Department of Critical Care Medicine, University of Pittsburgh School of Medicine, PA 15261, USA.
Health care information systems have the potential to enable better care of patients in much the same manner as the widespread use of the automobile and telephone did in the early 20th century. The car and phone were rapidly accepted and embraced throughout the world when these breakthroughs occurred. However, the automation of health care with use of computerized information systems has not been as widely accepted and implemented as computer technology use in all other sectors of the global economy. In this article, the authors examine the need, risks, and rewards of clinical informatics in health care as well as its specific relationship to critical care medicine.
Publication Types: Journal Article Review PMID: 15154996

J Med Syst. 2005; 29(6): 633-46.
ICASP: an intensive-care acquisition and signal processing integrated framework.
Siachalou EJ, Kitsas IK, et al.
Department of Electrical & Computer Engineering, Aristotle University of Thessaloniki, University Campus, Thessaloniki, Greece.
This paper presents an intensive-care acquisition and signal processing integrated framework in the area of intensive care units. The framework includes nearly all monitored biosignals in the intensive care, along with metadata and processing results. It is structured on two basic applications, i.e., the acquisition and the database one, running in two different PCs that are connected through a local area network,

facilitating real-time data exchange between them. The analytical rundown shows that the proposed framework is a serious effort to give a complete clinical condition of a patient and a form of a diagnostic analysis implement in the intensive care by taking in real-time processing.
Publication Types: Journal Article PMID: 16235817

J Public Health Manag Pract. 2004; Suppl: S36-47.
Key elements for successful integrated health information systems: lessons from the States.
Wild EL, Hastings TM, et al.
All Kids Count, Public Health Informatics Institute, Task Force for Child Survival and Development, Decatur, GA 30030, USA. ewild@phii.org
The Genetic Services Branch, Maternal and Child Health Bureau of the Health Services and Resources Administration has provided funding to state health departments to integrate their newborn dried blood-spot screening programs with other early child health information systems since 1999. In 2001, All Kids Count conducted site visits to these grantees to identify and describe best practices in planning, developing, and implementing their integration projects. The site visits were organized around 9 key elements considered critical to the success of an information systems integration project: leadership, project governance, project management, stakeholder involvement, organizational and technical strategy, technical support and coordination, financial support and management, policy support and evaluation. Best practices for each of the key elements and 5 lessons learned were documented in Integration of Newborn Screening and Genetic Service Systems with Other Maternal & Child Health Systems: A Sourcebook for Planning and Development. The lessons learned are overarching conclusions that agencies should consider when planning and implementing integrated information systems. This article briefly describes the key elements, their best practices as implemented by states, and the lessons learned.
Publication Types: Journal Article PMID: 15643357

Jama. 2005; 293(10): 1197-203.
Role of computerized physician order entry systems in facilitating medication errors.
Koppel R, Metlay JP, et al.
Department of Sociology, Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania School of Medicine, Philadelphia 19104 USA. rkoppel@sas.upenn.edu
CONTEXT: Hospital computerized physician order entry (CPOE) systems are widely regarded as the technical solution to medication ordering errors, the largest identified source of preventable hospital medical error. Published studies report that CPOE reduces medication errors up to 81%. Few researchers, however, have focused on the existence or types of medication errors facilitated by CPOE. OBJECTIVE: To identify and quantify the role of CPOE in facilitating prescription error risks. DESIGN, SETTING, AND PARTICIPANTS: We performed a qualitative and quantitative study of house staff interaction with a CPOE system at a tertiary-care teaching hospital (2002-2004). We surveyed house staff (N = 261; 88% of CPOE users); conducted 5 focus groups and 32 intensive one-on-one interviews with house staff, information technology leaders, pharmacy leaders, attending physicians, and nurses; shadowed house staff and nurses; and observed them using CPOE. Participants included house staff, nurses, and hospital leaders. MAIN OUTCOME MEASURE: Examples of medication errors caused or exacerbated by the CPOE system. RESULTS: We found that a widely used CPOE system facilitated 22 types of medication error risks. Examples include fragmented CPOE displays that prevent a coherent view of patients' medications, pharmacy inventory displays mistaken for dosage guidelines, ignored antibiotic renewal notices placed on paper charts rather than in the CPOE system, separation of functions that facilitate double dosing and incompatible orders, and inflexible ordering formats generating wrong orders. Three quarters of the house staff reported observing each of these error risks, indicating that they occur weekly or more often. Use of multiple qualitative and survey methods identified and quantified error risks not previously considered, offering many opportunities for error reduction. CONCLUSIONS: In this study, we found that a leading CPOE system often facilitated medication error risks, with many reported to occur frequently. As CPOE systems are implemented, clinicians and hospitals must attend to errors that these systems cause in addition to errors that they prevent.
Publication Types: Evaluation Studies Journal Article PMID: 15755942

Jama. 2005; 293(10): 1223-38.
Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review.
Garg AX, Adhikari NK, et al.
Division of Nephrology, University of Western Ontario, London, Canada.

CONTEXT: Developers of health care software have attributed improvements in patient care to these applications. As with any health care intervention, such claims require confirmation in clinical trials. OBJECTIVES: To review controlled trials assessing the effects of computerized clinical decision support systems (CDSSs) and to identify study characteristics predicting benefit. DATA SOURCES: We updated our earlier reviews by searching the MEDLINE, EMBASE, Cochrane Library, Inspec, and ISI databases and consulting reference lists through September 2004. Authors of 64 primary studies confirmed data or provided additional information. STUDY SELECTION: We included randomized and nonrandomized controlled trials that evaluated the effect of a CDSS compared with care provided without a CDSS on practitioner performance or patient outcomes. DATA EXTRACTION: Teams of 2 reviewers independently abstracted data on methods, setting, CDSS and patient characteristics, and outcomes. DATA SYNTHESIS: One hundred studies met our inclusion criteria. The number and methodologic quality of studies improved over time. The CDSS improved practitioner performance in 62 (64%) of the 97 studies assessing this outcome, including 4 (40%) of 10 diagnostic systems, 16 (76%) of 21 reminder systems, 23 (62%) of 37 disease management systems, and 19 (66%) of 29 drug-dosing or prescribing systems. Fifty-two trials assessed 1 or more patient outcomes, of which 7 trials (13%) reported improvements. Improved practitioner performance was associated with CDSSs that automatically prompted users compared with requiring users to activate the system (success in 73% of trials vs 47%; P = .02) and studies in which the authors also developed the CDSS software compared with studies in which the authors were not the developers (74% success vs 28%; respectively, P = .001). CONCLUSIONS: Many CDSSs improve practitioner performance. To date, the effects on patient outcomes remain understudied and, when studied, inconsistent.
Publication Types: Journal Article Review PMID: 15755945

Jama. 2005; 293(10): 1261-3.
Computer technology and clinical work: still waiting for Godot.
Wears RL, Berg M.
Publication Types: Comment Editorial PMID: 15755949

Jt Comm J Qual Patient Saf. 2005; 31(10): 585-93.
Integrating the intensive care unit safety reporting system with existing incident reporting systems.
Thompson DA, Lubomski L, et al.
Johns Hopkins University Schools of Medicine and Nursing, Baltimore, USA. dthomps1@jhmi.edu
BACKGROUND: Voluntary incident reporting systems that identify risks can be integrated into existing hospital reporting systems and can improve patient safety. FINDINGS: A voluntary and anonymous Web-based intensive care unit safety reporting system (ICUSRS) was implemented in a cohort of intensive care units (ICUs). The reporting system was integrated into hospitals' reporting systems after the adverse event reporting structures were investigated. Reporting systems were classified as mandatory or voluntary and internal or external; the extent of formal training was identified and the trajectory of completed adverse events in the exisiting systems were tracked. Information from reported incidents was sent back monthly to the hospital ICUs through case discussions and a quarterly newsletter. RESULTS: All seven hospitals had internal reporting systems and two also used external reporting systems. In general, the majority of incident reports were completed by registered nurses and were reported to the nursing chain of command. Many of the sites had little knowledge or understanding of their existing reporting systems. CONCLUSION: Voluntary external reporting systems such as the ICUSRS hold promise for improving patient safety.
Publication Types: Journal Article PMID: 16294671

Med Eng Phys. 2004; 26(6): 459-71.
Modeling and control of the agitation-sedation cycle for critical care patients.
Chase JG, Rudge AD, et al.
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Agitation-sedation cycling in critically ill patients, characterized by oscillations between states of agitation and over-sedation, is damaging to patient health, and increases length of stay and healthcare costs. The mathematical model presented captures the essential dynamics of the agitation-sedation system for the first time, and is statistically validated using recorded infusion data for 37 patients. Constant patient-specific patient parameters are used, illustrating the commonality of these fundamental dynamics over a broad range of patients. The validated model serves as a basis for comparison of sedation administration methods, devices, therapeutics and protocols. Heavy derivative feedback control is shown to be an effective means of managing agitation, given consistent agitation measurement. The improved

agitation management reduces the modeled mean and peak agitation levels 68.4% and 52.9% on average, respectively. Some patients showed over 90% reduction in mean agitation level through increased control gains. This improved agitation management is achieved via heavy derivative feedback control of sedation administration, which provides an essentially bolus-driven management approach, aligned with recent sedation practices.
Publication Types: Clinical Trial Journal Article Validation Studies PMID: 15234682

Med Inform Internet Med. 2005; 30(2): 173-8.
Usability: a critical success factor for managing change in the clinical info-structure.
Kay S.
The University of Salford, Salford, UK.
There can be no doubt that the clinical info-structure is being significantly enriched with the deployment of new systems throughout the health sector. From a technological perspective, the initial emphasis has been mainly on functionality and only latterly on the usability of these clinical information systems. However, the large scale and rapid pace of the changes being wrought in the health sector will have a major impact on clinicians and patients, not least in how they interact with the technology. Therefore, it is not only hardware and software but people-ware, too, that needs to be actively managed; not simply a one-off functional specification but an ongoing, complex relationship. Usability is the human factor that encompasses the ethical, educational, and evaluative aspects of design. There is also a strong case for regarding usability of clinical information systems as a key critical success factor for the management of change within the health-care domain. In particular, the relationship between usability, and education and training is examined.
Publication Types: Journal Article PMID: 16338806

Medinfo. 2004; 11(Pt 2): 1086-90.
Seamless information systems for critical care--myth or magic?
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SHIRE, The Faculty of Health and Social Care, The University of Salford, Greater Manchester, UK. samina.munir@hotmail.com
A multi-site study is described that evaluates the scope for seamless Clinical Information Systems (CIS) in critical care. Observations, shadowing of clinical staff, interviews and questionnaires show a triangulation in data collection methods as well as location triangulation as the study is conducted across four sites, two each in UK and Denmark. Role Activity Diagrams (RAD) are used to capture critical care work processes. The RADs are analysed to show the 'simplified complexity' of the work processes, which are changed by the introduction of information systems for the everyday use and management of all clinical information. Further, CIS that reconcile expectations of both hospital management and clinical staff and that have the potential to adapt to their organisational environment have a greater chance of surviving in autopoietic organisations such as critical care. Despite decades of Informatics, no such system exists in its entirety; this study shows that 'ancient problems' of clinical information systems development, implementation and integration are still heavily prevalent. However, the potential for CIS that consider integrating all clinical information requirements is immense.
Publication Types: Journal Article PMID: 15360980

Medinfo. 2004; 11(Pt 1): 227-31.
An evaluation of automatically generated briefings of patient status.
Jordan D, Whalen G, et al.
Department of Anesthesiology, Columbia University College of Physicians and Surgeons, New York, NY 10027, USA.
We report on an evaluation of MAGIC, a system that automatically generates briefings of patient status after coronary bypass surgery, completed in the Cardio Thoracic Intensive Care Unit at New York Presbyterian Hospital. Through enhancements in system design, robustness and speed, we compared information obtained by nurses against two briefings, one automatically generated by MAGIC and one provided by physicians upon the patient's arrival to the ICU. Our results show that MAGIC and the physician briefing provide a substantial increase in the amount of information than is available prior to the patient's arrival and that the information MAGIC provides is accurate. In many aspects, MAGIC out-performs the physician briefing; information is reported earlier and is always available. We conclude that MAGIC provides the CT ICU staff early on with a better assessment of the patient's status than in current practice and allows them to better prepare for the patient's arrival.
Publication Types: Evaluation Studies Journal Article PMID: 15360808

Medinfo. 2004; 11(Pt 1): 597-601.
Context in care--requirements for mobile context-aware patient charts.
Dahl Y, Sorby ID, et al.
Department of Computer and Information Science, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway. yngve.dahl@idi.ntnu.no
The hospital ward is a highly dynamic work environment, in which healthcare personnel rapidly switch from one task to another. The process is partly planned, and partly driven by events and interrupts. A mobile electronic patient chart (MEPC) will be an important tool for supporting order entry and accessing, communicating, and recording clinical information. The users need to switch from one context to another with minimal delay and effort. Context-awareness, the ability to sense relevant situational information, can allow the user interface of the MEPC to adapt to various situations. In this paper, we present a future scenario from the coronary care unit. This scenario is analyzed and discussed in order to develop requirements for design methods, context models, and system properties of the MEPC.
Publication Types: Journal Article PMID: 15360882

Medinfo. 2004; 11(Pt 2): 999-1002.
A tale of two hospitals: a sociotechnical appraisal of the introduction of computerized physician order entry in two Dutch hospitals.
Aarts J, Berg M.
Institute of Health Policy and Management, Erasmus University Medical Center, Rotterdam, The Netherlands. j.aarts@bmg.eur.nl
We compared the implementation of computerized physician order entry (CPOE) in two Dutch hospitals, one being an academic medical center and the other a large regional non-academic hospital. Both implemented the TDS7000 system that was running on the same computer, located in the computing department of the academic medical center. The outcomes of the implementation were different. The introduction of CPOE in the university medical center failed, while it was a success in the non-academic hospital. An appraisal of the different outcomes is possible when we consider the implementation of information as a thorough social process in which the technical and the social are closely interrelated. Our findings suggest that organizational change associated with CPOE implementation should not focus on individual physician behavior but on medical work as a collaborative professional effort
Publication Types: Journal Article PMID: 15360962

Medinfo. 2004; 11(Pt 1): 631-4.
Dealing with organizational change when implementing EHR systems.
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Over the past years researchers at Aalborg University have been developing a method for examining change readiness of hospital staff during the implementation of new IT-systems. (CRR; Change readiness-research). The aim is to provide the hospital-management with a tool that will lead to an optimal implementation of new IT-systems. The method has recently been used in department Y at Skejby Hospital, Skejby, Denmark. 81% out of 241 employees answered the distributed questionnaire, and the results showed, that the employees have some expectations to the new EHR-system, which are important to either confirm or reject; on the other hand a great part of the employees lack basic computer skills. Thus the CRR-method has provided the Organization with important information before the implementation of the new EHR-system.
Publication Types: Journal Article PMID: 15360889

Methods Inf Med. 2003; 42(4): 410-5.
"Computers can land people on Mars, why can't they get them to work in a hospital?" Implementation of an Electronic Patient Record System in a UK Hospital.
Jones MR.
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OBJECTIVES: This paper aims to describe and interpret the implementation of a hospital information system in a large UK hospital. METHODS: The paper is based on a longitudinal case study over a three-year period in which a cross section of hospital staff involved with the information system were interviewed. RESULTS AND CONCLUSIONS: Ambitious government targets for the use of Information Technology in the UK National Health Service sit alongside a history of notable project failures. The decision by a UK hospital to install an advanced, integrated electronic patient record system therefore faced conflicting demands

and expectations. This paper suggests that its simple categorisation as either a success or failure is problematic. Rather, the differing viewpoints that lead some clinicians to express "disappointment" with its performance, while others described its features as "tremendous" and managers suggested that the system had become "taken for granted" are explored. A number of broader phenomena relating to the organisational processes surrounding information systems implementation are also identified.
Publication Types: Journal Article PMID: 14534642

Minerva Anestesiol. 2002; 68(3): 71-5.
Daily classification of complexity/level of intensive medical care. Does it allow the monitoring of the managerial process in ICU?
Iapichino G.
Chair of Anaesthesiology and Resuscitation, San Paolo Hospital, University of Milan, Milan, Italy.
Publication Types: Journal Article Review PMID: 11981514

Minerva Anestesiol. 2004; 70(6): 521-3.
Clinical information system and quality of care in intensive care medicine: state of the art.
Pietropaoli P, Donati A.
Department of Anesthesiology and Resuscitation, La Sapienza, University, Rome, Italy.
Publication Types: Journal Article Review PMID: 15235560

Nurs Econ. 2003; 21(2): 89-90, 93.
Implementing clinical IT in critical care: keys to success.
Meadows G.
McKesson Information Solutions, Alpharetta, GA, USA.
Ensuring the success of a clinical information system in critical care requires careful selection of the right system to address the unique needs in this area. In addition, the methodology used for implementation must include key stakeholders, ensure nursing and physician leadership, understand and improve clinical processes, and provide ongoing training and support. These guidelines can be applied to the implementation of any clinical information system. They provide the opportunity to demonstrate value and benefits from CIS in critical care and beyond.
Publication Types: Journal Article PMID: 12739200

Pediatr Crit Care Med. 2003; 4(1): 26-32.
Interpretation of digital radiographs by pediatric critical care physicians using Web-based bedside personal computers versus diagnostic workstations.
Sterling L, Tait GA, et al.
McMaster University, Hamilton, Ontario, Canada.
OBJECTIVE: To determine whether the interpretations of digital radiographs by pediatric critical care physicians displayed on the bedside personal computer differ from the interpretations of images displayed on the diagnostic workstation. DESIGN: Paired comparison. SETTING: A 38-bed pediatric critical care unit in a 372-bed pediatric university hospital. SUBJECTS: Four pediatric critical care fellows and four pediatric critical care staff physicians. INTERVENTIONS: Eight critical care physicians interpreted 114 radiographs in random order on two separate occasions. Each radiograph was assessed for the presence or absence of five chest abnormalities, the correct or incorrect endotracheal tube position, and the position of central venous catheters. These interpretations were scored against a gold standard. MEASUREMENTS AND MAIN RESULTS: Sensitivity and specificity were calculated for the presence or absence of five chest abnormalities and the identification of correct or incorrect endotracheal tube position. Kappa was calculated to assess agreement in the interpretation of central catheter position. Regarding chest abnormalities, improvement in sensitivity on the diagnostic workstation was statistically significant for one critical care fellow. The specificity on the diagnostic workstation was significantly worse for two critical care fellows and two critical care staff physicians. Regarding endotracheal tube position, improvement in sensitivity on the diagnostic workstation was statistically significant for one critical care staff physician. There were no statistically significant differences between the two viewing modalities for specificity measures. For central venous catheter position, there were no statistically significant differences in the interobserver or intra-observer agreements between the two viewing modalities. CONCLUSIONS: With the exception of diffuse chest abnormalities, pediatric critical care physicians can use the Web-based bedside personal computer for clinical decision-making with the confidence that the decisions will be similar to those made on the diagnostic workstation.
Publication Types: Journal Article PMID: 12656538

Pediatr Crit Care Med. 2004; 5(5): 493-4.
The wired pediatric intensive care unit today: what is your patient's URL?
Markovitz BP. Publication Types: Comment Editorial PMID: 15356395

Pediatrics. 2004; 113(3 Pt 1): 450-4.
The effect of point-of-care personal digital assistant use on resident documentation discrepancies.
Carroll AE, Tarczy-Hornoch P, et al.
Children's Health Services Research, Indiana University School of Medicine, Indianapolis, Indiana 46202, USA. aaecarro@iupui.edu
BACKGROUND: We recently found documentation discrepancies in 60% of resident daily-progress notes with respect to patient weight, medications, or vascular lines. To what extent information systems can decrease such discrepancies is unknown. OBJECTIVE: To determine whether a point-of-care personal digital assistant (PDA)-based patient record and charting system could reduce the number of resident progress-note documentation discrepancies in a neonatal intensive care unit (NICU). DESIGN/METHODS: We conducted a before-and-after trial in an academic NICU. Our intervention was a PDA-based patient record and charting system used by all NICU resident physicians over the study period. We analyzed all resident daily-progress notes from 40 randomly selected days over 4 months in both the baseline and intervention periods. Using predefined reference standards, we determined the accuracy of recorded information for patient weights, medications, and vascular lines. Logistic and Poisson regression were used in analyses to control for potential confounding factors. RESULTS: A total of 339 progress notes in the baseline period and 432 progress notes in the intervention period were reviewed. When controlling for covariates in the regression, there were significantly fewer documentation discrepancies of patient weights in notes written by using the PDA system (14.4%-4.4% of notes; odds ratio [OR]: 0.29; 95% confidence interval [CI]: 0.15-0.56). When using the PDA system, there were no significant changes in the numbers of notes with documentation discrepancies of medications (27.7%-17.1% of notes; OR: 0.63; 95% CI: 0.35-1.13) or vascular lines (33.6%-36.1% of notes; OR: 1.11; 95% CI: 0.66-1.87). CONCLUSIONS: The use of our PDA-based point-of-care patient record and charting system showed a modest benefit in reducing the number of documentation discrepancies in resident daily-progress notes. Further study of PDAs in information systems is warranted before they are widely adopted.
Publication Types: Journal Article PMID: 14993533

Perform Improv Advis. 2005; 9(7): 81-3, 73.
Risk managers looking to EMR systems for proactive reduction of medical errors.
An initiative combining risk management and electronic medical records (EMRs) at MedStar Health, Columbia, MD, is expected to reduce medical errors and cut malpractice losses by an average of approximately $2 million a year.
Publication Types: Journal Article PMID: 16114484

Proc (Bayl Univ Med Cent). 2004; 17(3): 265-9.
Ten commandments for implementing clinical information systems.
Shabot MM.
Surgical Intensive Care Unit and Department of Information Services, Cedars-Sinai Medical Center, Los Angeles, California 90048, USA. michael.shabot@cshs.org
Publication Types: Journal Article PMID: 16200110

Qual Lett Healthc Lead. 2005; 17(11): 10-2, 1.
Addressing the barriers to greater implementation of electronic health records.
A recent study released last month by RAND researchers said that widespread adoption of electronic health record systems and networking could eventually save more than dollar 81 billion annually through improvement of healthcare efficiency and safety.
Publication Types: Journal Article PMID: 16422153

Qual Saf Health Care. 2004; 13(4): 265-71.
Design of a safer approach to intravenous drug infusions: failure mode effects analysis.
Apkon M, Leonard J, et al.
333 Cedar Street, New Haven, CT 06520-8064, USA. michael.apkon@yale.edu
OBJECTIVES: A set of standard processes was developed for delivering continuous drug infusions in order to improve (1) patient safety; (2) efficiency in staff workflow; (3) hemodynamic stability during infusion changes, and (4) efficient use of resources. Failure modes effects analysis (FMEA) was used to examine the impact of process changes on the reliability of delivering drug infusions. SETTING: An 11 bed

multidisciplinary pediatric ICU in the children's hospital of an academic medical center staffed by board certified pediatric intensivists. The hospital uses computerized physician order entry for all medication orders. METHODS: A multidisciplinary team characterized key elements of the drug infusion process. The process was enhanced to increase overall reliability and the original and revised processes were compared using FMEA. Resource consumption was estimated by reviewing purchasing and pharmacy records for the calendar year after full implementation of the revised process. Staff satisfaction was evaluated using an anonymous questionnaire administered to staff nurses in the ICU and pediatric residents who had rotated through the ICU. RESULTS: The original process was characterized by six elements: selecting the drug; selecting a dose; selecting an infusion rate; calculating and ordering the infusion; preparing the infusion; programming the infusion pump and delivering the infusion. The following practice changes were introduced: standardizing formulations for all infusions; developing database driven calculators; extending infusion hang times from 24 to 72 hours; changing from bedside preparation by nurses to pharmacy prepared or premanufactured solutions. FMEA showed that the last three elements of the original process had high risk priority numbers (RPNs) of >225 whereas the revised process had no elements with RPNs >100. The combined effect of prolonging infusion hang times, preparation in the pharmacy, and purchasing premanufactured solutions resulted in 1500 fewer infusions prepared by nurses per year. Nursing staff expressed a significant preference and pediatric residents unanimously expressed a strong preference for the revised process. CONCLUSIONS: Standardization of infusion delivery reduced the frequency for completing the most unreliable elements of the process and reduced the riskiness of the individual elements. Both contribute to a safer system.
Publication Types: Journal Article PMID: 15289629

Semin Nurse Manag. 2002; 10(2): 76-7; discussion 78-9.
Information systems enhance efficient and effective nursing practice and management.
Conner DA.
Nursing Informatics Program, New York University, School of Nursing, New York, NY, USA.
Publication Types: Journal Article PMID: 12092269

Stud Health Technol Inform. 2000; 77: 767-71.
Dimension reduction for highdimensional online-monitoring data in intensive care.
Bauer M, Fried R, et al.
Department of Statistics, University of Dortmund, Germany.
Nowadays high dimensional data in intensive care medicine can be captured, stored, and retrieved with the help of clinical information systems. Intelligent alarm systems are needed for an adequate bedside decision support, in the course of which the detection of qualitative patterns in physiologic monitoring data such as outliers, level changes, or trends aims at a proper classification of the patients state. Statistical time series techniques have already been applied successfully to the analysis of single physiological variables. The simultaneous online analysis of the multivariate patient curve yields further challenges. We describe methods for reducing the dimension and for keeping the computational efforts necessary for monitoring low. We present preliminary results of an ongoing study on monitoring critically ill patients.
Publication Types: Journal Article PMID: 11187656

Stud Health Technol Inform. 2000; 77: 208-12.
Evaluation of DICE, a terminological system for intensive care.
de Keizer NF, Abu-Hanna A, et al.
Academic Medical Center, Dept. of Medical Informatics, P.O.Box 22700, 1100 DE Amsterdam.
Evaluative research and the introduction of the Patient Data Management System to support care have increased the need for structured and standardized registration of diagnostic information in Dutch intensive cares (IC). To this end a terminological system to describe diagnoses is needed. A terminological system is a system that denotes terms to concepts in a domain based on specifications of these concepts. During the last two years we have developed DICE (Diagnoses for Intensive Care Evaluation), a terminological system application which includes knowledge about the IC diagnoses domain, such as the anatomical localization, the pathophysiology and the etiology. This paper briefly describes the design of DICE and focus on the preliminary evaluation of DICE. DICE was evaluated on the basis of 126 diagnoses collected. The knowledge modeller as well as the intensivists judged DICE positively. However, there were some points for improvement. The knowledge modeller observed a problem in modelling dependencies between qualifiers of a concept and the intensivists observed some gaps in the knowledge base and were critical about the current interface to compose plural operative procedures.
Publication Types: Evaluation Studies Journal Article PMID: 11187543